

DESCRIPTION
FILTRATION SYSTEM

Technical Field

[0001]

The present invention relates to a filtration system.

Background Art

[0002]

Conventionally, there is known a filtration system including a plurality of filtration membrane units each including a filtration membrane and a discharge port for discharging a filtrate obtained by the filtration membrane, and a water collection tube including a main tube portion and a plurality of individual water collection paths arranged in an axial direction of the main tube portion and communicating with the main tube portion.

[0003]

For example, a membrane module unit as a filtration system described in Patent Literature 1 includes a plurality of membrane modules as a filtration membrane unit and a water collection header as a water collection tube. The water collection header includes a cylindrical portion as a main tube portion, and a plurality of intermediate connection portions (individual water collection paths) communicating with the cylindrical portion from a

cylindrical portion radial direction and arranged in a cylindrical portion axial direction. In addition, the membrane module includes a filtration membrane (hollow fiber membrane sheet) having a flat plate shape and a housing fixed to each of both end portions of the filtration membrane in a longitudinal direction. A water intake port as a drain port is disposed at one end of the housings at both end portions in a filtration membrane lateral direction. This water intake port is connected individually to one of the plurality of intermediate connection portions in the water collection header by a pipe. When a suction force is generated in the filtration membrane of each membrane module via the cylindrical portion and the intermediate connection portion of the water collection header by power of a pump or the like, moisture in sludge existing around the filtration membrane is sucked into the filtration membrane as a filtrate. The sucked filtrate is collected in the cylindrical portion of the water collection header via the water intake port of the housing of the membrane module, the pipe connected thereto, and the intermediate connection portion of the water collection header.

Citation List

Patent Literature

[0004]

Patent Literature 1: JP 6319510 B2

Summary of Invention

Technical Problem

[0005]

Patent Literature 1 does not specifically describe how the plurality of intermediate connection portions of the water collection header and the pipes extending from the water intake ports of the plurality of membrane modules are connected. However, in the drawings, since a male screw is drawn on the outer peripheral surface of the intermediate connection portion having a cylindrical shape, it is considered that connection by a union joint capable of being screwed to the male screw is adopted. In the union joint, a female screw formed on the inner peripheral surface of a rotatable screw cup is screwed to a male screw on the outer peripheral surface of a pipe to be connected. In the membrane module unit described in Patent Literature 1, when each of the plurality of membrane modules is individually connected to the intermediate connection portion of the water collection header by the pipe, it is troublesome to screw the screw cup of the union joint by rotating the screw cup a plurality of times for each connection. In addition, also when removing each membrane

module for maintenance and inspection, it is troublesome to unscrew the screw cup of the union joint by reversely rotating the screw cup a plurality of times. Further, in order to operate the membrane module unit in a state in which a damaged membrane module is removed, it is necessary to seal the intermediate connection portion released by removal with a screw cap, and also in this case, it is troublesome to screw the screw cap by rotating the screw cap a plurality of times.

[0006]

The present invention has been made in view of the above background, and an object thereof is to provide a filtration system capable of reducing time and effort for maintenance and inspection work of a filtration membrane unit such as a filtration system.

Solution to Problem

[0007]

An aspect of the present invention is a filtration system including: a plurality of filtration membrane units each including a filtration membrane and a discharge port for discharging a filtrate obtained by the filtration membrane; and a water collection tube that includes a main tube portion and a plurality of individual water collection paths arranged in an axial direction of the main tube

portion and communicating with the main tube portion, the filtration system collecting the filtrate filtrated by the filtration membrane in each of a plurality of the filtration membrane units to the main tube of the water collection tube via the individual water collection path of the water collection tube, the filtration system including: a locking member that locks movement of the discharge pipe in an axial direction in each of a plurality of the filtration membrane units,

each of a plurality of the filtration membrane units includes an O-ring made of an elastic material on an outer peripheral surface of a front end portion of the discharge pipe, and movement of the discharge pipe in an axial direction is locked by the locking member in a state where the discharge pipe is inserted into the individual water collection path.

Advantageous Effects of Invention

[0008]

According to the present invention, there is an excellent effect that time and effort for maintenance and inspection work of a filtration membrane unit can be reduced.

Brief Description of Drawings

[0009]

Fig. 1 is a diagram illustrating a schematic configuration of a water treatment facility using a filtration system according to an embodiment.

