

Description

Title of Invention: WATER PUMPING AND RETURN UNIT, WATER
PUMPING AND RETURN CONTROL SYSTEM, AND GEOTHERMAL HEAT
UTILIZATION SYSTEM

5

Technical Field

[0001]

The present disclosure relates to a water pumping and return unit, a
water pumping and return control system, and a geothermal heat utilization
10 system.

The present application claims priority to Japanese Patent Application
No. 2023-190291 filed in Japan on November 7, 2023, the content of which is
incorporated herein by reference.

15

Background Art

[0002]

In recent years, geothermal heat utilization systems have been proposed
in which groundwater is pumped from a well and used as a heat source or a
cold energy source.

20

[0003]

As a technique related to this, for example, Patent Document 1 discloses
a configuration in which a pressure regulating valve that regulates water
injection into a well and a check valve that is arranged in parallel with the
pressure regulating valve and formed integrally with the pressure regulating
25 valve are provided inside the well.

Citation List

Patent Literature

[0004]

30

Patent Document 1: JP 7108665 B

Summary of Invention

Technical Problem

[0005]

35

However, in the configuration described in Patent Document 1, the
pressure regulating valve and the check valve are formed integrally and
arranged in parallel inside the well. Consequently, a unit including these
pressure regulating valve and check valve tends to be large. Therefore, during

construction or maintenance of the geothermal heat utilization system, depending on an inside diameter of the well, it may be difficult to insert or remove the unit including the pressure regulating valve and the check valve into or from inside the well.

5 [0006]

The present disclosure has been made to solve the above problem, and aims to provide a water pumping and return unit, a water pumping and return control system, and a geothermal heat utilization system that facilitate insertion into and removal from inside a well.

10

Solution to Problem

[0007]

In order to solve the above problem, a water pumping and return unit according to the present disclosure includes a housing having a flow path
15 through which water pumped from a well and water returned to the well flow, and a diverging flow path, a first flange provided at a first end of the housing and having an opening on one end side of the flow path, a second flange provided at a second end of the housing and having an opening on another end side of the flow path, and a water injection valve mechanism capable of
20 opening and closing the diverging flow path, in which the diverging flow path branches from the flow path within the housing and communicates with the outside of the housing, and the water injection valve mechanism is accommodated in a region having a peripheral surface that is a surface connecting an outer periphery of the first flange and an outer periphery of the
25 second flange.

[0008]

A water pumping and return control system according to the present disclosure includes the above water pumping and return unit, and a pilot mechanism provided outside the housing and configured to supply pressure to
30 drive the water injection valve mechanism by supplying and discharging water to and from the water injection valve mechanism.

[0009]

A geothermal heat utilization system according to the present disclosure includes the above water pumping and return control system, a main pipe
35 connected to the first flange, a pump enabling pumping of the water to the main pipe, a check valve provided between the second flange and the pump, the well, and a heat exchanger configured to exchange heat with the main pipe.

Advantageous Effects of Invention

[0010]

According to the water pumping and return unit, the water pumping and return control system, and the geothermal heat utilization system of the present disclosure, insertion into and removal from inside a well can be easily performed.

Brief Description of Drawings

[0011]

FIG. 1 is a system diagram of a geothermal heat utilization system according to an embodiment of the present disclosure.

FIG. 2 is a system diagram of a water injection control system according to the embodiment of the present disclosure.

FIG. 3 is a cross-sectional view of a water pumping and return unit according to the embodiment of the present disclosure.

FIG. 4 is a perspective view of the water pumping and return unit according to the embodiment of the present disclosure.

FIG. 5 is a cross-sectional view of the water pumping and return unit during return water operation according to the embodiment of the present disclosure.

FIG. 6 is a diagram illustrating a water pumping and return control system during water pumping operation according to the embodiment of the present disclosure.

Description of Embodiments

[0012]

An embodiment according to the present disclosure will be described below with reference to the drawings. In all drawings, the same or corresponding configurations are denoted by the same reference signs, and commonly applicable descriptions are omitted.

[0013]

Embodiments

An embodiment of a geothermal heat utilization system according to the present disclosure will be described with reference to FIGS. 1 to 6.

[0014]

Configuration of Geothermal Heat Utilization System

As illustrated in FIG. 1, a geothermal heat utilization system 9 includes a water pumping and return control system 1, a well 2, a main pipe 3, a heat exchanger 4, a pump 5, and a check valve 6.

For example, the geothermal heat utilization system 9 may include a plurality of water pumping and return control systems 1, a plurality of wells 2, a main pipe 3, a heat exchanger 4, a plurality of pumps 5, and a plurality of check valves 6.

[0015]

Configuration of Wells

10 The plurality of wells 2 extend from a ground OG into an aquifer LY.

For example, the plurality of wells 2 may include a hot water well 21 and a cold water well 22.

The hot water well 21 and the cold water well 22 are configured to take in groundwater in an aquifer and return groundwater from the inside of the hot water well 21 and the cold water well 22 to the aquifer, respectively.

The following will describe a case where stored water pumped from the hot water well 21 is used for heat utilization. However, the geothermal heat utilization system 9 can utilize not only heat of the stored water pumped from the hot water well 21, but also utilize heat of stored water pumped from the cold water well 22.

[0016]

Each well 2 includes a casing 2a embedded in a borehole HOL drilled toward the underground from the ground OG to the aquifer LY.

A plurality of slits 2b are formed in the casing 2a, for example.

25 The well 2 is configured with the plurality of slits 2b such that groundwater in the aquifer LY can be taken inside the casing 2a and stored water can be returned from the inside of the casing 2a to the aquifer LY.

[0017]

Configuration of Main Pipe

30 The main pipe 3 extends inside the well 2.

For example, the main pipe 3 may be immersed at both ends in water stored in the hot water well 21 and the cold water well 22, respectively, so as to connect the hot water well 21 and the cold water well 22.

For example, one end of the main pipe 3 may be provided in the hot water well 21 and the other end of the main pipe 3 may be provided in the cold water well 22, so that the stored water pumped by the pump 5 can flow from the hot water well 21 to the cold water well 22.

[0018]

Configuration of Heat Exchanger

The heat exchanger 4 exchanges heat with water in the main pipe 3 via the main pipe 3.

