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(54) **SLURRY FILTER REPLACEMENT ROBOT**

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CPC ***B25J 11/005*** (2013.01); ***B25J 15/0038*** (2013.01); ***B25J 19/02*** (2013.01)

(57) **ABSTRACT**

A slurry filter replacement robot for replacing a first filter at an operating station includes one or more manipulators, a support frame disposed in a lower portion of the one or more manipulators and configured to support the one or more manipulators, a loader coupled with the support frame and configured to load the first filter and a second filter thereon, and a mover disposed in a lower portion of the support frame and configured to move the support frame. Each of the one or more manipulators includes an arm and a robot tool coupled with a first side of the arm. Each of the one or more manipulators is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader.

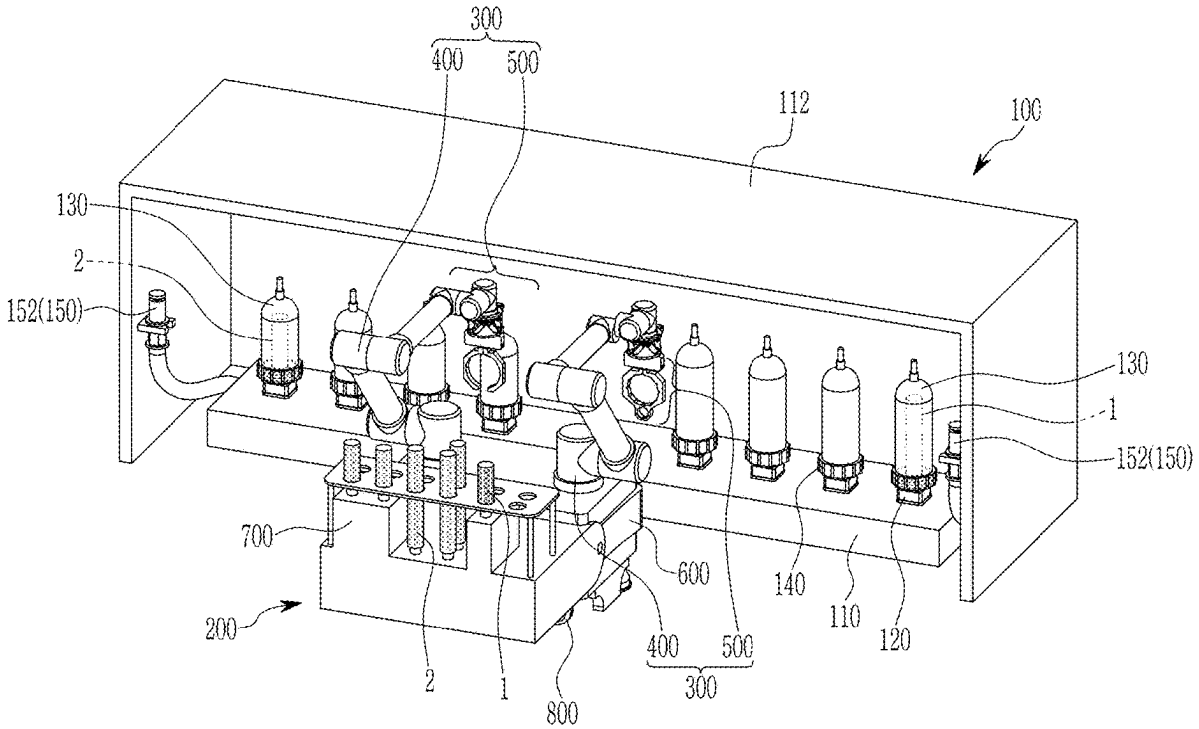

FIG. 1

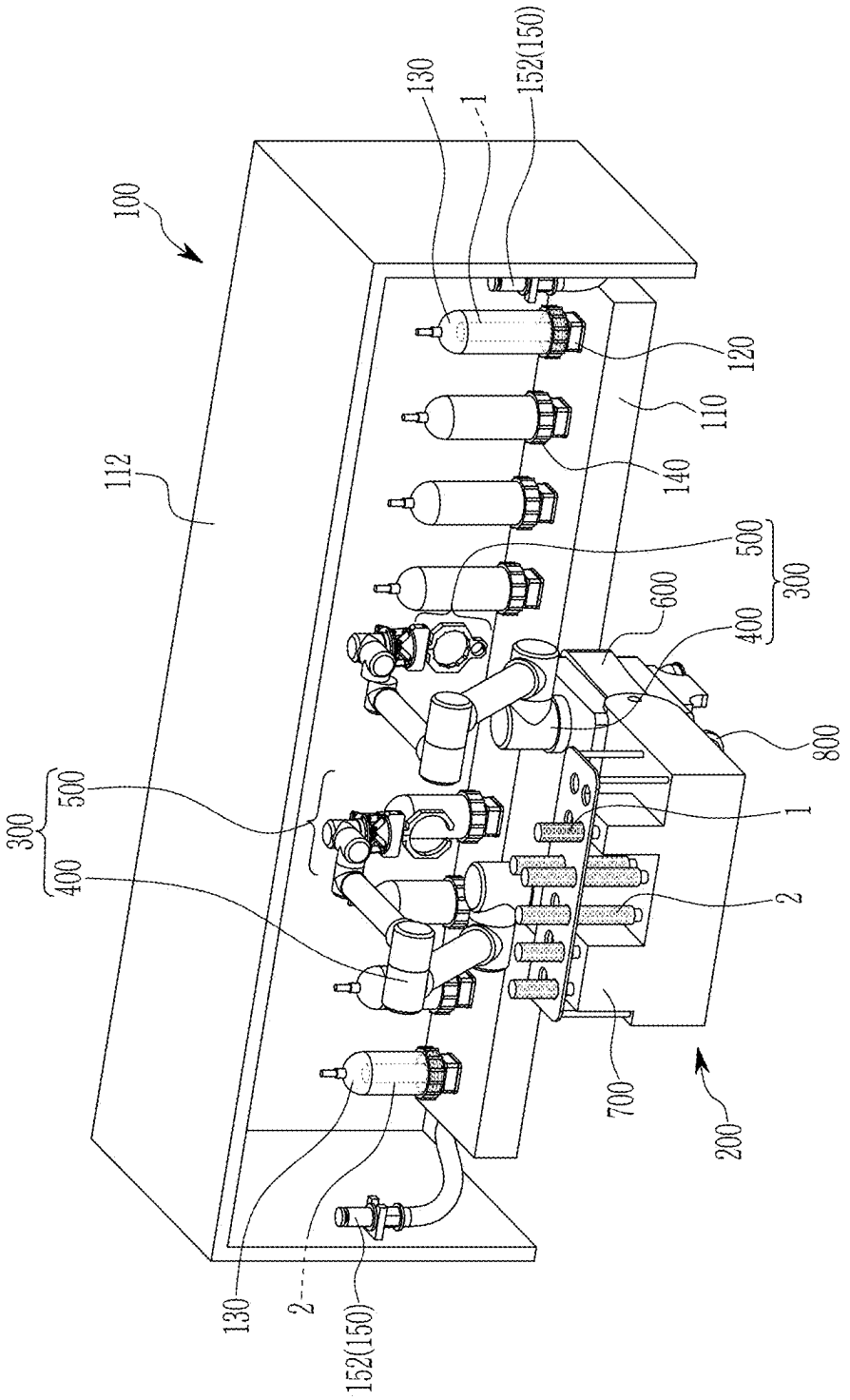
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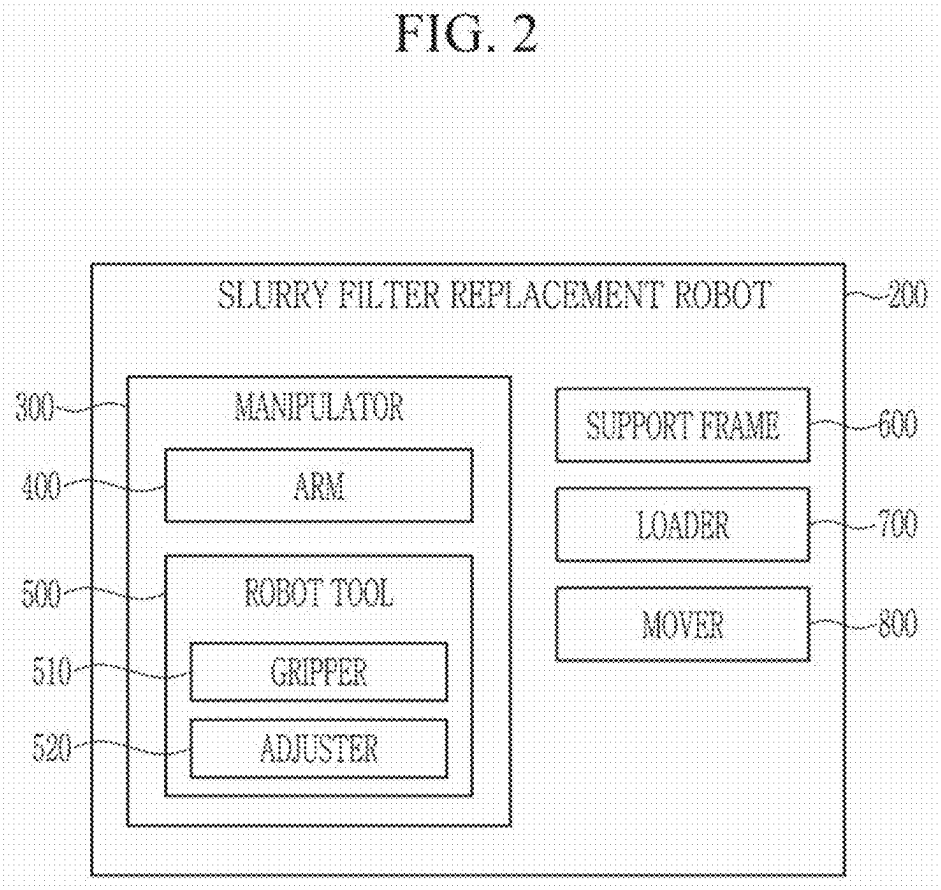
FIG. 2


SLURRY FILTER REPLACEMENT ROBOT
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MANIPULATOR
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ARM
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ROBOT TOOL
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GRIPPER
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ADJUSTER
SUPPORT FRAME
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LOADER
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MOVER
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FIG. 3

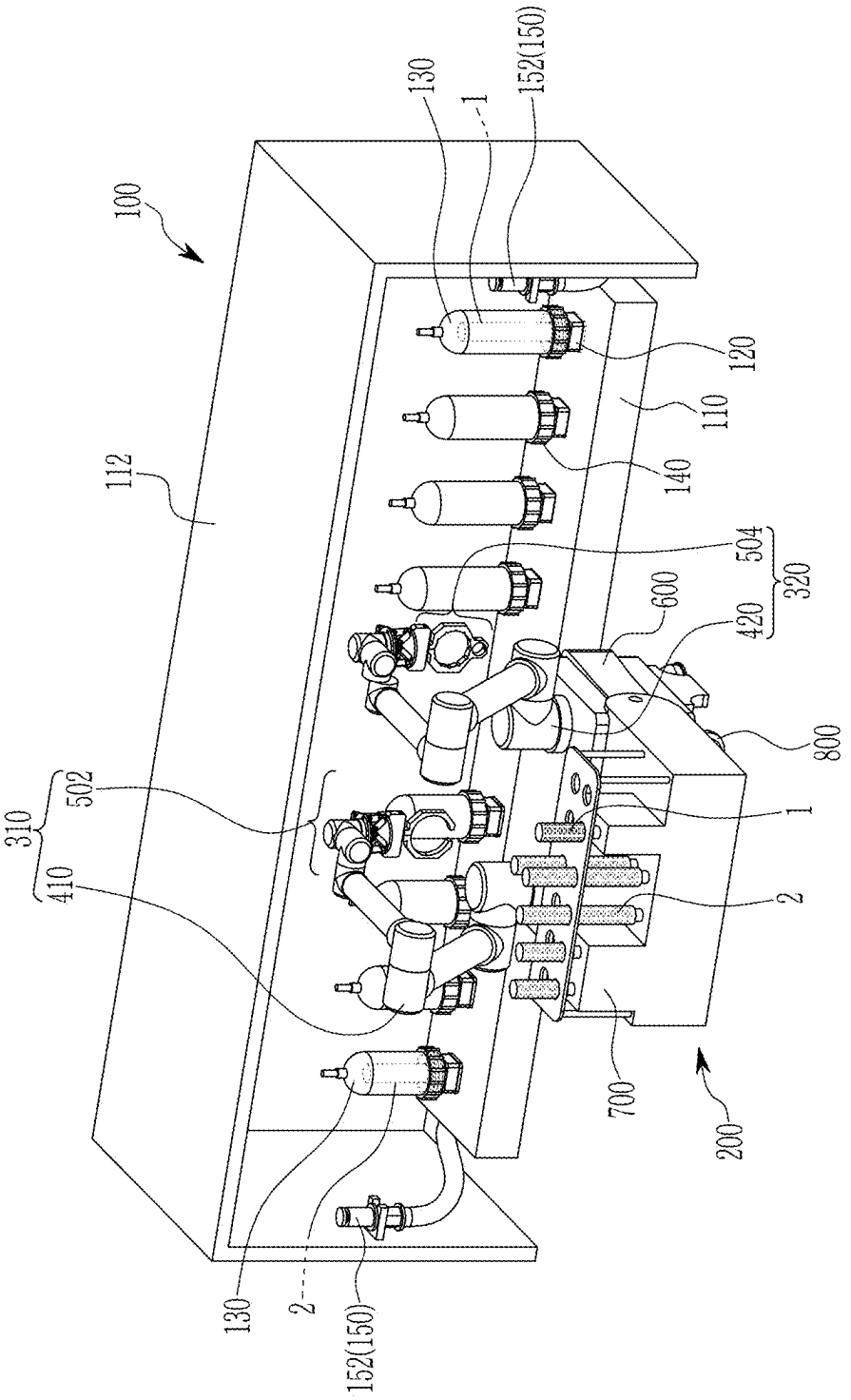
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FIG. 4

