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(54) INKJET PRINTER AND METHOD FOR CONTROLLING INKJET PRINTER

(57) Provided is an inkjet printer capable of continuing a printing operation even during replacement work of a main tank, the inkjet printer including: an inkjet head for discharging ink; a sub-tank for accommodating the ink to be supplied to the inkjet head; and a main tank for accommodating the ink to be supplied to the sub-tank. An inkjet printer 1 is provided with: an inkjet head 5; a sub-tank 11; a main tank 17; a buffer tank 18 which is disposed in a piping path between the sub-tank 11 and the main tank 17, and in which ink is accommodated; a pump 19 which is disposed in a piping path between the sub-tank **11** and the buffer tank 18; and a check valve 20 which is disposed in parallel with the buffer tank 18 in a piping path between the main tank 17 and the pump 19, and which allows a flow of ink only in a direction from the main tank 17 to the pump 19.

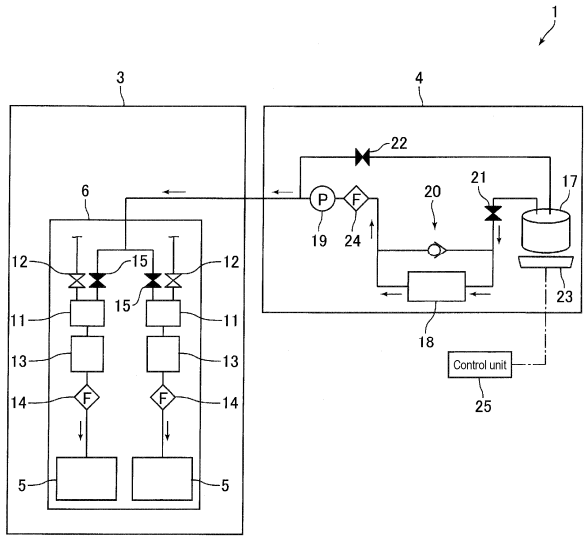

FIG. 1

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Description

Technical Field

[0001] The present invention relates to an inkjet printer for performing printing and the like on a medium. The present invention also relates to a method for controlling such an inkjet printer.

Background Art

[0002] Conventionally, inkjet printers that perform printing on a medium such as paper are known (for example, see Patent Document 1). The inkjet printer described in Patent Document 1 includes: an inkjet head that discharges ink, a carriage on which the inkjet head is mounted, a sub tank that accommodates ink to be supplied to the inkjet head, a main tank that accommodates ink to be supplied to the sub tank, and an ink pump for sending ink from the main tank to the sub tank. The sub tank is mounted on the carriage. The main tank is detachably attached to a body frame of the inkjet printer.

[0003] Further, conventionally, inkjet printers that perform printing on a medium such as paper are known (for example, see Patent Document 2). The inkjet printer described in Patent Document 2 includes: an inkjet head that discharges ink, a main tank that accommodates ink, and an ink supply system for supplying ink from the main tank to the inkjet head. The main tank is, for example, an ink container capable of being removed from the inkjet printer and replaced.

[0004] In the inkjet printer described in Patent Document 2, the ink supply system includes: a sub tank provided midway in a supply route of ink from the main tank to the inkjet head, a flow path for supply through which ink flows from the main tank toward the sub tank, a route for circulation through which ink flows from the sub tank toward the main tank, a pump for flowing ink in the route for supply, and a pump for flowing ink in the route for circulation. The flow path for supply and the route for circulation are, for example, tubes through which ink passes. In the inkjet printer described in Patent Document 2, since ink is capable of being circulated between the main tank and the sub tank, it becomes possible to suppress sedimentation of ink particles and the like in the main tank and the sub tank.

[0005] Further, conventionally, inkjet recording apparatuses including a recording head (inkjet head) are known (for example, see Patent Document 3). In the inkjet recording apparatus described in Patent Document 3, an ink supply system that supplies ink to the recording head includes: a main tank, a buffer tank, a supply sub tank connected to a supply port of the recording head, and a recovery sub tank connected to a discharge port of the recording head. The supply sub tank is connected to the main tank via the buffer tank.

[0006] Further, in the inkjet recording apparatus described in Patent Document 3, a pump for supplying ink to the supply sub tank is provided in a flow path between the buffer tank and the supply sub tank. Further, a pump for supplying ink to the buffer tank is provided in a flow path between the main tank and the buffer tank. An opening and closing valve is provided in a flow path between the pump and the main tank. In the inkjet recording apparatus described in Patent Document 3, replacement of the main tank is performed in a state where the opening and closing valve is completely closed to block the flow path.

Related Art Documents

Patent Documents

[0007]

Patent Document 1: Japanese Patent Application Laid-Open No. 2020-116813
Patent Document 2: Japanese Patent Application Laid-Open No. 2023-7061
Patent Document 3: Japanese Patent Application Laid-Open No. 2010-83021

SUMMARY OF INVENTION

Problem to Be Solved by Invention

[0008] In the inkjet printer described in Patent Document 1, the main tank is replaced when ink runs out in the main tank. In the case of such an inkjet printer, during a replacement work of the main tank, ink cannot be supplied from the main tank to the sub tank, so the printing operation of the inkjet printer cannot be continued. That is, in the case of the inkjet printer described in Patent Document 1, during the replacement work of the main tank, the printing operation of the inkjet printer has to be interrupted.

[0009] Therefore, an objective of the present invention is to provide an inkjet printer that includes an inkjet head discharging ink, a sub tank accommodating ink to be supplied to the inkjet head, and a main tank accommodating ink to be supplied to the sub tank, and is capable of continuing the printing operation even during the replacement work of the main tank.

[0010] Further, in the inkjet printer described in Patent Document 2, in the case where the main tank is a replaceable ink container, for example, if a connection failure occurs in which the flow path for supply is not appropriately connected to the main tank after replacement, the quantity of ink flowing out from the main tank toward the sub tank decreases, and a failure may occur in ink supply in which ink is not appropriately supplied from the main tank to the sub tank. In the inkjet printer described in Patent Document 2, if such a failure occurs in ink supply, the printing on the medium may be hindered.

[0011] Further, in the inkjet printer described in Patent Document 2, if such a failure occurs in ink supply, when

ink is circulated between the main tank and the sub tank, while an appropriate quantity of ink flows into the main tank, the quantity of ink flowing out from the main tank decreases, so ink may overflow from the main tank. Accordingly, in the inkjet printer described in Patent Document 2, it is preferable to easily enable an operator of the inkjet printer to recognize that a failure occurs in ink supply in which ink is not appropriately supplied from the main tank to the sub tank.

[0012] Therefore, an objective of the present invention is to provide an inkjet printer that includes a main tank accommodating ink and a supplied side tank provided closer to an inkjet head side than the main tank in a piping route between the main tank and the inkjet head and accommodating ink supplied from the main tank, and the inkjet printer is capable of enabling an operator to easily recognize that a failure occurs in ink supply in which ink is not appropriately supplied from the main tank to the supplied side tank. Further, an objective of the present invention is to provide a method for controlling an inkjet printer that includes a main tank and a supplied side tank accommodating ink supplied from the main tank, and the method for controlling an inkjet printer is capable of enabling an operator to easily recognize that a failure occurs in ink supply in which ink is not appropriately supplied from the main tank to the supplied side tank.

[0013] Further, the inventors of the present application are developing an inkjet printer that includes a sub tank accommodating ink to be supplied to an inkjet head, a buffer tank accommodating ink to be supplied to the sub tank, a main tank accommodating ink to be supplied to the buffer tank, and a pump provided in a piping route between the buffer tank and the sub tank. The inventors of the present application have decided to provide a piping route for returning ink from the buffer tank to the main tank to circulate ink between the main tank and the buffer tank and suppress sedimentation of ink particles in the buffer tank in the inkjet printer under development.

[0014] Specifically, the inventors of the present application have decided to provide a first piping route, which is a piping route connecting the pump and the sub tank, a second piping route, which is a piping route connecting the first piping route and the main tank, a first opening and closing valve provided in a piping route between the sub tank and a connection spot connecting the first piping route and the second piping route, and a second opening and closing valve provided in the second piping route. In such an inkjet printer, upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, ink flows from the buffer tank toward the main tank and ink circulates between the main tank and the buffer tank. Further, upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, ink flows from the buffer tank toward the sub tank and ink is supplied to the sub tank.

[0015] Further, the inventors of the present application have decided to connect the second piping route and the main tank by a joint having a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected in the inkjet printer under development. Furthermore, the inventors of the present application have decided to adopt a piping side joint portion that is sealed when separated from the tank side joint portion to prevent ink from flowing out from the piping side joint portion when the piping side joint portion and the tank side joint portion are separated.

[0016] In the inkjet printer under development, if a connection failure occurs in the joint in which the piping side joint portion and the tank side joint portion are not normally connected, when ink is to be circulated between the main tank and the buffer tank, the pump becomes unable to send ink, an excessive load acts on the pump, and the pump may malfunction. Further, if a connection failure occurs in the joint, when ink is to be circulated between the main tank and the buffer tank, the pressure inside the second piping route becomes excessively high, and ink may leak out from the second piping route. Therefore, in the inkjet printer under development, when a connection failure occurs in the joint, it is preferable that the circulation operation of ink is not performed between the main tank and the buffer tank.

[0017] Therefore, an objective of the present invention is to provide an inkjet printer that includes a sub tank, a buffer tank, a main tank, a pump provided in a piping route between the buffer tank and the sub tank, a first piping route connecting the pump and the sub tank, and a second piping route connecting the first piping route and the main tank, and the inkjet printer is capable of preventing execution of the circulation operation of ink between the main tank and the buffer tank when a connection failure occurs between a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected.

[0018] Further, an objective of the present invention is to provide a method for controlling an inkjet printer that includes a sub tank, a buffer tank, a main tank, a pump provided in a piping route between the buffer tank and the sub tank, a first piping route connecting the pump and the sub tank, and a second piping route connecting the first piping route and the main tank, and the method for controlling an inkjet printer makes it possible to prevent execution of the circulation operation of ink between the main tank and the buffer tank when a connection failure occurs between a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected.

Means for Solving Problem

[0019] To solve the above problems, an inkjet printer of the present invention includes: an inkjet head discharging an ink; a sub tank accommodating the ink to be

supplied to the inkjet head; a main tank accommodating the ink to be supplied to the sub tank; a buffer tank provided in a piping route between the sub tank and the main tank and accommodating the ink; a pump provided in a piping route between the sub tank and the buffer tank; and a check valve provided in parallel with the buffer tank in a piping route between the main tank and the pump and allowing a flow of the ink only in a direction from the main tank toward the pump.

[0020] In the present invention, the inkjet printer includes a buffer tank provided in a piping route between the sub tank and the main tank. Therefore, in the present invention, it becomes possible to supply ink from the buffer tank to the sub tank even during a replacement work of the main tank. Accordingly, in the present invention, it becomes possible to continue a printing operation of the inkjet printer even during the replacement work of the main tank.

[0021] Here, in the present invention, for example, if a quantity per unit time of the ink flowing out from the buffer tank to the sub tank increases due to an increase in consumption of ink discharged from the head for performing high-density printing, or if the quantity per unit time of the ink flowing into the buffer tank from the main tank decreases due to an increase in ink viscosity in a low-temperature environment, the ink supply from the main tank to the buffer tank may not keep up during printing, and the remaining quantity of ink in the buffer tank may become very small during printing. On the other hand, in the present invention, since a pump is provided in a piping route between the sub tank and the buffer tank, and ink is supplied from the buffer tank to the sub tank, if the remaining quantity of ink in the buffer tank becomes very small during printing and ink is not supplied from the buffer tank to the sub tank anymore, it may become difficult to perform appropriate printing with the inkjet printer.

[0022] However, in the present invention, the inkjet printer includes a check valve provided in parallel with the buffer tank in a piping route between the main tank and the pump and allowing a flow of the ink only in a direction from the main tank toward the pump. Therefore, in the present invention, even if the remaining quantity of ink in the buffer tank becomes very small during printing and ink is not supplied from the buffer tank to the sub tank anymore, it becomes possible to supply ink from the main tank to the sub tank via the check valve. Accordingly, in the present invention, even if the remaining quantity of ink in the buffer tank becomes very small during printing and ink is not supplied from the buffer tank to the sub tank anymore, it becomes possible to continue an appropriate printing operation of the inkjet printer.