For example, heat exchange may be performed between the heat
5 exchanger 4 and water pumped from the well 2 and flowing through the main pipe 3, and the water after the heat exchange may flow through the main pipe 3 and be injected into the well 2.

For example, the heat exchanger 4 may be provided in the middle of the main pipe 3 at the ground OG.

10 [0019]

Configuration of Pump

The pump 5 pumps water from the well 2 into the main pipe 3.

For example, the pumps 5 may be provided at both ends of the main pipe 3 and immersed in water stored in the wells 2.

15 For example, output of the pump 5 may be changed by inverter control.
[0020]

Configuration of Check Valve

The check valve 6 is provided at the main pipe 3.

20 The check valve 6 is provided between a water pumping and return unit 50 to be described below and the pump 5.

The check valve 6 ensures water to flow one way in the main pipe 3 between the pump 5 and the water pumping and return unit 50.

The check valve 6 is configured to allow water to flow from the pump 5 toward the water pumping and return unit 50 to be described below, while
25 prevent water from flowing from the water pumping and return unit 50 toward the pump 5.

[0021]

Configuration of Water Pumping and Return Control System

30 As illustrated in FIG. 2, the water pumping and return control system 1 includes the water pumping and return unit 50 and a pilot mechanism 100.

The water pumping and return control system 1 is provided for each well 2.

[0022]

Configuration of Water Pumping and Return Unit

35 The water pumping and return unit 50 is provided in each well 2.

The water pumping and return unit 50 may be provided in the middle of the main pipe 3 in the well 2.

The water pumping and return unit 50 may be located above the pump 5 and the check valve 6.

[0023]

As illustrated in FIGS. 3 and 4, the water pumping and return unit 50 includes a housing 51, a first flange 52, a second flange 53, and a water injection valve mechanism 60.

As illustrated in FIG. 3, the housing 51 has a flow path 55, a diverging flow path 56, and a communication port 57.

The housing 51 may be provided such that a direction connecting a first end 51s and a second end 51t of the housing 51 is aligned with an up-down direction in the well 2.

The housing 51 may integrally include a housing first part 51a and a housing second part 51b.

[0024]

The housing first part 51a extends in the direction connecting the first end 51s and the second end 51t of the housing 51.

The flow path 55 is formed inside the housing first part 51a.

Pumped water from the well 2 and return water to the well 2 flow through the flow path 55.

The flow path 55 may be formed to pass through the first end 51s and the second end 51t of the housing 51.

The housing first part 51a is formed such that an intermediate portion 51c between the first end 51s and the second end 51t extends to one side in a radial direction Dr of the housing 51 that intersects the up-down direction, relative to the first end 51s and the second end 51t. Accordingly, the flow path 55 is formed such that a flow path intermediate portion 55c between the flow path first end portion 55s and the flow path second end portion 55t extends in the up-down direction at a position biased to one side in the radial direction Dr, relative to the flow path first end portion 55s on the first end 51s side and the flow path second end portion 55t on the second end 51t side.

[0025]

As illustrated in FIGS. 3 and 4, the first flange 52 is provided at the first end 51s of the housing 51.

The first flange 52 is formed to protrude outward in the radial direction Dr from the housing first part 51a.

The first flange 52 has an opening 55d, on the inner side thereof, on a side of the flow path first end portion 55s of the flow path 55.

A piping member (not illustrated) that constitutes the main pipe 3 is detachably connected to the first flange 52 from above with a plurality of bolts.
[0026]

5 The second flange 53 is provided at the second end 51t of the housing 51.

The second flange 53 is formed to protrude outward in the radial direction Dr from the housing first part 51a.

The second flange 53 has an opening 55e, on the inner side thereof, on a side of the flow path second end portion 55t of the flow path 55.

10 A piping member (not illustrated) that constitutes the main pipe 3 is detachably connected to the second flange 53 from below with a plurality of bolts.
[0027]

15 The housing second part 51b may be provided so as to protrude from an outside surface 51f of the housing first part 51a outward in the radial direction Dr of the housing 51.

The housing second part 51b may extend from the outside surface 51f of the housing first part 51a outward in the radial direction Dr of the housing 51.

20 The housing second part 51b may be provided so as to protrude from the outside surface 51f of the housing first part 51a to the other side in the radial direction Dr of the housing 51.

The housing second part 51b may be provided so as to protrude from the intermediate portion 51c of the housing first part 51a to the other side in the radial direction Dr.

25 [0028]

As illustrated in FIG. 3, the housing second part 51b may include a first tubular portion 51g and a second tubular portion 51h.

30 The first tubular portion 51g may be provided so as to protrude from the outside surface 51f of the housing first part 51a to the other side in the radial direction Dr.

A flange 51r having a diameter increasing from the first tubular portion 51g may be provided at a tip portion of the first tubular portion 51g.

[0029]

35 The second tubular portion 51h is provided inside the first tubular portion 51g with a space therebetween.

The diverging flow path 56 is formed in the second tubular portion 51h.

A tip portion of the second tubular portion 51h is formed so as to be located on one side in the radial direction Dr relative to the tip portion of the first tubular portion 51g.

5 An annular space S is formed between the first tubular portion 51g and the second tubular portion 51h when viewed from an extension direction C of the diverging flow path 56.

[0030]

The diverging flow path 56 is provided to branch from the flow path 55 in the housing 51.

10 The diverging flow path 56 may branch from the flow path intermediate portion 55c between the flow path first end portion 55s and the flow path second end portion 55t of the flow path 55 in the housing 51.

The diverging flow path 56 may be formed to extend in the radial direction Dr of the housing 51 that intersects the direction connecting the first end 51s and the second end 51t.

The diverging flow path 56 has an opening 56d at a tip portion of the second tubular portion 51h on the outer side in the radial direction Dr.

The diverging flow path 56 is configured to be able to communicate with the outside of the housing 51.

20 The diverging flow path 56 may communicate with the outside of the housing 51 via the communication port 57.

[0031]

The communication port 57 is formed in the housing second part 51b.

25 The communication port 57 may be provided in the first tubular portion 51g.

The communication port 57 may be formed so as to pass through an inner surface and an outer surface of the first tubular portion 51g.

A plurality of communication ports 57 may be provided in the first tubular portion 51g at intervals in a circumferential direction.