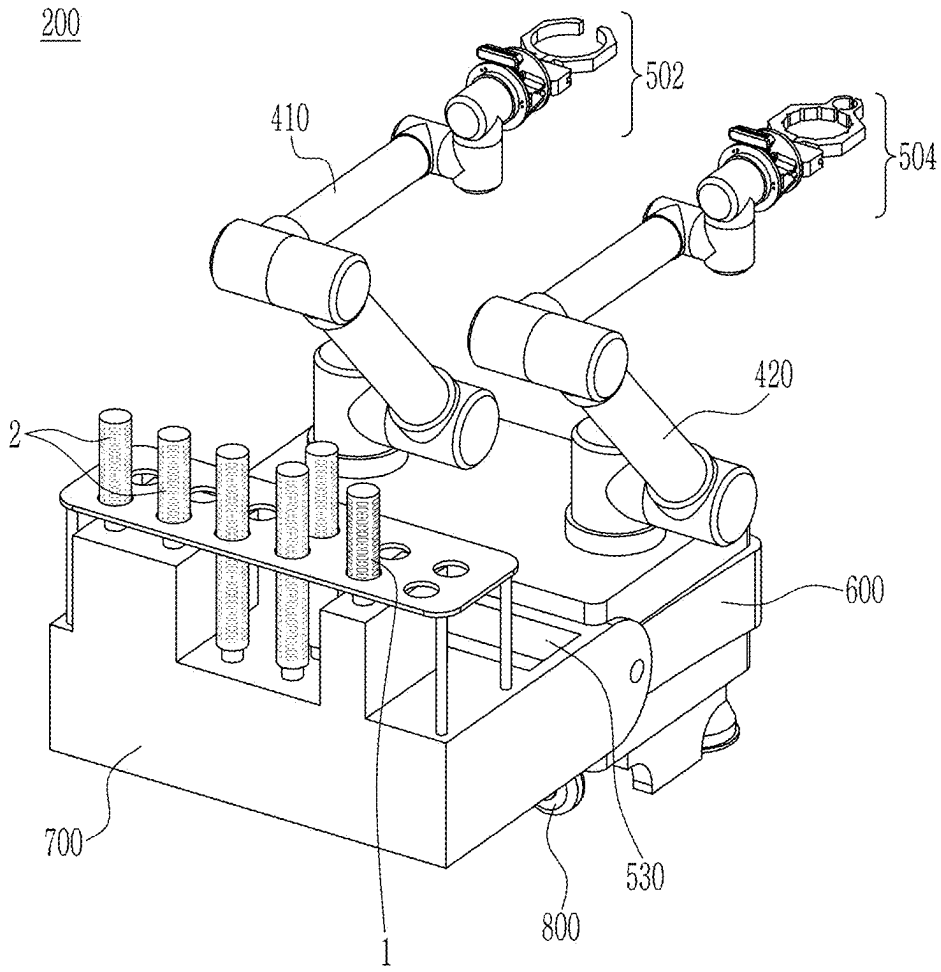

FIG. 5

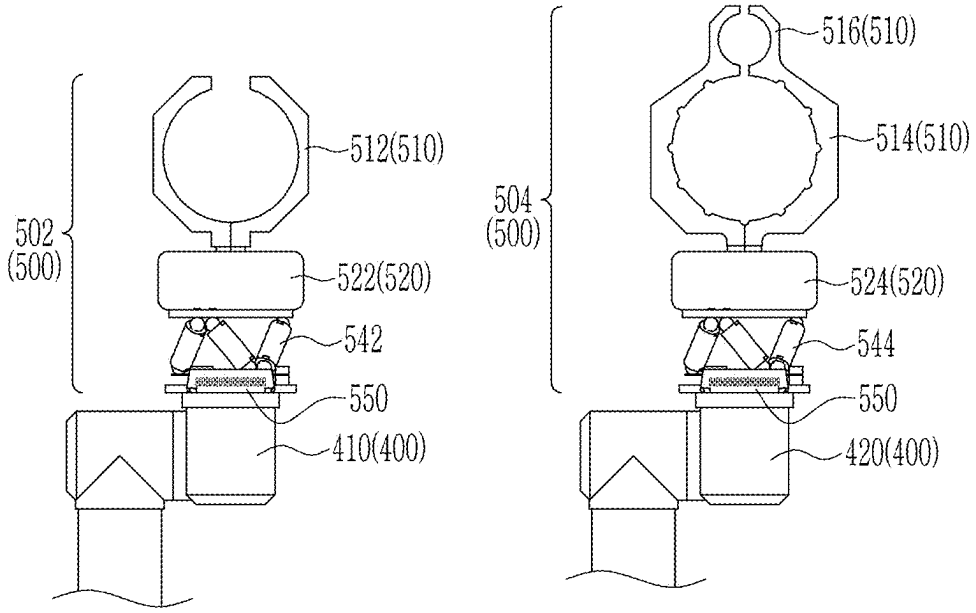
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FIG. 6

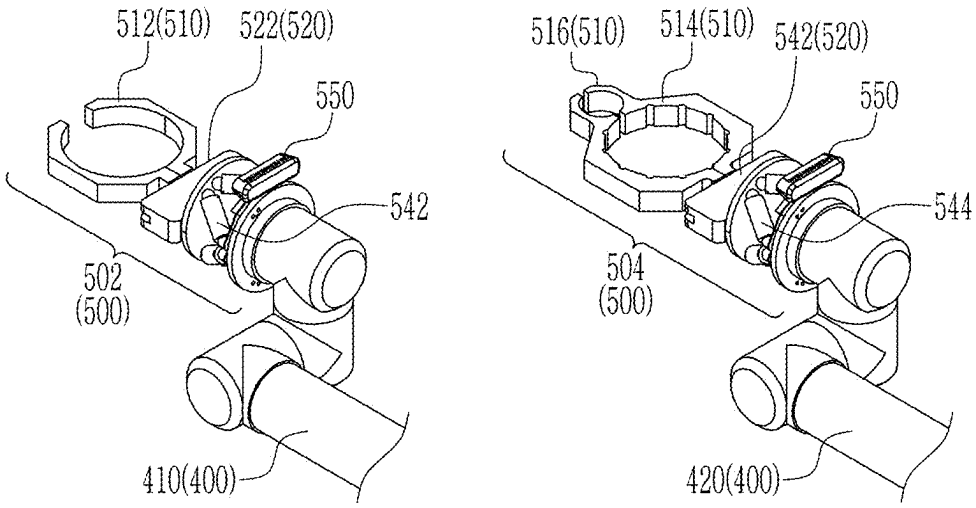
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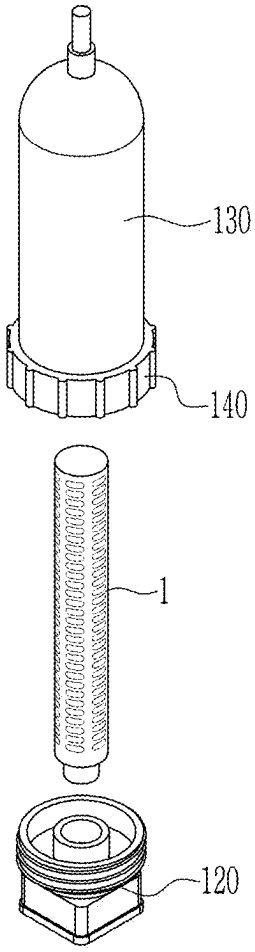
FIG. 7



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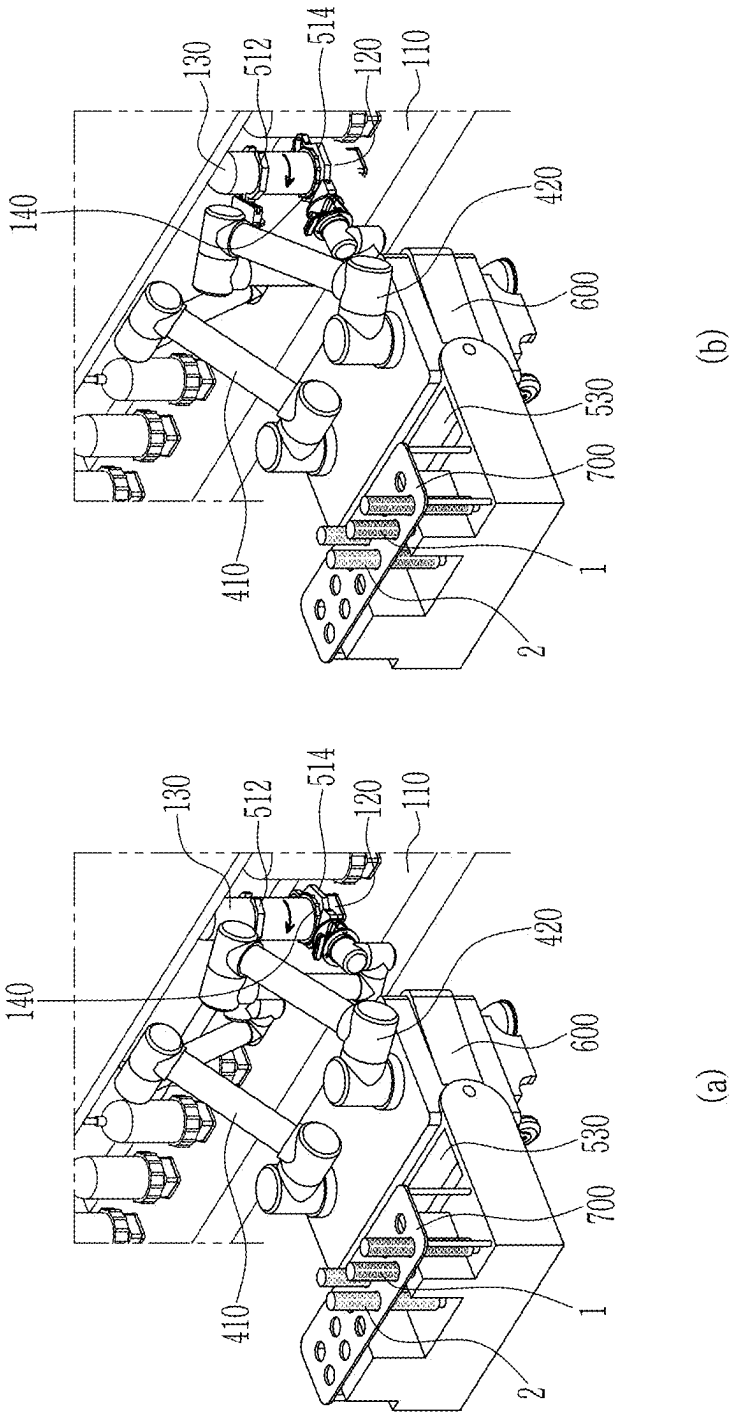
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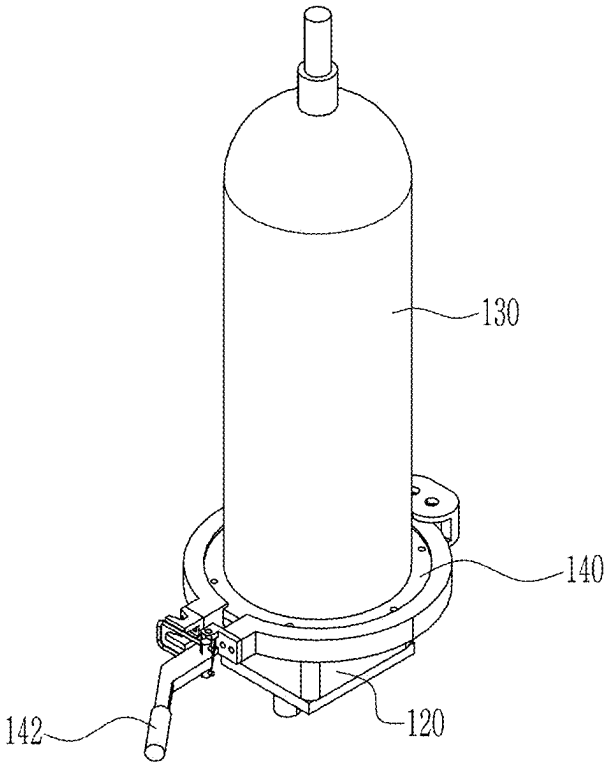
FIG. 9



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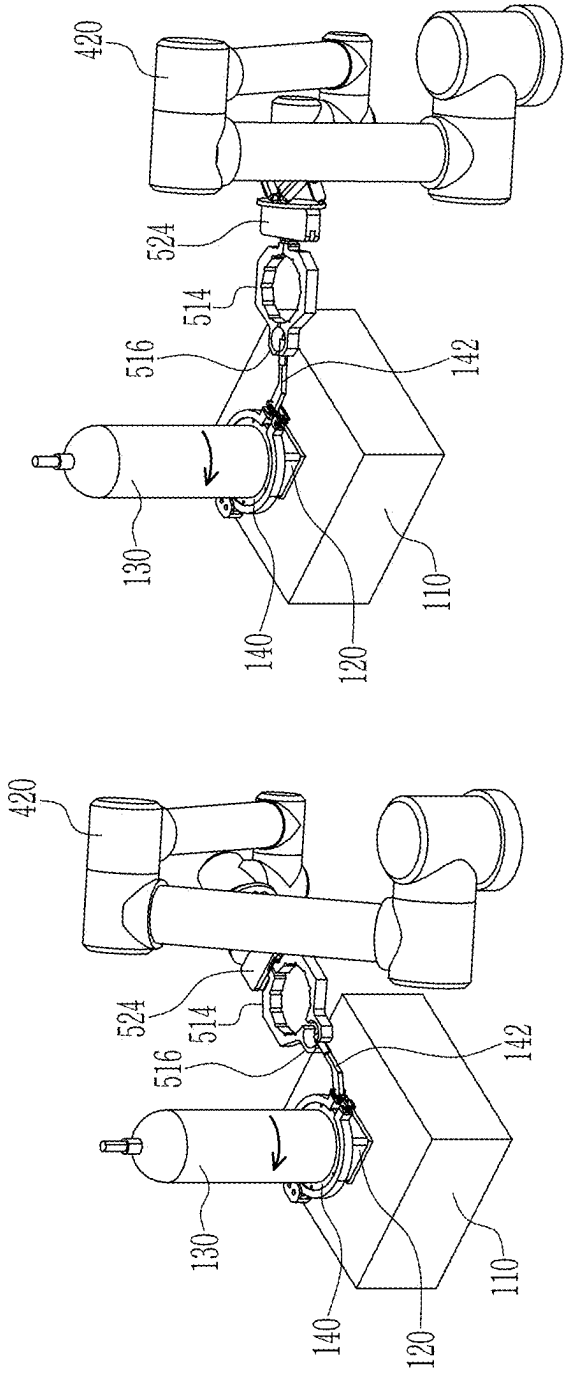
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FIG. 11

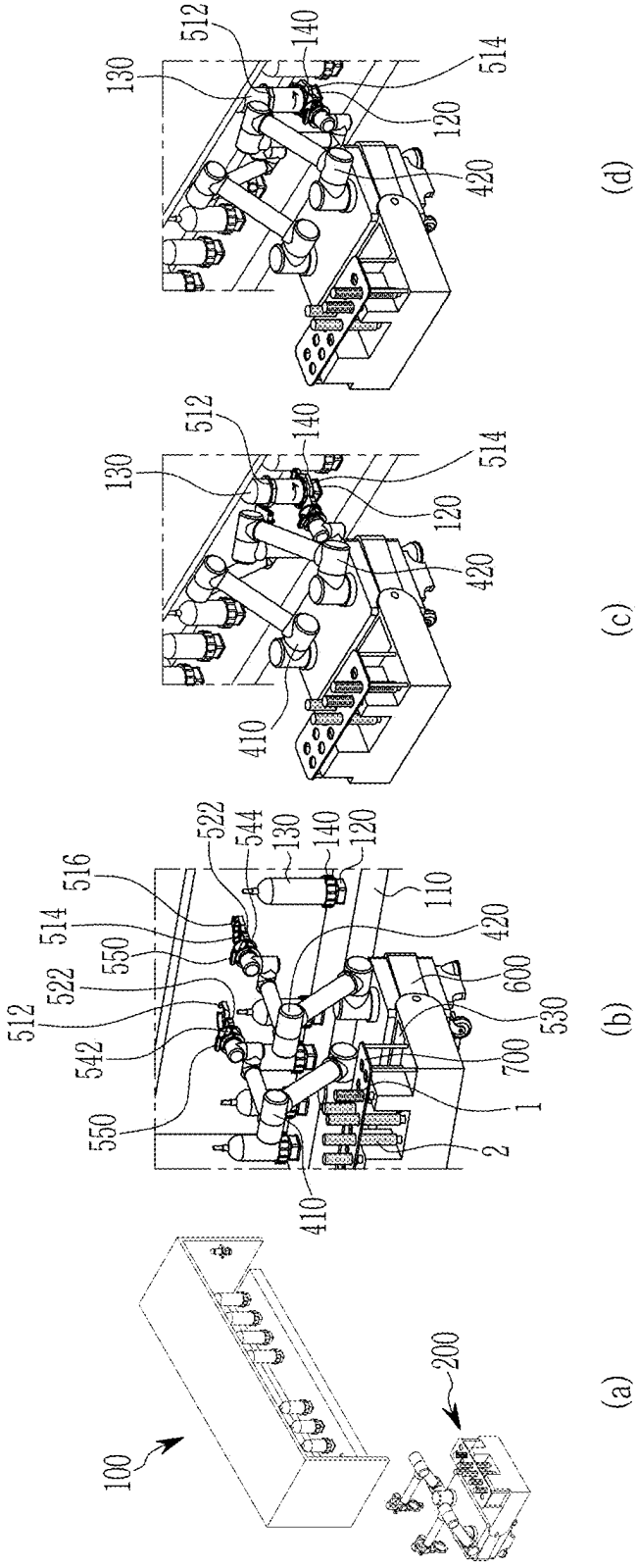
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FIG. 12

