

DESCRIPTION

Title of Invention: REVERSE OSMOSIS DEVICE AND SEAWATER
DESALINATION PLANT PROVIDED WITH SAME

5 Technical Field

[0001]

The present invention relates to a reverse osmosis
device whose additional installation to an existing
seawater desalination plant is possible and a seawater
10 desalination plant which is provided with it.

Background Art

[0002]

Recently, a request for increase in quantity of
water that a seawater desalination plant produces has been
15 increased in association with an increase in water demand.

For example, in Patent Literature 1, there is
disclosed a seawater desalination system which is provided
with a reverse osmosis membrane module having a reverse
osmosis membrane, and a pressure vessel in which the
20 reverse osmosis membrane is contained and obtains filtered
water and concentrated water by the reverse osmosis
membrane which is contained in the reverse osmosis
membrane module by supplying sea water to the reverse
osmosis membrane module. Then, there is described a
25 configuration that the seawater desalination system is

provided with a module group which is configured by
connecting a plurality of reverse osmosis membrane modules
in parallel with one another, sea water passes and flows
in a first sea water supply system and a second sea water
5 supply system and is supplied to the module group and
thereby the sea water is supplied to the respective
reverse osmosis membrane modules, and the first sea water
supply system and the second sea water supply system are
provided with liquid delivery pumps which are adapted to
10 supply the sea water which passes and flows therein to the
module group.

[0003]

In addition, in Patent Literature 2, there is
disclosed a configuration that a first treatment module
15 which has an ultrafiltration membrane and treats fresh
surface water or excavated fresh water, a second treatment
module which treats brackish water or the sea water by
means of a reverse osmosis membrane, and a third treatment
module which treats water which is contaminated with
20 radiation by means of a two-stage reverse osmosis membrane
are provided in a conveyable container.

Citation List

Patent Literature

[0004]

25 PTL 1: Japanese Patent Application Laid-Open No.

2016-221446

PTL 2: Japanese Unexamined Patent Application

Publication (Translation of PCT Application) No. 2009-
539597

5 Summary of Invention

Technical Problem

[0005]

However, in the reverse osmosis membrane module
which is described in Patent Literature 1 and is
10 configured by the plurality of pressure vessels which are
connected in parallel with one another, recovery rate
heightening (improvement of a recovery rate at which fresh
water which is filtered water is recovered from sea water
which is water to be treated by membrane separation) is
15 difficult from the first. In addition, in Patent
Literature 1, nothing is taken into consideration as to
additional installation thereof to an existing facility
for the recovery rate heightening.

In addition, in the configuration which is described
20 in Patent Literature 2, the treatment is completed by the
above-described first treatment module, second treatment
module, and third treatment module which are contained in
the conveyable container.

Accordingly, although it is conveyable, nothing is
25 taken into consideration as to the point that it is

installed on the front stage of the existing reverse osmosis membrane module so as to perform treatment in cooperation with the existing reverse osmosis membrane module, that is, as to additional installation thereof to the existing facility for the recovery rate heightening.

[0006]

Accordingly, the present invention provides a reverse osmosis device which is installed on the front stage of the reverse osmosis membrane module which configures an existing seawater desalination plant and is capable of promoting the frequency rate heightening with ease by mutually connecting pipes and a seawater desalination plant which is provided with it.

Solution to Problem

[0007]

In order to solve the abovementioned problems, the reverse osmosis device pertaining to the present invention is provided with, in one container, a plurality of first pressure vessels in which a plurality of reverse osmosis membrane elements are filled and are contained in parallel with one another, and a supply water connection pipe one end of which is connected to inlets of the first pressure vessels so as to supply pressurized supply water thereto, wherein the supply water is membrane-separated into filtered water and high-pressure concentrated water by the

reverse osmosis membrane elements which are filled in the first pressure vessels, a concentrated water high-pressure connection pipe one end of which is connected to first outlets of the first pressure vessels and in which the high-pressure concentrated water passes and flows, and a filtered water connection pipe one end of which is connected to second outlets of the first pressure vessels and in which the filtered water passes and flows, in which a supply water connection pipe connector which is provided on the other end of the supply water connection pipe, a concentrated water high-pressure connection pipe connector which is provided on the other end of the concentrated water high-pressure connection pipe, and a filtered water connection pipe connector which is provided on the other end of the filtered water connection pipe are arranged so as to locate on the same side face of the container.