Fig. 2 is a perspective diagram illustrating a filtration membrane unit of the filtration system.

Fig. 3 is a perspective diagram illustrating a water collection tube mounted on the filtration system.

Fig. 4 is a cross-sectional diagram illustrating the water collection tube and a filtration membrane unit connected to the individual water collection path of the water collection tube.

Fig. 5 is a diagram illustrating the water collection tube and the filtration membrane unit from an axial direction of a main tube portion of the water collection tube.

Fig. 6 is a perspective diagram illustrating a sealing plug.

Fig. 7 is a cross-sectional diagram illustrating the sealing plug immediately before being inserted into the individual water collection path of the water collection tube, and the water collection tube.

Fig. 8 is a cross-sectional diagram illustrating the sealing plug being inserted into the individual water collection path, and the water collection tube.

Fig. 9 is a cross-sectional diagram illustrating the sealing plug inserted into the individual water collection path, and the water collection tube.

Fig. 10 is a cross-sectional diagram for describing a pull-out preparation operation of the sealing plug.

Fig. 11 is a cross-sectional diagram illustrating the sealing plug immediately after the pull-out preparation operation is performed, and the water collection tube.

Fig. 12 is a cross-sectional diagram illustrating the sealing plug being pulled out, and the water collection tube.

Fig. 13 is a perspective diagram illustrating a filtration treatment facility.

Description of Embodiments

[0010]

Hereinafter, an embodiment of a liquid filtration device to which the present invention is applied will be described with reference to the drawings. In the embodiment, for the sake of easy description, structures and elements other than a main part of the present invention will be described in a simplified or omitted manner. In addition, in the drawings, the same elements are denoted by the same reference numerals. Note that the shapes, dimensions, and the like of the elements

illustrated in the drawings are schematically illustrated, and do not indicate actual shapes, dimensions, and the like.

[0011]

Fig. 1 is a diagram illustrating a schematic configuration of a water treatment facility using a filtration system according to an embodiment. The water treatment facility includes a pre-treatment water tank 1, a filtration treatment water tank 2, a treatment water tank 3, a control device 4, a raw water pump 5, a first water level sensor 6, a raw water transfer pipe 7, a treatment water transfer pipe 8, a suction pump 9, a second water level sensor 11, a third water level sensor 12, and the like. In addition, the water treatment facility includes a blower 13, an air supply pipe 14, a mount 15, a filtration system 20, a bubble generation device 30, and the like.

[0012]

In the pre-treatment water tank 1, pre-treatment water (raw water) W_1 as a liquid is stored. The first water level sensor including an ultrasonic sensor or the like installed in the pre-treatment water tank 1 senses the water level (water surface height) of the pre-treatment water W_1 in the pre-treatment water tank 1, and transmits the sensing result to the control device 4 as a water level signal. The raw water pump 5 installed in the pre-

treatment water tank 1 sucks and discharges the pre-treatment water W_1 in the pre-treatment water tank 1, and sends the pre-treatment water W_1 to the filtration treatment water tank 2 through the raw water transfer pipe 7. As the raw water pump 5, one including a submersible pump has been exemplified, but one including a land pump may be used.

[0013]

The filtration treatment water tank 2 is a water tank made of reinforced concrete. A liquid filtration device 50 is installed in the filtration treatment water tank 2. The liquid filtration device 50 includes the mount 15, the filtration system 20, and the bubble generation device 30, and is entirely immersed in the pre-treatment water W_1 in the filtration treatment water tank 2. The blower 13 discharges the air as the gas sucked from a suction port to the air supply pipe 14 through a discharge port. The air discharged to the air supply pipe 14 is supplied to the bubble generation device 30 of the liquid filtration device 50. The third water level sensor 12 installed in the filtration treatment water tank 2 senses the water level of the pre-treatment water W_1 in the filtration treatment water tank 2, and transmits the sensing result to the control device 4 as a water level signal.

[0014]

The suction pump 9 sucks the pre-treatment water W_1 in the filtration treatment water tank 2 through the treatment water transfer pipe 8 and a filtration membrane described below installed in the filtration system 20. The sucked pre-treatment water W_1 is filtrated by the filtration membrane to become treated water W_2 , and then sent to the treatment water tank 3 through the treatment water transfer pipe 8. The second water level sensor 11 set on the treatment water tank 3 senses the water level of the treated water W_2 in the treatment water tank 3, and transmits the sensing result to the control device 4 as a water level signal.