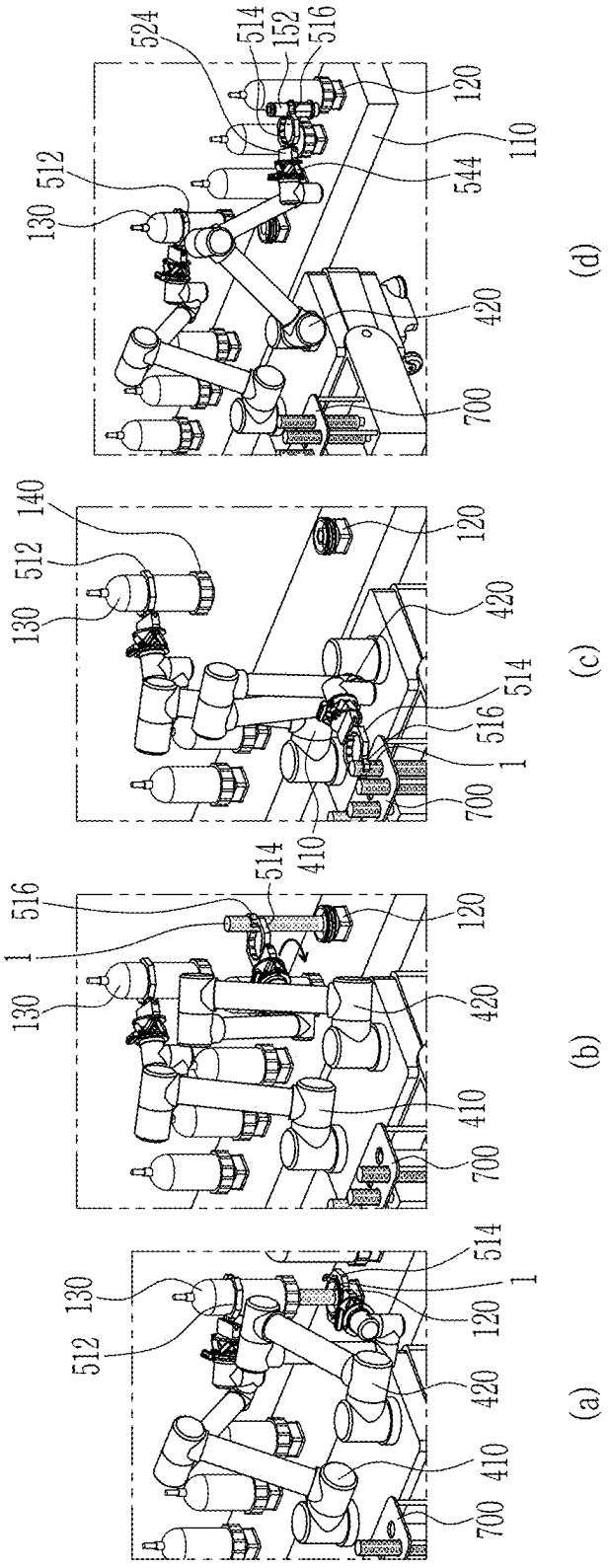

FIG. 13

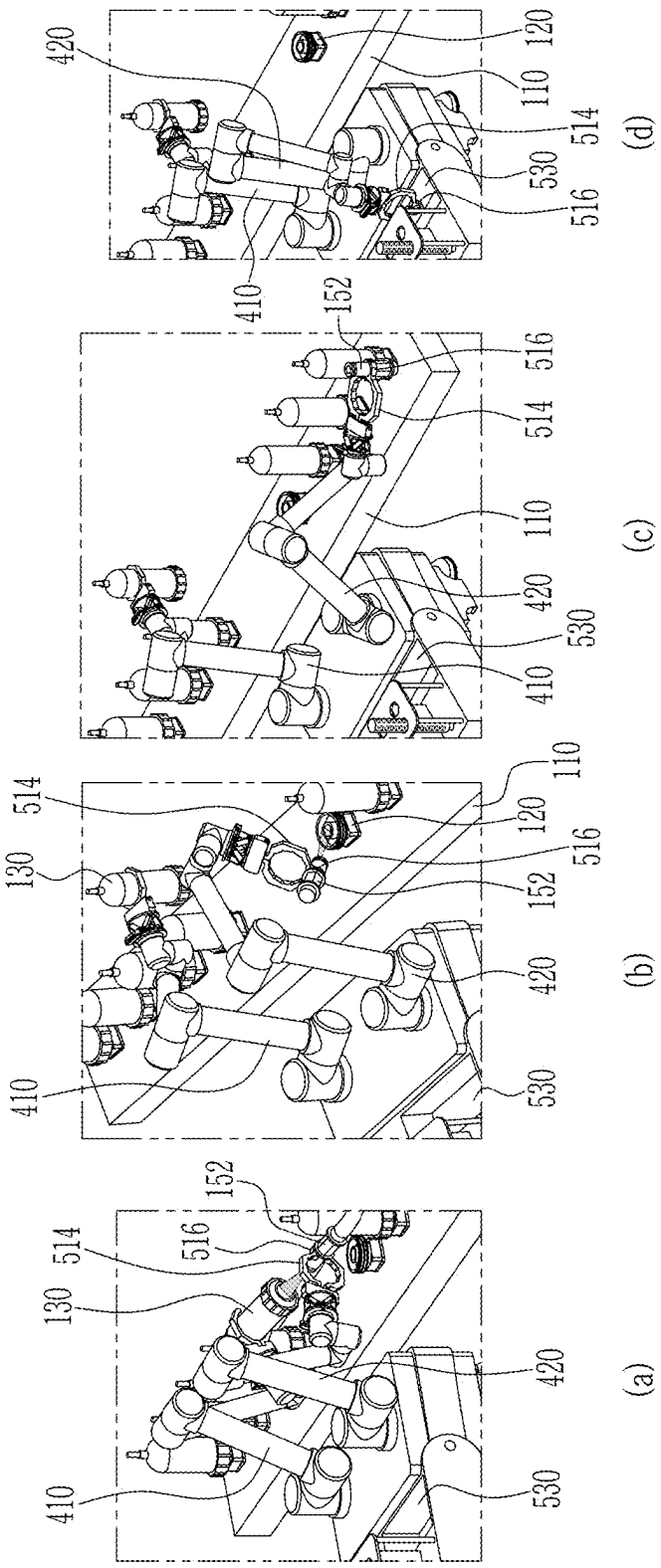
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FIG. 14

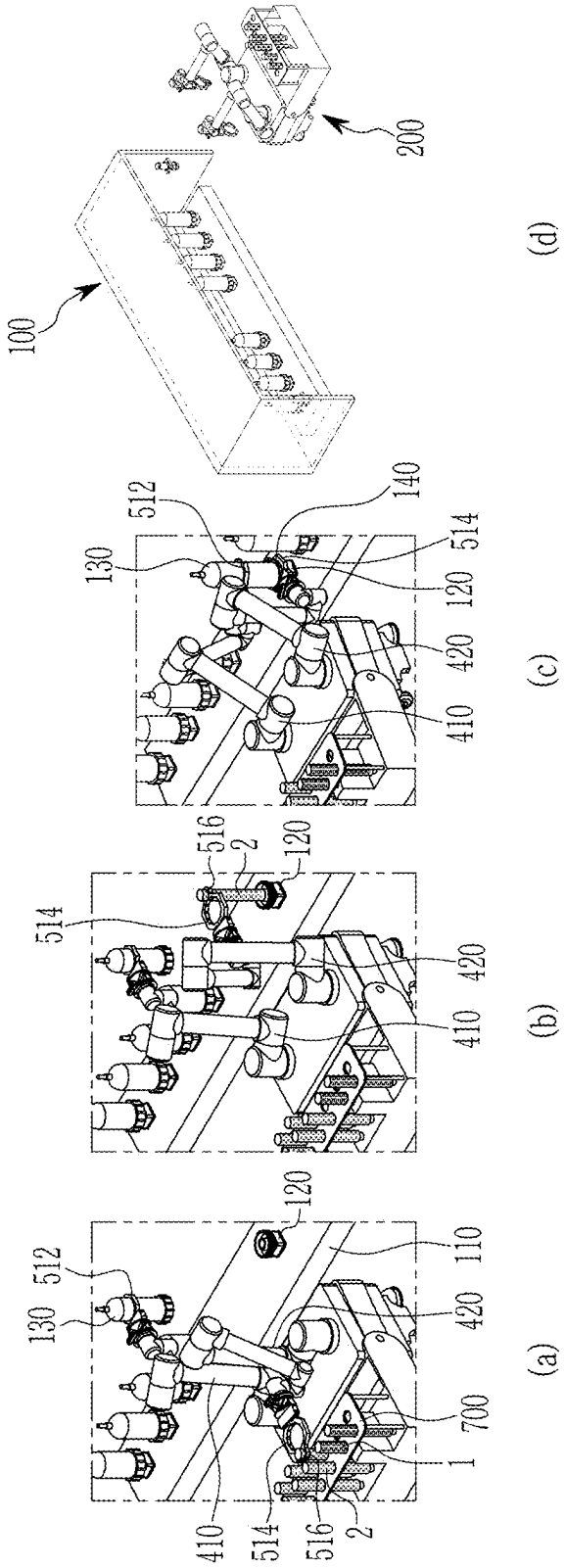

FIG. 15

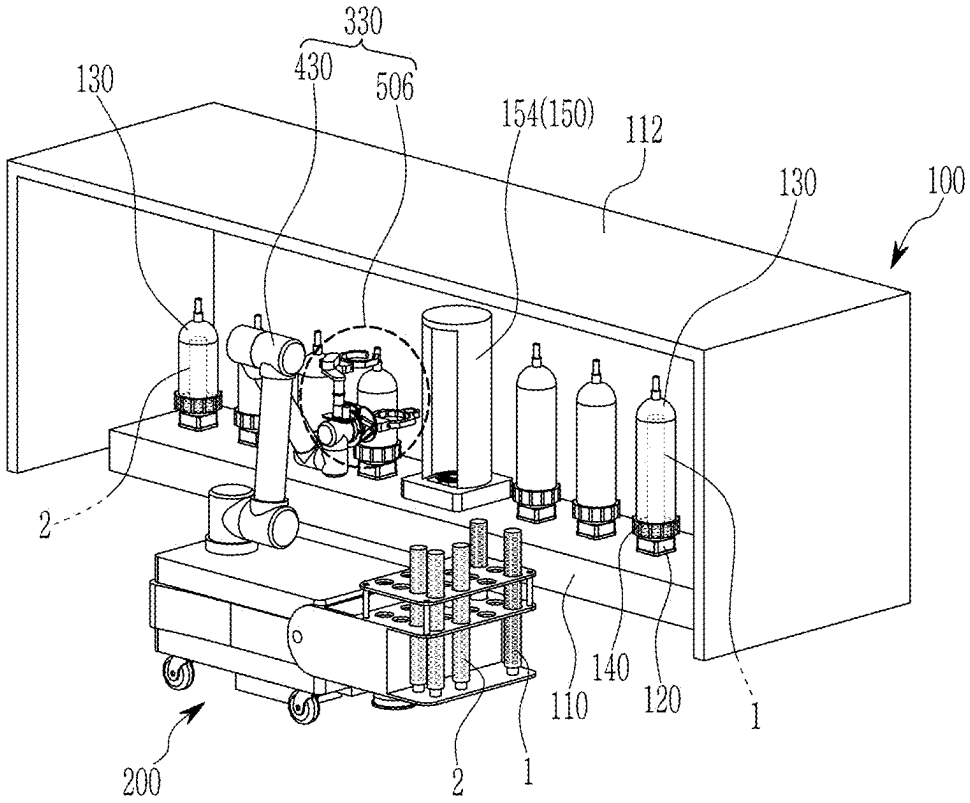

FIG. 16

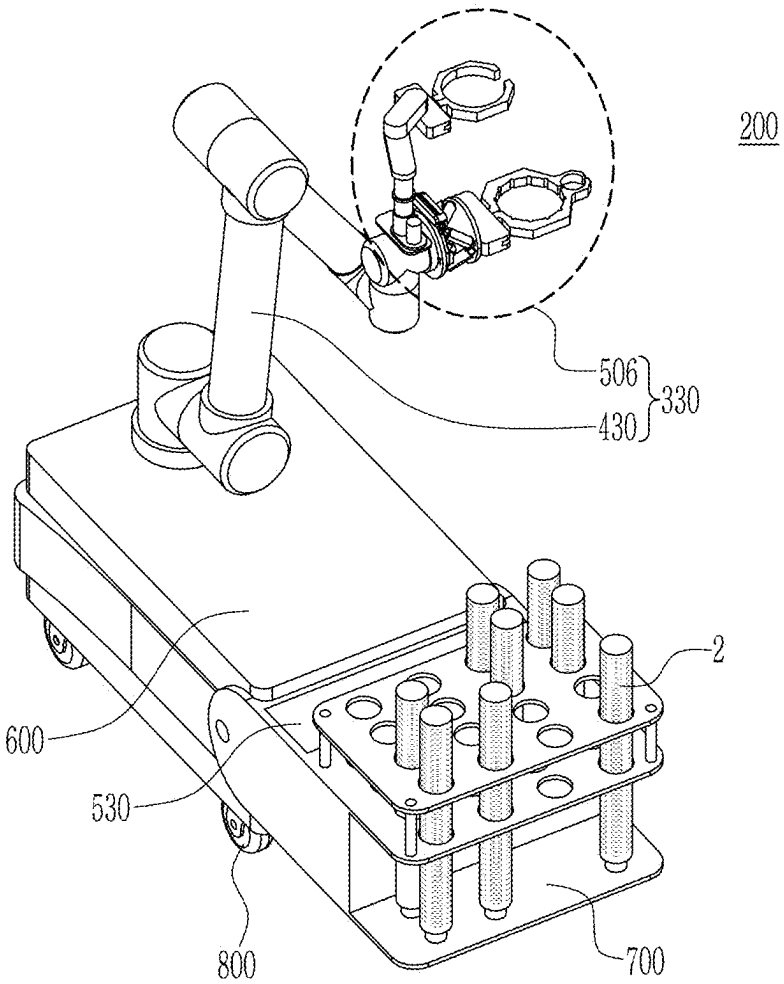

FIG. 17

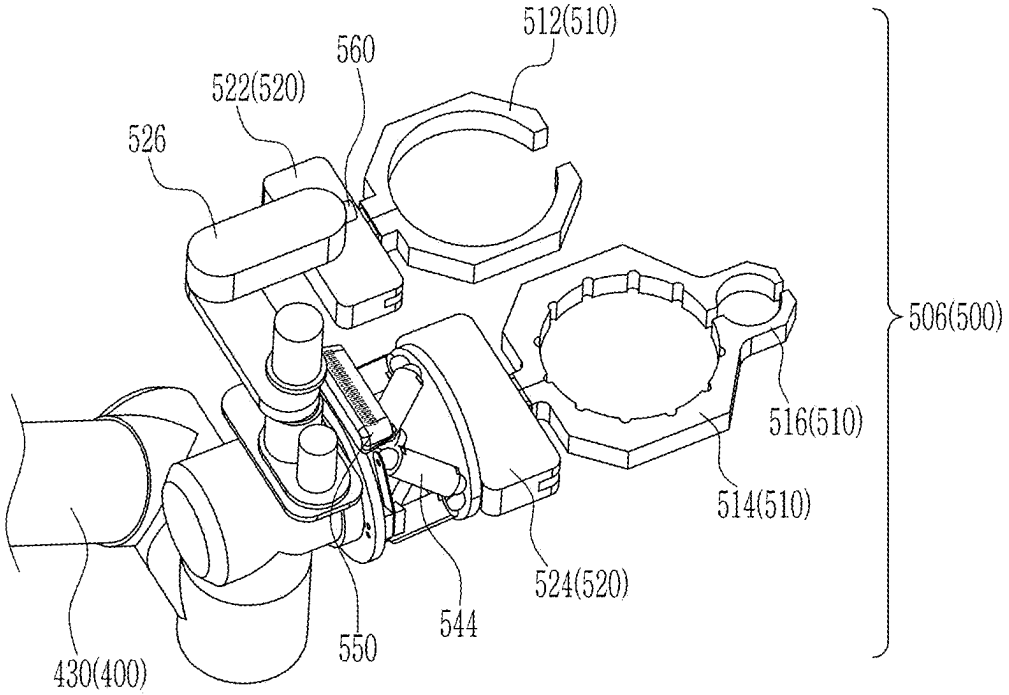
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FIG. 18