30 The communication ports 57 communicate the inside of the diverging flow path 56 with the outside of the housing 51 when the opening 56d of the diverging flow path 56 is opened by the water injection valve mechanism 60 to be described below.

[0032]

35 Configuration of Water Injection Valve Mechanism

The water injection valve mechanism 60 is configured to be able to open and close the diverging flow path 56.

The water injection valve mechanism 60 may be provided at a flow path end portion on the outer side in the radial direction Dr in the diverging flow path 56.

5 The water injection valve mechanism 60 is configured to be able to open and close the opening 56d of the diverging flow path 56.
[0033]

The water injection valve mechanism 60 includes a valve body 61, a diaphragm 62, a cover 63, and a guide mechanism 64.

10 The valve body 61 is configured to be able to open and close the diverging flow path 56.

The valve body 61 is configured to be able to open and close the opening 56d of the diverging flow path 56.

15 The valve body 61 is configured to be able to open and close the opening 56d by moving back and forth along the extension direction C of the diverging flow path 56.

The valve body 61 is formed in a disc shape extending along a plane orthogonal to the extension direction C.

The valve body 61 has an outside diameter larger than an inside diameter of the opening 56d.

20 [0034]

The valve body 61 has a seating surface 61s that can come into contact with an inner peripheral edge of the opening 56d.

25 The seating surface 61s may be tapered so that a diameter dimension thereof gradually decreases as the seating surface 61s approaches the opening 56d in the radial direction.

The valve body 61 can close the opening 56d with the seating surface 61s in contact with the inner peripheral edge of the opening 56d.

30 As illustrated in FIG. 5, the valve body 61 can open the opening 56d with the seating surface 61s spaced outward in the radial direction Dr from the inner peripheral edge of the opening 56d.

With the seating surface 61s of the valve body 61 spaced outward in the radial direction Dr from the inner peripheral edge of the opening 56d, a gap H is formed between the valve body 61 and the inner peripheral edge of the opening 56d.

35 With the seating surface 61s of the valve body 61 spaced outward in the radial direction Dr from the inner peripheral edge of the opening 56d, the inside of the diverging flow path 56 communicates with the outside of the housing 51 through the gap H, the annular space S, and the communication port 57.

[0035]

As illustrated in FIG. 3, a reinforcing plate 61p is provided in the valve body 61 on a side spaced apart from the opening 56d in the direction along the extension direction C (outer side in the radial direction Dr).

5 The reinforcing plate 61p is a plate with the same diameter as the valve body 61.

The reinforcing plate 61p is made of metal and reinforces the valve body 61 by fitting along the valve body 61.

[0036]

10 The diaphragm 62 is connected to the valve body 61.

The diaphragm 62 is provided in a film shape so as to extend from the valve body 61 to the outer peripheral side.

The thickness of the diaphragm 62 is smaller than the thickness of the valve body 61.

15 The diaphragm 62 is provided so as to close the first tubular portion 51g of the housing second part 51b.

An outer peripheral portion of the diaphragm 62 is sandwiched between the cover 63 and the flange 51r of the first tubular portion 51g.

[0037]

20 The diaphragm 62 may be formed integrally with the valve body 61.

The diaphragm 62 is elastically deformable in the opening and closing directions of the valve body 61.

When the valve body 61 moves back and forth in the opening and closing directions, the diaphragm 62 elastically deforms in an extension
25 direction of the housing second part 51b.

The diaphragm 62 may be formed using, for example, a rubber-based material.

The valve body 61 formed integrally with the diaphragm 62 may be formed using the same rubber-based material as the diaphragm 62.

30 [0038]

The guide mechanism 64 is connected to the valve body 61.

The guide mechanism 64 guides the valve body 61 so that the valve body 61 moves in the diverging flow path 56 in the extension direction of the diverging flow path 56.

35 The guide mechanism 64 includes, for example, a shaft 65 and guide vanes 66.

[0039]

The shaft 65 extends in the extension direction of the diverging flow path 56.

A base end portion of the shaft 65 is connected to the valve body 61.

5 A tip portion of the shaft 65 is inserted into a guide tube portion 51p provided in the housing first part 51a.

The tip portion of the shaft 65 is supported in the guide tube portion 51p so as to be movable in the extension direction C of the diverging flow path 56.
[0040]

The guide vanes 66 are connected to the valve body 61.

10 The plurality of guide vanes 66 are provided at intervals in the circumferential direction around a central axis of the shaft 65.

The guide vanes 66 are inserted into the diverging flow path 56.

The plurality of guide vanes 66 guide the valve body 61 by sliding against an inside surface of the second tubular portion 51h.

15 [0041]

The cover 63 is provided so as to close the first tubular portion 51g of the housing second part 51b together with the diaphragm 62.

An outer peripheral portion 63a of the cover 63 is attached to the flange 51r of the first tubular portion 51g with a plurality of bolts (not illustrated).

20 A central portion 63b of the cover 63 protrudes outward in the radial direction Dr from the diaphragm 62 relative to the outer peripheral portion 63a.
[0042]

A diaphragm chamber 67 is formed between the cover 63 and the diaphragm 62.

25 As illustrated in FIGS. 3 and 4, the diaphragm chamber 67 has a water injection port 68 and a drain port 69.

The water injection port 68 is configured to allow water to be injected into the diaphragm chamber 67 from the pilot mechanism 100 to be described below.

30 The drain port 69 is configured to allow water to be drained from the diaphragm chamber 67 to the pilot mechanism 100.
[0043]

The diaphragm chamber 67 is configured so that pressure for driving the diaphragm 62 in the opening and closing directions can be supplied from the pilot mechanism 100 outside the housing 51.

35 By injecting water into the diaphragm chamber 67 through the water injection port 68, the diaphragm chamber 67 generates pressure that drives the diaphragm 62 and the valve body 61 in the closing direction.

By discharging water in the diaphragm chamber 67 to the outside through the drain port 69, the diaphragm chamber 67 reduces pressure that drives the diaphragm 62 and the valve body 61 in the closing direction.

[0044]

5 As illustrated in FIG. 3, the entire water injection valve mechanism 60 is accommodated in a region A having a peripheral surface that is a surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53.

The region A, that is, the first flange 52 and the second flange 53, may
10 have an outside diameter of, for example, 315 mm or less.