In addition, the seawater desalination plant pertaining to the present invention is provided with at least, a supply water pipe which supplies sea water which is treated by a pretreatment unit to a reverse osmosis membrane module as supply water, the reverse osmosis membrane module which membrane-separates the supply water into filtered water and high-pressure concentrated water which is high-concentration saltwater, a filtered water pipe which supplies the filtered water to a fresh water

storage tank, a concentrated water pipe which supplies the high-pressure concentrated water to a concentrated water storage tank, and a reverse osmosis device which is installed in the supply water pipe, in which the reverse osmosis device has, in one container, a plurality of first pressure vessels in which a plurality of reverse osmosis membrane elements are filled and are contained in parallel with one another, a supply water connection pipe one end of which is connected to inlets of the first pressure vessels so as to supply pressurized supply water thereto, wherein the supply water is membrane-separated into filtered water and high-pressure concentrated water by the reverse osmosis membrane elements which are filled in the first pressure vessels, a concentrated water high-pressure connection pipe one end of which is connected to first outlets of the first pressure vessels and in which the high-pressure concentrated water passes and flows, and a filtered water connection pipe one end of which is connected to second outlets of the first pressure vessels and in which the filtered water passes and flows, and a supply water connection pipe connector which is provided on the other end of the supply water connection pipe, a concentrated water high-pressure connection pipe connector which is provided on the other end of the concentrated water high-pressure connection pipe, and a filtered water

connection pipe connector which is provided on the other end of the filtered water connection pipe are arranged so as to locate on the same side face of the container.

Advantageous Effects of Invention

5 [0008]

According to the present invention, it becomes possible to provide the reverse osmosis device which is installed on the front stage of the reverse osmosis membrane module which configures the existing seawater
10 desalination plant and is capable of promoting the recovery rate heightening with ease by mutually connecting the pipes and the seawater desalination plant which is provided with it.

Problems, configurations and effects other than the
15 above-described ones will become apparent from the following description of embodiments.

Brief Description of Drawings

[0009]

Figure 1 is an overall schematic configuration
20 diagram of a reverse osmosis device of Example 1 pertaining to one example of the present invention.

Figure 2 is an overall schematic configuration diagram of a seawater desalination plant.

Figure 3 is a diagram illustrating a configuration
25 example of a reverse osmosis membrane module which

configures the seawater desalination plant illustrated in Figure 2.

Figure 4 is an overall schematic configuration diagram of a reverse osmosis device of Example 2

5 pertaining to another example of the present invention.

Figure 5 is a diagram illustrating a modified example of the reverse osmosis device illustrated in Figure 4.

Figure 6 is an overall schematic configuration

10 diagram of a reverse osmosis device of Example 3

pertaining to another example of the present invention.

Description of Embodiments

[0010]

First, a seawater desalination plant will be

15 described. Figure 2 is an overall schematic configuration

diagram of a seawater desalination plant. In Figure 2, a solid-line arrow indicates a flow of water and each pipe.

A seawater desalination plant 100 is configured by a raw water storage tank 41 which stores taken-in raw water, an

20 MMF (Multi Media Filter) 42, an ultrafiltration membrane

(UF membrane: Ultrafiltration Membrane) 43, an

intermediate tank 49, a reverse osmosis membrane module 50

which is configured by a pressure vessel (vessel) which

contains therein a reverse osmosis membrane element (an RO

25 membrane element), an energy recovery device 48, a fresh

water storage tank 51 and a concentrated water storage tank 52, in order from taking-in of sea water (the water to be treated) which is the raw water toward the downstream.

5 The sea water as the raw water to be taken in is stored in the raw water storage tank 41. Concerning the raw water, impurities which are contained in the raw water are separated through the MMF 42, the ultrafiltration membrane 43 by a pump and the raw water (the water to be
10 treated) after separation is once stored in the intermediate tank 49.

[0011]

 The raw water (the water to be treated) which is stored in the intermediate tank 49 is supplied to the
15 reverse osmosis membrane module 50 by a high-pressure pump 54 via a supply water pipe 53 as supply water. The supply water is membrane-separated into concentrated water which is high-concentration saltwater and filtered water (fresh water) by the reverse osmosis membrane module 50. The
20 filtered water is supplied to the fresh water storage tank 51 from one end of the reverse osmosis membrane module 50 via a filtered water pipe 56. In addition, the high-pressure concentrated water is supplied to the concentrated water storage tank 52 via the energy recovery
25 device 48 and a concentrated water pipe 57. Energy which

is recovered by the energy recovery device 48 is used as a driving source of the high-pressure pump 54.

[0012]

Incidentally, a configuration of a pretreatment unit is not limited to the abovementioned configuration and may be a configuration having only one of the MMF 42 and the ultrafiltration membrane 43. In addition, an MMF membrane (Microfiltration Membrane) may be used.

[0013]

The seawater desalination plant 100 has, for example, the abovementioned MMF 42, ultrafiltration membrane 43, MF membrane or the like in this way.

In addition, as described above, since a request for increase in quantity of water that the seawater desalination plant 100 produces is increased, in the present invention, recovery rate heightening (improvement of the recovery rate at which the fresh water which is the filtered water is recovered from the sea water which is the water to be treated by membrane separation) is promoted by installing a reverse osmosis device 1 which will be described later on the existing seawater desalination plant 100 which is illustrated in Figure 2, for example, at a position which is indicated by a broken line, that is, in the high-pressure pump 54 and the supply water pipe 53 which connects the high-pressure pump 54

with the reverse osmosis membrane module 50.