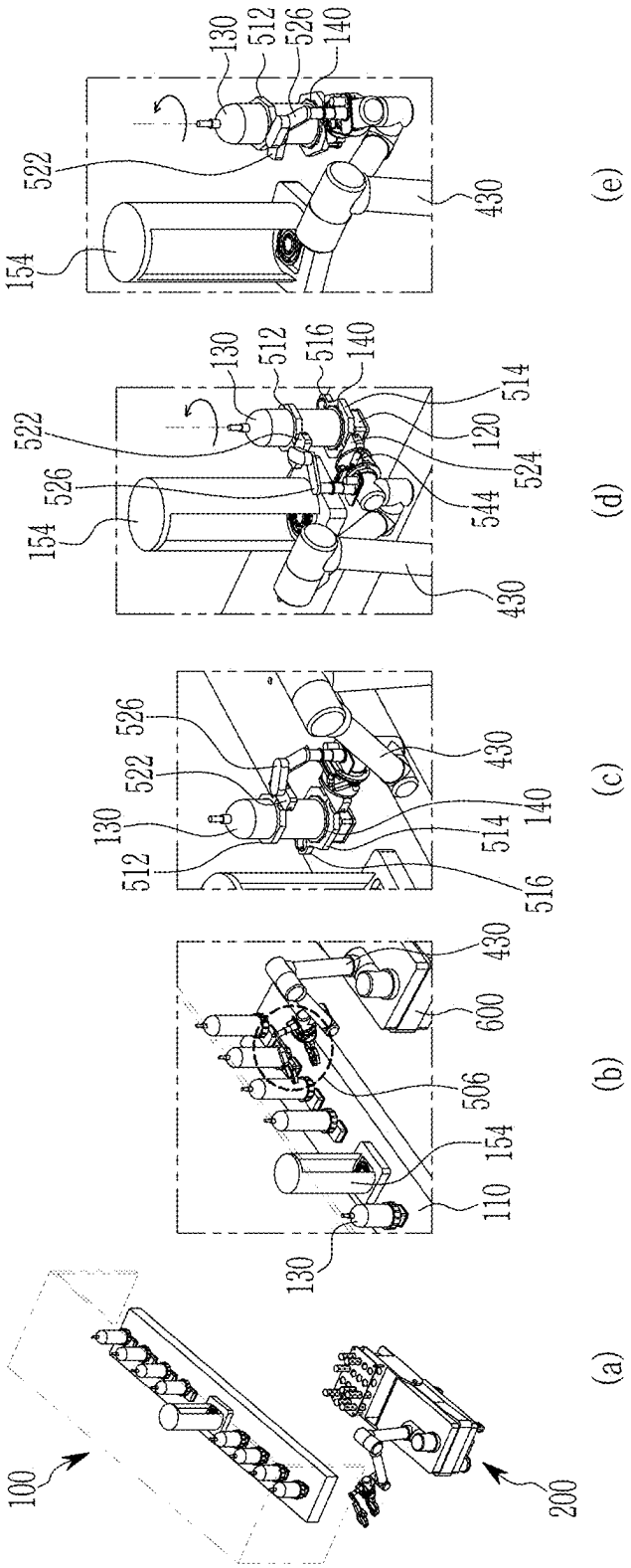
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FIG. 19

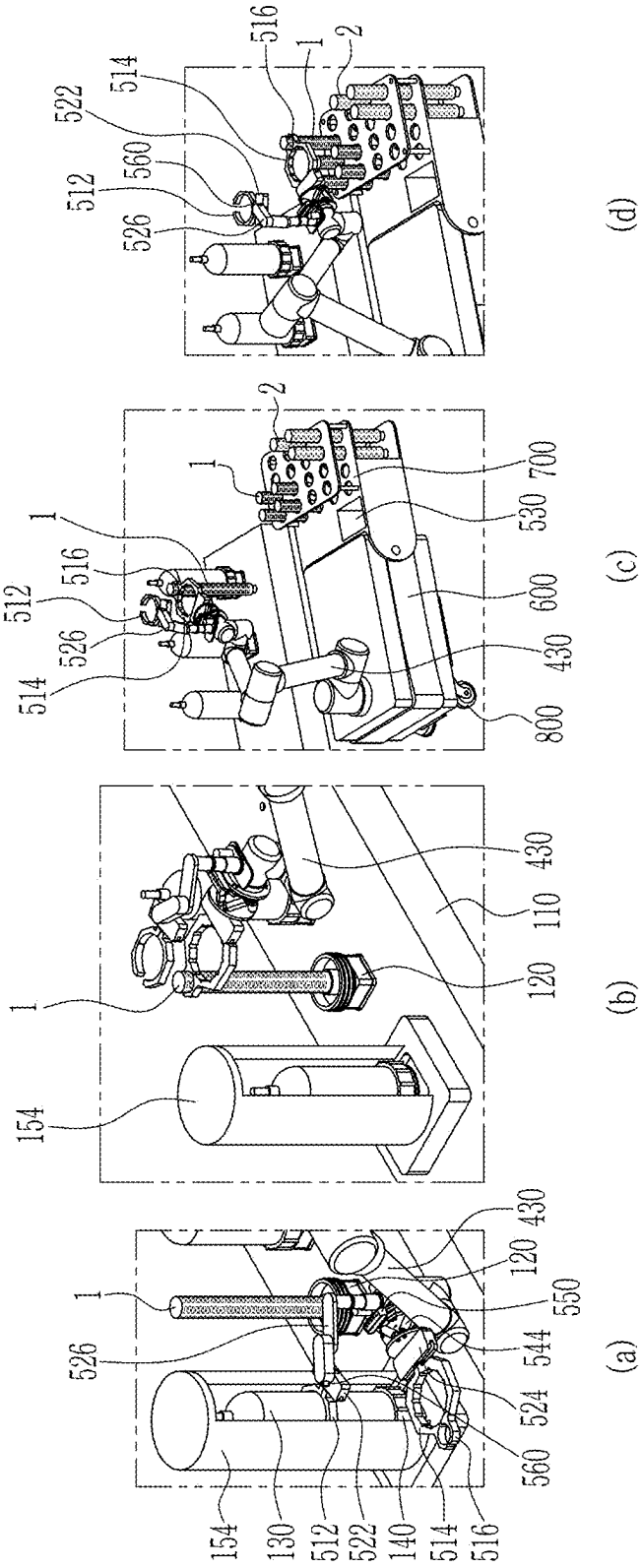
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FIG. 20

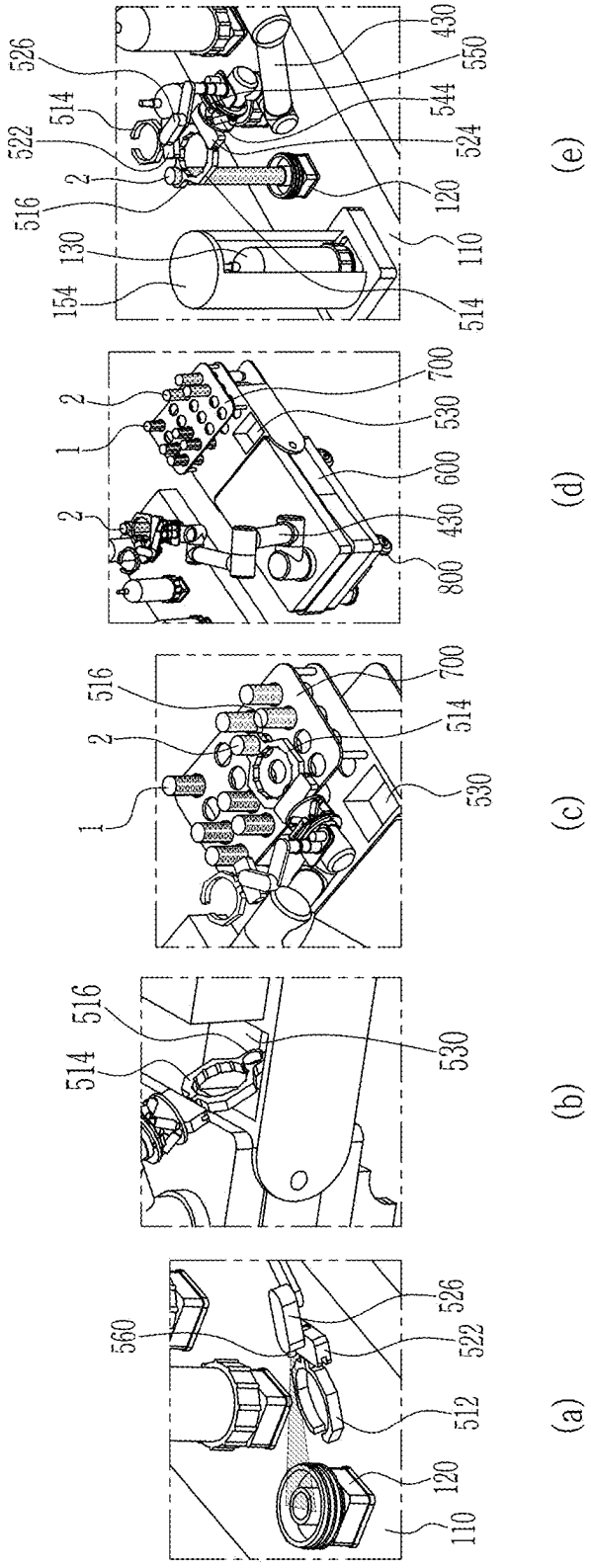
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FIG. 21

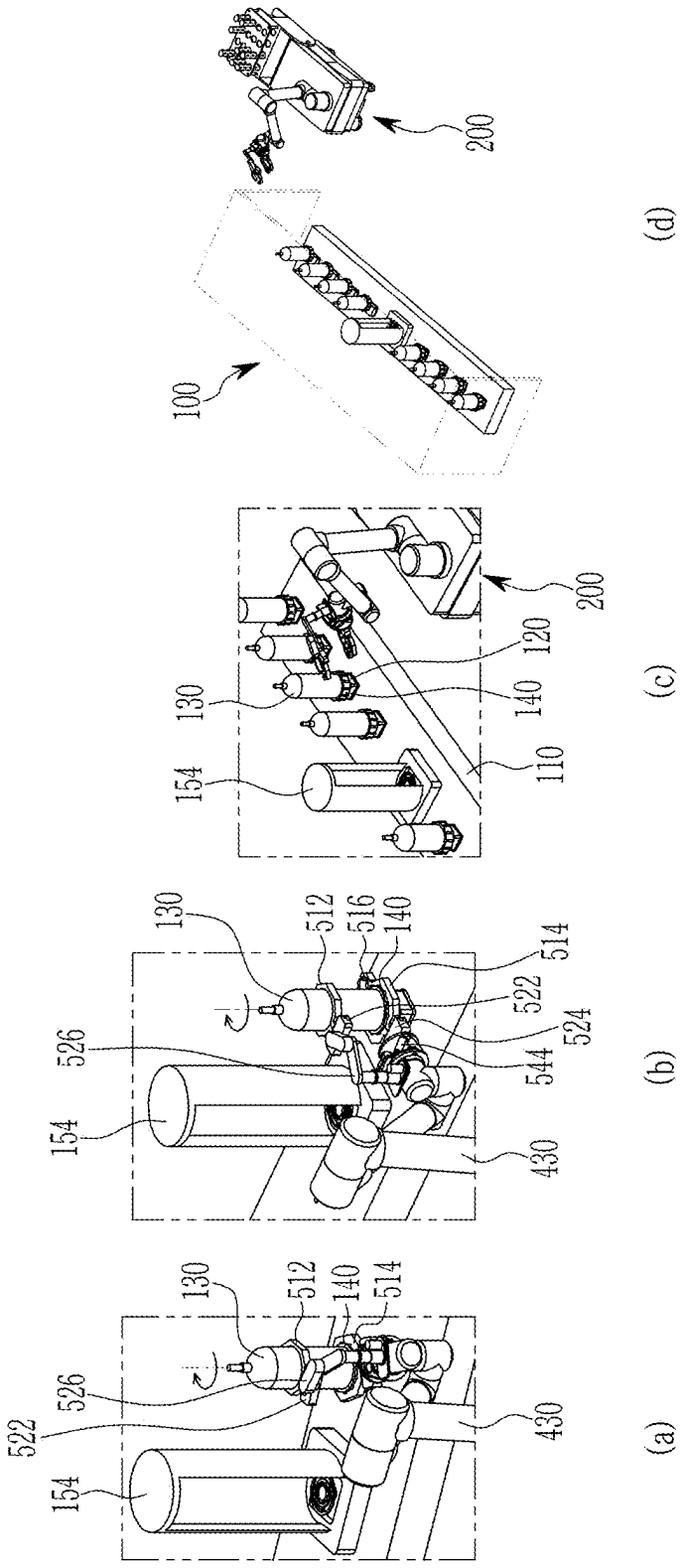
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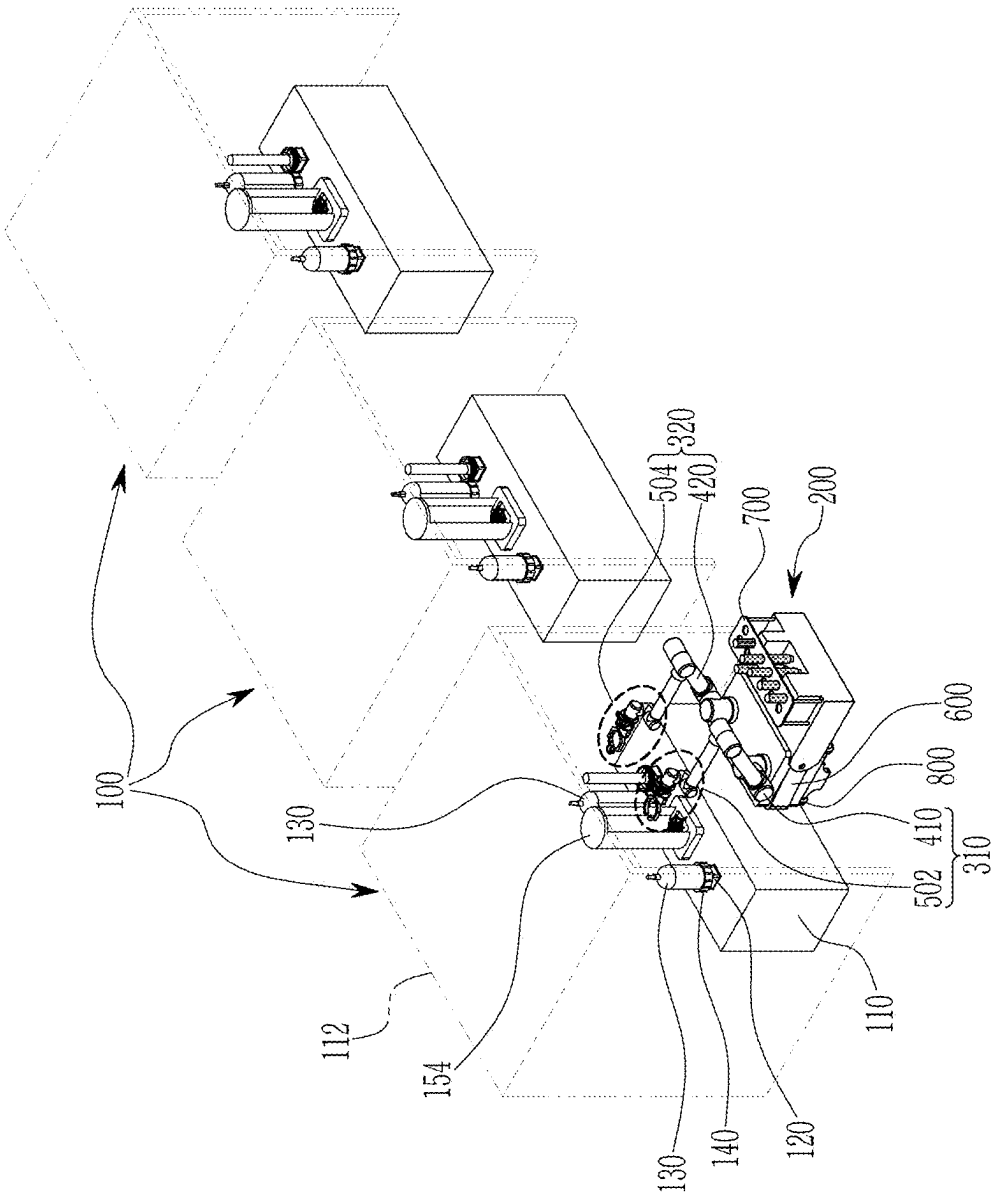
FIG. 22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SLURRY FILTER REPLACEMENT ROBOT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2024-0023588, filed on Feb. 19, 2024, in the Korean Intellectual Property Office, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

