

DESCRIPTION

CENTRIFUGAL CIRCULATING PURIFICATION SYSTEM

5 **Technical Field**

The present invention relates, in general, to centrifugal circulating purification systems and, more particularly, to a centrifugal circulating purification system which is configured such that fluid required to be purified circulates
10 and passes at least two times through a centrifugal filter, whereby a rate of removing impurities from the fluid can be enhanced.

Background Art

15 Generally, centrifugal filters are devices, in which a rotor is rotated via fluid pressure; and centrifugal force generated by the rotation of the rotor is used to remove impurities from contaminated fluid. Such centrifugal filters are widely used in engines or other various kinds of machine
20 components so as to remove defect-causing impurities from oil.

Fig. 1 is a view showing the structure of a system for removing impurities from oil using a centrifugal filter in an engine.

Engine oil is typically used to minimize friction, which
25 occurs between parts while an engine is operated, thus

preventing damage to the parts and making it possible for the engine to maintain optimal performance. Such engine oil is contaminated while circulating through the interior of the engine.

5 Engine oil is stored in a sump tank 10, and a pump 20 is used to circulate engine oil through the interior of the engine. To remove impurities from engine oil while the oil is circulating in the engine, an element filter 30 and a centrifugal filter 40 are provided.

10 The conventional filtering system having the above-mentioned construction bypasses 10% of the entire amount of fluid to the centrifugal filter 40 and separately includes a main filter (the element filter) for filtering out impurities.

15 However, there are problems in that the element filter which is used as the main filter is disposable, in other words, not permanent, and as the amount of impurities attached to the element filter increases, flow resistance of fluid increases.

[Prior art document]

20 [Patent document]

Korean Patent Registration No. 1003524 (Dec. 30, 2010)

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Disclosure

25 **Technical Problem**

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide, as a fluid purification system using a centrifugal filter, a centrifugal circulating purification system which is configured, without a separate main filter, such that fluid circulates and passes several times through a centrifugal filter, thus enhancing a rate of removing impurities from the fluid.

10 **Technical Solution**

In order to accomplish the above object, in an aspect, the present invention provides a centrifugal circulating purification system, including: a first tank storing contaminated fluid therein; a first centrifugal filter receiving the fluid and removing impurities from the fluid; a second circulation tank storing fluid to be recirculated through the first centrifugal filter after having been purified by the first centrifugal filter; a suction pump drawing fluid stored in the first tank or the second circulation tank and moving the fluid to the first centrifugal filter; a drain pump moving fluid discharged the first centrifugal filter; a third tank storing therein fluid that has purified while having circulated through the first centrifugal filter and the second circulation tank; a first valve provided on a flow passage connecting the first tank to

the suction pump, the first valve controlling the flow passage; a second valve provided on a flow passage connecting the second circulation tank to the suction pump, the second valve controlling the flow passage; a third valve provided on
5 a flow passage connecting the second circulation tank to the drain pump, the third valve controlling the flow passage; a fourth valve provided on a flow passage connecting the drain pump to the third tank, the fourth valve controlling the flow passage; and a controller controlling the suction pump, the
10 drain pump and the first, second, third and fourth valves in such a way that: after contaminated fluid is discharged from the first tank, the first valve and the fourth valve are controlled to close the corresponding flow passages, and the second valve and the third valve are opened, so that the
15 contaminated fluid circulates through the first centrifugal filter and the second circulation tank; and when purification of the contaminated fluid by means of circulating the contaminated fluid through the first centrifugal filter and the second circulation tank is completed, the third valve is
20 controlled to close the corresponding flow passage, and the fourth valve is opened, so that purified fluid is supplied into the third tank.

The centrifugal circulating purification system may further include a first centrifugal filter provided on a flow
25 passage connecting the drain pump to the third tank, the first

centrifugal filter removing impurities from fluid flowing towards the third tank. The first centrifugal filter may include: a housing having an oil inlet; a rotor assembly rotating in the housing; a shaft provided in the housing to
5 support rotation of the rotor assembly, the shaft having therein a flow passage through which oil drawn from the oil inlet moves; a spindle tube configured to rotate along with the rotor assembly and receive the shaft therein, the spindle tube injecting oil, discharged from the shaft, into the rotor
10 assembly; a separation film partitioning a space in the rotor assembly into an upper space and a lower space; and a filter layer provided on the separation film and made of polyester or glass fiber, the filter layer additionally removing impurities from oil flowing into the lower space through the separation
15 film.