[0014]

Figure 3 is a diagram illustrating a configuration example of the reverse osmosis membrane module 50 which configures the seawater desalination plant 100 which is illustrated in Figure 2. As illustrated in Figure 3, the reverse osmosis membrane module 50 has a configuration that a plurality of reverse osmosis membrane elements 13 are filled in a pressure vessel (vessel) 12 and these are connected in parallel with one another. Although, in the example illustrated in Figure 3, a case where six reverse osmosis membrane elements 13 are filled in one pressure vessel 12 is illustrated by way of example, the number of the reverse osmosis membrane elements 13 which are filled in the pressure vessel 12 is not limited to this. In addition, in the example illustrated in Figure 3, the reverse osmosis membrane module 50 is provided with a configuration that six pressure vessels are connected in parallel with one another. The supply water which is increased in pressure by the high-pressure pump 54, passes and flows in the supply water pipe 53 and is introduced into the reverse osmosis membrane module 50 flows into each of the abovementioned six pressure vessels via a branch pipe. The supply water is membrane-separated into the concentrated water which is the high-concentration

saltwater and the filtered water (the fresh water) by means of the plurality of reverse osmosis membrane elements 13 which are filled in the abovementioned six pressure vessels and they join with one another in the concentrated water pipe 57 and the filtered water pipe 56 and pass and flow in the concentrated water pipe 57 and the filtered water pipe 56 respectively. The concentrated water which is the high-concentration saltwater after joined passes and flows in the concentrated water pipe 57 and is supplied to the concentrated water storage tank 52 via the energy recovery device 48. In addition, the filtered water (the fresh water) after joined passes and flows in the filtered water pipe 56 and is supplied to the fresh water storage tank 51.

In the following, reverse osmosis devices pertaining to examples of the present invention will be described using the drawings.

Example 1

[0015]

Figure 1 is an overall schematic configuration diagram of a reverse osmosis device of Example 1 pertaining to one example of the present invention. As illustrated in Figure 1, a reverse osmosis device 1 has a configuration that a plurality of pressure vessels (vessels) 12 in which the plurality of reverse osmosis

membrane elements 13 are filled are contained in one container 11 and the plurality of these pressure vessels (vessels) 12 are connected in parallel with one another. Although, in Figure 1, a case where two reverse osmosis membrane elements 13 are filled in one pressure vessel 12 is illustrated by way of example, the number of the reverse osmosis membrane elements 13 which are filled in the pressure vessel 12 is not limited to this and there may be a configuration that, for example, three reverse osmosis membrane elements 13 are filled therein.

Incidentally, the number of the reverse osmosis membrane elements 13 which are filled in each pressure vessel 12 which is contained in one container 11 which configures the reverse osmosis device 1 is, at least, smaller than the number of the reverse osmosis membrane elements 13 which are filled in each pressure vessel (vessel) 12 which configures the existing reverse osmosis membrane module 50 which is illustrated in the abovementioned Figure 3.

[0016]

In addition, in Figure 1, eight pressure vessels 12 in which two reverse osmosis membrane elements 13 are filled are contained and these eight pressure vessels 12 are connected in parallel with one another by means of a supply water connection pipe 16, a filtered water connection pipe 17, and a concentrated water high-pressure

connection pipe 18. In addition, a high-pressure pump 14 is installed in the supply water connection pipe 16 and the supply water which flows into the supply water connection pipe 16 via the supply water pipe 53 of the existing seawater desalination plant 100 is increased in pressure and is supplied to each pressure vessel 12. The supply water pipe 53 is branched at a plurality of places on the downstream side along a flow of the supply water which is increased in pressure by the high-pressure pump 14 and one end of the supply water pipe 53 after each branching is connected to an inlet (not illustrated) of each pressure vessel 12. On the other hand, a supply water connection pipe connector 16a is provided on the other end of the supply water pipe 53 on the upstream side of the high-pressure pump 14. The supply water which is supplied to each pressure vessel 12 is membrane-separated into the concentrated water which is the high-concentration saltwater and the filtered water (the fresh water) by means of the reverse osmosis membrane element 13.