The region A, that is, the first flange 52 and the second flange 53, may have an outside diameter of, for example, 250 mm or less.

[0045]

Configuration of Pilot Mechanism

15 As illustrated in FIG. 2, the pilot mechanism 100 is provided outside each well 2.

The pilot mechanism 100 may be provided at the ground OG outside each well 2.

At least a portion of the pilot mechanism 100 may be provided inside the
20 well 2.

[0046]

The pilot mechanism 100 supplies and discharges water to and from the water injection valve mechanism 60, thereby supplying pressure for driving the water injection valve mechanism 60 in the opening and closing directions.

25 The pilot mechanism 100 may include a pressurization line 110, a strainer 111, a pilot valve 112, and a register 113.

[0047]

The pressurization line 110 is provided to branch from the main pipe 3 connected to the first flange 52.

30 One end of the pressurization line 110 is connected to the main pipe 3 above the water pumping and return unit 50.

The other end of the pressurization line 110 is connected to the water injection port 68.

The pressurization line 110 introduces some of the water flowing
35 through the main pipe 3, thereby applying pressure to the water injection valve mechanism 60 in a direction of closing the water injection valve mechanism 60.

The pressurization line 110 injects water from the water injection port 68 into the diaphragm chamber 67, thereby applying pressure to the water

injection valve mechanism 60 in the direction of closing the water injection valve mechanism 60.

[0048]

The strainer 111 is provided in the pressurization line 110.

5 The strainer 111 collects foreign matter and the like contained in water flowing from the main pipe 3 into the pressurization line 110.

[0049]

The pilot valve 112 is provided in the pressurization line 110.

10 The pilot valve 112 has a drain line 114 connected to the pressurization line 110.

The pilot valve 112 is configured to be able to open and close the drain line 114.

15 The pilot valve 112 is configured to release pressure in the pressurization line 110 when the pressure in the pressurization line 110 reaches or exceeds a set pressure.

The pilot valve 112 is configured to be able to release the pressure in the pressurization line 110 by discharging some of the water in the pressurization line 110 to the outside of the pressurization line 110.

[0050]

20 The pilot valve 112 may have a pressure detection unit 112s that detects the pressure in the pressurization line 110.

The pilot valve 112 is configured to be able to release the pressure in the pressurization line 110 when pressure detected by the pressure detection unit 112s reaches or exceeds a set pressure.

25 The pilot valve 112 may be biased by a spring (not illustrated) in a direction to close the drain line 114.

A plurality of types of springs having different elastic coefficients may be prepared for the pilot valve 112.

30 The spring for the pilot valve 112 may be selected appropriately from the plurality of types according to a set pressure.

[0051]

The register 113 is provided in the pressurization line 110.

The register 113 may be provided in the pressurization line 110 between the pressure detection unit 112s and the pilot valve 112.

35 The register 113 is configured to be able to adjust changes in a flow rate of water in the pressurization line 110 when the pilot valve 112 releases the pressure in the pressurization line 110.

The register 113 is configured to suppress sudden changes in the water flow rate in the pressurization line 110 when the pilot valve 112 releases the pressure in the pressurization line 110.

[0052]

- 5 The pilot mechanism 100 may include a decompression line 120, a solenoid valve 121, and an orifice 122.

[0053]

- 10 The decompression line 120 is configured to be able to discharge water from the water injection valve mechanism 60 when the water injection valve mechanism 60 is opened.

One end of the decompression line 120 is connected to the drain port 69 of the water injection valve mechanism 60.

The decompression line 120 discharges water drained from the drain port 69 to the outside of the water pumping and return unit 50.

- 15 The decompression line 120 is configured to be able to discharge water from the water injection valve mechanism 60 when the water injection valve mechanism 60 is opened.

- 20 The decompression line 120 may be configured to be able to discharge water from the diaphragm chamber 67 when the water injection valve mechanism 60 is opened.

The decompression line 120 discharges water from the diaphragm chamber 67, thereby reducing the pressure applied to the water injection valve mechanism 60.

[0054]

- 25 The solenoid valve 121 is provided in the decompression line 120.

The solenoid valve 121 is configured to be able to open and close the decompression line 120.

The solenoid valve 121 may be driven by a control device (not illustrated) or the like.

- 30 The solenoid valve 121 is configured to be able to discharge water from the water injection valve mechanism 60 through the decompression line 120 while the decompression line 120 is opened.

[0055]

- 35 The orifice 122 is provided in the decompression line 120 on the upstream side of the solenoid valve 121.

The orifice 122 is a member that throttles a flow rate of water flowing in the decompression line 120.

The flow path inside diameter of the orifice 122 may be smaller than the inner diameter of the decompression line 120.

[0056]

Operation of Water Pumping and Return Control System: During Water

5 Pumping Operation

In the water pumping and return control system 1 as described above, when pumping water from the well 2, the solenoid valve 121 is closed by a control device (not illustrated) or the like, as illustrated in FIG. 6.

10 When pumping water from the well 2, the pump 5 is operated by a control device or the like.

When pumping water from the well 2, the pump 5 is operated and the pump 5 sucks up the water in the well 2.

The water pumped by the pump 5 is sent through the main pipe 3 to the water pumping and return unit 50.

15 The water pumped by the pump 5 flows only in a direction toward the water pumping and return unit 50 by passing through the check valve 6.

The water pumped by the pump 5 and passing through the check valve 6 is prevented from flowing back toward the pump 5 side from the water pumping and return unit 50 by the check valve 6.

20 [0057]

The water sent to the water pumping and return unit 50 passes through the flow path 55, flows into the main pipe 3 above the water pumping and return unit 50, and is pumped from the well 2.

25 Some of the water that passes through the flow path 55 and flows into the main pipe 3 above the water pumping and return unit 50 flows into the pressurization line 110.

The water flowing into the pressurization line 110 passes through the strainer 111 and the register 113 and is sent from the water injection port 68 into the diaphragm chamber 67.

30 Pressure of the water sent into the diaphragm chamber 67 presses against the diaphragm 62 and the valve body 61, causing the valve body 61 to close the opening 56d.

[0058]

35 In this manner, the water pumping and return unit 50 pumps water through the flow path 55.

Here, when the pressure of the water flowing into the pressurization line 110 reaches or exceeds the set pressure, the pilot valve 112 opens and some of the water in the pressurization line 110 is drained from the drain line 114. This

reduces the pressure in the pressurization line 110, preventing the pressure in the diaphragm chamber 67 from increasing excessively.