1. Field

[0002] The present disclosure relates generally to semiconductor cleaning processes, and more particularly, to a slurry filter replacement robot.

2. Description of Related Art

[0003] A semiconductor chemical mechanical polishing (CMP) process may refer to a process of refining and/or smoothing curves of a wafer surface and may include a process of polishing and/or planarizing a thin film surface of a wafer that may have irregularities and/or curves through chemical and/or mechanical elements.

[0004] The semiconductor CMP process may utilize the principle that when parts having different heights in a chip are in contact with a pad, the parts may receive different pressures, and a part that is relatively high may be first polished by a high pressure. The semiconductor CMP process may be performed with a polishing liquid, which may be referred to as a slurry, which may be distributed on a contact surface to potentially prevent and/or mitigate scratches on the wafer surface and to potentially compensate for instability in a process control.

[0005] CMP slurries may be and/or may include solutions that may include combinations of polishing particles that may perform mechanical polishing, chemical additives that may perform chemical polishing, and/or various other functions. For example, metal oxide ceramic materials, such as, but not limited to, silica and ceria, may be used as polishing particles, and the types and/or combinations of chemical additives may be very diverse.

[0006] The CMP slurries may vary depending on a material of a thin film to be polished, and may be divided and/or categorized into an insulating film slurry, a metal film slurry (e.g., copper (Cu), tungsten (W), or the like), and/or an organic film slurry (e.g., an amorphous carbon (C) film).

[0007] In a slurry supply process, in order to minimize impurities included in slurries, slurries may be supplied through a slurry filter. A filter for filtering slurries used in a CMP process may need to be replaced at regular intervals.

[0008] However, when an operator manually replaces the slurry filter, since the operator may need to separate and fasten the slurry filter by using separate tools, a significant amount of time and/or expenses may be consumed in a replacement process, and as a result, the efficiency of a slurry filter replacement job is not high. Furthermore, additional contamination and equipment damage may occur during a slurry filter replacement process, as well as, the operator may be exposed to danger due to chemical handling.

SUMMARY

[0009] One or more example embodiments of the present disclosure provide a slurry filter replacement robot that replaces a slurry filter disposed at an operating station by using the slurry filter replacement robot, thereby preventing or mitigating a problem in that an operator is exposed to danger during a replacement process, and minimizing additional contamination and equipment damage that may occur during the slurry filter replacement process by cleaning surrounding equipment using a cleaning device disposed inside the operating station during the replacement process.

[0010] According to an aspect of the present disclosure, a slurry filter replacement robot for replacing a first filter at an operating station includes one or more manipulators, a support frame disposed in a lower portion of the one or more manipulators and configured to support the one or more manipulators, a loader coupled with the support frame and configured to load the first filter and a second filter thereon, and a mover disposed in a lower portion of the support frame and configured to move the support frame. Each of the one or more manipulators includes an arm and a robot tool coupled with a first side of the arm. Each of the one or more manipulators is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader.

[0011] According to an aspect of the present disclosure, a slurry filter replacement robot for replacing a first filter at an operating station includes a first manipulator including a first arm and a first robot tool coupled with a side of the first arm, a second manipulator including a second arm and a second robot tool coupled with a side of the second arm, a support frame disposed in a lower portion of the first manipulator and the second manipulator, a loader coupled with the support frame and configured to load the first filter and a second filter thereon, and a mover disposed in a lower portion of the support frame and configured to move the support frame. The second manipulator is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader.

[0012] According to an aspect of the present disclosure, a slurry filter replacement robot for replacing a first filter disposed at an operating station includes a manipulator, a support frame disposed in a lower portion of the manipulator, a loader coupled with the support frame and configured to load the first filter and a second filter, and a mover disposed in a lower portion of the support frame and configured to move the support frame. The manipulator includes a robot tool configured to grip a ball of the operating station, a nut of the operating station, and the first filter, and a third arm having a first side coupled with the robot tool. The manipulator is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader. The ball of the operating station is coupled with a head disposed on an operating table of the operating station. The nut of the operating station is disposed between the ball and the head and is configured to couple the ball to the head.

[0013] According to embodiments, the slurry filter replacement robot may be used to replace a used slurry filter (e.g., a first filter) disposed at the operating station with a new slurry filter (e.g., a second filter), thereby potentially increasing the efficiency of the slurry filter replacement operation, and minimizing equipment damage and human damage.

[0014] Additional aspects may be set forth in part in the description which follows and, in part, may be apparent from the description, and/or may be learned by practice of the presented embodiments.

BRIEF DESCRIPTION OF DRAWINGS

[0015] The above and other aspects, features, and advantages of certain embodiments of the present disclosure may be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[0016] FIG. **1** is a diagram showing the overall configuration of a slurry filter replacement robot, according to an embodiment;

[0017] FIG. **2** is a diagram showing the configuration of a slurry filter replacement robot, according to an embodiment;

[0018] FIG. **3** is a diagram showing the overall configuration of a slurry filter replacement robot, according to another embodiment;

[0019] FIG. **4** is a diagram illustrating the slurry filter replacement robot of FIG. **3**, according to an embodiment;

[0020] FIG. **5** is a diagram depicting manipulators of the slurry filter replacement robot of FIG. **4**, according to an embodiment;

[0021] FIG. **6** is a diagram illustrating manipulators of the slurry filter replacement robot of FIG. **4**, according to an embodiment;

[0022] FIG. **7** is a diagram depicting a structure in which a slurry filter is coupled with an operating station in a slurry filter replacement robot, according to an embodiment;

[0023] FIG. **8** is a diagram illustrating a process of coupling the slurry filter to the operating station, according to an embodiment;

[0024] FIG. **9** is a diagram depicting a structure in which a slurry filter is coupled with an operating station in a slurry filter replacement robot, according to an embodiment;

[0025] FIG. **10** is a diagram illustrating a process of coupling the slurry filter to the operating station, according to an embodiment;

[0026] FIGS. **11** to **14** are diagrams depicting a process in which the slurry filter replacement robot replaces a slurry filter, according to an embodiment;

[0027] FIG. **15** is a diagram showing the overall configuration of a slurry filter replacement robot, according to an embodiment;

[0028] FIG. **16** is a diagram illustrating the slurry filter replacement robot of FIG. **15**, according to an embodiment;

[0029] FIG. **17** is a diagram depicting a manipulator of the slurry filter replacement robot of FIG. **15**, according to an embodiment;

[0030] FIGS. **18** to **21** are diagrams illustrating a process in which the slurry filter replacement robot replaces a slurry filter, according to an embodiment; and

[0031] FIG. **22** is a diagram depicting a replacement process by using a slurry filter replacement robot, according to an embodiment.

DETAILED DESCRIPTION

[0032] Hereinafter, with reference to the accompanying drawings, various embodiments of the present disclosure are described so that those skilled in the art may carry out the present disclosure. The present disclosure may be embodied in many different forms and may not be limited to the embodiments set forth herein.

[0033] In order to explain the present disclosure in the drawings, parts irrelevant to the description may be omitted, and the same reference numerals may be used for the same or similar elements throughout the specification.

[0034] In addition, since the size and thickness of each component shown in the drawings may be arbitrarily shown for convenience of description, the present disclosure is not necessarily limited to those shown. In the drawings, the thickness of layers and regions may be exaggerated for clarity. In addition, in the drawings, for convenience of explanation, thicknesses of some layers and areas may be exaggerated.

[0035] Throughout the present disclosure, when an element is referred to as being "connected" to another element, this includes not only the element being "directly connected" but also being "indirectly connected" to the other element with other members therebetween. In addition, unless explicitly described to the contrary, the word "comprise", and variations such as "comprises" or "comprising", may be understood to imply the inclusion of stated elements but not the exclusion of any other elements.

[0036] In addition, it is to be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, the element may be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" another element, there may be no intervening elements present. In addition, being "above" or "on" a reference part may refer to being above or below the reference part, and may not necessarily refer to being "above" or "on" in the opposite direction of gravity.

[0037] Throughout the present disclosure, when an element or view is "on a plane" may refer to when a target portion is viewed from above, and when an element or view is "on a cross section" may refer to when a cross section obtained by vertically cutting a target portion is viewed from the side.

[0038] It is to be understood that a singular form of a noun corresponding to an item may include one or more of the things, unless the relevant context clearly indicates otherwise. As used herein, each of such phrases as "A or B," "at least one of A and B," "at least one of A or B," "A, B, or C," "at least one of A, B, and C," and "at least one of A, B, or C," may include any one of, or all possible combinations of the items enumerated together in a corresponding one of the phrases. As used herein, such terms as "1st" and "2nd," or "first" and "second" may be used to simply distinguish a corresponding component from another, and does not limit the components in other aspect (e.g., importance or order). It is to be understood that if an element (e.g., a first element) is referred to, with or without the term "operatively" or "communicatively", as "coupled with," "coupled to," "connected with," or "connected to" another element (e.g., a second element), it means that the element may be coupled with the other element directly (e.g., wired), wirelessly, or via a third element.

[0039] The terms "upper," "middle", "lower", and the like may be replaced with terms, such as "first," "second," third" to be used to describe relative positions of elements. The terms "first," "second," third" may be used to describe various elements but the elements are not limited by the terms and a "first element" may be referred to as a "second element". Alternatively or additionally, the terms "first", "second", "third", and the like may be used to distinguish

components from each other and do not limit the present disclosure. For example, the terms "first", "second", "third", and the like may not necessarily involve an order or a numerical meaning of any form.

[0040] Reference throughout the present disclosure to "one embodiment," "an embodiment," "an example embodiment," or similar language may indicate that a particular feature, structure, or characteristic described in connection with the indicated embodiment is included in at least one embodiment of the present solution. Thus, the phrases "in one embodiment", "in an embodiment," "in an example embodiment," and similar language throughout this disclosure may, but do not necessarily, all refer to the same embodiment. The embodiments described herein are example embodiments, and thus, the disclosure is not limited thereto and may be realized in various other forms.

[0041] The embodiments herein may be described and illustrated in terms of blocks, as shown in the drawings, which carry out a described function or functions. These blocks, which may be referred to herein as units or modules or the like, or by names such as device, logic, circuit, controller, counter, comparator, generator, converter, or the like, may be physically implemented by analog and/or digital circuits including one or more of a logic gate, an integrated circuit, a microprocessor, a microcontroller, a memory circuit, a passive electronic component, an active electronic component, an optical component, and the like.

[0042] In the present disclosure, the articles "a" and "an" are intended to include one or more items, and may be used interchangeably with "one or more." Where only one item is intended, the term "one" or similar language is used. For example, the term "a processor" may refer to either a single processor or multiple processors. When a processor is described as carrying out an operation and the processor is referred to perform an additional operation, the multiple operations may be executed by either a single processor or any one or a combination of multiple processors.

[0043] Hereinafter, a slurry filter replacement robot, according to various embodiments of the present disclosure are described with reference to the accompanying drawings.

[0044] FIG. **1** is a diagram showing the overall configuration of a slurry filter replacement robot, according to an embodiment. FIG. **2** is a diagram showing the configuration of a slurry filter replacement robot, according to an embodiment.

[0045] Referring to FIGS. **1** and **2**, the slurry filter replacement robot **200** may replace a first filter **1** at an operating station **100** where the first filter **1** is disposed.

[0046] The slurry filter replacement robot **200** may include one or more manipulators **300** including an arm **400** and a robot tool **500** connected to one side of the arm **400**.

[0047] Although two (2) manipulators **300** are shown in FIG. **1**, the present disclosure is not limited in this regard. That is, the number of manipulators **300** included in the slurry filter replacement robot **200** may not be limited. As shown in FIG. **1**, the arm **400** may have the form of a multi-joint arm **400**, and a position of a robot tool **500** connected to one side of the arm **400** may be adjusted by adjusting a position of the arm **400**.

[0048] The slurry filter replacement robot **200** may include a support frame **600** disposed in a lower part of the manipulator **300** and configured to support the manipulator **300**, a loader **700** connected to the support frame **600** and configured to load the first filter **1** and the second filter **2**, and a mover **800** disposed in a lower part of the support frame **600** and configured to move the support frame **600**. For example, the support frame **600** may include a structure configured to support the manipulator **300**, the loader **700**, and the mover **800**. As another example, the mover **800** may include wheels, motors, axles, or the like configured to transport the slurry filter replacement robot **200** along the operating table **110**.

[0049] The slurry filter replacement robot **200** may be configured to move close to the operating station **100** through the mover **800**, and replace the first filter **1** disposed on the operating station **100** with the second filter **2** loaded in the loader **700** by using the manipulator **300**.

[0050] The slurry filter replacement process, which may be manually performed in related operating stations, may be performed in an unmanned manner by using an automated system that may include the slurry filter replacement robot **200**. Consequently, aspects of the present disclosure may provide for preventing and/or mitigating adverse effects on the human operators that may occur during a manual replacement process, and/or preventing and/or mitigating additional contamination that may occur during the manual replacement process due to the operation of the human operator.

[0051] In addition, the slurry filter replacement robot **200** may be applicable to an operating environment in which the existing slurry filter may be disposed. For example, although the present disclosure may focus on a slurry filter replacement operation that may be performed at the operating station **100**, the present disclosure is not limited thereto, and the slurry filter replacement operation may also be applicable in an existing slurry supply device. That is, the slurry filter replacement robot **200** may have an advantage in that the slurry filter replacement robot **200** may be applicable to an existing slurry supply device because the installation cost is not excessively high and the volume thereof is not relatively large.