[0015]

Note that, instead of the suction pump 9, a pump that generates a suction force using hydraulic head pressure may be used. A means for suction is not particularly limited.

[0016]

When the water level of the treatment water tank 3 does not reach the upper limit and a predetermined operation execution condition is satisfied, the control device 4 operates the suction pump 9 and the blower 13 to execute the filtration treatment of the pre-treatment water W_1 . However, even when the operation execution condition is satisfied, when the water level of the pre-treatment water W_1 in the pre-treatment water tank 1 is lower than or equal

to the lower limit and when the water level of the pre-treatment water W_1 in the filtration treatment water tank 2 is lower than or equal to the lower limit, the control device 4 stops the execution of the filtration treatment. Note that the role of the blower 13 will be described below.

[0017]

Fig. 2 is a perspective diagram illustrating a filtration membrane unit 21. The filtration membrane unit 21 includes a filtration membrane 22 having a flat plate shape, a socket pipe 16, and a sealing holder 17. The filtration membrane unit 21 is held by four holding members 24 of a frame described below. In the liquid filtration device (50) according to the embodiment, a filtration membrane made of a flat membrane having a plate shape is used as the filtration membrane 22, but the type of filtration membrane 22 is not limited to the flat membrane, and other types such as a hollow fiber membrane may be used. The material of the filtration membrane 22 may be an organic material such as polyvinyl chloride (PVC) or polyvinylidene fluoride (PVDF), or may be a ceramic composed of one type or a plurality of types of alumina, cordierite, silicon carbide, and other metal oxides. In addition, the filtration membrane 22 may be a composite membrane in which an organic membrane and a ceramic

membrane are combined.

[0018]

The filtration membrane 22 includes a plurality of hollows 22a extending in the up-down direction. These hollows 22a are arranged at predetermined intervals in a lateral direction of the filtration membrane 22, and the upper ends of the hollows 22a are openings facing the "above".

[0019]

The socket pipe 16 is attached to one end portion of the filtration membrane 22 in a longitudinal direction. The socket pipe 16 includes an inner space communicating with the hollows 22a of the filtration membrane 22, and receives the treated water (W_2) filtrated by the filtration membrane 22 into the inner space. One end portion of the socket pipe 16 in the longitudinal direction is a discharge pipe 16a protruding from an end of the filtration membrane 22. The discharge pipe 16a forms a discharge path inside, and is inserted into the individual water collection path of the water collection tube described below. Two O-rings 16b arranged in an insertion portion axial direction are attached to the outer peripheral surface of the discharge pipe 16a. The O-ring 16b is made of an elastic material such as rubber or resin.

[0020]

When the suction pump (9 in Fig. 1) is operated, a suction force is generated on the surface of the filtration membrane 22, and the pre-treatment water (W_1 in Fig. 1) existing around the filtration membrane 22 is sucked into the hollows 22a through the countless fine holes of the filtration membrane 22. At this time, the pre-treatment water W_1 is filtrated, and the contamination substances in the pre-treatment water W_1 remain on the surface of the filtration membrane 22. The treated water W_2 sucked into the hollows 22a moves in the longitudinal direction in the hollows 22a, flows into the inner space of the socket pipe 16, and is then discharged from the discharge pipe 16a of the socket pipe 16.

[0021]

In Fig. 1, the bubble generation device 30 installed below the filtration system 20 releases bubbles toward the above filtration system 20. The released bubbles float in the pre-treatment water W_1 , reach the filtration membrane 22, are divided into a plurality of parts by the filtration membranes 22, and then enter a region between the filtration membranes 22 adjacent to each other. The bubbles floating in this region vigorously shake the pre-treatment water W_1 near the surfaces of the filtration membranes 22 to detach the contamination substances adhering to the surfaces of the filtration membranes 22

from the surfaces.

[0022]

Fig. 3 is a perspective diagram illustrating a water collection tube 90 mounted on the filtration system (20). The water collection tube 90 is molded by injection molding a resin material such as polyethylene, polypropylene, or polyvinyl chloride, or polyvinyl chloride, and includes a main tube portion 91 having a cylindrical shape, a water collection portion 92 having a flat box shape, and two rubber sheets 95. The water collection portion 92 includes a plurality of individual water collection paths 93 that is arranged in an axis (L1) direction of the main tube portion 91 and communicate with the main tube portion 91 from a direction orthogonal to the axis L1. As illustrated in the drawing, the individual water collection paths 93 are provided on both sides of the water collection portion 92 relative to a center line L2 of the main tube portion 91.