[0023] Further, in the present invention, the inkjet printer preferably includes an opening and closing valve provided in a piping route between the main tank and the buffer tank. According to such a configuration, it becomes possible to perform a replacement work of the main tank with the opening and closing valve closed. Accordingly, it becomes possible to easily perform the replacement work of the main tank.

[0024] Further, in the present invention, the ink is preferably supplied from the main tank to the buffer tank using a head difference. According to such a configuration, it becomes possible to simplify the configuration of the inkjet printer compared to the case where a pump is provided in a piping route between the main tank and the buffer tank. On the other hand, compared to the case where the ink is supplied from the main tank to the buffer tank by a pump, with the ink supplied from the main tank to the buffer tank using a head difference, it is more difficult to supply ink to the buffer tank, and it is more likely that the remaining quantity of ink in the buffer tank may become very small during printing. However, in the present invention, even if the remaining quantity of ink in the buffer tank becomes very small during printing, it becomes possible to continue an appropriate printing operation of the inkjet printer.

[0025] Further, in the present invention, the buffer tank is, for example, an ink pack formed in a bag shape. In such a case, if the remaining quantity of ink in the buffer tank becomes very small, the buffer tank, which is an ink pack, collapses.

[0026] In the present invention, the inkjet printer preferably further includes: a second opening and closing valve provided in a piping route between the sub tank and the pump; and a third opening and closing valve provided in a piping route that has one end connected to a piping route between the second opening and closing valve and the pump and has another end connected to the main tank. According to such a configuration, if the second opening and closing valve is closed and the third opening and closing valve is opened, it becomes possible to form a circulation route of ink passing through the main tank and the buffer tank. Accordingly, if the pump is driven with the second opening and closing valve closed and the third opening and closing valve opened, it becomes possible to circulate ink in the circulation route, and as a result, it becomes possible to suppress sedimentation of ink particles in the main tank and in the buffer tank.

[0027] In the present invention, the inkjet printer preferably includes an opening and closing valve provided in a piping route between the main tank and the buffer tank. According to such a configuration, it becomes possible to perform a replacement work of the main tank with the opening and closing valve closed. Accordingly, it becomes possible to easily perform the replacement work of the main tank. Further, according to such a configuration, if the pump is driven with the opening and closing valve and the second opening and closing valve closed and the third opening and closing valve opened, it becomes possible to discharge ink in the buffer tank to the main tank. Accordingly, for example, in the case where replacement of the buffer tank is required, it becomes possible to discharge ink in the buffer tank.

[0028] In the present invention, the inkjet printer preferably includes a detection mechanism for detecting a

volume of the ink accommodated in the main tank, and a volume of the ink accommodated in the buffer tank is preferably indirectly detected by the detection mechanism. According to such a configuration, even if a mechanism is not provided for detecting the volume of ink accommodated in the buffer tank, it becomes possible to detect the volume of ink accommodated in the buffer tank. Accordingly, it becomes possible to simplify the configuration of the inkjet printer.

[0029] Further, to solve the above problems, an inkjet printer of the present invention includes: an inkjet head discharging an ink. The inkjet printer further includes: a main tank accommodating the ink; a supplied side tank provided closer to the inkjet head side than the main tank in a piping route between the main tank and the inkjet head and accommodating the ink supplied from the main tank; a pump for circulating the ink between the main tank and the supplied side tank; a first piping route, which is a piping route for supply through which the ink flows from the main tank toward the supplied side tank; a second piping route, which is a piping route for circulation in which the pump is provided and through which the ink flows from the supplied side tank toward the main tank; a detection mechanism for detecting a quantity of the ink accommodated in the main tank; and a control unit for controlling the inkjet printer. The control unit is configured to: calculate an increase quantity of the ink over a predetermined first specific time in the main tank at intervals of the first specific time based on a detection result of the detection mechanism during ink circulation in which the pump is driven to circulate the ink between the main tank and the supplied side tank, and execute a predetermined error processing in a case where the calculated increase quantity is equal to or greater than a predetermined first reference quantity consecutively for a plurality of times; and calculate a variation quantity of the ink over a predetermined second specific time in the main tank at intervals of the second specific time based on the detection result of the detection mechanism during the ink circulation, calculate an ink variation quantity difference, which is a difference between a variation quantity of the ink over the second specific time in the main tank calculated a previous time and the variation quantity of the ink over the second specific time in the main tank calculated this time, at intervals of the second specific time, store a quantity of the ink in the main tank as an ink initial quantity in a case where an absolute value of the calculated ink variation quantity difference is equal to or less than a predetermined second reference quantity, which is less than the first reference quantity, consecutively for a plurality of times, and thereafter execute the error processing also in a case where an increase quantity of the ink in the main tank from the stored ink initial quantity is a predetermined third reference quantity, which is greater than the first reference quantity.

[0030] Further, to solve the above problems, a method for controlling an inkjet printer of the present invention is a method for controlling an inkjet printer including: an inkjet head discharging an ink; a main tank accommodating the ink; a supplied side tank provided closer to the inkjet head side than the main tank in a piping route between the main tank and the inkjet head and accommodating the ink supplied from the main tank; a pump for circulating the ink between the main tank and the supplied side tank; a first piping route, which is a piping route for supply through which the ink flows from the main tank toward the supplied side tank; a second piping route, which is a piping route for circulation in which the pump is provided and through which the ink flows from the supplied side tank toward the main tank; and a detection mechanism for detecting a quantity of the ink accommodated in the main tank. The method for controlling an inkjet printer includes: calculating an increase quantity of the ink over a predetermined first specific time in the main tank at intervals of the first specific time based on a detection result of the detection mechanism during ink circulation in which the pump is driven to circulate the ink between the main tank and the supplied side tank, and executing a predetermined error processing in a case where the calculated increase quantity is equal to or greater than a predetermined first reference quantity consecutively for a plurality of times; and calculating a variation quantity of the ink over a predetermined second specific time in the main tank at intervals of the second specific time based on the detection result of the detection mechanism during the ink circulation, calculating an ink variation quantity difference, which is a difference between a variation quantity of the ink over the second specific time in the main tank calculated a previous time and the variation quantity of the ink over the second specific time in the main tank calculated this time, at intervals of the second specific time, storing a quantity of the ink in the main tank as an ink initial quantity in a case where an absolute value of the calculated ink variation quantity difference is equal to or less than a predetermined second reference quantity, which is less than the first reference quantity, consecutively for a plurality of times, and thereafter executing the error processing also in a case where an increase quantity of the ink in the main tank from the stored ink initial quantity is a predetermined third reference quantity, which is greater than the first reference quantity.

[0031] In the present invention, an increase quantity of the ink over a first specific time in the main tank is calculated at intervals of the first specific time based on a detection result of the detection mechanism during ink circulation in which the ink is circulated between the main tank and the supplied side tank, and a predetermined error processing is executed in a case where the calculated increase quantity is equal to or greater than a first reference quantity consecutively for a plurality of times. Also, a variation quantity of the ink over a second specific time in the main tank is calculated at intervals of the second specific time based on the detection result of the detection mechanism during the ink circulation, an ink variation quantity difference, which is a difference between a variation quantity of the ink over the second

specific time in the main tank calculated a previous time and the variation quantity of the ink over the second specific time in the main tank calculated this time, is calculated at intervals of the second specific time, a quantity of the ink in the main tank is stored as an ink initial quantity in a case where an absolute value of the calculated ink variation quantity difference is equal to or less than a second reference quantity, which is less than the first reference quantity, consecutively for a plurality of times, and thereafter the error processing is executed also in a case where an increase quantity of the ink in the main tank from the stored ink initial quantity is a third reference quantity, which is greater than the first reference quantity.

[0032] That is, in the present invention, the error processing is executed in the case where an increase quantity of the ink over the first specific time in the main tank is equal to or greater than the first reference quantity consecutively for a plurality of times, and in the case where an increase quantity of the ink from the ink initial quantity, which is a quantity of the ink in the main tank stored at a predetermined timing, is the third reference quantity. Accordingly, in the present invention, it becomes possible to easily enable an operator to recognize that a failure occurs in ink supply in which ink is not adequately supplied from the main tank to the supplied side tank.

[0033] Further, in the present invention, by executing the error processing in the case where an increase quantity of the ink over the first specific time in the main tank is equal to or greater than the first reference quantity consecutively for a plurality of times, and in the case where an increase quantity of the ink from the ink initial quantity stored at a predetermined timing is the third reference quantity, which is greater than the first reference quantity, it becomes possible to execute the error processing while suppressing effects of errors of the detection mechanism and noise on the detection mechanism. Accordingly, in the present invention, it becomes possible to enable an operator to accurately recognize that a failure occurs in ink supply from the main tank to the supplied side tank.

[0034] Furthermore, in the present invention, since the error processing is executed in the case where an increase quantity of the ink over the first specific time in the main tank is equal to or greater than the first reference quantity consecutively for a plurality of times, when a degree of decrease of ink supplied from the main tank to the supplied side tank is large and the quantity of ink in the main tank significantly increases in a relatively short time, it becomes possible to enable an operator to recognize in a short time that a failure occurs in ink supply from the main tank to the supplied side tank.

[0035] Further, in the present invention, since the error processing is executed in the case where an increase quantity of the ink from the ink initial quantity stored at a predetermined timing is the third reference quantity, even if the degree of decrease of ink supplied from the main tank to the supplied side tank is small and the quantity of ink in the main tank does not significantly increase in a short time despite a failure occurring in ink supply from the main tank to the supplied side tank, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank to the supplied side tank.

[0036] Further, in the present invention, a variation quantity of the ink over the second specific time in the main tank is calculated at intervals of the second specific time, an ink variation quantity difference, which is a difference between a variation quantity of the ink over the second specific time in the main tank calculated a previous time and the variation quantity of the ink over the second specific time in the main tank calculated this time, is calculated at intervals of the second specific time, and a quantity of the ink in the main tank is stored as the ink initial quantity in a case where an absolute value of the calculated ink variation quantity difference is equal to or less than the second reference quantity consecutively for a plurality of times. Therefore, it becomes possible to store a quantity of ink in the main tank as the ink initial quantity when no disturbance or the like occurs in the main tank (that is, when the state of the main tank is stable). That is, in the present invention, it becomes possible to set the ink initial quantity with high accuracy. Accordingly, in the present invention, based on the ink initial quantity set with high accuracy, it becomes possible to enable an operator to recognize with high accuracy that a failure occurs in ink supply from the main tank to the supplied side tank.

[0037] In the present invention, for example, the main tank is capable of being removed from the inkjet printer and replaced. In such a case, it may become more likely that a connection failure or the like occurs in which the main tank after replacement is not appropriately connected to the first piping route, and a failure occurs in ink supply from the main tank to the supplied side tank. However, in the present invention, it becomes possible to enable an operator to easily recognize that a failure occurs in ink supply from the main tank to the supplied side tank.

[0038] In the present invention, the inkjet printer further includes, for example: a sub tank accommodating the ink to be supplied to the inkjet head; a buffer tank serving as the supplied side tank accommodating the ink to be supplied to the sub tank and supplied from the main tank; a first opening and closing valve; and a second opening and closing valve. A connection spot is provided midway in a piping route connecting the buffer tank and the sub tank, and a piping route having one end connected to the main tank has another end connected to the connection spot. The second piping route is constituted by a third piping route, which is a piping route between the buffer tank and the connection spot, and a fourth piping route, which is a piping route between the connection spot and the main tank. The pump is provided in the third piping route. The first opening and closing valve is provided in a piping route between the connection spot and the sub

tank. The second opening and closing valve is provided in the fourth piping route. Upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, the ink flows from the buffer tank toward the main tank. Upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, the ink flows from the buffer tank toward the sub tank.