[0052] For example, since the one or more manipulators **300** included in the slurry filter replacement robot **200** may perform various operations by using the arm **400** and the robot tool **500**, it may be possible to identify a precise position needed for the replacement operation through a robot vision **550** connected to one side of the arm **400**, and to adjust an amount of force and/or torque that may be applied.

[0053] Continuing to refer to FIG. **1**, the operating station **100** may be and/or may include a space where the first filter **1** is disposed and the operation of replacing the first filter **1** with the second filter **2** is performed.

[0054] The operating station **100** may include an operating table **110**, a head **120** disposed on the operating table **110** and coupled with the first filter **1** and the second filter **2**, a ball **130** surrounding the first filter **1** and the second filter **2** coupled with the head **120**, and a nut **140** disposed between the ball **130** and the head **20** and coupling the ball **130** to the head **120**.

[0055] The operating station **100** may further include a housing **112** that may accommodate the operating table **110** by surrounding the entire operating table **110**, and a cleaning device **150** disposed inside the housing **112** and cleaning the ball **130** and the head **120**.

[0056] FIG. **1** shows a cleaning hose **152** as an embodiment of the cleaning device **150**. A process in which the

slurry filter replacement robot **200** cleans the ball **130** and the head **120** by using the cleaning hose **152** is described with reference to FIG. **13**.

[0057] As shown in FIGS. **1** and **2**, the robot tool **500** connected to the arm **400** of the slurry filter replacement robot **200** may include a gripper **510** and an adjuster **520**.

[0058] The gripper **510** may serve to grip the ball **130**, the nut **140**, the first filter **1**, and the second filter **2** disposed on the operating station **100**.

[0059] The adjuster **520** may have one side connected to the gripper **510** and another side connected to the arm **400**, and may serve to adjust the gripper **510**. An example of a structure of the robot tool **500** is described with reference to FIGS. **5** and **6**.

[0060] In an embodiment of the slurry filter replacement robot **200** as described above, the number of manipulators **300** is not limited, and the one or more manipulators **300** are included.

[0061] FIG. **3** is a diagram showing the overall configuration of a slurry filter replacement robot, according to an embodiment.

[0062] The slurry filter replacement robot **200** shown in FIG. **3** may include two (2) manipulators (e.g., a first manipulator **310** and a second manipulator **320**, hereinafter generally referred to as "**300**").

[0063] Compared to the embodiments shown with reference to FIG. **1** in which the number of manipulators **300** is not specified, the embodiments shown in FIG. **3** may be different in that the number of manipulators **300** is defined. The slurry filter replacement robot **200**, as shown in FIG. **3**, may be and/or may include a double-arm robot arm having two arms (e.g., a first arm **410** and a second arm **420**).

[0064] As shown in FIG. **3**, the slurry filter replacement robot **200** may replace the first filter **1** at the operating station **100** where the first filter **1** is disposed.

[0065] The operating station **100** may include the operating table **110**, the head **120** disposed on the operating table **110**, the ball **130** surrounding the first filter **1** and the second filter **2** coupled with the head **120**, and the nut **140** disposed between the ball **130** and the head **20** and coupling the ball **130** to the head **120**.

[0066] The slurry filter replacement robot **200** may be in the form of the double-arm robot arm, and may include a first manipulator **310** including a first arm **410** and a first robot tool **502** connected to one side of the first arm **410** and a second manipulator **320** including a second arm **420** and a second robot tool **504** connected to one side of the second arm **420**.

[0067] The slurry filter replacement robot **200** may include a support frame **600** disposed in a lower part of the first manipulator **310** and the second manipulator **320**, a loader **700** loading the first filter **1** and the second filter **2** connected to the support frame **600**, and a mover **800** disposed in a lower part of the support frame **600** and configured to move the support frame **600**. The slurry filter replacement robot **200** may be capable of horizontal movement through the mover **800**, and may move closer to and/or away from the operating station **100** to replace a slurry filter.

[0068] In the case of the slurry filter replacement robot **200** being in the form of the double-arm robot arm, the second manipulator **320** may serve to replace the first filter **1** disposed on the operating station **100** with the second filter **2** disposed on the loader **700**.

[0069] FIG. **4** is a diagram illustrating the slurry filter replacement robot of FIG. **3**, according to an embodiment. FIG. **5** is a diagram depicting manipulators of the slurry filter replacement robot of FIG. **4**, according to an embodiment. FIG. **6** is a diagram illustrating the manipulators of the slurry filter replacement robot of FIG. **4**, according to an embodiment.

[0070] Referring to FIGS. **4** to **6**, the gripper **510** of the slurry filter replacement robot **200** may include a first gripper **512** that grips the ball **130**, a second gripper **514** that grips the nut **140**, and a third gripper **516** that grips the first filter **1** and the second filter **2**.

[0071] In the slurry filter replacement robot **200**, the first manipulator **310** may include the first gripper **512** that grips the ball **130**, a first adjuster **522** having one side connected to the other side of the first gripper **512** and configured to adjust the gripper **512**, and the first arm **410** connected to the other side of the first adjuster **522** and having the form of a multi-joint arm.

[0072] The second manipulator **320** may include the second gripper **514** that grips the nut **140**, the third gripper **516** having the other side connected to one side of the second gripper **514** and grips the first filter **1** and the second filter **2**, a second adjuster **524** having one side connected to the other side of the second gripper **514** and configured to adjust the second gripper **514** and the third gripper **516**, and the second arm **420** connected to the other side of the second adjuster **524** and having the form of the multi-joint arm.

[0073] The slurry filter replacement robot **200** may further include a gripper cleaner **530** that cleans the third gripper **516**. The third gripper **516** grips the first filter **1**, separates the first filter **1** from the head **120**, loads the first filter **1** on the loader **700**, and grips the second filter **2** loaded on the loader **700**, and couples the second filter **2** to the head **120** of the operating table **110**.

[0074] In a process of the third gripper **516** gripping the first filter **1**, since there is a possibility that the third gripper **516** may be contaminated, before gripping the second filter **2**, the gripper cleaner **530** may clean the third gripper **516**.

[0075] As shown in FIG. **3**, the operating station **100** may further include the housing **112** that accommodates the operating table **110**, and the cleaning hose **152** disposed inside the housing **112**, and the third gripper **516** of the slurry filter replacement robot **200** may grip the cleaning hose **152**.

[0076] The third gripper **516** may grip the cleaning hose **152** and clean the inside of the ball **130** and the head **120** while the first filter **1** is separated, as described with reference to FIG. **13**.

[0077] As shown in FIGS. **5** and **6**, the adjuster **520** of the slurry filter replacement robot **200** may include the first adjuster **522** that adjusts the first gripper **512**, and the second adjuster **524** that adjusts the second gripper **514** and the third gripper **516**.

[0078] The other side of the first gripper **512** may be connected to one side of the first adjuster **522**, the other side of the second gripper **514** may be connected to one side of the second adjuster **524**, and the other side the third gripper **516** may be connected to one side of the second gripper **514**.

[0079] According to an embodiment, as shown in FIGS. **5** and **6**, the manipulator **300** may further include adaptation sensors **542** and **544** between the arm **400** and the robot tool **500**. The first adaptation sensor **542** may be disposed between the first arm **410** and the first robot tool **502**, and the

second adaptation sensor **544** may be disposed between the second arm **420** and the second robot tool **504**.

[0080] For example, the manipulator **300** may further include the first adaptation sensor **542** disposed between the first adjuster **522** and the first arm **410**, and the second adaptation sensor **544** disposed between the second adjuster **524** and the second arm **420**. The first adaptation sensor **542** and the second adaptation sensor **544** serve to compensate for position errors that may occur during a gripping process of the gripper **510**.

[0081] The first adaptation sensor **542** may provide adaptability between the first gripper **512** and the first adjuster **522**, and may include a force-torque (F/T) sensor capable of measuring force and/or torque.

[0082] The F/T sensor may have adaptability of several millimeters (mm) between the gripper **510** and the adjuster **520**, and may be designed as a parallel mechanism. According to an embodiment, the first adaptation sensor **542** may further include a strain gauge and a capacitance measurement unit, and may monitor force and torque in 6 axes (e.g., 3 linear axes and 3 rotational axes) through the strain gauge and the capacitance measurement unit.

[0083] For example, the F/T sensor may be used to compensate for large internal forces that may occur upon coupling components in the 6 axes and potentially prevent and/or minimize occurrence of internal forces. At the same time, the gripper **510** may enable active position compensation, by measuring force and torque generated between the robot tool **500** and its surroundings. In addition, various coupling operations performed during the replacement process of the slurry filter may be precisely performed, by controlling force and position to minimize internal forces.

[0084] The second adaptation sensor **544** may provide adaptability between the second gripper **514** and the second adjuster **524**, and may include an F/T sensor having adaptation capable of measuring force and/or torque. The second adaptation sensor **544** may also provide adaptability between the third gripper **516** and the second adjuster **524**.

[0085] The F/T sensor may be used to stably perform a slurry filter replacement operation while absorbing and/or controlling a negative tolerance of an O-ring and contact force and impact force with a surrounding environment with respect to a chemical mechanical polishing (CMP) slurry filter replacement.

[0086] As shown in FIGS. **5** and **6**, the manipulator **300** may further include the robot visions **550** disposed on one side of the arm **400**. That is, the robot visions **550** may be respectively disposed on one side of the first arm **410** of the first manipulator **310** and on one side of the second arm **420** of the second manipulator **320**.

[0087] The robot visions **550** may determine positions at which the gripper **510** of the robot tool **500** is to grip the ball **130**, the nut **140**, the first filter **1**, and the second filter **2**. In an embodiment, the robot vision **550** may be and/or may include one or more image sensors (e.g., cameras, video cameras, depth cameras, time-of-flight (TOF) cameras, stereoscopic cameras, or the like) to determine the position of the gripper **510**. Alternatively or additionally, the robot vision **550** may include one or more additional sensors for determining the position, such as, but not limited to, global positioning system (GPS) components, accelerometers, gyroscopes, actuators, transducers, contact sensors, proximity sensors, ranging devices, or the like.

[0088] That is, the robot vision **550** disposed on one side of the first arm **410** may accurately derive the position at which the first gripper **512** of the first robot tool **502** grips the ball **130**. The robot vision **550** may derive the position at which the first gripper **512** of the first robot tool **502** grips the ball **130** to within a predetermined accuracy threshold. The accuracy threshold may be predetermined based on design constraints.

[0089] In an embodiment, the robot vision **550** disposed on one side of the second arm **420** may accurately (e.g., within the predetermined accuracy threshold) derive the positions at which the second gripper **514** of the second robot tool **504** grips the nut **140**, and the third gripper **516** grips the first filter **1** and the second filter **2**.

[0090] The robot visions **550** respectively disposed on one side of the first arm **410** and one side of the second arm **420** may accurately derive coupling positions for coupling the ball **130**, the nut **140**, the first filter **1**, and the second filter **2** to each other.

[0091] According to an embodiment, the robot vision **550** may be used to respectively derive gripping points and replacement positions of the first filter **1** and the second filter **2** as coordinates, and determine whether there are abnormalities in equipment and operations during a slurry filter replacement process by monitoring abnormal conditions or emergency situations in the surrounding environment.

[0092] In an embodiment, the slurry filter replacement robot **200** may further include a controller that may actively compensate for and/or control the positions of the first gripper **512**, the second gripper **514**, and the third gripper **516**, by using force and torque information measured by the first adaptation sensor **542** and the second adaptation sensor **544**. The controller may use a control algorithm to control the positions of the first gripper **512**, the second gripper **514**, and the third gripper **516**, while simultaneously controlling the forces applied to the first gripper **512**, the second gripper **514**, and the third gripper **516**. The controller may be embodied as various numbers of hardware, software and/or firmware structures that may execute respective functions described above, according to an example embodiment. According to example embodiments, at least one of these components may use a direct circuit structure, such as a memory, a processor, a logic circuit, a look-up table, and the like, that may execute the respective functions through controls of one or more microprocessors or other control apparatuses. Also, at least one of these components may be specifically embodied by a module, a program, or a part of code, which contains one or more executable instructions for performing specified logic functions, and executed by one or more microprocessors or other control apparatuses.

[0093] FIG. **7** is a diagram depicting a structure in which a slurry filter is coupled with an operating station in a slurry filter replacement robot, according to an embodiment. FIG. **8** is a diagram illustrating a process of coupling the slurry filter to the operating station, according to an embodiment.

[0094] FIG. **7** shows the head **120** disposed on the operating table **110** of the operating station **100**, the first filter **1** coupled with the head **120**, the ball **130** surrounding the first filter **1**, and the nut **140** disposed between the ball **130** and the head **120**.

[0095] As shown in FIG. **7**, an upper part of the head **120** includes a groove coupled with a lower part of the first filter **1**, and the first filter **1** may be fit into and coupled with the groove.

[0096] After the first filter **1** is coupled with the groove of the head **120**, the ball **130** may be disposed to surround the outside of the first filter **1**, and a lower end of the ball **130** may be coupled with the head **120**. For example, the nut **140** may be disposed on a lower part of the ball **130**, a screw thread may be formed on an inner surface of the nut **140** to engage with a screw groove part of the head **120**, and the nut **140** and the head **120** disposed on the lower end of the ball **130** may be coupled with and separated from each other by rotating such that the screw thread and thread groove engage with each other.

[0097] That is, the nut **140** surrounding an outer circumference of the lower part of the ball **130** may be disposed in accordance with the head **120**, the nut **140** may be rotated to engage the screw thread on an inner circumference of the nut **140** and the screw groove in an outer circumference of the head **120** with each other, and the nut **140** may be gripped and rotated.

[0098] FIG. **8** shows a state in which the nut **140** coupled with the lower part of the ball **130** is rotated, by using the first manipulator **310** and the second manipulator **320** of the slurry filter replacement robot **200**, in order to couple the ball **130** to the head **120**.

[0099] Diagram (a) of FIG. **8** shows that the first gripper **512** disposed on one side of the first arm **410** of the first manipulator **310** grips the ball **130**, and the second gripper **514** disposed on one side of the second arm **420** of the second manipulator **320** grips the nut **140** coupled with the ball **130**.

[0100] The nut **140** gripped by the second gripper **514** may be rotated, by moving the position of the second gripper **514** in an arrow direction shown in diagram (a) of FIG. **8**, and accordingly, the nut **140** and the head **120** may be coupled with each other.

[0101] Diagram (b) of FIG. **8** shows a state in which the second gripper **514** rotates in an arrow direction. In order to rotate the second gripper **514**, the position of the second arm **420** is moved, and accordingly, a direction and position of the second gripper **514** connected to one side of the second arm **420** faces change together. Accordingly, as shown in diagram (b) of FIG. **8**, the nut **140** may be rotated clockwise to couple the screw thread of the nut **140** and the thread groove of the head **120** to each other.

[0102] The ball **130** and the nut **140** may be gripped by the first gripper **512** and the second gripper **514**, and the nut **140** may be rotated to separate the ball **130** from the head **120**, or to couple the ball **130** to the head **120**. In such a process, a position at which an object to be gripped is disposed, a position at which a gripper needs to move to grip the object, or the like may be derived through the robot vision **550**.

[0103] The first adaptation sensor **542** and the second adaptation sensor **544** may precisely measure and adjust the force and/or torque while the first adaptation sensor **542** provides adaptability between the first gripper **512** and the first adjuster **522**, and the second adaptation sensor **544** provides adaptability between the second gripper **514** and the second adjuster **524**.