[0017]

The concentrated water which is the high-concentration saltwater after membrane separation passes and flows in the concentrated water high-pressure connection pipe 18 one end of which is connected to a first outlet (not illustrated) of each pressure vessel 12

in a high-pressure maintained state. As illustrated in Figure 1, the outflows of the high-pressure concentrated water from the respective pressure vessels 12 join with one another at a plurality of places with the aid of the concentrated water high-pressure connection pipe 18 and pass and flow toward a concentrated water high-pressure connection pipe connector 18a which is provided on the other end which is on the opposite side of the first outlet of each pressure vessel 12. On the other hand, the filtered water (the fresh water) after membrane separation passes and flows in the filtered water connection pipe 17 one end of which is connected to a second outlet (not illustrated) of each pressure vessel 12. As illustrated in Figure 1, the outflows of the filtered water (fresh water) from the respective pressure vessels 12 join with one another at a plurality of places with the aid of the filtered water connection pipe 17 and pass and flow toward a filtered water connection pipe connector 17a which is provided on the other end which is on the opposite side of the second outlet of each pressure vessel 12. A filtered water flow rate adjustment valve 15 is installed in the filtered water connection pipe 17 between a place where the outflows of the filtered water (the fresh water) from all the pressure vessels 12 finally join with one another and the filtered water connection pipe connector 17a. The

quantity of the filtered water (the fresh water) which passes and flows in the filtered water connection pipe 17 and is discharged from the filtered water connection pipe connector 17a to the outside of the reverse osmosis device 1 is controlled by adjusting an aperture of the filtered water flow rate adjustment valve 15.

As illustrated in Figure 1, the supply water connection pipe connector 16a, the filtered water connection pipe connector 17a, and the concentrated water high-pressure connection pipe connector 18a are arranged so as to locate on one side face of the container 11, that is, on the same side face. In addition, the supply water connection pipe 16 and the concentrated water high-pressure connection pipe 18 are high-pressure pipes, and the filtered water connection pipe 17 is the high-pressure pipe or a low-pressure pipe.

[0018]

Next, installation of the reverse osmosis device to the seawater desalination plant 100 which is the existing facility will be described. The concentrated water high-pressure connection pipe connector 18a of the reverse osmosis device 1 is connected to a supply water pipe connector 53a which is provided on an inflow-side end of the supply water pipe 53 which is connected to the reverse osmosis membrane module 50 which is illustrated in Figure

3. As described above, the concentrated water high-pressure connection pipe 18 is the high-pressure pipe, and the supply water pipe 53 which is connected to the reverse osmosis membrane module 50 is also the high-pressure pipe.

5 Therefore, the concentrated water high- pressure connection pipe connector 18a and the supply water pipe connector 53a is water-tightly connected by, for example, bolting together a flange which is provided on the concentrated water high-pressure connection pipe connector
10 18a and a flange which is provided on the supply water pipe connector 53a via an O-ring or a rubber seal member. Incidentally, victaulic connection using a victaulic joint may be made in place of such flange connection. In addition, connection by welding may be made. Incidentally,
15 in a case of considering alignment of the concentrated water high-pressure connection pipe connector 18a of the reverse osmosis device 1 with the supply water pipe connector 53a which is provided on the inflow-side end of the supply water pipe 53 which is connected to the reverse
20 osmosis membrane module 50 in installation of the reverse osmosis device 1 at the time of additional installation, easiness in installation work is improved by making the victaulic connection.

[0019]

25 In addition, the supply water connection pipe

connector 16a of the reverse osmosis device 1 is connected with an unillustrated connector of the supply water pipe 53 which connects together the intermediate tank 49 and the reverse osmosis membrane module 50 which configure the seawater desalination plant 100 which is the existing facility illustrated in Figure 2, the unillustrated connector being provided on intermediate tank 49 side end of the supply water pipe 53. Since the supply water connection pipe 16 is the high-pressure pipe as described above, the supply water connection pipe 16 and the supply water pipe 53 is water-tightly connected by, for example, bolting together a flange which is provided on the supply water connection pipe connector 16a and a flange which is a connector which is provided on the supply water pipe 53 via the O-ring or the rubber seal member. Incidentally, the victaulic connection using the victaulic joint may be made in place of such flange connection. In addition, the connection by welding may be made. Incidentally, in a case of considering alignment of the supply water connection pipe connector 16a of the reverse osmosis device 1 with the connector which is provided on an end of the supply water pipe 53 in installation of the reverse osmosis device 1 at the time of additional installation, the easiness in the installation work is improved by making the victaulic connection.

[0020]

In addition, the filtered water connection pipe connector 17a of the reverse osmosis device 1 is connected so as to join with, for example, the filtered water pipe 56 which connects together the reverse osmosis membrane module 50 and the fresh water storage tank 51 which configure the seawater desalination plant 100 which is the existing facility illustrated in Figure 2. In this case, a branch pipe for connection is provided on the filtered water pipe 56 so as to connect a connector (not illustrated) of this branch pipe with the filtered water connection pipe connector 17a. In a case where the filtered water connection pipe 17 is the high-pressure pipe, they are connected together by a system which is the same as that of the above-described connection between the concentrated water high-pressure connection pipe connector 18a and the supply water pipe connector 53a, and the connection between the supply water connection pipe connector 16a and the connector of the supply water pipe 53. On the other hand, in a case where the filtered water connection pipe 17 is the low-pressure pipe, connection between the filtered water connection pipe connector 17a and the connector (not illustrated) of the branch pipe which is provided on the filtered water pipe 56 is made by, for example, the flange connection or union connection.