[0039] In such a case, it becomes possible to perform supply of ink to the sub tank and circulation of ink between the main tank and the supplied side tank by a common pump. Accordingly, it becomes possible to simplify the configuration of the inkjet printer. Further, in such a case, since the buffer tank is provided in the piping route between the main tank and the sub tank, it becomes possible to supply ink from the buffer tank to the sub tank even during the replacement work of the main tank. Accordingly, it becomes possible to continue the printing operation of the inkjet printer even during the replacement work of the main tank.

[0040] In the present invention, the inkjet printer includes, for example, an ink filter provided in the third piping route, and the ink is supplied from the main tank to the buffer tank using a head difference.

[0041] In such a case, since the ink filter is provided in the third piping route, depending on the state of the ink filter (specifically, the degree of clogging of the ink filter), the quantity of ink circulating between the main tank and the buffer tank during ink circulation may become small, and the quantity of ink in the main tank may not increase significantly in a short time despite occurrence of a failure in ink supply from the main tank to the supplied side tank. However, in the present invention, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank to the supplied side tank even if the quantity of ink in the main tank does not increase significantly in a short time.

[0042] Further, in such a case, since the ink is supplied from the main tank to the buffer tank using a head difference, if air is mixed into the first piping route when connecting one end of the first piping route and the main tank, the mixed air may remain in the first piping route, and a failure may occur in ink supply from the main tank to the buffer tank. On the other hand, even if such a supply failure occurs, since the degree of decrease in ink supplied from the main tank to the buffer tank is small, the quantity of ink in the main tank does not increase significantly in a short time. However, in the present invention, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank to the buffer tank even if the quantity of ink in the main tank does not increase significantly in a short time.

[0043] Further, to solve the above problems, an inkjet printer of the present invention includes an inkjet head discharging an ink. The inkjet printer further includes: a sub tank accommodating the ink to be supplied to the inkjet head; a buffer tank accommodating the ink to be supplied to the sub tank; a main tank accommodating the ink to be supplied to the buffer tank; a pump provided in a piping route between the buffer tank and the sub tank; a first piping route, which is a piping route connecting the pump and the sub tank; a second piping route, which is a piping route connecting the first piping route and the main tank; a joint having a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected; a first opening and closing valve provided in a piping route between the sub tank and a connection spot connecting the first piping route and the second piping route; a second opening and closing valve provided in the second piping route; a detection mechanism for detecting a quantity of the ink accommodated in the sub tank; and a control unit for controlling the inkjet printer. Upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, the ink flows from the buffer tank toward the main tank. Upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, the ink flows from the buffer tank toward the sub tank. Upon driving the pump with the first opening and closing valve and the second opening and closing valve opened in a case where the piping side joint portion and the tank side joint portion are normally connected, a quantity of the ink flowing from the buffer tank to the main tank is greater than a quantity of the ink flowing from the buffer tank to the sub tank. With the piping side joint portion and the tank side joint portion separated, the piping side joint portion is sealed such that the ink does not flow out. The control unit is configured to execute a confirmation operation in which, in a state where the quantity of the ink in the sub tank is set to a predetermined first reference quantity, the first opening and closing valve and the second opening and closing valve are opened and the pump is driven at a constant speed for a predetermined first time, and it is determined whether the quantity of the ink in the sub tank exceeds a predetermined second reference quantity based on a detection result of the detection mechanism.

[0044] Further, to solve the above problems, a method for controlling an inkjet printer of the present invention is a method for controlling an inkjet printer including: an inkjet head discharging an ink; a sub tank accommodating the ink to be supplied to the inkjet head; a buffer tank accommodating the ink to be supplied to the sub tank; a main tank accommodating the ink to be supplied to the buffer tank; a pump provided in a piping route between the buffer tank and the sub tank; a first piping route, which is a piping route connecting the pump and the sub tank; a second piping route, which is a piping route connecting the first piping route and the main tank; a joint having a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected; a first opening and closing valve provided in a piping route between the sub tank and a connection spot connecting the first piping route and the second piping

route; a second opening and closing valve provided in the second piping route; and a detection mechanism for detecting a quantity of the ink accommodated in the sub tank. Upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, the ink flows from the buffer tank toward the main tank. Upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, the ink flows from the buffer tank toward the sub tank. Upon driving the pump with the first opening and closing valve and the second opening and closing valve opened in a case where the piping side joint portion and the tank side joint portion are normally connected, a quantity of the ink flowing from the buffer tank to the main tank is greater than a quantity of the ink flowing from the buffer tank to the sub tank. With the piping side joint portion and the tank side joint portion separated, the piping side joint portion is sealed such that the ink does not flow out. The method for controlling an inkjet printer includes: executing a confirmation operation in which, in a state where the quantity of the ink in the sub tank is set to a predetermined first reference quantity, the first opening and closing valve and the second opening and closing valve are opened and the pump is driven at a constant speed for a predetermined first time, and it is determined whether the quantity of the ink in the sub tank exceeds a predetermined second reference quantity based on a detection result of the detection mechanism.

[0045] In the present invention, the confirmation operation is executed in which, in a state where the quantity of the ink in the sub tank is set to the predetermined first reference quantity, the first opening and closing valve and the second opening and closing valve are opened and the pump is driven at a constant speed for the predetermined first time, and it is determined whether the quantity of the ink in the sub tank exceeds the predetermined second reference quantity based on the detection result of the detection mechanism. Further, in the present invention, upon driving the pump with the first opening and closing valve and the second opening and closing valve opened in the case where the piping side joint portion and the tank side joint portion are normally connected, the quantity of the ink flowing from the buffer tank to the main tank is greater than the quantity of the ink flowing from the buffer tank to the sub tank, and with the piping side joint portion and the tank side joint portion separated, the piping side joint portion is sealed such that the ink does not flow out.

[0046] Therefore, in the present invention, it becomes possible to configure such that the quantity of the ink in the sub tank does not exceed the second reference quantity in the confirmation operation when the piping side joint portion and the tank side joint portion are normally connected, and, the quantity of the ink in the sub tank exceeds the second reference quantity in the confirmation operation when the piping side joint portion and the tank side joint portion are not normally connected. Accordingly, in the present invention, by executing a predetermined processing for preventing execution of the circulation operation of ink between the main tank and the buffer tank when the quantity of ink in the sub tank exceeds the second reference quantity in the confirmation operation, it becomes possible to prevent execution of the circulation operation of ink between the main tank and the buffer tank when a connection failure occurs in the joint. Further, in the present invention, by executing a predetermined processing for notifying an operator that a connection failure occurs in the joint when the quantity of ink in the sub tank exceeds the second reference quantity in the confirmation operation, it becomes possible to enable the operator to easily recognize that a connection failure occurs in the joint.

[0047] In the present invention, for example, the main tank is capable of being removed from the inkjet printer and replaced. In such a case, the possibility of occurrence of a connection failure in the joint after replacement of the main tank becomes high. However, in the present invention, even if a connection failure occurs in the joint, it becomes possible to prevent execution of the circulation operation of ink between the main tank and the buffer tank.

[0048] In the present invention, a drive speed of the pump during executing the confirmation operation is preferably lower than a drive speed of the pump during printing by the inkjet printer in which the pump is driven with the first opening and closing valve opened and the second opening and closing valve closed and the ink flows from the buffer tank toward the sub tank.

[0049] If the drive speed of the pump during printing by the inkjet printer, in which the pump is driven with the first opening and closing valve opened and the second opening and closing valve closed and the ink flows from the buffer tank toward the sub tank, is defined as a "normal drive speed", according to studies by the inventors of the present application, in the case where the drive speed of the pump when executing the confirmation operation is equal to or higher than the normal drive speed, even if the piping side joint portion and the tank side joint portion are normally connected, ink flows easily from the buffer tank to the sub tank upon driving the pump with the first opening and closing valve and the second opening and closing valve opened. Therefore, in such a case, even if the piping side joint portion and the tank side joint portion are normally connected, the quantity of ink in the sub tank may still exceed the second reference quantity in the confirmation operation.

[0050] In contrast, according to studies by the inventors of the present application, in the case where the drive speed of the pump when executing the confirmation operation is lower than the normal drive speed, if the piping side joint portion and the tank side joint portion are normally connected, it becomes difficult for ink to flow from the buffer tank to the sub tank upon driving the pump with the first opening and closing valve and the second opening and closing valve opened. Therefore, if the drive speed of the pump when executing the confirmation operation is lower than the normal drive speed, in the

case where the piping side joint portion and the tank side joint portion are normally connected, it becomes possible to prevent the quantity of ink in the sub tank from exceeding the second reference quantity in the confirmation operation.

[0051] In the present invention, for example, the inkjet printer includes a maintenance unit with which a cleaning operation of the inkjet head is performed for preventing clogging of a plurality of nozzles of the inkjet head, and the control unit is configured to execute the confirmation operation during the cleaning operation.

[0052] In the present invention, the cleaning operation preferably includes a purging operation in which pressure in the sub tank is configured to be a positive pressure to discharge the ink from the inkjet head. After the purging operation, the quantity of the ink in the sub tank preferably becomes the first reference quantity. The control unit is preferably configured to execute the confirmation operation upon satisfying predetermined conditions after the purging operation. According to such a configuration, it is not required to discharge ink from the inkjet head until the quantity of ink in the sub tank becomes the first reference quantity solely for executing the confirmation operation. Accordingly, even in executing the confirmation operation, it becomes possible to suppress wasteful consumption of ink.

[0053] In the present invention, the control unit is preferably configured to: drive the pump with the first opening and closing valve opened and the second opening and closing valve closed after the purging operation to supply the ink to the sub tank until the quantity of the ink in the sub tank reaches the second reference quantity; and measure a second time, which is a time until the quantity of the ink in the sub tank reaches the second reference quantity, store the measured latest second time in a case where the confirmation operation is not executed after the purging operation, and calculate the first time based on the second time. According to such a configuration, even if the state of a supply route of ink from the buffer tank to the sub tank changes over time, the control unit is capable of accurately determining whether the quantity of ink in the sub tank exceeds the second reference quantity in the confirmation operation.

[0054] In the present invention, a drive speed of the pump during executing the confirmation operation is preferably lower than a drive speed of the pump during supplying the ink to the sub tank without executing the confirmation operation after the purging operation. If a drive speed of the pump when supplying the ink to the sub tank without executing the confirmation operation after the purging operation is defined as a "normal drive speed", according to studies by the inventors of the present application, in the case where the drive speed of the pump when executing the confirmation operation is equal to or higher than the normal drive speed, even if the piping side joint portion and the tank side joint portion are normally connected, ink flows easily from the buffer tank to the sub tank upon driving the pump with the first opening and closing valve and the second opening and closing valve opened. Therefore, in such a case, even if the piping side joint portion and the tank side joint portion are normally connected, the quantity of ink in the sub tank may still exceed the second reference quantity in the confirmation operation.

[0055] In contrast, according to studies by the inventors of the present application, in the case where the drive speed of the pump when executing the confirmation operation is lower than the normal drive speed, if the piping side joint portion and the tank side joint portion are normally connected, it becomes difficult for ink to flow from the buffer tank to the sub tank upon driving the pump with the first opening and closing valve and the second opening and closing valve opened. Therefore, if the drive speed of the pump when executing the confirmation operation is lower than the normal drive speed, in the case where the piping side joint portion and the tank side joint portion are normally connected, it becomes possible to prevent the quantity of ink in the sub tank from exceeding the second reference quantity in the confirmation operation.

[0056] In the present invention, the cleaning operation preferably includes a soft cleaning operation and a hard cleaning operation in which a quantity of discharging the ink from the inkjet head increases and a required time is longer compared to the soft cleaning operation. The soft cleaning operation preferably includes a first purging operation in which pressure in the sub tank is configured to be a positive pressure to discharge the ink from the inkjet head. The hard cleaning operation preferably includes a second purging operation in which pressure in the sub tank is configured to be a positive pressure to discharge the ink from the inkjet head. A quantity of the ink discharged from the inkjet head in the second purging operation is preferably greater than a quantity of the ink discharged from the inkjet head in the first purging operation. A time required for the second purging operation is preferably longer than a time required for the first purging operation. After the first purging operation, the quantity of the ink in the sub tank preferably becomes the first reference quantity. The control unit is preferably configured to execute the first purging operation before executing the second purging operation upon satisfying predetermined conditions in a case where the hard cleaning operation is executed, execute the confirmation operation upon satisfying predetermined conditions after the first purging operation, and thereafter execute the second purging operation. According to such a configuration, it becomes possible to shorten the time required for the confirmation operation compared to the case of executing the confirmation operation upon satisfying the predetermined conditions after the second purging operation.