[0023]

Fig. 4 is a cross-sectional diagram illustrating the water collection tube 90 and the filtration membrane unit 21 connected to the individual water collection path 93 of the water collection tube 90. As illustrated in the drawing, the discharge pipe 16a of the filtration membrane unit 21 is inserted into the individual water collection path 93 of the water collection tube 90. Since the O-rings

16b are interposed between the outer peripheral surface of the inserted discharge pipe 16a and the inner peripheral surface of the individual water collection path 93, sealability therebetween is secured.

[0024]

The rubber sheet 95 of the water collection tube 90 is for preventing the filtration membrane 22 of the filtration membrane unit 21 from directly hitting the main tube portion 91 of the water collection tube 90 during the operation of attaching the filtration membrane unit 21 to the water collection tube 90.

[0025]

Fig. 5 is a diagram illustrating the water collection tube 90 and the filtration membrane unit 21 from an axial direction of the main tube portion 91 of the water collection tube 90. A locking member 98 is in contact with the socket pipe 16 of the filtration membrane unit 21 attached to the water collection tube 90 from the side opposite to the water collection tube 90. The locking member 98 made of U-shaped steel is bolted to a frame to be described below, and in contact with the socket pipes 16 of all the filtration membrane units 21 arranged in an axial direction in a state of extending in the axial direction of the main tube portion 91 of the water collection tube 90. In each of the plurality of filtration membrane units 21,

the movement of the discharge pipe (16a) in the axial direction is locked by the locking member 98 in a state where the discharge pipe (16a) is inserted into the individual water collection path (93) of the water collection tube 90. In the filtration membrane unit 21 locked in this manner, the discharge pipe (16a) that is not screwed to the individual water collection path (93) is prevented from being removed from the individual water collection path (93).

[0026]

In such a configuration, when the drain pipe (16a) in each of the plurality of filtration membrane units 21 is individually connected to the individual water collection path (93) of the water collection tube 90, it is not troublesome to screw the screw cup of the union joint by rotating the screw cup. It is simply necessary to insert the drain pipe (16a) into the individual water collection path (93). In addition, also when removing each filtration membrane unit 21 for maintenance and inspection, it is not troublesome to unscrew the screw cup of the union joint by reversely rotating the screw cup a plurality of times. It is simply necessary to pull out the drain pipe (16a) from the individual water collection path (93). Note that when the filtration system (20) is operated in a state where a damaged filtration membrane unit 21 is removed, the

individual water collection path (93) released by removal is sealed with a sealing plug to be described below.

[0027]

Fig. 6 is a perspective diagram illustrating a sealing plug 100. The sealing plug 100 includes a hook portion 101, a bendable portion 102, a main body portion 103, and a handle 105 from the front end side toward the rear end side. The hook portion 101 includes a slope portion 101a that increases the radial dimension of the main body portion 103 from the front end side to the rear end side in the axial direction of the main body portion 103 having a columnar shape, and a step portion 101b that rapidly decreases the radial dimension at the rear end of the slope portion 101a. The bendable portion 102 has an elongated shape integrally formed with the hook portion 101 and the main body portion 103, and can be bent in the radial direction of the main body portion 103. The main body portion 103 having a columnar shape includes two O-rings 104 arranged in the axial direction on the outer peripheral surface on the front end side. The O-ring 104 is made of an elastic material such as resin or rubber. The handle 105 protrudes rearward from the rear end surface of the main body portion 103 in the axial direction and extends in the radial direction of the main body portion 103.

[0028]

Fig. 7 is a cross-sectional diagram illustrating the sealing plug 100 immediately before being inserted into the individual water collection path 93 of the water collection tube 90, and the water collection tube 90. Fig. 8 is a cross-sectional diagram illustrating the sealing plug 100 being inserted into the individual water collection path 93, and the water collection tube 90. Fig. 9 is a cross-sectional diagram illustrating the sealing plug 100 inserted into the individual water collection path 93, and the water collection tube 90.