In another aspect, the present invention provides a centrifugal circulating purification system, including: a first tank storing contaminated fluid therein; a first centrifugal filter receiving the contaminated fluid and
20 removing impurities from the contaminated fluid; a suction pump provided on a supply flow passage connecting the first tank to the first centrifugal filter, the suction pump moving fluid to the first centrifugal filter; a circulation pump provided on a discharge flow passage extending from an outlet
25 of the first centrifugal filter, the circulation pump moving

fluid, discharged from the first centrifugal filter, such that the fluid circulates into the first centrifugal filter through a circulation flow passage connecting the discharge flow passage to the supply flow passage; a second tank connected to
5 a branching flow passage branching off from the discharge flow passage, the second tank storing fluid that has been purified while having circulated through the first centrifugal filter; a first centrifugal filter provided on the branching flow passage, the first centrifugal filter additionally removing
10 impurities from fluid flowing to the second tank; a drain pump provided on the branching flow passage, the drain pump moving fluid, drawn into the branching flow passage, to the first centrifugal filter; a first three-way valve provided on a junction between the supply flow passage and the circulation
15 flow passage; a second three-way valve provided on a junction between the discharge flow passage and the branching flow passage; and a timer controlling the first three-way valve and the second three-way valve so that fluid circulates through the first centrifugal filter for a preset time period.

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Advantageous Effects

In a centrifugal circulating purification system according to the present invention, a rate of removing impurities from fluid can be enhanced only by using a
25 centrifugal filter without a separate main filter.

Furthermore, an additional centrifugal filter may be used to remove a specific size of impurities from fluid. In this case, components of an engine can be more reliably protected from being damaged by impurities contained in fluid.

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Description of Drawings

Fig. 1 is a view showing the structure of a system for removing impurities from oil using a centrifugal filter in an engine;

10 Fig. 2 is a view showing the construction of a centrifugal circulating purification system according to a first embodiment of the present invention;

Fig. 3 is a sectional view illustrating the structure of a second centrifugal filter according to the present
15 invention;

Fig. 4 is a sectional view illustrating the structure of a filter layer provided on a separation film according to the present invention; and

20 Fig. 5 is a view showing the construction of a centrifugal circulating purification system according to a second embodiment of the present invention.

<Description of the Reference Numerals in the Drawings>

111: first tank 112: second circulation tank

25 113: third tank 120: first centrifugal filter

130: suction pump 140: drain pump
 151: first valve 152: second valve
 153: third valve 154: fourth valve
 160: controller 170: first centrifugal filter
 5 171: housing 172: rotor assembly
 173: shaft 174: spindle tube
 175: separation film 176: filter layer
 181: flow passage 182: flow passage
 184: flow passage 185: flow passage
 10 211: first tank 212: second tank
 220: first centrifugal filter 230: suction pump
 240: circulation pump 250: first centrifugal filter
 260: drain pump 271: first three-way valve
 272: second three-way valve 280: timer
 15 291: supply flow passages 292: discharge flow passage
 293: circulation flow passage 294: branching flow passage

Best Mode

Hereinafter, the present invention will be described with
 20 reference to the attached drawings. If in the specification,
 detailed descriptions of well-known functions or
 configurations would unnecessarily obfuscate the gist of the
 present invention, the detailed descriptions will be omitted.

Although the conventional centrifugal filter separately
 25 includes a main filter and purifies fluid in such a way so as

to bypass only 10 percent of the overall amount of fluid, the present invention, with regard to removing impurities from fluid using the centrifugal filter, repetitively purifies fluid in such a way that fluid circulates through the centrifugal filter for a predetermined time period or a predetermined number of times, so that a rate of removing impurities from fluid can be enhanced to suit an apparatus that uses the fluid.

Fig. 2 is a view showing the construction of a centrifugal circulating purification system according to a first embodiment of the present invention.

The centrifugal circulating purification system according to the first embodiment of the present invention includes a first tank 111, a first centrifugal filter 120, a second circulation tank 112, a suction pump 130, a drain pump 140, a third tank 113, a first valve 151, a second valve 152, a third valve 153, a fourth valve 154 and a controller 160.

The first tank 111 provides space for storing contaminated fluid needed to be purified.

The first centrifugal filter 120 receives fluid stored in the first tank 111 and purifies the fluid. The construction of the first centrifugal filter 120 is the same as that of a well-known centrifugal filter, and therefore detailed description of the structure of the first centrifugal filter will be omitted.