Effects of Invention

[0057] As described above, in the present invention, in

the inkjet printer that includes the inkjet head discharging an ink, the sub tank accommodating the ink to be supplied to the inkjet head, and the main tank accommodating the ink to be supplied to the sub tank, it becomes possible to continue a printing operation of the inkjet printer even during the replacement work of the main tank.

[0058] Further, as described above, in the present invention, in the inkjet printer that includes the main tank accommodating an ink, and the supplied side tank provided closer to the inkjet head side than the main tank in a piping route between the main tank and the inkjet head and accommodates the ink supplied from the main tank, it becomes possible to enable an operator to easily recognize that a failure occurs in ink supply in which the ink is not adequately supplied from the main tank to the supplied side tank.

[0059] Further, as described above, in the present invention, in the inkjet printer that includes the sub tank, the buffer tank, the main tank, the pump provided in a piping route between the buffer tank and the sub tank, the first piping route connecting the pump and the sub tank, and the second piping route connecting the first piping route and the main tank, it becomes possible to prevent execution of the circulation operation of ink between the main tank and the buffer tank when a connection failure occurs in the joint in which the piping side joint portion attached to an end of the second piping route and the tank side joint portion attached to the main tank and to which the piping side joint portion is connected are not normally connected.

BRIEF DESCRIPTION OF THE DRAWINGS

[0060]

[FIG. 1] is a schematic diagram illustrating a configuration of an inkjet printer according to an embodiment of the present invention.

[FIG. 2] is a schematic diagram illustrating a configuration of a printer body shown in FIG. 1.

[FIG. 3] is a diagram illustrating a supply route of ink when a remaining quantity of ink in a buffer tank shown in FIG. 1 becomes very small.

[FIG. 4] is a diagram illustrating a circulation route of ink that passes through a main tank and the buffer tank shown in FIG. 1.

[FIG. 5] is a diagram illustrating a route of ink when returning the ink accommodated in the buffer tank shown in FIG. 1 to the main tank.

[FIG. 6] is a schematic diagram illustrating the configuration of the inkjet printer according to an embodiment of the present invention.

[FIG. 7] is a schematic diagram illustrating the configuration of the inkjet printer shown in FIG. 6.

[FIG. 8] is a block diagram illustrating the configuration of the inkjet printer shown in FIG. 6.

[FIG. 9] is a flowchart representing a procedure when detecting that a failure occurs in ink supply in which ink is not adequately supplied from the main tank to a supplied side tank shown in FIG. 7.

[FIG. 10] is a flowchart representing a procedure when detecting that a failure occurs in ink supply in which ink is not adequately supplied from the main tank to the supplied side tank shown in FIG. 7.

[FIG. 11] is a graph illustrating a procedure when detecting that a failure occurs in ink supply in which ink is not adequately supplied from the main tank to the supplied side tank shown in FIG. 7.

[FIG. 12] is a schematic diagram illustrating the configuration of the inkjet printer according to an embodiment of the present invention.

[FIG. 13] is a schematic diagram illustrating the configuration of the inkjet printer shown in FIG. 12.

[FIG. 14] is a block diagram illustrating the configuration of the inkjet printer shown in FIG. 12.

[FIG. 15] is a flowchart representing an example of procedures of a soft cleaning operation and a normal cleaning operation of the inkjet head shown in FIG. 12.

[FIG. 16] is a flowchart representing an example of a procedure of a hard cleaning operation of the inkjet head shown in FIG. 12.

EMBODIMENTS FOR IMPLEMENTING INVENTION

<First Embodiment>

[0061] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

(Configuration of Inkjet Printer)

[0062] FIG. 1 is a schematic diagram illustrating a configuration of an inkjet printer 1 according to an embodiment of the present invention. FIG. 2 is a schematic diagram illustrating a configuration of a printer body 3 shown in FIG. 1. FIG. 3 is a diagram illustrating a supply route of ink when the remaining quantity of ink in a buffer tank 18 shown in FIG. 1 becomes very small. FIG. 4 is a diagram illustrating a circulation route of ink passing through a main tank 17 and the buffer tank 18 shown in FIG. 1. FIG. 5 is a diagram illustrating a route of ink when returning ink accommodated in the buffer tank 18 shown in FIG. 1 to the main tank 17.

[0063] In the present embodiment, the inkjet printer 1 (hereinafter referred to as "printer 1") is, for example, a commercial inkjet printer, and performs printing on a medium 2 such as paper. The printer 1 includes a printer body 3 and an external supply unit 4 that supplies ink to the printer body 3. The printer body 3 includes an inkjet head 5 (hereinafter referred to as "head 5") that discharges ink, a carriage 6 on which the head 5 is mounted, a carriage drive mechanism 7 that moves the carriage 6 in a main scanning direction, a guide rail 8 for guiding the carriage 6 in the main scanning direction, and a platen 9 on which the medium 2 is placed during printing. When

performing printing on the medium 2 with the printer 1, the head 5 discharges ink while the carriage 6 reciprocates in the main scanning direction.

[0064] Further, the printer body 3 includes a sub tank 11 that accommodates ink to be supplied to the head 5, a pressure adjustment mechanism (not shown) for adjusting pressure in the sub tank 11, an opening and closing valve 12, a degassing module 13 for removing gas in the ink, and a filter 14. A liquid level detection mechanism is attached to the sub tank 11 to detect a height of a liquid level of ink accommodated in the sub tank 11. The liquid level detection mechanism includes, for example, a float provided in the sub tank 11 and a sensor that detects the float. The opening and closing valve 12 is, for example, a solenoid valve. The opening and closing valve 12 is provided in a piping route between the sub tank 11 and the pressure adjustment mechanism. The degassing module 13 and the filter 14 are provided in a piping route between the sub tank 11 and the head 5.

[0065] Further, the printer body 3 includes an opening and closing valve 15 provided in a piping route between a pump 19 (to be described later) included in the external supply unit 4 and the sub tank 11. The opening and closing valve 15 is a solenoid valve. In the present embodiment, the opening and closing valve 15 is a second opening and closing valve. The sub tank 11, the opening and closing valves 12 and 15, the degassing module 13, and the filter 14 are mounted on the carriage 6. The opening and closing valves 12 and 15 may also be manual valves that are opened and closed manually.

[0066] The external supply unit 4 is formed separately from the printer body 3 and is attached to the printer body 3. The external supply unit 4 includes a main tank 17 that accommodates ink to be supplied to the sub tank 11, a buffer tank 18 that is provided in a piping route between the sub tank 11 and the main tank 17 and accommodates ink, a pump (liquid feeding pump) 19 that is provided in a piping route between the sub tank 11 and the buffer tank 18, and a check valve 20 that is provided in parallel with the buffer tank 18 in a piping route between the main tank 17 and the pump 19.

[0067] Further, the external supply unit 4 includes an opening and closing valve 21 provided in a piping route between the main tank 17 and the buffer tank 18, an opening and closing valve 22 provided in a piping route having one end connected to the piping route between the opening and closing valve 15 and the pump 19 and having another end connected to the main tank 17, a detection mechanism 23 for detecting a volume of ink accommodated in the main tank 17, and a filter 24 provided upstream of the pump 19 in a direction of supplying ink to the sub tank 11. In the present embodiment, the opening and closing valve 22 is a third opening and closing valve.

[0068] The external supply unit 4 and the carriage 6 are connected by a piping for ink supply. Such a piping for ink supply is formed of a flexible resin tube. Most of such a piping for ink supply is accommodated in a Cableveyor (registered trademark). One end of the Cableveyor (registered trademark) is fixed to the external supply unit 4. Another end of the Cableveyor (registered trademark) is fixed to the carriage 6. Although one main tank 17 is shown in FIG. 1, the external supply unit 4 includes a plurality of main tanks 17. Further, the external supply unit 4 includes a plurality of buffer tanks 18, pumps 19, check valves 20, and the like corresponding to the number of main tanks 17. The printer body 3 includes a plurality of sub tanks 11 and the like corresponding to the number of main tanks 17.

[0069] The main tank 17 is, for example, a rigid ink bottle formed of resin. The volume of the main tank 17 is, for example, 10 liters. The buffer tank 18 is an ink pack formed in a bag shape. The buffer tank 18 includes a bag-shaped tank body constituted by a flexible film, and an ink inlet and an ink outlet provided at the tank body. The buffer tank 18 is, for example, an aluminum pack having a tank body made of aluminum. The volume of the buffer tank 18 is, for example, 2 liters.

[0070] The ink accommodated in the buffer tank 18 is supplied from the main tank 17. In the present embodiment, ink is supplied from the main tank 17 to the buffer tank 18 using a head difference. That is, ink is supplied from the main tank 17 to the buffer tank 18 utilizing a difference between a height of a liquid level of ink in the main tank 17 and a height of a liquid level of ink in the buffer tank 18.

[0071] The check valve 20 includes a valve body and a spring member that biases the valve body toward the main tank 17 side, and allows ink flow only in a direction from the main tank 17 toward the pump 19. With the pressure in the piping route on the pump 19 side with respect to the check valve 20 becoming lower than the pressure in the piping route on the main tank 17 side with respect to the check valve 20 by a specific value or more, an ink flow passing through the check valve 20 from the main tank 17 toward the pump 19 is generated. The opening and closing valves 21 and 22 are, for example, solenoid valves. The opening and closing valve 21 is provided in the piping route between the buffer tank 18, the check valve 20, and the main tank 17. The opening and closing valves 21 and 22 may also be manual valves.

[0072] The detection mechanism 23 is a load cell for detecting a weight of the ink accommodated in the main tank 17. The detection mechanism 23 is electrically connected to a control unit 25 of the printer 1. The control unit 25 detects a volume of the ink accommodated in the main tank 17 based on the detection result of the detection mechanism 23. In the present embodiment, as the volume of the ink in the buffer tank 18 decreases, ink is supplied from the main tank 17 to the buffer tank 18, and the volume of the ink in the main tank 17 decreases. The control unit 25 indirectly detects the volume of the ink accommodated in the buffer tank 18 based on the detection result of the detection mechanism 23. That is, in the present embodiment, the volume of the ink accommodated in the buffer tank 18 is indirectly detected by the

detection mechanism 23.

[0073] In the printer 1, printing is performed on the medium 2 in a state where the opening and closing valves 15 and 21 are opened and the opening and closing valve 22 is closed. During printing of the medium 2, ink is normally supplied from the buffer tank 18 to the sub tank 11 by the pump 19 (see arrows in FIG. 1). That is, during printing of the medium 2, the pump 19 normally sends ink from the buffer tank 18 to the sub tank 11. Therefore, even when ink in the main tank 17 runs out during printing of the medium 2 and a replacement work of the main tank 17 is performed, ink is supplied from the buffer tank 18 to the sub tank 11. The replacement work of the main tank 17 is performed after closing the opening and closing valve 21, and the opening and closing valve 21 is opened upon completion of the replacement work of the main tank 17.

[0074] Here, for example, if a quantity per unit time of the ink flowing out from the buffer tank 18 to the sub tank 11 increases due to an increase in consumption of ink discharged from the head 5 for performing high-density printing on the medium 2, or if the quantity per unit time of the ink flowing into the buffer tank 18 from the main tank 17 decreases due to an increase in ink viscosity in a low-temperature environment, the ink supply from the main tank 17 to the buffer tank 18 may not keep up during printing of the medium 2, and the remaining quantity of ink in the buffer tank 18 may become very small during printing of the medium 2. With the remaining quantity of ink in the buffer tank 18 becoming very small, ink is not supplied from the buffer tank 18 to the sub tank 11 anymore.

[0075] Specifically, with the remaining quantity of ink in the buffer tank 18 becoming very small, the buffer tank 18, which is an ink pack, collapses and ink is not supplied from the buffer tank 18 to the sub tank 11 anymore. Since the pump 19 is driven during printing of the medium 2, with the remaining quantity of ink in the buffer tank 18 becoming very small during printing of the medium 2 and ink not being supplied from the buffer tank 18 to the sub tank 11 anymore, the pressure in the piping route on the pump 19 side with respect to the check valve 20 becomes negative pressure.