[0059]

Operation of Water Pumping and Return Control System: During Return Water
5 Operation

In the water pumping and return control system 1 described above, when water is normally returned to the well 2, the solenoid valve 121 is kept closed by a control device (not illustrated) or the like.

10 When water pumped from another well 2 flows into the main pipe 3 above the water pumping and return unit 50, the water flows from the main pipe 3 into the flow path 55.

The water flowing into the flow path 55 is prevented from flowing from the flow path 55 to the pump 5 side by the check valve 6.

15 The water flowing into the flow path 55 flows into the diverging flow path 56 and presses the valve body 61 in the opening direction.

[0060]

Some of the water flowing from the other well 2 into the main pipe 3 flows into the pressurization line 110.

20 The water flowing into the pressurization line 110 passes through the strainer 111 and the register 113 and is sent from the water injection port 68 into the diaphragm chamber 67.

25 When the pressure of the water flowing into the pressurization line 110 reaches or exceeds the set pressure, the pilot valve 112 opens and some of the water in the pressurization line 110 is drained from the drain line 114. This reduces the pressure in the pressurization line 110, and the pressure in the diaphragm chamber 67 decreases.

30 Therefore, when the pressure of the water flowing into the diverging flow path 56 exceeds the pressure in the diaphragm chamber 67, the water in the diaphragm chamber 67 is pushed out through the decompression line 120 to the outside, and the valve body 61 opens.

When the valve body 61 opens, the water in the diverging flow path 56 flows out through the gap H, the annular space S, and the communication port 57. This enables water to be returned to the well 2.

[0061]

35 However, when water is forcibly returned to the well 2, the solenoid valve 121 is opened by a control device (not illustrated) or the like, as illustrated in FIG. 2.

When the solenoid valve 121 opens, the water in the diaphragm chamber 67 can be discharged from the drain port 69 through the decompression line 120.

5 When the pressure of the water flowing into the diverging flow path 56 exceeds the pressure in the diaphragm chamber 67, the water in the diaphragm chamber 67 is pushed out through the decompression line 120 to the outside, and the valve body 61 opens.

When the valve body 61 opens, the water in the diverging flow path 56 flows out through the gap H, the annular space S, and the communication port 10 57. This enables water to be returned to the well 2.

[0062]

Operations and Effects

According to the present embodiment, in the water pumping and return unit 50, the water injection valve mechanism 60 is accommodated in the region 15 A having a peripheral surface that is a surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53.

Therefore, the water injection valve mechanism 60 is prevented from protruding outward beyond the first flange 52 and the second flange 53.

20 This prevents the water injection valve mechanism 60 from interfering with the inner surface of the well 2 when the water pumping and return unit 50 is inserted into or removed from inside the well 2 for installation or maintenance.

Therefore, it is possible to provide the water pumping and return unit 50 that can be easily inserted into and removed from inside the well 2.

25 [0063]

Further, according to an example of the present embodiment, by supplying pressure from the pilot mechanism 100 to the diaphragm chamber 67, the diaphragm 62 connected to the valve body 61 is elastically deformed, thereby driving the valve body 61 in the opening and closing directions.

30 Thus, the diverging flow path 56 can be opened and closed by the valve body 61. When the diverging flow path 56 is opened by the valve body 61, water flowing in the flow path 55 is discharged from the diverging flow path 56 to the outside of the housing 51, thereby being able to inject the water into the well 2 when returning the water to the well 2.

35 [0064]

Further, according to an example of the present embodiment, by injecting water from the pilot mechanism 100 into the diaphragm chamber 67

through the water injection port 68, the diaphragm chamber 67 can be pressurized, thereby driving the valve body 61 in the closing direction.

By draining water from the diaphragm chamber 67 to the pilot mechanism 100 through the drain port 69, the diaphragm chamber 67 can be
5 depressurized, thereby being able to operate the valve body 61 in the opening direction.

[0065]

Further, according to an example of the present embodiment, by guiding the valve body 61 with the guide mechanism 64, the valve body 61 can be
10 stably moved in the extension direction C of the diverging flow path 56.

[0066]

Further, according to an example of the present embodiment, by forming the diverging flow path 56 to extend from the flow path 55 in the radial direction Dr of the housing 51, and providing the water injection valve
15 mechanism 60 at the flow path end portion of the diverging flow path 56, the water injection valve mechanism 60 is easily laid out to be accommodated in the region A having a peripheral surface that is a surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53.

By forming the diverging flow path 56 so as to extend from the flow path 55 in the radial direction Dr of the housing 51, even when the valve body 61 and the diaphragm 62 of the water injection valve mechanism 60 are made larger in diameter, the water injection valve mechanism 60 can be easily laid out while accommodating the water injection valve mechanism 60 in the region
20 A.

[0067]

Further, according to an example of the present embodiment, by forming the communication port 57 in the housing second part 51b, which protrudes outward in the radial direction Dr from the outside surface 51f of the housing
30 first part 51a, it becomes easy to secure a large opening area of the communication port 57. Therefore, water flowing from the flow path 55 into the diverging flow path 56 can be efficiently injected into the well 2 through the communication port 57.

[0068]

Further, according to an example of the present embodiment, by making the outside diameter of the region A having a peripheral surface that is a surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53, 315 mm or less, the water pumping and
35

return unit 50 can be easily inserted into and removed from inside the well 2 even in a well 2 having a small inside diameter. This also makes it possible to reduce the diameter of the well 2.

[0069]

5 Further, according to the water pumping and return control system 1 of the present embodiment, it is possible to provide the water pumping and return control system 1 including the water pumping and return unit 50 that can be easily inserted into and removed from inside the well 2.

[0070]

10 Further, according to an example of the present embodiment, the water pumping and return control system 1 includes the pilot valve 112 and the register 113 in the pressurization line 110.

Accordingly, when the pressure in the pressurization line 110 reaches or exceeds the set pressure, the pilot valve 112 releases the pressure in the
15 pressurization line 110, thereby making it possible to appropriately adjust the pressure applied to the water injection valve mechanism 60.

Further, when the pilot valve 112 releases the pressure in the pressurization line 110, the register 113 adjusts the change in the flow rate of water in the pressurization line 110.