The second circulation tank 112 provides space for storing fluid which has been purified by the first centrifugal filter 120 and which is to be recirculated through the first centrifugal filter 120.

5 The suction pump 130 draws fluid that is stored in the first tank 111 or the second circulation tank 112 and moves the fluid into the first centrifugal filter 120.

Flow passages 181 and 182 are respectively connected to the first tank 111 and the second circulation tank 112 so that
10 fluid can be moved to the suction pump 130 through the flow passages 181 and 182. The flow passages 181 and 182 which are respectively connected to the first tank 111 and the second circulation tank 112 join together before being coupled to the suction pump 130.

15 The drain pump 140 moves fluid that is discharged from the first centrifugal filter 120 into the second circulation tank 112 or the third tank 113. The drain pump 140 is installed on a flow passage 183 which extends from an outlet of the first centrifugal filter 120.

20 Although in Fig. 2, the first centrifugal filter 120, the suction pump 130 and drain pump 140 are illustrated as being integrated into a single module 100, the first centrifugal filter 120, the suction pump 130 and the drain pump 140 may be separately formed to be independent modules. Alternatively,
25 the first, second, third and fourth valves 151, 152, 153 and

154 and the first, second and third tanks 111, 112 and 113 including the first centrifugal filter 120, the suction pump 130 and the drain pump 140 may be integrated into a single module. As such, if the components of the centrifugal
5 circulating purification system are modularized, it can be used as a movable purification system.

The third tank 113 provides space for storing fluid that has circulated through the first centrifugal filter 120 several times and has thus been completely purified.

10 The first valve 151 is installed on the flow passage 181 which connects the first tank 111 to the suction pump 130. The first valve 151 operates under the control of the controller 160 and controls the flow passage 181.

The second valve 152 is installed on the flow passage 182
15 which connects the second circulation tank 112 to the suction pump 130. The second valve 152 operates under the control of the controller 160 and controls the flow passage 182.

The third valve 153 is installed on a flow passage 184 which connects the second circulation tank 112 to the drain
20 pump 140. The third valve 153 operates under the control of the controller 160 and controls the flow passage 184.

The fourth valve 154 is installed in a flow passage 185 which connects the third tank 113 to the drain pump 140. The fourth valve 154 operates under the control of the controller
25 160 and controls the flow passage 185.

The controller 160 controls the suction pump 130, the drain pump 140 and the first, second, third and fourth valves 151, 152, 153 and 154.

To supply a predetermined amount of initial fluid from
5 the first tank 111 to the second circulation tank 112 via the first centrifugal filter 120, the controller 160 opens the first valve 151 and the third valve 153 and operates the suction pump 130 and the drain pump 140 after closing the second and fourth valves 152 and 154.

10 When a predetermined amount of fluid is discharged from the first tank 111, the controller 160 closes the first and fourth valves 151 and 154 and opens the second and third valve 152 and 153. Then, the fluid is repetitively purified while circulating through the first centrifugal filter 120 and the
15 second circulation tank 112.

As such, if the number of times fluid circulates through the first centrifugal filter 120 and the second circulation tank 112 is increased, a rate of removing impurities from the fluid is increased, but there is a disadvantage in that the
20 time it takes to purify the fluid is increased. Therefore, it is preferable that the time required to purify fluid be derived from tests in consideration of cleanliness of fluid that is required in an apparatus that uses the fluid, and the derived time be previously set in the controller 160.
25 Although the number of times fluid circulates through the

first centrifugal filter 120 may be previously set in the controller 160, it is difficult to determine the number of times fluid circulates. Therefore, the method of controlling the time period is more preferable in controlling the
5 circulation of fluid.

Meanwhile, after the preset time has passed and the purification of fluid has been completed, the controller 160 closes the first, second and third valves 151, 152 and 153 and opens the fourth valve 154 so that fluid moves from the second
10 circulation tank 112 to the third tank 113.

Provided to additionally remove specific sizes (4 μm , 6 μm , 7 μm , 10 μm , 15 μm) of impurities from fluid that moves into the third tank 113, a second centrifugal filter 170 is installed on the flow passage 185 which connects the drain
15 pump 140 to the third tank 113.

Although the general construction of the second centrifugal filter 170 is the same as that of a well-known centrifugal filter in the same manner as that of the first centrifugal filter 120, the second centrifugal filter 170
20 further includes a filter layer which additionally filters out specific sizes of impurities.