[0076] In the present embodiment, with the pressure in the piping route on the pump 19 side with respect to the check valve 20 becoming negative pressure, and the pressure in the piping route on the pump 19 side with respect to the check valve 20 becoming lower than the pressure in the piping route on the main tank 17 side with respect to the check valve 20 by a specific value or more, an ink flow passing through the check valve 20 is generated. That is, with the remaining quantity of ink in the buffer tank 18 becoming very small during printing of the medium 2 and ink not being supplied from the buffer tank 18 to the sub tank 11 anymore, a bypass route (bypass flow path) of ink passing through the check valve 20 is formed, and ink is supplied from the main tank 17 to the sub tank 11 via the check valve 20 by the pump 19 (see arrows in FIG. 3).

[0077] Further, in the printer 1, to suppress sedimentation of ink particles in the main tank 17 and the buffer tank 18, ink is circulated between the main tank 17 and the buffer tank 18 when the carriage 6 is stopped for a predetermined time or more without performing printing on the medium 2. Specifically, the opening and closing valve 15 is closed and the opening and closing valves 21 and 22 are opened to form a circulation route of ink passing through the main tank 17 and the buffer tank 18, and then the pump 19 is driven to circulate ink in such a circulation route (see arrows in FIG. 4). Further, in the printer 1, for example, when replacement of the buffer tank 18 becomes necessary and ink in the buffer tank 18 is to be discharged, the opening and closing valves 15 and 21 are closed and the opening and closing valve 22 is opened, and then the pump 19 is driven to return ink in the buffer tank 18 to the main tank 17 (see arrows in FIG. 5).

(Main Effects of Present Embodiment)

[0078] As described above, in the present embodiment, the printer 1 includes the buffer tank 18 provided in the piping route between the sub tank 11 and the main tank 17, and during printing of the medium 2, ink is normally supplied from the buffer tank 18 to the sub tank 11 by the pump 19. Therefore, in the present embodiment, as described above, even when ink in the main tank 17 runs out during printing of the medium 2 and a replacement work of the main tank 17 is performed, ink is supplied from the buffer tank 18 to the sub tank 11. Accordingly, in the present embodiment, it becomes possible to continue the printing operation of the printer 1 even during the replacement work of the main tank 17.

[0079] In the present embodiment, the printer 1 includes the check valve 20 provided in parallel with the buffer tank 18 in the piping route between the main tank 17 and the pump 19. Therefore, in the present embodiment, as described above, even with the remaining quantity of ink in the buffer tank 18 becomes very small during printing of the medium 2 and ink not being supplied from the buffer tank 18 to the sub tank 11 anymore, an ink flow passing through the check valve 20 is generated, and ink is supplied from the main tank 17 to the sub tank 11 via the check valve 20 by the pump 19. Accordingly, in the present embodiment, even with the remaining quantity of ink in the buffer tank 18 becoming very small during printing of the medium 2 and ink not being supplied from the buffer tank 18 to the sub tank 11 anymore, it becomes possible to continue an appropriate printing operation of the printer 1.

[0080] In the present embodiment, ink is supplied from the main tank 17 to the buffer tank 18 using a head difference. Therefore, in the present embodiment, it becomes possible to simplify the configuration of the external supply unit 4 compared to a case where a pump is installed in the piping route between the main tank 17 and the buffer tank 18.

[0081] Compared to the case where ink is supplied

from the main tank 17 to the buffer tank 18 by a pump, with ink supplied from the main tank 17 to the buffer tank 18 using a head difference, it is more difficult to supply ink from the main tank 17 to the buffer tank 18, and it is more likely that the remaining quantity of ink in the buffer tank 18 becomes very small during printing of the medium 2. In particular, upon reducing the difference between the height of the liquid level of ink in the main tank 17 and the height of the liquid level of ink in the buffer tank 18 (that is, reducing the head difference) to downsize the external supply unit 4, it becomes more difficult to supply ink from the main tank 17 to the buffer tank 18, and it becomes more likely that the remaining quantity of ink in the buffer tank 18 becomes very small during printing of the medium 2. However, in the present embodiment, even with the remaining quantity of ink in the buffer tank 18 becoming very small during printing of the medium 2, it becomes possible to continue an appropriate printing operation of the printer 1.

[0082] In the present embodiment, the printer 1 includes the opening and closing valve 15 provided in the piping route between the sub tank 11 and the pump 19, and the opening and closing valve 22 provided in the piping route having one end connected to the piping route between the opening and closing valve 15 and the pump 19 and having another end connected to the main tank 17. Therefore, in the present embodiment, as described above, a circulation route of ink passing through the main tank 17 and the buffer tank 18 can be formed by closing the opening and closing valve 15 and opening the opening and closing valves 21 and 22. Further, in the present embodiment, by driving the pump 19 in such a state, ink can be circulated in the formed circulation route. Accordingly, in the present embodiment, it becomes possible to suppress sedimentation of ink particles in the main tank 17 and in the buffer tank 18.

[0083] In the present embodiment, the printer 1 includes the opening and closing valve 21 provided in the piping route between the main tank 17 and the buffer tank 18, and closes the opening and closing valve 21 during the replacement work of the main tank 17. Therefore, in the present embodiment, it becomes possible to easily perform the replacement work of the main tank 17. Further, in the present embodiment, the opening and closing valves 15 and 21 are closed and the opening and closing valve 22 is opened, and then the pump 19 is driven to return the ink in the buffer tank 18 to the main tank 17. Accordingly, in the present embodiment, for example, it becomes possible to discharge the ink in the buffer tank 18 in the case where replacement of the buffer tank 18 becomes necessary.

[0084] In the present embodiment, the volume of the ink accommodated in the buffer tank 18 is indirectly detected by the detection mechanism 23. Therefore, in the present embodiment, it becomes possible to detect the volume of the ink accommodated in the buffer tank 18 even without installing a mechanism for detecting the volume of the ink accommodated in the buffer tank 18. Accordingly, in the present embodiment, it becomes possible to simplify the configuration of the printer 1.

(Other Embodiments)

[0085] The above-described embodiment is an example of a suitable embodiment of the present invention, but the present invention is not limited thereto, and various modifications may be implemented within a scope that does not change the gist of the present invention.

[0086] In the above-described embodiment, it is also possible that the buffer tank 18 is not an ink pack. For example, the buffer tank 18 may also be a rigid ink bottle formed of resin. In such a case as well, with the remaining quantity of ink in the buffer tank 18 becoming very small and ink not being supplied from the buffer tank 18 to the sub tank 11 anymore, an ink flow passing through the check valve 20 is generated. Further, in the above-described embodiment, the printer 1 may also include a pump provided in the piping route between the main tank 17 and the buffer tank 18. In such a case, ink is supplied from the main tank 17 to the buffer tank 18 by such a pump.

[0087] In the above-described embodiment, the detection mechanism 23 may also be a detection mechanism other than a load cell. Further, in the above-described embodiment, the printer 1 may also include a detection mechanism for detecting the volume of the ink accommodated in the buffer tank 18. Furthermore, in the above-described embodiment, the printer body 3 may also include the main tank 17, the buffer tank 18, the pump 19, the check valve 20, the opening and closing valves 21 and 22, the detection mechanism 23, and the filter 24. In such a case, the printer 1 does not include the external supply unit 4. Further, in the above-described embodiment, the printer 1 is an apparatus for performing printing on the medium 2, but the printer 1 may also be used for applications other than printing on the medium 2. For example, the printer 1 may also be a 3D printer for forming three-dimensional shaped objects. Further, the printer 1 may also be an inkjet printer for general consumers.

<Second Embodiment>

[0088] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

(Configuration of Inkjet Printer)

[0089] FIG. 6 is a schematic diagram illustrating a configuration of an inkjet printer 101 according to an embodiment of the present invention. FIG. 7 is a schematic diagram illustrating the configuration of the inkjet printer 101 shown in FIG. 6. FIG. 8 is a block diagram illustrating the configuration of the inkjet printer 101 shown in FIG. 6.

[0090] In the present embodiment, the inkjet printer 101 (hereinafter referred to as "printer 101") is, for ex-

ample, a commercial inkjet printer, and performs printing on a medium 102 such as paper. The printer 101 includes inkjet heads 103 (hereinafter referred to as "heads 103") that discharge ink, a carriage 104 on which the heads 103 are mounted, a carriage drive mechanism 105 that moves the carriage 104 in a main scanning direction, a guide rail 106 for guiding the carriage 104 in the main scanning direction, and a platen 107 on which the medium 102 is placed during printing. When performing printing on the medium 102 with the printer 101, the heads 103 discharge ink while the carriage 104 reciprocates in the main scanning direction.

[0091] Further, the printer 101 includes sub tanks 111 that accommodate ink to be supplied to the heads 103, a buffer tank 112 that accommodates ink to be supplied to the sub tanks 111, and a main tank 113 that accommodates ink to be supplied to the buffer tank 112. In the present embodiment, one buffer tank 112 is connected to one main tank 113. Further, two sub tanks 111 are connected to one buffer tank 112, and ink is supplied from one buffer tank 112 to the two sub tanks 111. In FIG. 7, only one main tank 113 is illustrated, but the printer 101 includes a plurality of main tanks 113. The printer 101 includes a plurality of buffer tanks 112 and sub tanks 111 corresponding to the number of main tanks 113.

[0092] Further, the printer 101 includes a pump (liquid feeding pump) 114 and an ink filter 115 (hereinafter referred to as "filter 115") provided in a piping route between the buffer tank 112 and the sub tank 111, a detection mechanism 116 for detecting a quantity of ink accommodated in the main tank 113, and a control unit 117 that controls the printer 101. Further, the printer 101 includes a piping route 119 that connects the main tank 113 and the buffer tank 112, a piping route 120 that connects the buffer tank 112 and the pump 114, a piping route 121 that connects the pump 114 and the two sub tanks 111, a piping route 122 that connects the piping route 121 and the main tank 113, an opening and closing valve 123 provided in the piping route 119, an opening and closing valve 124 provided in the piping route 121, and an opening and closing valve 125 provided in the piping route 122.

[0093] Further, the printer 101 includes an ink filter 127 (hereinafter referred to as "filter 127") provided in a piping route between the sub tank 111 and the head 103, a degassing module 128 for removing gas in the ink, and a pressure adjustment mechanism (not shown) for adjusting pressure in the sub tank 111. The degassing module 128 is provided in a piping route between the sub tank 111 and the filter 127. The pressure adjustment mechanism includes a negative pressure pump for creating negative pressure in the sub tank 111, a positive pressure pump for creating positive pressure in the sub tank 111, and the like.

[0094] A connection spot (connection point) 130 is provided midway in the piping route 121. One end of the piping route 122 is connected to the main tank 113, and another end of the piping route 122 is connected to the connection spot 130. That is, the connection spot 130 is provided midway in a piping route connecting the buffer tank 112 and the sub tank 111. In the present embodiment, a piping route 132 for circulation through which ink flows from the buffer tank 112 toward the main tank 113 is constituted by a piping route 131 between the buffer tank 112 and the connection spot 130, and the piping route 122 between the connection spot 130 and the main tank 113.

[0095] In the present embodiment, the piping route 132 is a second piping route, the piping route 131 is a third piping route, and the piping route 122 is a fourth piping route. Further, in the present embodiment, the piping route 119 is a first piping route, which is a piping route for supply through which ink flows from the main tank 113 toward the buffer tank 112. The pump 114 and the filter 115 are provided in the piping route 132, which is the second piping route. Specifically, the pump 114 and the filter 115 are provided in the piping route 131, which is the third piping route. Further, the filter 115 is provided in the piping route 120.

[0096] The two sub tanks 111 connected to the one buffer tank 112 are connected in parallel with each other to the pump 114 via the piping route 121. The piping route 121 branches on the sub tank 111 side with respect to the connection spot 130. The opening and closing valve 124 is provided in a piping route between the branch point of the piping route 121 and the sub tank 111, and two opening and closing valves 124 are provided in the piping route 121. That is, the opening and closing valve 124 is provided in the piping route between the connection spot 130 and the sub tank 111. In the present embodiment, the opening and closing valve 124 is a first opening and closing valve. Further, in the present embodiment, the opening and closing valve 125 is a second opening and closing valve provided in the piping route 122, which is the fourth piping route.