20 This makes it possible to suppress sudden fluctuations in the pressure applied from the pilot mechanism 100 to the water injection valve mechanism 60.

Therefore, the water injection valve mechanism 60 can be opened and closed smoothly, preventing occurrence of a water hammer phenomenon.

25 [0071]

Further, according to an example of the present embodiment, the solenoid valve 121 and the orifice 122 are provided in the decompression line 120.

30 Accordingly, by opening the decompression line 120 by the solenoid valve 121, the decompression line 120 can reduce the pressure applied to the water injection valve mechanism 60, thereby opening the water injection valve mechanism 60.

In this case, by providing the orifice 122 upstream of the solenoid valve 121 that throttles the flow rate of water flowing through the decompression line
35 120, an amount of water in the decompression line 120 can be appropriately adjusted when the solenoid valve 121 opens and closes, thereby stabilizing the operation of the water injection valve mechanism 60.

[0072]

The geothermal heat utilization system 9 of the present embodiment includes the water pumping and return control system 1.

Accordingly, it is possible to provide the geothermal heat utilization system 9 configured using the water pumping and return unit 50 that can be easily inserted into and removed from inside the well 2.

[0073]

Modification Example

In the example of the embodiment, the diverging flow path 56 branches from the flow path intermediate portion 55c of the flow path 55, but may be configured in any manner.

As a modification example, the diverging flow path 56 may branch from the flow path first end portion 55s of the flow path 55.

As another modification example, the diverging flow path 56 may branch from the flow path second end portion 55t of the flow path 55.

[0074]

In the example of the embodiment, the housing second part 51b is provided to protrude from the intermediate portion 51c of the housing first part 51a to the other side in the radial direction D_r , but may be configured in any manner.

As a modification example, the housing second part 51b may be provided to protrude to the other side in the radial direction D_r from a position offset to one side in the up-down direction relative to the intermediate portion 51c of the housing first part 51a.

[0075]

In the example of the embodiment, the diaphragm 62 is formed integrally with the valve body 61, but may be configured in any manner.

As a modification example, the diaphragm 62 may be a separate body from the valve body 61.

[0076]

In the example of the embodiment, the strainer 111 is provided in the pressurization line 110, but may be configured in any way.

As a modification example, the strainer 111 may be omitted in the pressurization line 110.

[0077]

Other Embodiments

While the embodiments of the present disclosure are described above, the embodiments are examples, and are not intended to limit the scope of the present disclosure. The embodiments can be implemented in various other

forms, and various omissions, substitutions, and modifications can be made without departing from the gist of the present disclosure. The embodiments and variations thereof are included in the scope of the present disclosure and equivalents thereof as well as in the scope and gist of the present disclosure.

5 [0078]

Supplementary Notes

The water pumping and return unit 50, the water pumping and return control system 1, and the geothermal heat utilization system 9 according to the embodiments are understood as follows, for example.

10 [0079]

(1) A water pumping and return unit 50 according to a first aspect includes a housing 51 having a flow path 55 configured to flow water being pumped from a well 2 and water being returned to the well 2, and a diverging flow path 56, a first flange 52 provided at a first end 51s of the housing 51 and having an opening 55d on one end side of the flow path 55, a second flange 53 provided at a second end 51t of the housing 51 and having an opening 55e on another end side of the flow path 55, and a water injection valve mechanism 60 configured to open and close the diverging flow path 56, in which the diverging flow path 56 branches from the flow path 55 in the housing 51 and communicates with the outside of the housing 51, and the water injection valve mechanism 60 is accommodated in a region A having a peripheral surface that is a surface connecting an outer periphery 52s of the first flange 52 and an outer periphery 53s of the second flange 53.

[0080]

25 In the water pumping and return unit 50, the water injection valve mechanism 60 is accommodated in the region A having the peripheral surface that is the surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53, so the water injection valve mechanism 60 is prevented from protruding outward beyond the first flange 52 and the second flange 53. This prevents the water injection valve mechanism 60 from interfering with the inner surface of the well 2 when the water pumping and return unit 50 is inserted into or removed from inside the well 2. Therefore, it is possible to provide the water pumping and return unit 50 that can be easily inserted into and removed from inside the well 2.

35 [0081]

(2) A water pumping and return unit 50 according to a second aspect is the water pumping and return unit 50 according to (1), in which the water injection valve mechanism 60 includes a valve body 61 configured to open and

close the diverging flow path 56, a diaphragm 62 configured to elastically deform in opening and closing directions of the valve body 61 and connected to the valve body 61, and a diaphragm chamber 67 configured to receive pressure from a pilot mechanism 100 outside the housing 51 and drive the diaphragm 62
5 in the opening and closing directions.

[0082]

According to this aspect, by supplying pressure from the pilot mechanism 100 to the diaphragm chamber 67, the diaphragm 62 connected to the valve body 61 is elastically deformed, thereby driving the valve body 61 in
10 the opening and closing directions. Thus, the diverging flow path 56 can be opened and closed by the valve body 61. When the diverging flow path 56 is opened by the valve body 61, water flowing in the flow path 55 is discharged from the diverging flow path 56 to the outside of the housing 51, thereby being able to inject the water into the well 2 when returning the water to the well 2.

15 [0083]

(3) A water pumping and return unit 50 according to a third aspect is the water pumping and return unit 50 according to (2), in which the diaphragm chamber 67 has a water injection port 68 configured to inject water from the pilot mechanism 100 into the diaphragm chamber 67, and a drain port 69
20 configured to drain water from the diaphragm chamber 67 to the pilot mechanism 100.

[0084]

According to this aspect, by injecting water from the pilot mechanism 100 into the diaphragm chamber 67 through the water injection port 68, the
25 diaphragm chamber 67 can be pressurized, thereby driving the valve body 61 in the closing direction. By draining water from the diaphragm chamber 67 to the pilot mechanism 100 through the discharge port, the diaphragm chamber 67 can be depressurized, thereby operating the valve body 61 in the opening direction.

[0085]

30 (4) A water pumping and return unit 50 according to a fourth aspect is the water pumping and return unit 50 according to (2) or (3), further including a guide mechanism 64 connected to the valve body 61 and configured to guide the valve body 61 and move the valve body 61 in an extension direction C of the diverging flow path 56.