[0029]

As illustrated in Fig. 7, the sealing plug 100 starts to be inserted, the hook portion 101 first, into the individual water collection path 93. As illustrated in Fig. 8, the sealing plug 100 being inserted slides the hook portion 101 on the front end side on the inner peripheral surface of the individual water collection path 93. As the bendable portion 102 bends radially outward as a result of the sliding, the hook portion 101 can be inserted.

[0030]

A hooked portion 91a on which the step portion 101b of the sealing plug 100 is hooked is disposed at a boundary between the individual water collection path 93 of the water collection tube 90 and the inner space of the main tube portion 91. As illustrated in Fig. 9, in the sealing

plug 100 fully inserted into the individual water collection path 93, the hook portion 101 on the front end side is positioned at the communicating portion between the individual water collection path 93 and the inner space of the main tube portion 91, and the sliding with the individual water collection path 93 is released. At this time, the bendable portion 102 that has been bent does not bend, so that the step portion 101b of the hook portion 101 is hooked on the hooked portion 91a as illustrated in the drawing. This hooking prevents the sealing plug 100 from being removed from the individual water collection path 93. The O-rings 104 of the main body portion 103 are interposed between the outer peripheral surface of the main body portion 103 and the inner peripheral surface of the individual water collection path 93 to secure sealability therebetween.

[0031]

Fig. 10 is a cross-sectional diagram for describing a pull-out preparation operation of the sealing plug 100.

Fig. 11 is a cross-sectional diagram illustrating the sealing plug 100 immediately after the pull-out preparation operation is performed, and the water collection tube 90.

Fig. 12 is a cross-sectional diagram illustrating the sealing plug 100 being pulled out, and the water collection tube 90.

[0032]

When the sealing plug 100 is pulled out from the individual water collection path 93, the pull-out preparation operation is performed prior to the pull-out. In this pull-out preparation operation, as illustrated in Fig. 10, the main body portion 103 is rotated in the clockwise direction or the counterclockwise direction about 90 [°] while gripping the handle 105. Then, as illustrated in Fig. 11, the hook portion 101 of the sealing plug 100 rotates to a position where the step portion (101b) is not hooked on the hooked portion 91a. In this state, as illustrated in Fig. 12, by pulling the sealing plug 100, the sealing plug 100 can be pulled out from the individual water collection path 93.

[0033]

In such a configuration, further, when the filtration system is operated in a state where a damaged filtration membrane unit (21) is removed from the water collection tube 90, the individual water collection path 93 released by removal is sealed with the sealing plug 100. When the sealing plug 100 is inserted or pulled out, as described above, it is not troublesome to rotate the screw cap a plurality of times.

[0034]

Therefore, with the filtration system (20) according to

the embodiment, it is possible to reduce time and effort for maintenance and inspection work of the filtration membrane unit (21).

[0035]

Fig. 13 is a perspective diagram illustrating a filtration treatment facility 18 including the filtration system 20 according to the embodiment. The filtration treatment facility 18 holds two filtration systems 20 in a vertically stacked state on a metal frame 19. The above-described locking member (98) is bolted to the frame 19.

[0036]

The present invention is not limited to the above-described embodiment and the example, and a configuration different from the embodiment and the example can be adopted within a range where the configuration of the present invention can be applied. The present invention has unique operations and effects for each aspect described below.

[0037]

[First Aspect]

A first aspect is a filtration system (filtration system 20) including: a plurality of filtration membrane units (filtration membrane units 21) each including a filtration membrane (filtration membrane 22) and a discharge path for discharging a filtrate obtained by the

filtration membrane; and a water collection tube (water collection tube 90) that includes a main tube portion (main tube portion 91) and a plurality of individual water collection paths (individual water collection paths 93) arranged in an axial direction of the main tube portion and communicating with the main tube portion, the filtration system collecting the filtrate filtrated by the filtration membrane in each of a plurality of the filtration membrane units to the main tube portion of the water collection tube via the discharge path and the individual water collection path of the water collection tube, the filtration system including: a locking member (locking member 98) that locks movement of the discharge path in an axial direction in each of a plurality of the filtration membrane units, each of a plurality of the filtration membrane units includes an O-ring (O-ring 16b) made of an elastic material on an outer peripheral surface of a discharge pipe (discharge pipe 16a) forming the discharge path, and movement of the discharge pipe in an axial direction is locked by the locking member in a state where the discharge pipe is inserted into the individual water collection path.