Incidentally, it is not limited to this and the connection by welding may be made. Although a case where the filtered water connection pipe connector 17a of the reverse osmosis device 1 is connected with the connector (not illustrated) of the branch pipe which is provided on the filtered water pipe 56 was described by way of example, it is not limited to this and it may also be configured in such manner that, for example, an extension pipe is connected to the filtered water connection pipe connector 17a of the reverse osmosis device 1 so as to supply the filtered water (the fresh water) directly to the fresh water storage tank 51 via the extension pipe.

[0021]

Since, as described above, the supply water connection pipe connector 18a, the filtered water connection pipe connector 17a, and the concentrated water high-pressure connection pipe connector 18a which configure the reverse osmosis device 1 are arranged so as to locate on one side face of the container 11, that is, on the same side face, in a case of installing the reverse osmosis device 1 to the seawater desalination plant 100 which is the existing facility, efficiency enhancement of workability thereof is promoted.

[0022]

Incidentally, although in the present example, it is

configured that the high-pressure pump 14 is contained in the container 11, it is not limited to this. For example, as for the high-pressure pump, it may be configured that the high-pressure pump 54 which configures the seawater desalination plant 100 which is the existing facility is used. In this case, the supply water connection pipe connector 16a of the reverse osmosis device 1 will be connected with the supply water pipe 53 in which the high-pressure pump 54 is installed.

10 [0023]

As described above, according to the present example, it becomes possible to provide the reverse osmosis device which is capable of promoting the recovery rate heightening with ease by being installed on the front stage of the reverse osmosis membrane module which configures the existing seawater desalination plant and mutually connecting the pipes and the seawater desalination plant which is provided with it.

In addition, according to the present example, since the supply water connection pipe connector 16a, the filtered water connection pipe connector 17a, and the concentrated water high-pressure connection pipe connector 18a which configure the reverse osmosis device 1 are arranged so as to locate on one side face of the container 11, that is, on the same side face, in a case of

installing the reverse osmosis device 1 to the seawater desalination plant 100 which is the existing facility, it becomes possible to improve the efficiency enhancement of the workability thereof or the easiness in the
5 installation work.

In addition, according to the present example, since it is configured in such a manner that the reverse osmosis device is installed between the intermediate tank 49 and the reverse osmosis membrane module 50 of the seawater
10 desalination plant which is the existing facility, or between the high-pressure pump 54 and the reverse osmosis membrane module 50 thereof, the recovery rate heightening becomes possible without additionally installing equipment which configures the pretreatment unit in particular, and
15 a reduction in cost involved in additional installation becomes possible.

Example 2

[0024]

Figure 4 is an overall schematic configuration
20 diagram of a reverse osmosis device of Example 2 pertaining to another example of the present invention. In the present example, it is different from Example 1 in the point that a filtered water energy recovery device is provided in the reverse osmosis device.

25 The same numerals are assigned to the constitutional

elements which are the same as those in Example 1 and description which overlaps that in Example 1 is omitted in the following.

[0025]

5 As illustrated in Figure 4, a reverse osmosis device 1a is provided with a filtered water energy recovery device 19 which is installed in the filtered water connection pipe 17 between the filtered water flow rate adjustment valve 15 which is installed in the filtered
10 water connection pipe 17 between a place where the outflows of the filtered water (the fresh water) from all the pressure vessels (vessels) 12 finally join with one another and the filtered water connection pipe connector 17a, and the filtered water connection pipe connector 17a.
15 Energy which is recovered by the filtered water energy recovery device 19 is used as an auxiliary of shaft power of the high-pressure pump 14 or for power generation or for pressure increasing of the supply water. Here, as the filtered water energy recovery device 19, for example, a
20 DWEER (Dual Work Exchanger Energy Recovery) which introduces some of the supply water which passes and flows in the supply water connection pipe 16 toward the high-pressure pump 14 and the filtered water (the fresh water) which passes and flows in the filtered water connection
25 pipe 17 toward the filtered water connection pipe

connector 17a into two cylinders respectively and transmits the pressure of the high-pressure concentrated water to sea water via pistons in the cylinders, the one which transmits the pressure of the filtered water (the
5 fresh water) which passes and flows in the filtered water connection pipe 17 toward the filtered water connection pipe connector 17a to the high-pressure pump 14 by a Turbocharger and so forth are used.

[0026]

10 Figure 5 is a diagram illustrating a modified example of the reverse osmosis device illustrated in Figure 4. As illustrated in Figure 5, the reverse osmosis device 1a is different in the point that installation of the filtered water flow rate adjustment valve 15 is
15 omitted in comparison with the reverse osmosis device 1a illustrated in Figure 4.