35 [0086]

According to this aspect, by guiding the valve body 61 with the guide mechanism 64, the valve body 61 can be stably moved in the extension direction C of the diverging flow path 56.

[0087]

(5) A water pumping and return unit 50 according to a fifth aspect is the water pumping and return unit 50 according to any one of (1) to (4), in which the diverging flow path 56 extends from the flow path 55 in a radial direction
5 Dr of the housing 51 that intersects with a direction connecting the first end 51s and the second end 51t of the housing 51, and the water injection valve mechanism 60 is provided at a flow path end portion on an outer side in the radial direction Dr in the diverging flow path 56.

[0088]

10 According to this aspect, by forming the diverging flow path 56 to extend from the flow path 55 in the radial direction Dr of the housing 51, and providing the water injection valve mechanism 60 at the flow path end portion of the diverging flow path 56, the water injection valve mechanism 60 is easily laid out to be accommodated in the region A having the peripheral surface that
15 is the surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53.

[0089]

(6) A water pumping and return unit 50 according to a sixth aspect is the water pumping and return unit 50 according to (5), in which the housing 51
20 includes a housing first part 51a extending in the direction connecting the first end 51s and the second end 51t and having the flow path 55 formed in the housing first part 51a, a housing second part 51b protruding outward in the radial direction Dr from an outside surface 51f of the housing first part 51a and having the diverging flow path 56 formed in the housing second part 51b, and
25 the housing 51 further has a communication port 57 formed in the housing second part 51b and configured to communicate the inside of the diverging flow path 56 with the outside of the housing 51 when the diverging flow path 56 is opened by the water injection valve mechanism 60.

[0090]

30 According to this aspect, by forming the communication port 57 in the housing second part 51b, which protrudes outward in the radial direction Dr from the outside surface 51f of the housing first part 51a, it becomes easy to secure a large opening area of the communication port 57. Therefore, water flowing from the flow path 55 into the diverging flow path 56 can be efficiently
35 injected into the well 2 through the communication port 57.

[0091]

(7) A water pumping and return unit 50 according to a seventh aspect is the water pumping and return unit 50 according to any one of (1) to (6), in which the region A has an outside diameter of 315 mm or less.

[0092]

5 According to this aspect, by making the outside diameter of the region A having the peripheral surface that is the surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53, 315 mm or less, the water pumping and return unit 50 can be easily inserted into and removed from inside the well 2 even in a well 2 having a small inside
10 diameter. This also makes it possible to reduce the diameter of the well 2.

[0093]

 (8) A water pumping and return control system 1 according to an eighth aspect includes the water pumping and return unit 50 according to any one of (1) to (7), and a pilot mechanism 100 provided outside the housing 51 and
15 configured to supply pressure and drive the water injection valve mechanism 60 by supplying and discharging water to and from the water injection valve mechanism 60.

[0094]

 According to this aspect, the water injection valve mechanism 60 driven
20 in opening and closing directions by the pilot mechanism 100 is accommodated in the region A having the peripheral surface that is the surface connecting the outer periphery 52s of the first flange 52 and the outer periphery 53s of the second flange 53, so the water injection valve mechanism 60 is prevented from protruding outward beyond the first flange 52 and the second flange 53. This
25 prevents the water injection valve mechanism 60 from interfering with the inner surface of the well 2 when the water pumping and return unit 50 is inserted into or removed from inside the well 2. Therefore, it is possible to provide the water pumping and return control system 1 including the water pumping and return unit 50 that can be easily inserted into and removed from
30 inside the well 2.

[0095]

 (9) A water pumping and return control system 1 according to a ninth aspect is the water pumping and return control system 1 according to (8), in which the pilot mechanism 100 includes a pressurization line 110 branching
35 from a main pipe 3 connected to the first flange 52 and applying pressure to the water injection valve mechanism 60 in a direction of closing the water injection valve mechanism 60 by introducing some of the water flowing through the main pipe 3, a pilot valve 112 provided in the pressurization line 110 and

configured to release pressure in the pressurization line 110 by discharging water in the pressurization line 110 to the outside of the pressurization line 110 when the pressure in the pressurization line 110 reaches or exceeds a set pressure, and a register 113 provided in the pressurization line 110 and
5 configured to adjust a change in a flow rate of the water in the pressurization line 110 when the pilot valve 112 releases the pressure in the pressurization line 110.

[0096]

According to this aspect, when the pressure in the pressurization line
10 110 reaches or exceeds the set pressure, the pilot valve 112 releases the pressure in the pressurization line 110, thereby making it possible to appropriately adjust the pressure applied to the water injection valve mechanism 60. Further, when the pilot valve 112 releases the pressure in the pressurization line 110, the register 113 adjusts the change in the flow rate of
15 water in the pressurization line 110, thereby preventing the pressure applied from the pilot mechanism 100 to the water injection valve mechanism 60 from fluctuating suddenly. This enables the water injection valve mechanism 60 to open and close smoothly, preventing occurrence of a water hammer phenomenon.

20 [0097]

(10) A water pumping and return control system 1 according to a tenth aspect is the water pumping and return control system 1 according to (8) or (9), in which the pilot mechanism 100 includes a decompression line 120 configured to reduce pressure applied to the water injection valve mechanism
25 60 by discharging water from the water injection valve mechanism 60 when the water injection valve mechanism 60 is opened, a solenoid valve 121 configured to open and close the decompression line 120, and an orifice 122 provided upstream of the solenoid valve 121 in the decompression line 120 and configured to throttle a flow rate of water flowing through the decompression
30 line 120.

[0098]

According to this aspect, by opening the decompression line 120 by the solenoid valve 121, the decompression line 120 can reduce the pressure applied to the water injection valve mechanism 60, thereby opening the water injection
35 valve mechanism 60. In this case, by providing the orifice 122 upstream of the solenoid valve 121 that throttles the flow rate of water flowing through the decompression line 120, an amount of water in the decompression line 120 can

be appropriately adjusted when the solenoid valve 121 opens and closes, thereby stabilizing the operation of the water injection valve mechanism 60.
[0099]

(11) A geothermal heat utilization system 9 according to an eleventh aspect includes the water pumping and return control system 1 according to any one of (8) to (10), a main pipe 3 connected to the first flange 52, a pump 5 configured to pump water into the main pipe 3, a check valve 6 provided between the second flange 53 and the pump 5, the well 2, and a heat exchanger 4 configured to exchange heat with the main pipe 3.