[0097] The sub tank 111 is mounted on the carriage 104. The main tank 113 is, for example, a rigid ink bottle formed of resin. The main tank 113 accommodates ink to be supplied to the head 103 via the buffer tank 112 and the sub tank 111 and discharged from the head 103. The volume of the main tank 113 is, for example, 10 liters. The main tank 113 is capable of being removed from the printer 101 and replaced, and with ink running out in the main tank 113, the main tank 113 is replaced. One end of the piping route 119 is connected to the main tank 113 via a joint 133. One end of the piping route 122 (that is, one end of the piping route 132) is connected to the main tank 113 via a joint 134. At the joints 133 and 134, the main tank 113 is capable of being separated from the piping routes 119 and 122.

[0098] The buffer tank 112 is an ink pack formed in a bag shape. The buffer tank 112 includes a bag-shaped tank body constituted by a flexible film, and an ink inlet and an ink outlet provided at the tank body. The buffer tank 112 is, for example, an aluminum pack having a tank body made of aluminum. The volume of the buffer tank 112 is, for example, 2 liters. Ink is supplied from the main

tank 113 to the buffer tank 112 using a head difference. That is, ink is supplied from the main tank 113 to the buffer tank 112 utilizing a difference between a height of a liquid level of the ink in the main tank 113 and a height of a liquid level of the ink in the buffer tank 112. In the present embodiment, the buffer tank 112 is a supplied side tank that accommodates ink supplied from the main tank 113, and is provided closer to the head 103 side than the main tank 113 in the piping route between the main tank 113 and the head 103.

[0099] The opening and closing valves 123 to 125 are solenoid valves. The opening and closing valves 123 to 125 are electrically connected to the control unit 117. In the present embodiment, upon driving the pump 114 with the opening and closing valve 124 opened and the opening and closing valve 125 closed, ink flows from the buffer tank 112 toward the sub tank 111. Further, upon driving the pump 114 with the opening and closing valve 125 opened and the opening and closing valve 124 closed, ink flows from the buffer tank 112 toward the main tank 113, and the ink in the buffer tank 112 returns to the main tank 113. Further, upon driving the pump 114 with the opening and closing valves 123 and 125 opened and the opening and closing valve 124 closed, ink circulates between the main tank 113 and the buffer tank 112.

[0100] In such a manner, the pump 114 serves a function of supplying ink from the buffer tank 112 to the sub tank 111, and a function of circulating ink between the main tank 113 and the buffer tank 112. The pump 114 is electrically connected to the control unit 117. The detection mechanism 116 is a load cell for detecting the weight of the ink accommodated in the main tank 113. The detection mechanism 116 includes a sensor 135. The sensor 135 is a strain gauge and is electrically connected to the control unit 117. The control unit 117 calculates the quantity of ink accommodated in the main tank 113 based on the detection result of the detection mechanism 116 (specifically, the detection result of the sensor 135).

(Method for Controlling Inkjet Printer)

[0101] FIG. 9 and FIG. 10 are flowcharts representing a procedure in detecting that an ink supply failure has occurred in which ink is not adequately supplied from the main tank 113 to the buffer tank 112 shown in FIG. 7. FIG. 6 is a graph illustrating a procedure in detecting that an ink supply failure has occurred in which ink is not adequately supplied from the main tank 113 to the buffer tank 112 shown in FIG. 7.

[0102] During printing of the medium 102, the control unit 117 drives the pump 114 with the opening and closing valves 123 and 124 opened and the opening and closing valve 125 closed to supply ink from the buffer tank 112 to the sub tank 111, based on the detection result of a detection mechanism (not shown) for detecting the quantity of ink accommodated in the sub tank 111. During printing of the medium 102, ink is supplied from the buffer tank 112 to the sub tank 111. Therefore, even when the ink in the main tank 113 runs out during printing of the medium 102 and the replacement work of the main tank 113 is performed, ink is supplied from the buffer tank 112 to the sub tank 111. The replacement work of the main tank 113 during printing of the medium 102 is performed after closing the opening and closing valve 123, and upon completion of the replacement work of the main tank 113, the opening and closing valve 123 is opened.

[0103] Further, in the printer 101, to suppress sedimentation of ink particles in the main tank 113 and the buffer tank 112, when the carriage 104 stops for a predetermined time or more without performing printing on the medium 102, ink is circulated between the main tank 113 and the buffer tank 112. Specifically, the control unit 117 closes the opening and closing valve 124 and opens the opening and closing valves 123 and 125 to form a circulation route of ink passing through the main tank 113 and the buffer tank 112, and then drives the pump 114 to circulate ink in such a circulation route.

[0104] As described above, in the present embodiment, the main tank 113 is replaceable, and with the ink in the main tank 113 running out, the main tank 113 is replaced. Therefore, for example, upon occurrence of a connection failure in which the piping route 119 is not properly connected to the main tank 113 after replacement (that is, a state in which the main tank 113 and the piping route 119 are not properly connected by the joint 133), the quantity of ink flowing out from the main tank 113 to the buffer tank 112 may decrease, and an ink supply failure may occur in which ink is not adequately supplied from the main tank 113 to the buffer tank 112.

[0105] Therefore, in the present embodiment, during ink circulation in which the pump 114 is driven with the opening and closing valve 124 closed and the opening and closing valves 123 and 125 opened to circulate ink between the main tank 113 and the buffer tank 112, as shown in the flowchart of FIG. 9, the control unit 117 detects whether a failure occurs in ink supply from the main tank 113 to the buffer tank 112, and executes a predetermined error processing when a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0106] That is, upon starting ink circulation, first, the control unit 117 calculates a quantity of ink in the main tank 113 based on the detection result of the detection mechanism 116 (step S1). Thereafter, when a specific time T1 elapses after calculating the quantity of ink in the main tank 113 in step S1, the control unit 117 calculates a quantity of ink in the main tank 113 again based on the detection result of the detection mechanism 116 (steps S2, S3). In the present embodiment, the specific time T1 is 1 minute. Further, in the present embodiment, in steps S1 and S3, the control unit 117 calculates the volume of the ink in the main tank 113 based on the weight of the main tank 113 measured by the detection mechanism 116.

[0107] Thereafter, the control unit 117 calculates an increase quantity of ink by subtracting the quantity of ink calculated in step S1 from the quantity of ink calculated in

step S3 (step S4). That is, in step S4, the control unit 117 calculates the increase quantity of ink over the specific time T1 in the main tank 113. Further, in step S4, the control unit 117 calculates an increased volume of ink. Thereafter, the control unit 117 determines whether the increase quantity of ink calculated in step S4 is equal to or greater than a predetermined reference quantity M1 (step S5). In the present embodiment, the volume of ink sent from the buffer tank 112 toward the main tank 113 by the pump 114 is 90 cc (ml) per minute, and the reference quantity M1 is 50 cc, which is approximately half of the volume of ink per minute sent from the buffer tank 112 toward the main tank 113.

[0108] In step S5, if the increase quantity of ink is equal to or greater than the reference quantity M1, the control unit 117 increments a count value indicating the number of times by which the increase quantity of ink is equal to or greater than the reference quantity M1 (step S6). That is, in step S6, the control unit 117 increases the count value by one. In an initial step S6 after ink circulation is started, the count value is "1". On the other hand, in step S5, if the increase quantity of ink is less than the reference quantity M1, the control unit 117 resets the count value (step S9) and returns to step S2. In step S9, the control unit 117 resets the count value to "0". Upon returning to step S2, after the specific time T1 elapses from calculation of the quantity of ink in the main tank 113 in step S3 the previous time, the control unit 117 calculates a quantity of ink in the main tank 113 again (steps S2 and S3).

[0109] Further, upon incrementing the count value in step S6, the control unit 117 determines whether the count value is a predetermined reference value V1 (step S7). The reference value V1 is an integer of 2 or more. In the present embodiment, the reference value V1 is "3". In step S7, if the count value is not the reference value V1, returning to step S2, after the specific time T1 elapses from calculating the quantity of ink in the main tank 113 in step S3 the previous time, the control unit 117 calculates a quantity of ink in the main tank 113 again (steps S2 and S3).

[0110] On the other hand, in step S7, if the count value is the reference value V1 (that is, if the increase quantity of ink calculated in step S4 is equal to or greater than the reference quantity M1 for three consecutive times), the control unit 117 determines that a failure occurs in ink supply from the main tank 113 to the buffer tank 112 and executes a predetermined error processing (step S8). In step S8, the control unit 117 displays, for example, a predetermined error indication on a predetermined display unit 145 such as a display.

[0111] In step S4 after going through steps S7 and S9, the control unit 117 calculates an increase quantity of ink by subtracting the quantity of ink calculated in step S3 the previous time from the quantity of ink calculated in step S3 this time. Further, the control on the printer 101 shown in the control flow of FIG. 9 is stopped upon ending of the ink circulation (for example, upon ending of the ink circulation to supply ink from the buffer tank 112 to the sub tank 111), and is resumed upon restart of the ink circulation thereafter.

[0112] For example, in the case where the quantity of ink in the main tank 113 before starting ink circulation is 6 liters (that is, 6000 (cc)), and the increase quantity of ink calculated from the initial step S4 to the third-time step S4 after ink circulation is started is consecutively 50 (cc), the quantity of ink in the main tank 113 increases as shown by a straight line L1 in FIG. 11 with the passage of time. In such a case, an error processing is executed 3 minutes after ink circulation is started.

[0113] In such a manner, during ink circulation in which ink is circulated between the main tank 113 and the buffer tank 112, the control unit 117 calculates an increase quantity of ink over the specific time T1 in the main tank 113 at intervals of the specific time T1 based on the detection result of the detection mechanism 116, and executes an error processing in the case where the calculated increase quantity of ink is equal to or greater than the reference quantity M1 consecutively for a plurality of times (specifically, three times). In the present embodiment, the specific time T1 is a first specific time, and the reference quantity M1 is a first reference quantity.

[0114] Further, in the present embodiment, in addition to the above, the control unit 117 detects whether a failure occurs in ink supply from the main tank 113 to the buffer tank 112 as shown in the flowchart of FIG. 10, and executes a predetermined error processing when a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0115] Upon start of ink circulation, first, the control unit 117 calculates a quantity of ink in the main tank 113 based on the detection result of the detection mechanism 116 (step S11). Thereafter, the control unit 117 stands by until a specific time T2 elapses, and again calculates a quantity of ink in the main tank 113 based on the detection result of the detection mechanism 116 (steps S12 and S13). In the present embodiment, the specific time T2 is 1 minute. Further, in the present embodiment, in steps S11 and S13, the control unit 117 calculates the volume of the ink in the main tank 113 based on the weight of the main tank 113 measured by the detection mechanism 116. In the present embodiment, since the specific time T1 and the specific time T2 are equal, the processing of steps S1 to S3 shown in FIG. 9 is the processing of steps S11 to S13 shown in FIG. 10.

[0116] Thereafter, the control unit 117 calculates and stores an ink variation quantity, which is a difference between the quantity of ink calculated in step S11 and the quantity of ink calculated in step S13 (step S14). That is, in step S14, the control unit 117 calculates and stores a variation quantity of ink after the specific time T2 in the main tank 113. Further, in step S14, the control unit 117 calculates and stores a variation volume of ink. Thereafter, after the specific time T2 elapses from calculating the quantity of ink in the main tank 113 in step S13, the control unit 117 again calculates a quantity of ink in the main tank 113 based on the detection result of the detec-

tion mechanism 116 (steps S15 and S16).

[0117] Thereafter, the control unit 117 calculates an ink variation quantity, which is a difference between the quantity of ink calculated in step S13 and the quantity of ink calculated in step S16 (step S17). Further, the control unit 117 calculates an ink variation quantity difference, which is a difference between the variation quantity of ink calculated and stored in step S14 and the variation quantity of ink calculated in step S17 (step S18). That is, in step S18, the control unit 117 calculates an ink variation quantity difference, which is a difference between the variation quantity of ink over the specific time T2 in the main tank 113 calculated the previous time and the variation quantity of ink over the specific time T2 in the main tank 113 calculated this time.