For the purpose of explaining the filter layer, the construction of the second centrifugal filter 170 will be briefly described.

25 Fig. 3 is a sectional view illustrating the structure of

the second centrifugal filter according to the present invention. Fig. 4 is a sectional view illustrating the structure of the filter layer provided on a separation film according to the present invention.

5 In the same manner as conventional centrifugal filters, the second centrifugal filter 170 includes: a housing 171 having an oil inlet 171a; a rotor assembly 172 which is rotated in the housing 171; a shaft 173 which is provided in the housing 171 to support rotation of the rotor assembly 172
10 and has therein a flow passage through which oil drawn from the oil inlet 171a moves; a spindle tube 174 which is configured to rotate along with the rotor assembly 172 and receive the shaft 173 therein, and injects oil discharged from the shaft into the rotor assembly; and a separation film 175
15 which partitions space in the rotor assembly into an upper space S1 and a lower space S2.

However, unlike a conventional centrifugal filter, in the second centrifugal filter 170, a filter layer 176 which is made of polyester or glass fiber is installed on the
20 separation film 175 to additionally remove impurities from oil moving into the lower space S2 through the separation film 175.

The filter layer 176 covers an upper portion of the separation film 175 in which a plurality of holes 175a are
25 formed to allow movement of fluid. The filter layer 176

functions to additionally remove impurities from fluid that passes through the separation filter 175 through the holes 175a.

In more detail, the filter layer 176 is a cylindrical
5 polyester filter or cylindrical glass fiber filter and is fitted over an outer surface of the upper portion of the separation film 175.

A filter capable of removing impurities having specific particle sizes, for example, 4 μm , 6 μm , 8 μm , 10 μm or 15 μm ,
10 is used as the polyester filter or glass fiber filter which forms the filter layer 176. Such a filter may be formed using a cartridge filter which is produced by Korea Filter Co., Ltd. of Korea and is being sold.

When the polyester filter or glass fiber is installed on
15 the separation film 175 to form the filter layer 176, the polyester filter or glass fiber may be installed in such a way that it is attached to the separation filter 175. Alternatively, the polyester filter or glass fiber may be installed in such a way that it is fitted over the separation
20 film 175 and then a filter removal prevention cap 176-1 is coupled to the upper end of the separation filter 175.

If the filter layer 176 of the second centrifugal filter
170 is replaced with an appropriate one depending on the size of impurities required to be removed before fluid is drawn
25 into the third tank 113, or the second centrifugal filter 170

having a filter layer having appropriate purification performance with regard to the size of impurities required to be removed is installed on the flow passage 185, only qualified fluid from which a specific size of impurities that
5 may cause severe damage to the apparatus have been removed can be supplied into the third tank 113.

In the centrifugal circulating purification system according to the first embodiment of the present invention, the process of circulating fluid between the first tank 111
10 and the first centrifugal filter 120 to purify it and subsequently transferring the fluid to the third tank 113 has been already explained in the description of the controller 160. Therefore, further explanation of the process of purifying fluid will be omitted.

15 As described above, the centrifugal circulating purification system according to the first embodiment purifies fluid in such a way that a predetermined amount of contaminated fluid is drawn into the second circulation tank 112, and the fluid is circulated between the second
20 circulation tank 112 and the first centrifugal filter 120 for a preset time period or a preset number of times. The rate of removing impurities from the fluid can be changed by controlling the fluid circulation time (or the number of times the fluid circulates). As a result, the impurity removal rate
25 can be appropriately controlled to suit the apparatus that

uses the fluid, whereby the optimum operating conditions for the apparatus can be embodied.

Furthermore, before the fluid is supplied into the third tank 113, the second centrifugal filter 170 additionally
5 filters out a specific size of impurities. Therefore, the system can provide the function of verifying removal of a specific size of impurities, thus enhancing the reliability.

Fig. 5 is a view showing the construction of a centrifugal circulating purification system according to a
10 second embodiment of the present invention.

The centrifugal circulating purification system according to the second embodiment of the present invention, without having a separate tank for circulation of fluid, controls the flow of fluid by means of controlling valves such that the
15 fluid circulates through a centrifugal filter several times for a preset time period.

The centrifugal circulating purification system according to the second embodiment includes a first tank 211, a first centrifugal filter 220, a suction pump 230, a circulation pump
20 240, a second tank 212, a second centrifugal filter 250, a drain pump 260, a first three-way valve 271, a second three-way valve 272 and a timer 280.