Incidentally, although in the present example, it is configured that the high-pressure pump 14 is contained in the container 11, it is not limited to this. For example,
20 as for the high-pressure pump, it may be configured that the high-pressure pump 54 which configures the seawater desalination plant 100 which is the existing facility is used. In this case, the supply water connection pipe connector 16a of the reverse osmosis device 1 will be
25 connected with the supply water pipe 53 in which the high-

pressure pump 54 is installed.

[0027]

According to the present example, in addition to the effect of Example 1, the auxiliary of the shaft power of the high-pressure pump 14 or the power generation or the pressure increasing of the supply water becomes possible owing to provision of the filtered water energy recovery device 19 in the reverse osmosis device 1a, and as a result, power saving becomes possible.

10 Example 3

[0028]

Figure 6 is an overall schematic configuration diagram of a reverse osmosis device of Example 3 pertaining to another example of the present invention.

15 In the present example, it is different from Example 1 in a center-point system, that is, a configuration that one end of the supply water connection pipe 16 in which the supply water which is increased in pressure by the high-pressure pump 14 passes and flows to an inlet near an
20 approximately central part in a longitudinal direction of each pressure vessel 12. The same numerals are assigned to the constitutional elements which are the same as those in Example 1 and description which overlaps that in Example 1 is omitted in the following.

25 [0029]

As illustrated in Figure 6, a reverse osmosis device 1b has a configuration that four reverse osmosis membrane elements 13 are filled in the pressure vessel (vessel) 12 and the four pressure vessels (vessels) 12 are connected in parallel with one another in one container 11. As illustrated in Figure 6, one end of the supply water connection pipe 16 in which the supply water which is increased in pressure by the high-pressure pump 14 passes and flows is connected to the inlets (not illustrated) near the approximately central parts in the longitudinal direction of the four pressure vessels (vessels) 12 and it has the supply water connection pipe connector 16a on the other end. The supply water which flows into the pressure vessel (vessel) 12 via the supply water connection pipe 16 and is increased in pressure by the high-pressure pump 14 is membrane-separated by every two reverse osmosis membrane elements 13 which are filled on the left and the right (facing the drawing) therein into the concentrated water which is the high-concentration saltwater and the filtered water (the fresh water). Other configurations are the same as those of Example 1. Incidentally, the number of the pressure vessels (vessels) 12 is not limited to four, and the number of the reverse osmosis membrane elements 13 to be filled in each pressure vessel (vessel) 12 is not limited to four.

[0030]

Incidentally, although in the present example, it is configured that the high-pressure pump 14 is contained in the container 11, it is not limited to this. For example,
5 as for the high-pressure pump, it may be configured that the high-pressure pump 54 which configures the seawater desalination plant 100 which is the existing facility is used. In this case, the supply water connection pipe connector 16a of the reverse osmosis device 1 will be
10 connected with the supply water pipe 53 in which the high-pressure pump 54 is installed.

[0031]

According to the present example, in addition to the effect of Example 1, a pipeline length of the supply water
15 connection pipe 16 adapted to supply the supply water which is increased in pressure by the high-pressure pump 14 into each pressure vessel (vessel) 12 can be made short, and routing of the supply water connection pipe 16, or laying of the supply water connection pipe 16 becomes easy
20 in the container 11 which is a limited space.

[0032]

Incidentally, the present invention is not limited to the above-described examples and various modified examples are included.

25 For example, the abovementioned examples are

described in detail for easy understanding of the present invention and it is not necessarily limited to the one which is provided with all the configurations which are described. In addition, it is possible to replace part of
5 a configuration of one example with a configuration of another example, and it is also possible to add a configuration of another example to a configuration of one example.

Reference Signs List

10 [0033]

1, 1a, 1b ... reverse osmosis device, 11 ... container, 12 ... pressure vessel (vessel), 13 ... reverse osmosis membrane element, 14 ... high-pressure pump, 15 ... filtered water flow rate adjustment valve, 16 ... supply water connection
15 pipe, 16a ... supply water connection pipe connector, 17 ... filtered water connection pipe, 17a ... filtered water connection pipe connector, 18 ... concentrated water high-pressure connection pipe, 18a ... concentrated water high-pressure connection pipe connector, 19 ... filtered water
20 energy recovery device, 41 ... raw water storage tank, 42 ... MMF, 43 ... ultrafiltration membrane, 48, ... energy recovery device, 49 ... intermediate tank, 50 ... reverse osmosis membrane module, 51 ... fresh water storage tank, 52 ... concentrated water storage tank, 53 ... supply water pipe,
25 53a ... supply water pipe connector, 54 ... high-pressure pump,

56 ... filtered water pipe, 57 ... concentrated water pipe,

100 ... seawater desalination plant

CLAIMS

[Claim 1]