[0038]

With such a configuration, it is possible to eliminate the need for a screw rotation operation when attaching and detaching the filtration membrane unit to and from the

water collection tube, and to reduce the time and effort for maintenance and inspection work of the filtration membrane unit.

[0039]

[Second Aspect]

A second aspect is the filtration system including the configuration of the first aspect and includes: a sealing plug (sealing plug 100) that is inserted into the individual water collection path into which the drain pipe of the filtration membrane unit is not inserted among a plurality of the individual water collection paths in the water collection tube to seal the individual water collection path.

[0040]

With such a configuration, even in a state where some of the filtration membrane units are removed from the filtration system due to damage or the like, the filtration system can be operated by sealing the individual water collection paths from which the filtration membrane units have been removed with the sealing plugs.

[0041]

[Third Aspect]

A third aspect is the filtration system including the configuration of the second aspect, wherein the sealing plug includes a hook portion (hook portion 101) disposed at

a front end portion in an axial direction, a main body portion (main body portion 103) having a columnar shape disposed at a central portion in the axial direction, a handle (handle 105) protruding rearward from a rear end surface of the main body portion in the axial direction and extending in a radial direction, and a bendable portion (bendable portion 102) positioned between the hook portion and the main body portion and capable of bending in the radial direction,

the main body portion includes an O-ring (O-ring 104) made of an elastic material on an outer peripheral surface, the hook portion includes a slope portion (slope portion 101a) that increases a radial dimension of the main body portion from a front end side toward a rear end side in the axial direction, and a step portion (step portion 101b) that rapidly decreases the radial dimension at a rear end of the slope portion, and the water collection tube includes a hooked portion (hooked portion 91a) on which the step portion of the hook portion is hooked.

[0042]

With such a configuration, it is possible to eliminate the need for a screw rotation operation when sealing the individual water collection path from which the filtration membrane unit has been removed, and to reduce the time and effort for maintenance and inspection work of the

filtration membrane unit.

[0043]

The present application claims priority based on Japanese Patent Application No. 2022-42256 filed on March 17, 2022, the entire contents of which are incorporated herein by reference.

Reference Signs List

[0044]

- 20 Filtration system
- 21 Filtration membrane unit
- 16a Drain pipe
- 90 Water collection tube
- 91 Main tube portion
- 91a Hooked portion
- 92 Water collection portion
- 93 Individual water collection path
- 98 Locking member
- 100 Sealing plug

CLAIMS

1. A filtration system comprising:

a plurality of filtration membrane units each including a filtration membrane and a discharge path for discharging a filtrate obtained by the filtration membrane; and

a water collection tube that includes a main tube portion and a plurality of individual water collection paths arranged in an axial direction of the main tube portion and communicating with the main tube portion,

the filtration system collecting the filtrate filtrated by the filtration membrane in each of a plurality of the filtration membrane units to the main tube portion of the water collection tube via the discharge path and the individual water collection path of the water collection tube, the filtration system comprising:

a locking member that locks movement of the discharge path in an axial direction in each of a plurality of the filtration membrane units,

wherein

each of a plurality of the filtration membrane units includes an O-ring made of an elastic material on an outer peripheral surface of a discharge pipe forming the discharge path, and movement of the discharge pipe in an axial direction is locked by the locking member in a state where the discharge pipe is inserted into the individual

water collection path.

2. The filtration system according to claim 1, comprising:

a sealing plug that is inserted into the individual water collection path into which the drain pipe of the filtration membrane unit is not inserted among a plurality of the individual water collection paths in the water collection tube to seal the individual water collection path.

3. The filtration system according to claim 2, wherein

the sealing plug includes a hook portion disposed at a front end portion in an axial direction, a main body portion having a columnar shape disposed at a central portion in the axial direction, a handle protruding rearward from a rear end surface of the main body portion in the axial direction and extending in a radial direction, and a bendable portion positioned between the hook portion and the main body portion and capable of bending in the radial direction,

the main body portion includes an O-ring made of an elastic material on an outer peripheral surface,

the hook portion includes a slope portion that increases a radial dimension of the main body portion from a front end side toward a rear end side in the axial direction, and a step portion that rapidly decreases the radial dimension at a rear end of the slope portion, and

the water collection tube includes a hooked portion on which the step portion of the hook portion is hooked.