The first tank 111 provides space for storing contaminated fluid needed to be purified.

25 The first centrifugal filter 120 receives fluid stored in

the first tank 111 and purifies the fluid. A well-known centrifugal filter is used as the first centrifugal filter 120.

The suction pump 230 is provided on a supply flow passages 291 which connects the first tank 211 to the first centrifugal filter 220. The suction pump 230 functions to move fluid from the first tank 211 to the first centrifugal filter 220.

The circulation pump 240 is provided on a discharge flow passage 292 which extends from an outlet of the first centrifugal filter 220. The discharge flow passage 292 is connected to the supply flow passages 291 by a circulation flow passage 293 so as to form a circulation structure in which fluid discharged from the first centrifugal filter 220 is supplied again to the first centrifugal filter.

Provided in the discharge flow passage 292, the circulation pump 240 circulates fluid discharged from the first centrifugal filter 220 in such a way that the fluid is re-supplied to the first centrifugal filter 220 through the circulation flow passage 293.

The second tank 212 is connected to a branching flow passage 294 which branches off from the discharge flow passage 292. The second tank 212 provides space for storing fluid that has circulated through the first centrifugal filter 220 and thus been purified.

The second centrifugal filter 250 is provided on the branching flow passage 294 so as to additionally remove a specific size of impurities from fluid before the fluid is drawn into the second tank 212.

5 The second centrifugal filter 250 has the same centrifugal filter structure as that of the second centrifugal filter 170 illustrated in Fig. 3, and therefore detailed explanation of the structure thereof will be omitted.

10 The drain pump 260 is provided on the branching flow passage 294 so as to move fluid, drawn into the branching flow passage, to the second centrifugal filter 250 and the second tank 212.

15 The first three-way valve 271 is provided on a junction between the supply flow passages 291 and the circulation flow passage 293. Under the control of the timer 280, the first three-way valve 271 controls the flow of fluid in such a way that when a port related to the circulation flow passage 293 is closed and a port pertaining to the first tank 211 is opened, fluid is allowed to flow from the first tank 211 to
20 the first centrifugal filter 220; or when the port pertaining to the first tank 211 is closed and the port related to the circulation flow passage 293 is opened, fluid is allowed to circulate through the circulation flow passage 293 and the supply flow passages 291.

25 The second three-way valve 272 is provided on a junction

between the discharge flow passage 292 and the branching flow passage 294. Under the control of the timer 280, the first three-way valve 271 controls the flow of fluid in such a way that when a port related to the branching flow passage 294 is closed and a port pertaining to the circulation flow passage 293 is opened, the fluid is allowed to circulate; or when the port pertaining to the circulation flow passage 293 is closed and the port related to the branching flow passage 294 is opened, fluid discharged from the first centrifugal filter 220 is allowed to be supplied into the second tank 212.

The timer 280 controls the first and second three-way valves 271 and 272 such that fluid circulates through the circulation flow passage 293, the supply flow passages 291 and the first centrifugal filter 220 for a preset time period. The timer 280 is electrically connected to the first and second three-way valves 271 and 272.

The preset time of the timer 280 is set by an operator. The timer 280 generates periodic signals corresponding to the pre-set time. The first and second three-way valves 271 and 272 appropriately control the flow passages in response to the signals generated from the timer 280 so that the inflow, circulation and discharge of fluid are repetitively conducted.

Meanwhile, the first tank 211, the first centrifugal filter 220, the suction pump 230, the circulation pump 240, the second tank 212, the second centrifugal filter 250, the

drain pump 260, the first three-way valve 271, the second three-way valve 272 and the timer 280 may be integrated into a single module to form a movable purification system.

Furthermore, the first tank 211 may be connected to the
5 second tank 212 so that purified fluid in the second tank 212 can be returned to the first tank 211.

As described above, the centrifugal circulating purification system according to the present invention purifies fluid using a centrifugal filter in such a way that
10 the fluid circulates and passes through the centrifugal filter several times. Therefore, an impurity removal rate can be easily increased.