10 [0100]

According to the geothermal heat utilization system 9, it is possible to provide the geothermal heat utilization system 9 configured using the water pumping and return unit 50 that can be easily inserted into and removed from inside the well 2.

15

Industrial Applicability

[0101]

According to the water pumping and return unit, the water pumping and return control system, and the geothermal heat utilization system of the present disclosure, insertion into and removal from inside a well can be easily performed.

20

Reference Signs List

[0102]

25 1 Water pumping and return control system

2 Well

21 Hot water well

22 Cold water well

2a Casing

30 2b Slit

3 Main pipe

4 Heat exchanger

5 Pump

6 Check valve

35 9 Geothermal heat utilization system

50 Water pumping and return unit

51 Housing

51a Housing first part

- 51b Housing second part
- 51c Intermediate portion
- 51f Outside surface
- 51g First tubular portion
- 5 51h Second tubular portion
- 51p Guide tube portion
- 51r Flange
- 51s First end
- 51t Second end
- 10 52 First flange
- 52s Outer periphery
- 53 Second flange
- 53s Outer periphery
- 55 Flow path
- 15 55c Flow path intermediate portion
- 55d Opening
- 55e Opening
- 55s Flow path first end portion
- 55t Flow path second end portion
- 20 56 Diverging flow path
- 56d Opening
- 57 Communication port
- 60 Water injection valve mechanism
- 61 Valve body
- 25 61p Reinforcing plate
- 61s Seating surface
- 62 Diaphragm
- 63 Cover
- 63a Outer peripheral portion
- 30 63b Central portion
- 64 Guide mechanism
- 65 Shaft
- 66 Guide vane
- 67 Diaphragm chamber
- 35 68 Water injection port
- 69 Drain port
- 100 Pilot mechanism
- 110 Pressurization line

- 111 Strainer
- 112 Pilot valve
- 112s Pressure detection unit
- 113 Register
- 5 114 Drain line
- 120 Decompression line
- 121 Solenoid valve
- 122 Orifice
- A Region
- 10 C Extension direction
- Dr Radial direction
- H Gap
- HOL Borehole
- LY Aquifer
- 15 OG Ground
- S Space

Claims

[Claim 1]

A water pumping and return unit comprising:
a housing having a flow path configured to flow water being pumped from a well and water being returned to the well, and a diverging flow path;
a first flange provided at a first end of the housing and having an opening on one end side of the flow path;
a second flange provided at a second end of the housing and having an opening on another end side of the flow path; and
a water injection valve mechanism configured to open and close the diverging flow path, wherein
the diverging flow path branches from the flow path in the housing and communicates with the outside of the housing, and
the water injection valve mechanism is accommodated in a region having a peripheral surface that is a surface connecting an outer periphery of the first flange and an outer periphery of the second flange.

[Claim 2]

The water pumping and return unit according to claim 1, wherein
the water injection valve mechanism includes
a valve body configured to open and close the diverging flow path,
a diaphragm configured to elastically deform in opening and closing directions of the valve body and connected to the valve body, and
a diaphragm chamber configured to receive pressure from a pilot mechanism outside the housing and drive the diaphragm in the opening and closing directions.

[Claim 3]

The water pumping and return unit according to claim 2, wherein
the diaphragm chamber has
a water injection port configured to inject water from the pilot mechanism into the diaphragm chamber, and
a drain port configured to drain water from the diaphragm chamber to the pilot mechanism.

[Claim 4]

The water pumping and return unit according to claim 2 or 3, further comprising:

a guide mechanism connected to the valve body and configured to guide the valve body and move the valve body in an extension direction of the diverging flow path.

[Claim 5]

The water pumping and return unit according to claim 1 or 2, wherein the diverging flow path extends from the flow path in a radial direction of the housing that intersects with a direction connecting the first end and the second end of the housing, and

the water injection valve mechanism is provided at a flow path end portion on an outer side in the radial direction in the diverging flow path.

[Claim 6]

The water pumping and return unit according to claim 5, wherein the housing includes

a housing first part extending in the direction connecting the first end and the second end and having the flow path formed in the housing first part,

a housing second part protruding outward in the radial direction from an outside surface of the housing first part and having the diverging flow path formed in the housing second part, and

the housing further has a communication port formed in the housing second part and configured to communicate the inside of the diverging flow path with the outside of the housing when the diverging flow path is opened by the water injection valve mechanism.

[Claim 7]

The water pumping and return unit according to claim 1 or 2, wherein the region has an outside diameter of 315 mm or less.

[Claim 8]

A water pumping and return control system comprising:

the water pumping and return unit according to claim 1; and

a pilot mechanism provided outside the housing and configured to supply pressure and drive the water injection valve mechanism by supplying and discharging water to and from the water injection valve mechanism.

[Claim 9]

The water pumping and return control system according to claim 8, wherein

- the pilot mechanism includes

- a pressurization line branching from a main pipe connected to the first flange and applying pressure to the water injection valve mechanism in a direction of closing the water injection valve mechanism by introducing some of the water flowing through the main pipe,

- a pilot valve provided in the pressurization line and configured to release pressure in the pressurization line by discharging water in the pressurization line to the outside of the pressurization line when the pressure in the pressurization line reaches or exceeds a set pressure, and

- a register provided in the pressurization line and configured to adjust a change in a flow rate of the water in the pressurization line when the pilot valve releases the pressure in the pressurization line.

[Claim 10]

The water pumping and return control system according to claim 8 or 9, wherein

- the pilot mechanism includes

- a decompression line configured to reduce pressure applied to the water injection valve mechanism by discharging water from the water injection valve mechanism when the water injection valve mechanism is opened,

- a solenoid valve configured to open and close the decompression line, and

- an orifice provided upstream of the solenoid valve in the decompression line and configured to throttle a flow rate of water flowing through the decompression line.

[Claim 11]

A geothermal heat utilization system comprising:

- the water pumping and return control system according to claim 8;

- a main pipe connected to the first flange;

- a pump configured to pump water into the main pipe;

- a check valve provided between the second flange and the pump;

- the well; and

- a heat exchanger configured to exchange heat with the main pipe.