[0104] FIG. **9** is a diagram depicting a structure in which a slurry filter is coupled with an operating station in a slurry filter replacement robot, according to an embodiment. FIG. **10** is a diagram illustrating a process of coupling the slurry filter to the operating station, according to an embodiment.

[0105] Referring back to FIG. **8**, the second gripper **514** may separate or couple the head **120** and the ball **130** from or to each other by rotating the nut **140** while gripping the nut **140** disposed on a lower part of the ball **130**. Alternatively, in the embodiments shown in FIG. **9**, a locker **142** disposed to surround the nut **140** may be further included.

[0106] As shown in FIG. **9** and diagram (a) of FIG. **10**, the locker **142** may be and/or may include a clamping type, and the third gripper **516** of the second arm **420** may grip a protruding pin part of the locker **142**. In addition, as shown in diagram (b) of FIG. **10**, by rotating the locker **142** and the nut **140** surrounded by the locker **142** while gripping the pin part, a connection between a screw thread of the ball **130** and a screw groove of the nut **140** may be tightened.

[0107] FIGS. **11** to **14** are diagrams depicting a process in which the slurry filter replacement robot replaces a slurry filter, according to an embodiment.

[0108] Referring back to FIG. **3**, the slurry filter replacement robot **200** may be in the form of a double-arm robot arm having two arms of the first arm **410** and the second arm **420**. FIGS. **11** to **14** show the process in which the slurry filter replacement robot **200** in the form of the double-arm robot arm replaces the first filter **1** disposed on the operating station **100** with the second filter **2** loaded on the loader **700**.

[0109] Diagrams (a), (b), (c), and (d) of FIG. **11** show the process in which the slurry filter replacement robot **200** separates the ball **130** fixed to the head **120** of the operating station **100** from the head **120**, from the time the slurry filter replacement robot **200** moves to the operating station **100**.

[0110] Diagram (a) of FIG. **11** shows the slurry filter replacement robot **200** moving to the operating station **100**. As shown in FIG. **3**, the mover **800** may be disposed on a lower part of the slurry filter replacement robot **200**, and thus, the slurry filter replacement robot **200** may freely move.

[0111] Diagram (b) of FIG. **11** shows the slurry filter replacement robot **200** moved to the front of the operating table **110**, in order to replace the first filter **1**, moving closer to the ball **130** on which the first filter **1** to be replaced is disposed.

[0112] Diagram (c) of FIG. **11** shows a state in which the first gripper **512** grips the ball **130**, and the second gripper **514** grips the nut **140**.

[0113] As shown in diagram (b) of FIG. **11**, the robot visions **550** may be respectively connected to one side of the first arm **410** and one side of the second arm **420**. The robot vision **550** may accurately derive positions at which the first gripper **512** and the second gripper **514** are to respectively grip the ball **130** and the nut **140**, in a process of gripping the ball **130** and the nut **140**. In this regard, diagrams (b) and (c) of FIG. **11** show processes of the robot visions **550** precisely deriving a position that is a gripping point for the first gripper **512** to grip the ball **130**, and a position that is a gripping point for the second gripper **514** to grip the nut **140**.

[0114] In an embodiment, the first adaptation sensor **542** disposed on the first arm **410** may measure and control force and torque while providing adaptability between the first gripper **512** and the first adjuster **522**. The second adaptation sensor **544** disposed on the second arm **420** may measure force and torque while providing adaptability between the second gripper **514** and the second adjuster **524**.

[0115] Alternatively or additionally, the robot visions **550** may determine respectively whether there are abnormalities in equipment and/or operations, adjust the moving positions of the first gripper **512** and the second gripper **514** by adjusting the first arm **410** and the second arm **420** according

to a result of determination, and adjust the force for gripping by using the first adjuster **522** and the second adjuster **524**.

[0116] Diagram (d) of FIG. **11** shows the second gripper **514** rotating the nut **140** in an opposite direction to that in diagram (b) of FIG. **8** according to the movement of the second arm **420**, while gripping the nut **140** disposed on a lower part of the ball **130**. The coupling between the ball **130** and the head **120** may be loosened, by the rotation of the nut **140**.

[0117] Diagrams (a), (b), (c), and (d) of FIG. **12** show processes in which the slurry filter replacement robot **200** separates the ball **130** fixed to the head **120** of the operating table **110** of the operating station **100** from the head **120**, removes the first filter **1** inserted in the head **120**, and grips the cleaning hose **152** for cleaning the ball **130** and the head **120**.

[0118] Diagram (a) of FIG. **12** shows that, after separating the nut **140** and the head **120** from each other in diagram (d) of FIG. **11**, the second gripper **514** loosely grips the nut **140**, and separates the ball **130** from the head **120** as the first arm **410** connected to the first gripper **512** gripping the ball **130** moves.

[0119] Diagram (b) of FIG. **12** shows the third gripper **516** connected to an end of the second arm **420** gripping the first filter **1** inserted into the head **120** while the ball **130** is completely separated. In an embodiment, the robot vision **550** may also precisely derive a position that is a gripping point for the third gripper **516** to grip the first filter **1**.

[0120] The second adaptation sensor **544** disposed on the second arm **420** may measure force and torque while providing adaptability between the third gripper **516** and the second adjuster **524**. In addition, the second adaptation sensor **544** may adjust the moving position of the third gripper **516** by adjusting the second arm **420** according to a result derived from the robot vision **550**, and the second adjuster **524** may adjust a gripping force of the third gripper **516**.

[0121] Diagram (c) of FIG. **12** shows the second arm **420** moving while the third gripper **516** is gripping the first filter **1**, and the third gripper **516** loading the first filter **1** on the loader **700**.

[0122] Diagram (d) of FIG. **12** shows the third gripper **516** gripping the cleaning hose **152** disposed inside the operating station **100**, in order to clean the ball **130** and the head **120**, while the first filter **1** is removed from the third gripper **516**.

[0123] Diagrams (a), (b), (c), and (d) of FIG. **13** show processes after cleaning the ball **130** and head **120** by using the cleaning hose **152** and before gripping the second filter **2**.

[0124] Diagram (a) of FIG. **13** shows moving appropriately the second arm **420** and cleaning the ball **130** gripped by the first gripper **512** while the third gripper **516** is gripping the cleaning hose **152**. The first arm **410** may also appropriately move to move a position of the ball **130** so that the ball **130** may be easily cleaned.

[0125] Diagram (b) of FIG. **13** shows moving appropriately the second arm **420** and cleaning the head **120** disposed on the operating table **110** while the third gripper **516** is gripping the cleaning hose **152**.

[0126] Diagram (c) of FIG. **13** shows that, after the cleaning of the ball **130** and the head **120** is completed, the second arm **420** and the third gripper **516** move the cleaning hose **152** to the original position at which the cleaning hose **152** is initially disposed.

[0127] Diagram (d) of FIG. **13** shows cleaning the third gripper **516**. The third gripper **516** grips the first filter **1** but also may grip the cleaning hose **152**, and thus, there may be a possibility of contamination during the operation process.

[0128] In this regard, the slurry filter replacement robot **200** may further include the gripper cleaner **530** that may clean the third gripper **516** before the third gripper **516** grips the second filter **2**.

[0129] The gripper cleaner **530** may be disposed close to the loader **700** where the second filter **2** is loaded. In this manner, contamination of the third gripper **516** may be prevented and/or mitigated by minimizing a moving time and distance, in the process of gripping the second filter **2** after the gripper cleaner **530** cleans the third gripper **516**.

[0130] Diagrams (a), (b), (c), and (d) of FIG. **14** show the slurry filter replacement robot **200** moving away from the operating station **100** after completing the slurry filter replacement operation by coupling the second filter **2** to the head **120** of the operating table **110**, and coupling the ball **130** to the head **120**.

[0131] Diagram (a) of FIG. **14** shows the third gripper **516** gripping the second filter **2** loaded on the loader **700** after cleaning the third gripper **516** as shown in diagram (d) of FIG. **13**.

[0132] Diagram (b) of FIG. **14** shows the third gripper **516** coupling the second filter **2** to the head **120** by inserting the second filter **2** into a groove of the head **120** of the operating table **110**.

[0133] The robot vision **550** connected to one side of the second arm **420** may precisely determine the position at which the third gripper **516** may need to move in the process of gripping the second filter **2** and coupling the second filter **2** to the head **120**, and the second adaptation sensor **544** disposed on the second arm **420** may provide adaptability between the third gripper **516** and the second adjuster **524**.

[0134] Diagram (c) of FIG. **14** shows the second gripper **514** gripping the nut **140** after the first arm **410** moves to move the ball **130** gripped by the first gripper **512** closer to the head **120** to which the second filter **2** is coupled and place the ball **130** at a position such that the lower part of the ball **130** is aligned with the head **120**.

[0135] The nut **140** and the head **120** may be coupled with each other by performing an opposite process to a separation process of the nut **140** and the head **120**. In an embodiment, the second gripper **514** may rotate the nut **140** while gripping the nut **140**, and accordingly, the screw thread on the inner circumference of the nut **140** and the screw groove in the outer circumference of the head **120** may be coupled with each other, and thus, the ball **130** may be fixed to the head **120**.

[0136] Diagram (d) of FIG. **14** shows the slurry filter replacement robot **200** moving away from the operating station **100** after the replacement operation is completed. The slurry filter replacement robot **200** that has completed the replacement operation at the corresponding operating station **100** may move to the other operating station **100** where replacement of a slurry filter may be needed and repeatedly perform a replacement operation of the slurry filter.

[0137] The slurry filter replacement robot **200**, according to the present disclosure, may differ from related cleaning processes in that an automated system is used for the slurry filter replacement process which may be manually performed in the related processes. In particular, by using the

automated system that may minimize intervention of an operator, industrial accidents, such as, but not limited to, human damage, which may occur upon handling chemicals may be prevented and/or mitigated, and additional contamination caused by an operation of the operator may be prevented and/or mitigated in advance.

[0138] Furthermore, in the related processes, when an emergency situation occurs, the operator may not approach the emergency situation due to danger, which may exacerbate a problem that may make it difficult to handle the replacement operation. However, aspects of the present disclosure provide for a slurry filter replacement robot **200** that has the advantage of being able to handle the replacement operation even in various situations in that the slurry filter replacement operation may be possible without intervention of the operator.

[0139] For example, in a situation where an operator may be needed in the related art, it may be difficult for the operator to directly intervene and solve a problem by using a dedicated mechanical device during the slurry filter replacement process. However, the slurry filter replacement robot **200**, according to the present disclosure, may implement an operation similar to human, and thus, intervention of the operator may be possible in the situation where the operator is essentially required may be needed.

[0140] That is, the slurry filter replacement robot **200** may be applicable even in an operation environment where the existing slurry filter is disposed. Advantageously, the slurry filter replacement robot **200** may be applicable to an existing slurry supply device because installation costs of the slurry filter replacement robot **200** may be relatively low, and its volume may not be excessively large.

[0141] FIG. **15** is a diagram showing the overall configuration of a slurry filter replacement robot, according to an embodiment. FIG. **16** is a diagram illustrating the slurry filter replacement robot of FIG. **15**, according to an embodiment. FIG. **17** is a diagram depicting a manipulator of the slurry filter replacement robot of FIG. **15**, according to an embodiment.

[0142] As shown in FIG. **15**, the slurry filter replacement robot **200** may replace the first filter **1** at the operating station **100** where the first filter **1** is disposed.

[0143] The slurry filter replacement robot **200** of FIG. **15** may include and/or may be similar in many respects to the slurry filter replacement robot **200** described above with reference to FIG. **3**, and may include additional features not mentioned above. For example, the slurry filter replacement robot **200** shown in FIG. **15** may include only a third manipulator **330**, and is in the form of a single robot arm having one arm as a third arm **430**.

[0144] The operating station **100** includes the operating table **110**, the head **120** disposed on the operating table **110**, the ball **130** surrounding the first filter **1** and the second filter **2** coupled with the head **120**, and the nut **140** disposed between the ball **130** and the head **120** and coupling the ball **130** to the head **120**.

[0145] The operating station **100** may further include the housing **112** that accommodates the operating table **110**, and a ball cleaner **154** disposed inside the housing **112** and accommodating and cleaning the ball **130**. In an embodiment, the ball cleaner **154** may be configured to clean the inside of the ball **130**. For example, the ball cleaner **154** may include hoses, sprayers, or the like to clean the ball **130**.

[0146] The slurry filter replacement robot **200**, according to the embodiments of FIG. **15**, may include the ball **130**, the nut **140**, a third robot tool **506** gripping the first filter **1** and the second filter **2**, and the third manipulator **330** including the third arm **430** having one side connected to the third robot tool **506**.

[0147] In addition, the slurry filter replacement robot **200** may include the support frame **600** disposed in a lower part of the third manipulator **330**, the loader **700** connected to the support frame **600** and configured to load the first filter **1** and the second filter **2**, and the mover **800** disposed in a lower part of the support frame **600** and configured to move the support frame **600**, and the third manipulator **330** may replace the first filter **1** disposed on the operating station **100** with the second filter **2** loaded in the loader **700**.

[0148] Referring to FIGS. **15** to **17**, the third robot tool **506** may include the first gripper **512** that grips the ball **130** and separates the ball **130** from the head **120**, the second gripper **514** that grips the nut **140** and separates the ball **130** and the head **120** from each other, and the third gripper **516** that grips the first filter **1** coupled with the head **120** and replaces the first filter **1** with the second filter **2**.

[0149] In an embodiment, the third robot tool **506** may include the first adjuster **522** having the other side connected to one side of the third arm **430** and configured to adjust the first gripper **512**, and second adjuster **524** having the other side connected to one side of the of the third arm **430** and configured to adjust the second gripper **514** and the third gripper **516**. The other side of the first gripper **512** may be connected to one side of the first adjuster **522**, the other side of the second gripper **514** may be connected to one side of the second adjuster **524**, and the other side of the third gripper **516** may be connected to one side of the second gripper **514**.

[0150] According to an embodiment, as shown in FIG. **17**, the third manipulator **330** may further include the second adaptation sensor **544** disposed between the second adjuster **524** and the third arm **430**. The second adaptation sensor **544** may provide adaptability between the second gripper **514** and the second adjuster **524**, and may include an F/T sensor having adaptation capable of measuring force and torque. The second adaptation sensor **544** may also provide adaptability between the third gripper **516** and the second adjuster **524**.

[0151] Unlike the double-arm robot arm form shown in FIG. **3**, in the case of the single robot arm form shown in FIGS. **15** to **17**, the first gripper **512**, the second gripper **514**, and the third gripper **516** may all be connected to one third arm **430**. In this regard, in order to freely move the first gripper **512**, a multi-axis connector **526** may be further included in a part to which the third arm **430** and the first gripper **512** are connected.

[0152] That is, as shown in FIG. **17**, the third robot tool **506** may further include the multi-axis connector **526** disposed between one side of the third arm **430** and the other side of the first adjuster **522**. The multi-axis connector **526** may have a structure including three (3) to four (4) axes, for example, however the number of axes or shape of the multi-axis connector **526** is not limited in this regard.

[0153] In an embodiment, the third robot tool **506** may further include a water gun **560** disposed on the multi-axis connector **526** and configured to clean the head **120**.

[0154] In the case of the single robot arm form of FIGS. **15** to **17**, one third arm **430** may need to grip all the ball **130**,

the nut **140**, the first filter **1**, and the second filter **2**, and thus, it may be difficult to clean the ball **130** and the head **120** by separately gripping the cleaning hose **152** as shown in FIG. **3**.

[0155] Consequently, rather than the cleaning hose **152**, the ball cleaner **154** may be disposed inside the operating station **100**, as shown in FIG. **15**, as the cleaning device **150**, and the water gun **560** that cleans the head **120** may be additionally disposed in the third robot tool **506**.