The centrifugal circulating purification system is not limited to purifying engine oil that is used in an engine,
15 but, for example, may be used in purifying contaminated water or oil which is caused in various industrial sites.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications,
20 additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

CLAIMS

1. A centrifugal circulating purification system, comprising:

5 a first tank (111) storing contaminated fluid therein;

a first centrifugal filter (120) receiving the fluid and removing impurities from the fluid;

a second circulation tank (112) storing fluid to be recirculated through the first centrifugal filter (120) after
10 having been purified by the first centrifugal filter (120);

a suction pump (130) drawing fluid stored in the first tank (111) or the second circulation tank (112) and moving the fluid to the first centrifugal filter (120);

a drain pump (140) moving fluid discharged the first
15 centrifugal filter (120);

a third tank (113) storing therein fluid that has purified while having circulated through the first centrifugal filter (120) and the second circulation tank (112);

a first valve (151) provided on a flow passage (181) connecting the first tank (111) to the suction pump (130), the
20 first valve (151) controlling the flow passage (181);

a second valve (152) provided on a flow passage (182) connecting the second circulation tank (112) to the suction pump (130), the second valve (152) controlling the flow
25 passage (182);

a third valve (153) provided on a flow passage (184) connecting the second circulation tank (112) to the drain pump (140), the third valve (153) controlling the flow passage (184);

5 a fourth valve (154) provided on a flow passage (185) connecting the drain pump (140) to the third tank (113), the fourth valve (154) controlling the flow passage (185); and

a controller (160) controlling the suction pump (130), the drain pump (140) and the first, second, third and fourth
10 valves (151), (152), (153) and (154) in such a way that: after contaminated fluid is discharged from the first tank (111), the first valve (151) and the fourth valve (154) are controlled to close the corresponding flow passages (181) and (185), and the second valve (152) and the third valve (153)
15 are opened, so that the contaminated fluid circulates through the first centrifugal filter (120) and the second circulation tank (112); and when purification of the contaminated fluid by means of circulating the contaminated fluid through the first centrifugal filter (120) and the second circulation tank (112)
20 is completed, the third valve (153) is controlled to close the corresponding flow passage (184), and the fourth valve (154) is opened, so that purified fluid is supplied into the third tank (113).

25 2. The centrifugal circulating purification system of

claim 1, further comprising:

a second centrifugal filter (170) provided on a flow passage (185) connecting the drain pump (140) to the third tank (113), the second centrifugal filter (170) removing
5 impurities from fluid flowing towards the third tank (113),

the second centrifugal filter (170) comprises: a housing (171) having an oil inlet (171a); a rotor assembly (172) rotating in the housing (171); a shaft (173) provided in the housing (171) to support rotation of the rotor assembly (172),
10 the shaft (173) having therein a flow passage through which oil drawn from the oil inlet (171a) moves; a spindle tube (174) configured to rotate along with the rotor assembly (172) and receive the shaft (173) therein, the spindle tube (174) injecting oil, discharged from the shaft, into the rotor
15 assembly; a separation film (175) partitioning a space in the rotor assembly into an upper space (S1) and a lower space (S2); and a filter layer (176) provided on the separation film (175) and made of polyester or glass fiber, the filter layer (176) additionally removing impurities from oil flowing into
20 the lower space (S2) through the separation film.

3. A centrifugal circulating purification system, comprising:

a first tank (211) storing contaminated fluid therein;

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a first centrifugal filter (220) receiving the contaminated fluid and removing impurities from the contaminated fluid;

5 a suction pump (230) provided on a supply flow passage (291) connecting the first tank (211) to the first centrifugal filter (220), the suction pump (230) moving fluid to the first centrifugal filter (220);

10 a circulation pump (240) provided on a discharge flow passage (292) extending from an outlet of the first centrifugal filter (220), the circulation pump (240) moving fluid, discharged from the first centrifugal filter (220), such that the fluid circulates into the first centrifugal filter (220) through a circulation flow passage (293) connecting the discharge flow passage (292) to the supply flow
15 passage (291);

a second tank (212) connected to a branching flow passage (294) branching off from the discharge flow passage (292), the second tank (212) storing fluid that has been purified while having circulated through the first centrifugal filter (220);

20 a second centrifugal filter (250) provided on the branching flow passage (294), the second centrifugal filter (250) additionally removing impurities from fluid flowing to the second tank (212);

a drain pump (260) provided on the branching flow passage
25 (294), the drain pump (260) moving fluid, drawn into the

branching flow passage, to the second centrifugal filter (250);

a first three-way valve (271) provided on a junction between the supply flow passage (291) and the circulation flow
5 passage (293);

a second three-way valve (272) provided on a junction between the discharge flow passage (292) and the branching flow passage (294); and

a timer (280) controlling the first three-way valve (271)
10 and the second three-way valve (272) so that fluid circulates through the first centrifugal filter (220) for a preset time period.