A reverse osmosis device comprising:

in one container,

5 a plurality of first pressure vessels in which a plurality of reverse osmosis membrane elements are filled and are contained in parallel with one another; a supply water connection pipe one end of which is connected to inlets of the first pressure vessels so as to supply
10 pressurized supply water thereto;

wherein the supply water is membrane-separated into filtered water and high-pressure concentrated water by the reverse osmosis membrane elements which are filled in the first pressure vessels, a concentrated water high-pressure
15 connection pipe one end of which is connected to first outlets of the first pressure vessels and in which the high-pressure concentrated water passes and flows; and

a filtered water connection pipe one end of which is connected to second outlets of the first pressure vessels
20 and in which the filtered water passes and flows,

wherein a supply water connection pipe connector which is provided on the other end of the supply water connection pipe, a concentrated water high-pressure connection pipe connector which is provided on the other
25 end of the concentrated water high-pressure connection

pipe, and a filtered water connection pipe connector which is provided on the other end of the filtered water connection pipe are arranged so as to locate on the same side face of the container.

5 [Claim 2]

The reverse osmosis device according to claim 1, comprising a high-pressure pump which is installed in the supply water connection pipe,

wherein the supply water pressurized by the high-
10 pressure pump is introduced thereinto through the inlets of the first pressure vessels via the supply water connection pipe.

[Claim 3]

The reverse osmosis device according to claim 1,
15 wherein the supply water which is pressurized by a high-pressure pump which is installed outside the container is introduced thereinto through the inlets of the first pressure vessels via the supply water connection pipe.

20 [Claim 4]

The reverse osmosis device according to claim 2,
wherein outflows of the filtered water from the second outlets of the plurality of first pressure vessels join with one another by means of the filtered water
25 connection pipe at a plurality of places, and the device

has a filtered water flow rate adjustment valve which is installed in the filtered water connection pipe between a place where the outflows of the filtered water from all the first pressure vessels join with one another and the filtered water connection pipe connector.

[Claim 5]

The reverse osmosis device according to claim 3, wherein outflows of the filtered water from the second outlets of the plurality of first pressure vessels join with one another by means of the filtered water connection pipe at a plurality of places, and the device has a filtered water flow rate adjustment valve which is installed in the filtered water connection pipe between a place where the outflows of the filtered water from all the first pressure vessels join with one another and the filtered water connection pipe connector.

[Claim 6]

The reverse osmosis device according to claim 4, comprising,

a filtered water energy recovery device which is installed in the filtered water connection pipe between the filtered water flow rate adjustment valve and the filtered water connection pipe connector,

wherein the filtered water energy recovery device supplies recovered energy to the high-pressure pump as an

auxiliary of shaft power of the high-pressure pump.

[Claim 7]

The reverse osmosis device according to claim 2,
wherein outflows of the filtered water from the
5 second outlets of the plurality of first pressure vessels
join with one another by means of the filtered water
connection pipe at a plurality of places, and the device
has a filtered water energy recovery device which is
installed in the filtered water connection pipe between a
10 place where the outflows of the filtered water from all
the first pressure vessels join with one another and the
filtered water connection pipe connector.

[Claim 8]

The reverse osmosis device according to claim 5,
15 comprising,

a filtered water energy recovery device which is
installed in the filtered water connection pipe between
the filtered water flow rate adjustment valve and the
filtered water connection pipe connector.

20 [Claim 9]

The reverse osmosis device according to claim 4,
wherein the inlet to which one end of the supply
water connection pipe is connected is disposed on an
approximately central part in a longitudinal direction of
25 the first pressure vessel.

[Claim 10]

The reverse osmosis device according to claim 5,
wherein the inlet to which one end of the supply
5 water connection pipe is connected is disposed on an
approximately central part in a longitudinal direction of
the first pressure vessel.

[Claim 11]

The reverse osmosis device according to any one of
10 claims 1 to 10,

wherein the supply water connection pipe has a
plurality of branches and one end thereof is connected to
the inlets of the first pressure vessels via the branches,
and

15 the concentrated water high-pressure connection pipe
has a plurality of junctions where outflows of the high-
pressure concentrated water from the first outlets of the
plurality of first pressure vessels join with one another.