[0118] Thereafter, the control unit 117 determines whether an absolute value of the ink variation quantity difference calculated in step S18 is equal to or less than a predetermined reference quantity M2 (step S19). The reference quantity M2 is a quantity smaller than the reference quantity M1, and in the present embodiment, is 10 (cc). In step S19, if the absolute value of the ink variation quantity difference is equal to or less than the reference quantity M2, the control unit 117 increments a count value indicating the number of times by which the absolute value of the ink variation quantity difference is equal to or less than the reference quantity M2 (step S20). That is, in step S20, the control unit 117 increases the count value by one. In an initial step S20 after ink circulation is started, the count value is "1".

[0119] On the other hand, in step S20, if the absolute value of the variation quantity of ink exceeds the reference quantity M2, the control unit 117 resets the count value (step S22), stores the variation quantity of ink calculated in step S17 (step S23), and then returns to step S15. In step S22, the control unit 117 resets the count value to "0". Upon returning to step S15, the control unit 117 calculates a quantity of ink in the main tank 113 again after the specific time T2 elapses from calculation of the quantity of ink in the main tank 113 in step S16 the previous time (steps S15 and S16).

[0120] Further, upon incrementing the count value in step S20, the control unit 117 determines whether the count value is a predetermined reference value V2 (step S24). The reference value V2 is an integer of 2 or more, and in the present embodiment, is "3". In step S24, if the count value is not the reference value V2, proceeding to step S23, the variation quantity of ink calculated in step S17 is stored, and then the process returns to step S15. After the specific time T2 elapses from calculating the quantity of ink in the main tank 113 in step S16 the previous time, the control unit 117 calculates a quantity of ink in the main tank 113 again (steps S15 and S16). On the other hand, in step S24, if the count value is the reference value V2 (that is, if the absolute value of the ink variation quantity difference calculated in step S18 is equal to or less than the reference quantity M2 for three consecutive times), the control unit 117 stores the quantity of ink in the main tank 113 at this time as an ink initial quantity (step S25).

[0121] Thereafter, the control unit 117 stands by until the specific time T2 elapses, and calculates a quantity of ink in the main tank 113 again based on the detection result of the detection mechanism 116 (steps S26 and S27). Thereafter, the control unit 117 calculates an increase quantity of ink by subtracting the ink initial quantity stored in step S25 from the quantity of ink calculated in step S27 (step S28). That is, in step S28, the control unit 117 calculates an increase quantity of ink in the main tank 113 from the ink initial quantity. Thereafter, the control unit 117 determines whether the increase quantity of ink calculated in step S28 is equal to or greater than a predetermined reference quantity M3 (step S29). The reference quantity M3 is a quantity greater than the reference quantity M1, and in the present embodiment, is 150 (cc).

[0122] In step S29, if the increase quantity of ink is less than the reference quantity M3, returning to step S26, after the specific time T2 elapses from calculating the quantity of ink in the main tank 113 in step S27 the previous time, the control unit 117 calculates a quantity of ink in the main tank 113 again (steps S26 and S27). On the other hand, in step S29, if the increase quantity of ink is equal to or greater than the reference quantity M3, the control unit 117 determines that a failure occurs in ink supply from the main tank 113 to the buffer tank 112, and executes an error processing (step S30). In step S30, the control unit 117 displays a predetermined error indication on the display unit 145, for example, in a manner similar to step S8.

[0123] In step S17 after going through step S23, the control unit 117 calculates an ink variation quantity, which is a difference between the quantity of ink calculated in step S16 the previous time and the quantity of ink calculated in step S16 this time. Further, in step S18 after going through step S23, the control unit 117 calculates an ink variation quantity difference, which is a difference between the variation quantity of ink stored in step S23 and the variation quantity of ink calculated in step S17. That is, in step S18 after going through step S23, the control unit 117 calculates an ink variation quantity difference, which is a difference between the variation quantity of ink over the specific time T2 in the main tank 113 calculated the previous time and the variation quantity of ink over the specific time T2 in the main tank 113 calculated this time. Further, the control on the printer 101 shown in the control flow of FIG. 10 is stopped upon ending of the ink circulation (for example, upon ending of the ink circulation to supply ink from the buffer tank 112 to the sub tank 111), and is resumed upon restart of the ink circulation thereafter.

[0124] For example, in the case where the quantity of ink in the main tank 113 before starting ink circulation is 6000 (cc), after the ink circulation is started, the absolute value of the ink variation quantity difference calculated from the initial step S18 to the third-time step S18 is

consecutively a specific quantity of 10 (cc) or less (specifically, being 0), and the quantity of ink in the main tank 113 is increasing, the quantity of ink in the main tank 113 increases as shown by a straight line L2 in FIG. 11 with the passage of time. In such a case, the quantity of ink in the main tank 113 four minutes after the ink circulation is started is stored as the ink initial quantity. Further, in such a case, for example, if the quantity of ink in the main tank 113 continues to increase at a specific rate as shown by the straight line L2 in FIG. 11, 19 minutes after the ink circulation is started, the increase quantity of ink in the main tank 113 from the ink initial quantity is 150 (cc) (that is, becoming the reference quantity M3), and an error processing is executed.

[0125] In such a manner, during ink circulation, the control unit 117 calculates the variation quantity of ink in the main tank 113 at intervals of the specific time T2 based on the detection result of the detection mechanism 116, and calculates the ink variation quantity difference, which is a difference between the ink variation quantity calculated the previous time and the ink variation quantity calculated this time at intervals of the specific time T2. Further, the control unit 117 stores the quantity of ink in the main tank 113 as an ink initial quantity when the absolute value of the calculated ink variation quantity difference is consecutively equal to or less than the reference quantity M2, which is less than the reference quantity M1, for a plurality of times (specifically three times), and thereafter executes an error processing in the case where the increase quantity of ink in the main tank 113 from the stored ink initial quantity is the reference quantity M3, which is greater than the reference quantity M1. In the present embodiment, the specific time T2 is a second specific time, the reference quantity M2 is a second reference quantity, and the reference quantity M3 is a third reference quantity.

[0126] If the quantity of ink in the buffer tank 112 is small before ink circulation is started, after the ink circulation is started, the quantity of ink flowing out from the main tank 113 to the buffer tank 112 may become greater than the quantity of ink flowing into the main tank 113 from the buffer tank 112, and the quantity of ink in the main tank 113 may decrease. Even in the case where the quantity of ink in the main tank 113 decreases after the ink circulation is started, with the absolute value of the ink variation quantity difference calculated in step S18 being equal to or less than the reference quantity M2, the process proceeds to step S20.

(Main Effects of Present Embodiment)

[0127] As described above, in the present embodiment, during ink circulation in which ink is circulated between the main tank 113 and the buffer tank 112, the control unit 117 executes an error processing in the case where the increase quantity of ink over the specific time T1 in the main tank 113 is consecutively equal to or greater than the reference quantity M1 for a plurality of times, and in the case where the increase quantity of ink from the ink initial quantity, which is the quantity of ink in the main tank 113 stored at a predetermined timing, is the reference quantity M3. Therefore, in the present embodiment, it becomes possible to easily enable an operator to recognize that an ink supply failure occurs in which ink is not adequately supplied from the main tank 113 to the buffer tank 112.

[0128] Further, in the present embodiment, an error processing is executed in the case where the increase quantity of ink over the specific time T1 in the main tank 113 is consecutively equal to or greater than the reference quantity M1 for a plurality of times, and in the case where the increase quantity of ink from the ink initial quantity stored at a predetermined timing is the reference quantity M3 which is greater than the reference quantity M1. Therefore, it becomes possible to execute the error processing while suppressing the influence of errors of the detection mechanism 116 and noise on the detection mechanism 116. Accordingly, in the present embodiment, it becomes possible to enable an operator to accurately recognize that a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0129] Furthermore, in the present embodiment, the error processing is executed in the case where the increase quantity of ink over the specific time T1 in the main tank 113 is consecutively equal to or greater than the reference quantity M1 for a plurality of times. Therefore, in the case of the degree of decrease in ink supplied from the main tank 113 to the buffer tank 112 is large and the quantity of ink in the main tank 113 increases significantly over a relatively short time, it becomes possible to enable an operator to recognize in a short time that a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0130] That is, for example, even if a failure occurs in the connection or the like between the replaced main tank 113 and the piping route 119 and the quantity of ink in the main tank 113 increases significantly in a short time, it becomes possible to enable an operator to recognize in a short time that a failure occurs in ink supply from the main tank 113 to the buffer tank 112. Specifically, for example, as shown in FIG. 11, by executing the error processing three minutes after starting ink circulation, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank 113 to the buffer tank 112 three minutes after starting ink circulation.

[0131] Further, in the present embodiment, the error processing is executed in the case where the increase quantity of ink from the ink initial quantity stored at a predetermined timing is the reference quantity M3. Therefore, even if the degree of decrease in ink supplied from the main tank 113 to the buffer tank 112 is small and the quantity of ink in the main tank 113 does not increase significantly in a short time despite a failure occurring in ink supply from the main tank 113 to the buffer tank 112, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank 113 to the

buffer tank 112. Specifically, for example, as shown by the straight line L2 in FIG. 11, even if the quantity of ink in the main tank 113 does not increase significantly in a short time, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0132] Further, in the present embodiment, since ink is supplied from the main tank 113 to the buffer tank 112 using a head difference, during replacement of the main tank 113 (specifically, when connecting the main tank 113 and the piping route 119), if air is mixed into the piping route 119, the mixed air may remain in the piping route 119, and a failure may occur in ink supply from the main tank 113 to the buffer tank 112. On the other hand, even if such a supply failure occurs, since the degree of decrease in ink supplied from the main tank 113 to the buffer tank 112 is small, the quantity of ink in the main tank 113 does not increase significantly in a short time. However, in the present embodiment, even if the quantity of ink in the main tank 113 does not increase significantly in a short time, it becomes possible to enable an operator to recognize that a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0133] Further, in the present embodiment, depending on the state of the filter 115 (specifically, the degree of clogging of the filter 115), the quantity of ink circulating between the main tank 113 and the buffer tank 112 during ink circulation may decrease, and even if a failure occurs in ink supply from the main tank 113 to the buffer tank 112, there may be cases where the quantity of ink in the main tank 113 does not increase significantly in a short time. However, in the present embodiment, even if the quantity of ink in the main tank 113 does not increase significantly in a short time, it becomes possible to enable an operator to recognize that a failure occurs ink supply from the main tank 113 to the buffer tank 112.

[0134] Further, in the present embodiment, the variation quantity of ink over the specific time T2 in the main tank 113 is calculated at intervals of the specific time T2, the ink variation quantity difference, which is the difference between the variation quantity of ink over the specific time T2 in the main tank 113 calculated the previous time and the variation quantity of ink over the specific time T2 in the main tank 113 calculated this time, is calculated at intervals of the specific time T2, and the quantity of ink in the main tank 113 is stored as the ink initial quantity when the absolute value of the calculated ink variation quantity difference is equal to or less than the reference quantity M2 consecutively for a plurality of times. Therefore, it becomes possible to store the quantity of ink in the main tank 113 as the ink initial quantity when no disturbance or the like occurs in the main tank 113 (that is, when the state of the main tank 113 is stable). That is, in the present embodiment, it becomes possible to set the ink initial quantity with high accuracy. Accordingly, in the present embodiment, based on the ink initial quantity set with high accuracy, it becomes possible to enable an operator to recognize with high accuracy that a failure occurs in ink supply from the main tank 113 to the buffer tank 112.

[0135] In the present embodiment, the supply of ink from the buffer tank 112 to the sub tank 111 and the circulation of ink between the main tank 113 and the buffer tank 112 are performed with the common pump 114. Therefore, in the present embodiment, compared to the case where a pump for supplying ink from the buffer tank 112 to the sub tank 111 and a pump for circulating ink between the main tank 113 and the buffer tank 112 are provided separately, it becomes possible to simplify the configuration of the printer 101.