[0156] In an embodiment, the third manipulator **330** may further include the robot vision **550** disposed on one side of the third arm **430**. The robot vision **550** may precisely determine positions at which the first gripper **512**, the second gripper **514**, and the third gripper **516** of the third robot tool **506** are to grip the ball **130**, the nut **140**, the first filter **1**, and the second filter **2**.

[0157] That is, the robot vision **550** may accurately derive the position at which the first gripper **512** grips the ball **130**, the position at which the second gripper **514** grips the nut **140**, and the position at which the third gripper **516** grips the first filter **1** and the second filter **2**. In addition, the robot vision **550** may accurately derive coupling positions for coupling the ball **130**, the nut **140**, the first filter **1**, and the second filter **2** to each other. According to an embodiment, the robot vision **550** may be used to respectively derive gripping points and replacement positions of the first filter **1** and the second filter **2** as coordinates, and determine whether there is an abnormality in equipment and/or operations during a slurry filter replacement process by monitoring abnormal conditions and/or emergency situations in the surrounding environment.

[0158] FIGS. **18** to **21** are diagrams illustrating a process in which the slurry filter replacement robot replaces a slurry filter, according to an embodiment.

[0159] The slurry filter replacement robot **200** shown in FIG. **15** is in the form of a single robot arm having one arm as the third arm **430**. FIGS. **18** to **21** show the process in which the slurry filter replacement robot **200** in the form of the single robot arm replaces the first filter **1** disposed on the operating station **100** with the second filter **2** loaded on the loader **700**.

[0160] Diagrams (a), (b), (c), (d), and (e) of FIG. **18** show the process in which the slurry filter replacement robot **200** separates the ball **130** fixed to the head **120** of the operating station **100** from the head **120**, from the time the slurry filter replacement robot **200** moves to the operating station **100**.

[0161] Diagram (a) of FIG. **18** shows the slurry filter replacement robot **200** moving to the operating station **100**. As shown in FIG. **16**, the mover **800** is disposed on a lower part of the slurry filter replacement robot **200**, and thus, the slurry filter replacement robot **200** may freely move in a horizontal direction.

[0162] Diagram (b) of FIG. **18** shows the slurry filter replacement robot **200** moved to the front of the operating table **110**, in order to replace the first filter **1**, moving closer to the ball **130** on which the first filter **1** to be replaced is disposed, and shows the third robot tool **506** adjusting a position to grip the ball **130** and the nut **140**.

[0163] As shown in FIG. **17**, the robot vision **550** is connected to one side of the third arm **430**, and may accurately derive positions at which the first gripper **512** and the second gripper **514** are to respectively grip the ball **130** and the nut **140**, in a process of gripping the ball **130** and the nut **140**. That is, the robot vision **550** may precisely derive a position that is a gripping point for the first gripper **512** to grip the ball **130**, and a position that is a gripping point for the second gripper **514** to grip the nut **140**. In an embodiment, the second adaptation sensor **544** disposed on the third arm **430** may provide adaptability between the second gripper **514** and the second adjuster **524**, and measure and adjust force and torque that are generated in a process of the second gripper **514** gripping the nut **140**.

[0164] The robot vision **550** may determine whether there are abnormalities in equipment and/or operations, adjust the moving positions of the first gripper **512** and the second gripper **514** by adjusting the third arm **430** according to a result of determination, and adjust the force for gripping by using the first adjuster **522** and the second adjuster **524**.

[0165] Diagram (c) of FIG. **18** shows a state in which the first gripper **512** grips the ball **130**, and the second gripper **514** grips the nut **140**, and diagrams (d) and (e) of FIG. **18** show the process of separating the ball **130** and the nut **140** from the head **120**.

[0166] Diagrams (d) and (e) of FIG. **18** show the second gripper **514** rotating the nut **140** counterclockwise according to the movement of the third arm **430**, while gripping the nut **140** disposed on a lower part of the ball **130**. Simultaneously and/or at a substantially similar time period with the rotation of the nut **140**, the ball **130** connected to the nut **140** may also rotate counterclockwise, and the first gripper **512** gripping the ball **130** may also move. In an embodiment, the first adjuster **522** may adjust the position of the first gripper **512**, and a position of an axis of the multi-axis connector **526** connected to the first adjuster **522** may be changed so that the positions of the first adjuster **522** and the first gripper **512** may be changed.

[0167] As shown in diagrams (d) and (e) of FIG. **18**, the ball **130** and the head **120** may be separated from each other by rotating the nut **140**.

[0168] Diagrams (a), (b), (c), and (d) of FIG. **19** show the process of cleaning the ball **130** separated from the head **120**, separating the first filter **1** from the head **120**, and loading the first filter **1** on the loader **700**.

[0169] Diagram (a) of FIG. **19** shows the first gripper **512** gripping the ball **130** separated from the head **120** and moving the ball **130** to the ball cleaner **154** disposed on an upper surface of the operating table **110**. The ball cleaner **154** may clean the inside of the ball **130** disposed inside the ball cleaner **154**.

[0170] Diagram (b) of FIG. **19** shows the third gripper **516** connected to an end of the third arm **430** gripping the first filter **1** inserted into the head **120** while the first gripper **512** completely separates the ball **130**. In an embodiment, the robot vision **550** may also precisely derive a position that is a gripping point for the third gripper **516** to grip the first filter **1**.

[0171] In addition, the second adaptation sensor **544** disposed on the third arm **430** may measure force and torque while providing adaptability between the third gripper **516** and the second adjuster **524**. The second adaptation sensor **544** may adjust the moving position of the third gripper **516** by adjusting the third arm **430** according to a result derived from the robot vision **550**, and the second adjuster **524** may adjust a gripping force of the third gripper **516**.

[0172] Diagrams (c) and (d) of FIG. **19** show the third arm **430** moving while the third gripper **516** is gripping the first filter **1**, and the third gripper **516** loading the first filter **1** on the loader **700**.

[0173] Diagrams (a), (b), (c), (d), and (e) of FIG. **20** show the process of coupling the second filter **2** to the head **120** after cleaning the head **120**.

[0174] Diagram (a) of FIG. **20** shows, after removing the first filter **1** from the head **120**, the water gun **560** disposed on the multi-axis connector **526** connected to the third arm **430** cleaning the head **120**.

[0175] Diagram (b) of FIG. **20** shows cleaning the third gripper **516**. The slurry filter replacement robot **200** may further include the gripper cleaner **530** that cleans the third gripper **516** before the third gripper **516** grips the second filter **2**.

[0176] Diagram (c) of FIG. **20** shows the third gripper **516** gripping the second filter **2** loaded on the loader **700** after cleaning the third gripper **516**, as shown in diagram (b) of FIG. **20**, and diagram (d) of FIG. **20** shows that the third arm **430** moves to move the second filter **2** in a direction in which the head **120** is disposed. Diagram (e) of FIG. **20** shows the third gripper **516** coupling the second filter **2** to the head **120** by inserting the second filter **2** into a groove of the head **120** of the operating table **110**.

[0177] The robot vision **550** connected to one side of the third arm **430** may precisely determine the position at which the third gripper **516** must move in the process of gripping the second filter **2** and coupling the second filter **2** to the head **120**, and the second adaptation sensor **544** disposed on the third arm **430** may provide adaptability between the third gripper **516** and the second adjuster **524**.

[0178] Diagrams (a), (b), (c), and (d) of FIG. **21** show the slurry filter replacement robot **200** moving away from the operating station **100**, after completing a slurry filter replacement operation, by coupling the ball **130** cleaned by the ball cleaner **154** to the head **120** again.

[0179] Diagram (a) of FIG. **21** shows that the third arm **430** moves, and the first gripper **512** grips the ball **130** disposed inside the ball cleaner **154**, moves the ball **130** closer to the head **120** to which the second filter **2** is coupled, and places the ball **130** at a position such that a lower part of the ball **130** is aligned with the head **120**, and shows the second gripper **514** gripping the nut **140** after placing the ball **130** at the position. When the nut **140** is rotated in a direction indicated by an arrow, the nut **140** and the head **120** may be coupled with each other.

[0180] Diagram (b) of FIG. **21** shows the process of coupling the nut **140** to the head **120** by rotating the nut **140** clockwise while the second gripper **514** is gripping the nut **140**. Simultaneously and/or at a substantially similar time period with the rotation of the nut **140**, the ball **130** also rotates, and thus, the first gripper **512** gripping the ball **130** may also be rotated, and the first adjuster **522** and the multi-axis connector **526** connected to the first gripper **512** may also be moved together.

[0181] Diagram (c) of FIG. **21** shows that the slurry filter replacement operation is completed by coupling the ball **130** to the head **120** to which the second filter **2** is coupled, and diagram (d) of FIG. **21** shows the slurry filter replacement robot **200** moving away from the operating station **100** after the replacement operation is completed. The slurry filter replacement robot **200** that has completed the replacement operation at the corresponding operating station **100** may move to the other operating station **100** where replacement of a slurry filter is required and repeatedly perform a replacement operation of the slurry filter.

[0182] FIG. **22** is a diagram depicting a replacement process by using a slurry filter replacement robot, according to an embodiment.

[0183] The slurry filter replacement robot **200** shown in FIG. **22** may include and/or may be similar in many respects to the slurry filter replacement robot **200** described above with reference to FIG. **3**, and may include additional features not mentioned above. The third gripper **516** may grip the first filter **1** and load the first filter **1** on the loader **700**, and the third gripper **516** may grip the second filter **2** loaded on the loader **700** and couple the second filter to the head **120** disposed on the operating table **110**.

[0184] However, unlike the operating station **100** in FIG. **3**, the operating station **100** shown in FIG. **22** may have a structure in which only two (2) balls **130** are disposed inside one housing **112**, and the ball cleaner **154** cleaning the ball **130** may be further disposed next to the ball **130**.

[0185] The slurry filter replacement robot **200**, according to the present disclosure, may not only replace the slurry filter at the designated operating station **100**, but may also replace the slurry filter in an existing equipment, and the structure of the operating station **100** is not limited to FIGS. **13** and **15** and may be the similar to the structure described with reference to FIG. **22**.

[0186] Although various embodiments of the present disclosure have been described above, the embodiments are not limited thereto, and various modifications may be made within the claims, the detailed description, and the accompanying drawings, and also belong to the scope of the present disclosure.

What is claimed is:

1. A slurry filter replacement robot for replacing a first filter at an operating station, the slurry filter replacement robot comprising:

one or more manipulators, each of the one or more manipulators comprising an arm and a robot tool coupled with a first side of the arm;

a support frame disposed in a lower portion of the one or more manipulators and configured to support the one or more manipulators;

a loader coupled with the support frame and configured to load the first filter and a second filter thereon; and

a mover disposed in a lower portion of the support frame and configured to move the support frame,

wherein each of the one or more manipulators is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader.

2. The slurry filter replacement robot of claim **1**, wherein the robot tool comprises:

a gripper configured to grip a ball of the operating station, a nut of the operating station, and at least one of the first filter or the second filter; and

an adjuster having a first side coupled with the gripper and a second side coupled with the arm, and configured to adjust the gripper,

wherein the ball of the operating station is coupled with a head disposed on an operating table of the operating station, and

wherein the nut of the operating station is disposed between the ball and the head and is configured to couple the ball to the head.

3. The slurry filter replacement robot of claim 2, wherein the gripper comprises:
a first gripper configured to grip the ball;
a second gripper configured to grip the nut; and
a third gripper configured to grip the at least one of the first filter or the second filter.

4. The slurry filter replacement robot of claim 3, wherein the adjuster comprises:
a first adjuster configured to adjust the first gripper; and
a second adjuster configured to adjust the second gripper and the third gripper.

5. The slurry filter replacement robot of claim 4, wherein a side of the first gripper is coupled with a side of the first adjuster,
wherein a first side of the second gripper is coupled with a side of the second adjuster, and
wherein a side of the third gripper is coupled with a second side of the second gripper.

6. The slurry filter replacement robot of claim 3, further comprising:
a gripper cleaner configured to clean the third gripper.

7. The slurry filter replacement robot of claim 4, wherein each of the one or more manipulators further comprise:
a first adaptation sensor disposed on a side of the first adjuster; and
a second adaptation sensor disposed on a side of the second adjuster.

8. The slurry filter replacement robot of claim 1, wherein each of the one or more manipulators further comprise:
a robot vision disposed on a second side of the arm.

9. The slurry filter replacement robot of claim 1, wherein the arm has a multi-joint arm form.

10. A slurry filter replacement robot for replacing a first filter at an operating station, the slurry filter replacement robot comprising:
a first manipulator comprising a first arm and a first robot tool coupled with a side of the first arm;
a second manipulator comprising a second arm and a second robot tool coupled with a side of the second arm;
a support frame disposed in a lower portion of the first manipulator and the second manipulator;
a loader coupled with the support frame and configured to load the first filter and a second filter thereon; and
a mover disposed in a lower portion of the support frame and configured to move the support frame,
wherein the second manipulator is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader.

11. The slurry filter replacement robot of claim 10, wherein the first manipulator comprises:
a first gripper configured to grip a ball of the operating station; and
a first adjuster having a first side coupled with the a side of the first gripper, and configured to adjust the first gripper,
wherein the first arm is coupled with the second side of the first adjuster and has a multi-joint arm form, and
wherein the ball of the operating station is coupled with a head disposed on an operating table of the operating station.

12. The slurry filter replacement robot of claim 11, wherein the second manipulator comprises:
a second gripper configured to grip a nut of the operating station; and
a third gripper coupled with a first side of the second gripper and configured to grip at least one of the first filter or the second filter, and
wherein the nut of the operating station is disposed between the ball and the head and is configured to couple the ball to the head.

13. The slurry filter replacement robot of claim 12, further comprising:
a second adjuster having a first side coupled with a second side of the second gripper, and configured to adjust the second gripper and the third gripper,
wherein the second arm is coupled with a second side of the second adjuster and has the multi-joint arm form.

14. The slurry filter replacement robot of claim 12, further comprising:
a gripper cleaner configured to clean the third gripper.

15. A slurry filter replacement robot for replacing a first filter disposed at an operating station, the slurry filter replacement robot comprising:
a manipulator comprising:
a robot tool configured to grip a ball of the operating station, a nut of the operating station, and the first filter; and
a third arm having a first side coupled with the robot tool;
a support frame disposed in a lower portion of the manipulator;
a loader coupled with the support frame and configured to load the first filter and a second filter; and
a mover disposed in a lower portion of the support frame and configured to move the support frame,
wherein the manipulator is configured to replace the first filter disposed on the operating station with the second filter loaded on the loader,
wherein the ball of the operating station is coupled with a head disposed on an operating table of the operating station, and
wherein the nut of the operating station is disposed between the ball and the head and is configured to couple the ball to the head.

16. The slurry filter replacement robot of claim 15, wherein the robot tool comprises:
a first gripper configured to grip the ball and separate the ball from the head;
a second gripper configured to grip the nut and separate the ball from the head; and
a third gripper configured to:
grip the first filter coupled with the head; and
replace the first filter with the second filter.

17. The slurry filter replacement robot of claim 16, wherein the first gripper is coupled with a first side of a first adjuster,
wherein the second gripper is coupled with a first side of a second adjuster, and
wherein the third gripper is coupled with a side of the second gripper.

18. The slurry filter replacement robot of claim 17, wherein the first adjuster has a second side coupled with a second side of the third arm and is configured to adjust the first gripper, and

wherein the second adjuster has a second side coupled with a third side of the third arm and is configured to adjust the second gripper and the third gripper.

19. The slurry filter replacement robot of claim **18**, wherein the robot tool further comprises:

a multi-axis connector disposed between a fourth side of the third arm and the second side of the first adjuster.

20. The slurry filter replacement robot of claim **19**, wherein the robot tool further comprises:

a water gun disposed on the multi-axis connector and configured to clean the head.

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