[Claim 12]

20 A seawater desalination plant comprising:

at least, a supply water pipe which supplies sea
water which is treated by a pretreatment unit to a reverse
osmosis membrane module as supply water; the reverse
osmosis membrane module which membrane-separates the
25 supply water into filtered water and high-pressure

concentrated water which is high-concentration saltwater;
a filtered water pipe which supplies the filtered water to
a fresh water storage tank; a concentrated water pipe
which supplies the high-pressure concentrated water to a
5 concentrated water storage tank; and a reverse osmosis
device which is installed in the supply water pipe,

wherein the reverse osmosis device includes, in one
container, a plurality of first pressure vessels in which
a plurality of reverse osmosis membrane elements are
10 filled and are contained in parallel with one another, a
supply water connection pipe one end of which is connected
to inlets of the first pressure vessels so as to supply
pressurized supply water thereto, wherein the supply water
is membrane-separated into filtered water and high-
15 pressure concentrated water by the reverse osmosis
membrane elements which are filled in the first pressure
vessels, a concentrated water high-pressure connection
pipe one end of which is connected to first outlets of the
first pressure vessels and in which the high-pressure
20 concentrated water passes and flows, and wherein a
filtered water connection pipe one end of which is
connected to second outlets of the first pressure vessels
and in which the filtered water passes and flows, and a
supply water connection pipe connector which is provided
25 on the other end of the supply water connection pipe, a

concentrated water high-pressure connection pipe connector which is provided on the other end of the concentrated water high-pressure connection pipe, and a filtered water connection pipe connector which is provided on the other
5 end of the filtered water connection pipe are arranged so as to locate on the same side face of the container.

[Claim 13]

The seawater desalination plant according to claim
12,

10 wherein the supply water connection pipe connector is connected to a first connector which is provided on the supply water pipe, the concentrated water high-pressure connection pipe connector is connected to a second connector which is provided on the supply water pipe and
15 on the side of flowing into the reverse osmosis membrane module, and

the filtered water connection pipe connector is connected to a branch pipe which is provided on the filtered water pipe or the other end of an extension pipe
20 one end of which is connected to the fresh water storage tank.

[Claim 14]

The seawater desalination plant according to claim
13,

25 wherein the reverse osmosis device is provided with

a high-pressure pump which is installed in the supply water connection pipe, and the supply water which is pressurized by the high-pressure pump is introduced through the inlet of the first pressure vessel via the supply water connection pipe.

[Claim 15]

The seawater desalination plant according to claim 13,

wherein the reverse osmosis device is configured such that the supply water which is pressurized by a high-pressure pump which is installed outside the container is introduced thereinto through the inlets of the first pressure vessels via the supply water connection pipe.

[Claim 16]

The seawater desalination plant according to claim 14,

wherein outflows of the filtered water from the second outlets of the plurality of first pressure vessels join with one another by means of the filtered water connection pipe at a plurality of places, and the plant has a filtered water flow rate adjustment valve which is installed in the filtered water connection pipe between a place where the outflows of the filtered water from all the first pressure vessels join with one another and the filtered water connection pipe connector.

[Claim 17]

The seawater desalination plant according to claim
15,

wherein outflows of the filtered water from the
5 second outlets of the plurality of first pressure vessels
join with one another by means of the filtered water
connection pipe at a plurality of places, and the plant
has a filtered water flow rate adjustment valve which is
installed in the filtered water connection pipe between a
10 place where the outflows of the filtered water from all
the first pressure vessels join with one another and the
filtered water connection pipe connector.

[Claim 18]

The seawater desalination plant according to claim
15 16, comprising,

a filtered water energy recovery device which is
installed in the filtered water connection pipe between
the filtered water flow rate adjustment valve and the
filtered water connection pipe connector,

20 wherein the filtered water energy recovery device
supplies recovered energy to the high-pressure pump as an
auxiliary of shaft power of the high-pressure pump.

[Claim 19]

The seawater desalination plant according to claim
25 14,

wherein outflows of the filtered water from the second outlets of the plurality of first pressure vessels join with one another by means of the filtered water connection pipe at a plurality of places, and the plant
5 has a filtered water energy recovery device which is installed in the filtered water connection pipe between a place where the outflows of the filtered water from all the first pressure vessels join with one another and the filtered water connection pipe connector.

10 [Claim 20]

The seawater desalination plant according to claim 17, comprising,

a filtered water energy recovery device which is installed in the filtered water connection pipe between
15 the filtered water flow rate adjustment valve and the filtered water connection pipe connector.

[Claim 21]

The seawater desalination plant according to claim 16,

20 wherein the inlet to which one end of the supply water connection pipe is connected is disposed on an approximately central part in a longitudinal direction of the first pressure vessel.

[Claim 22]

25 The seawater desalination plant according to claim

17,

wherein the inlet to which one end of the supply
water connection pipe is connected is disposed on an
approximately central part in a longitudinal direction of
5 the first pressure vessel.

[Claim 23]

The seawater desalination plant according to any one
of claims 12 to 22,

wherein the reverse osmosis module is provided with
10 a plurality of second pressure vessels in which a
plurality of reverse osmosis membrane elements are filled
and are contained in parallel with one another.

[Claim 24]

The seawater desalination plant according to claim
15 23,

wherein the number of the reverse osmosis membrane
elements which are filled in the first pressure vessel is
smaller than the number of the reverse osmosis membrane
elements which are filled in the second pressure vessel.

20