[0136] In the present embodiment, the buffer tank 112 is provided in the piping route between the main tank 113 and the sub tank 111. Therefore, in the present embodiment, even during a replacement work of the main tank 113, it becomes possible to supply ink from the buffer tank 112 to the sub tank 111. Accordingly, in the present embodiment, even during a replacement work of the main tank 113, it becomes possible to continue the printing operation of the printer 101.

(Other Embodiments)

[0137] The above-described embodiment is an example of a suitable embodiment of the present invention, but the present invention is not limited thereto, and various modifications may be implemented within the scope that does not change the gist of the present invention.

[0138] In the above-described embodiment, the specific time T1 and the specific time T2 are equal, but it is also possible that the specific time T1 and the specific time T2 are not equal. Further, in the above-described embodiment, it is also possible that the specific time in step S26 is not the specific time T2. For example, the specific time in step S26 may be longer than the specific time T2. Furthermore, in the above-described embodiment, the reference value V1 may also be an integer of "2", or "4" or more, and the reference value V2 may also be an integer of "2", or "4" or more. Further, in the above-described embodiment, a pump for supplying ink from the buffer tank 112 to the sub tank 111 and a pump for circulating ink between the main tank 113 and the buffer tank 112 may be provided separately.

[0139] In the above-described embodiment, at least any one of the opening and closing valves 123 to 125 may also be a manual valve with which opening and closing operations are performed manually. Further, in the above-described embodiment, the detection mechanism 116 may also be a detection mechanism other than a load cell. Furthermore, in the above-described embodiment, it is also possible that the buffer tank 112 is not an ink pack. For example, the buffer tank 112 may also be a rigid ink bottle formed of resin. Further, in the above-described embodiment, the filter 115 may be provided on the discharge side of the pump 114.

[0140] In the above-described embodiment, it is also possible that the printer 101 does not include the buffer

tank 112. In such a case, the sub tank 111 is the supplied side tank in which ink supplied from the main tank 113 is accommodated, and is provided closer to the head 103 side than the main tank 113 in the piping route between the main tank 113 and the head 103. In such a case, ink may be supplied from the main tank 113 to the sub tank 111 by a pump, or ink may be supplied from the main tank 113 to the sub tank 111 using a head difference. Further, in such a case, ink circulation is performed between the main tank 113 and the sub tank 111, and the printer 101 includes a pump that sends ink from the sub tank 111 toward the main tank 113. That is, the printer 101 includes a pump for circulating ink between the main tank 113 and the sub tank 111.

[0141] In the above-described embodiment, the printer 101 may include a pump provided in the piping route 119. In such a case, ink is supplied from the main tank 113 to the buffer tank 112 by such a pump. Further, in such a case, it is also possible that the printer 101 does not include the opening and closing valve 123. Further, in the above-described embodiment, the printer 101 is an apparatus for performing printing on the medium 102, but the printer 101 may also be used for applications other than printing on the medium 102. For example, the printer 101 may also be a 3D printer for forming three-dimensional shaped objects. Further, the printer 101 may also be an inkjet printer for general consumers.

<Third Embodiment>

[0142] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

(Configuration of Inkjet Printer)

[0143] FIG. 12 is a schematic diagram illustrating a configuration of an inkjet printer 201 according to an embodiment of the present invention. FIG. 13 is a schematic diagram illustrating the configuration of the inkjet printer 201 shown in FIG. 12. FIG. 14 is a block diagram illustrating the configuration of the inkjet printer 201 shown in FIG. 12.

[0144] In the present embodiment, the inkjet printer 201 (hereinafter referred to as "printer 201") is, for example, a commercial inkjet printer, and performs printing on a medium 202 such as paper. The printer 201 includes an inkjet head 203 (hereinafter referred to as "head 203") that discharges ink, a carriage 204 on which the head 203 is mounted, a carriage drive mechanism 205 that moves the carriage 204 in a main scanning direction, a guide rail 206 for guiding the carriage 204 in the main scanning direction, and a platen 207 on which the medium 202 is placed during printing.

[0145] The platen 207 is provided below the head 203. The head 203 discharges ink toward the lower side. A plurality of nozzles (specifically, a large number of nozzles) that discharge ink are formed on the lower surface of the head 203. The lower surface of the head 203 serves as an ink discharge surface. The head 203 includes piezoelectric elements (piezo elements) that cause ink to be discharged respectively from the plurality of nozzles. When performing printing on the medium 202 with the printer 201, the head 203 discharges ink while the carriage 204 reciprocates in the main scanning direction.

[0146] Further, the printer 201 includes sub tanks 211 that accommodate ink to be supplied to the head 203, a buffer tank 212 that accommodates ink to be supplied to the sub tanks 211, and a main tank 213 that accommodates ink to be supplied to the buffer tank 212. In the present embodiment, one buffer tank 212 is connected to one main tank 213. Further, two sub tanks 211 are connected to one buffer tank 212, and ink is supplied from the one buffer tank 212 to the two sub tanks 211. Although only one main tank 213 is shown in FIG. 13, the printer 201 includes a plurality of main tanks 213. The printer 201 includes a plurality of buffer tanks 212 and sub tanks 211 corresponding to the number of main tanks 213.

[0147] Further, the printer 201 includes a pump (liquid feeding pump) 214 and a filter (ink filter) 215 that are provided in a piping route between the buffer tank 212 and the sub tank 211, and a control unit 217 for controlling the printer 201. Further, the printer 201 includes a piping route 22219 that connects the main tank 213 and the buffer tank 212, a piping route 2220 that connects the buffer tank 212 and the pump 214, a piping route 2221 that connects the pump 214 and the two sub tanks 211, and a piping route 222 that connects the piping route 2221 and the main tank 213. In the present embodiment, the piping route 2221 is a first piping route, and the piping route 222 is a second piping route.

[0148] Further, the printer 201 includes an opening and closing valve 223 provided in the piping route 22219, an opening and closing valve 224 provided in the piping route 2221, an opening and closing valve 225 provided in the piping route 222, a pressure adjustment mechanism 226 for adjusting pressure in the sub tank 211, an opening and closing valve 227 provided in a piping route between the pressure adjustment mechanism 226 and the sub tank 211, and a detection mechanism 228 for detecting the quantity of ink accommodated in the sub tank 211. The pressure adjustment mechanism 226 includes a negative pressure pump for creating negative pressure in the sub tank 211, a positive pressure pump for creating positive pressure in the sub tank 211, and the like. The opening and closing valve 227 is a solenoid valve.

[0149] A connection spot (connection point) 230 is provided midway in the piping route 2221. One end of the piping route 222 is connected to the main tank 213, and another end of the piping route 222 is connected to the connection spot 230. That is, the connection spot 230 is provided midway in the piping route connecting the buffer tank 212 and the sub tank 211. In the present embodiment, a piping route for circulation through which ink flows from the buffer tank 212 toward the main tank 213 is constituted by a piping route 231 between the

buffer tank 212 and the connection spot 230, and the piping route 222 between the connection spot 230 and the main tank 213.

[0150] The two sub tanks 211 connected to one buffer tank 212 are connected in parallel with each other to the pump 214 via the piping route 2221. The piping route 2221 branches on the sub tank 211 side with respect to the connection spot 230. The opening and closing valve 224 is provided in the piping route between the branch point of the piping route 2221 and the sub tank 211, and two opening and closing valves 224 are provided in the piping route 2221. That is, the opening and closing valve 224 is provided in the piping route between the connection spot 230 connecting the piping route 2221 and the piping route 222 and the sub tank 211. The filter 215 is provided in the piping route 2220. In the present embodiment, the opening and closing valve 224 is a first opening and closing valve. Further, in the present embodiment, the opening and closing valve 225 is a second opening and closing valve provided in the piping route 222, which is the second piping route.

[0151] The sub tank 211 is mounted on the carriage 204. The main tank 213 is, for example, a rigid ink bottle formed of resin. The main tank 213 is attached to a body frame of the printer 201. The main tank 213 is capable of being removed from the printer 201 and replaced (that is, capable of being removed from the body frame of the printer 201 and replaced), and with the ink running out in the main tank 213, the main tank 213 is replaced. One end of the piping route 22219 is connected to the main tank 213 via a joint 233. One end of the piping route 222 is connected to the main tank 213 via a joint 234. That is, the printer 201 includes the joints 233 and 234. At the joints 233 and 234, the main tank 213 is capable of being separated from the piping routes 22219 and 222.

[0152] The joint 234 includes a piping side joint portion 235 attached to an end of the piping route 222, and a tank side joint portion 236 attached to the main tank 213. The joint 234 is constituted by the piping side joint portion 235 and the tank side joint portion 236. The piping side joint portion 235 is connected to the tank side joint portion 236. In a state where the piping side joint portion 235 and the tank side joint portion 236 are separated, the piping side joint portion 235 and the tank side joint portion 236 are sealed such that ink does not flow out from the piping side joint portion 235 and the tank side joint portion 236. The joint 233 is constituted by a piping side joint portion attached to an end of the piping route 22219 and a tank side joint portion attached to the main tank 213, in a manner similar to the joint 234.

[0153] The buffer tank 212 is an ink pack formed in a bag shape. The buffer tank 212 includes a bag-shaped tank body constituted by a flexible film, and an ink inlet and an ink outlet provided at the tank body. The buffer tank 212 is, for example, an aluminum pack having a tank body made of aluminum. The buffer tank 212 is provided in a piping route between the sub tank 211 and the main tank 213. Ink is supplied from the main tank 213 to the buffer tank 212 using a head difference. That is, a height of a liquid level of the ink in the main tank 213 is higher than a height of a liquid level of the ink in the buffer tank 212, and ink is supplied from the main tank 213 to the buffer tank 212 utilizing a difference (head difference) between the height of the liquid level of the ink in the main tank 213 and the height of the liquid level of the ink in the buffer tank 212.

[0154] The pump 214 includes a motor as a drive source. The pump 214 is electrically connected to the control unit 217. Specifically, the motor of the pump 214 is electrically connected to the control unit 217. The opening and closing valves 223 to 225 are solenoid valves. The opening and closing valves 223 to 225 are electrically connected to the control unit 217.

[0155] In the present embodiment, upon driving the pump 214 with the opening and closing valve 224 opened and the opening and closing valve 225 closed, ink flows from the buffer tank 212 toward the sub tank 211. Further, upon driving the pump 214 with the opening and closing valve 225 opened and the opening and closing valve 224 closed, ink flows from the buffer tank 212 toward the main tank 213, and the ink in the buffer tank 212 returns to the main tank 213. Further, upon driving the pump 214 with the opening and closing valves 223 and 225 opened and the opening and closing valve 224 closed, ink circulates between the main tank 213 and the buffer tank 212. In such a manner, the pump 214 serves a function of supplying ink from the buffer tank 212 to the sub tank 211 and a function of circulating ink between the main tank 213 and the buffer tank 212.

[0156] The detection mechanism 228 is a liquid level detection mechanism for detecting a height of a liquid level of the ink in the sub tank 211. The detection mechanism 228 includes a float 239 that floats on ink in the sub tank 211, a permanent magnet (not shown) built into the float 239, and three sensors 240 to 242 that are provided on an outer side of the sub tank 211 and detect the permanent magnet. The sensors 240 to 242 are magnetic sensors such as Hall ICs. The sensor 240 is fixed to an outer surface of the sub tank 211 on an upper end side of the sub tank 211. The sensor 241 is fixed to the outer surface of the sub tank 211 on a lower side of the sensor 240. The sensor 242 is fixed to the outer surface of the sub tank 211 on a lower end side of the sub tank 211.

[0157] The sensor 240 is a sensor for detecting that the height of the liquid level of the ink in the sub tank 211 is higher than a predetermined upper limit position. The sensor 241 is a sensor for detecting that the height of the liquid level of the ink in the sub tank 211 is within an appropriate range. The sensor 242 is a sensor for detecting that the height of the liquid level of the ink in the sub tank 211 is lower than a predetermined lower limit position. The sensors 240 to 242 are electrically connected to the control unit 217. The control unit 217 detects a quantity (volume) of the ink accommodated in the sub tank 211 by detecting the height of the liquid level of the ink in the sub tank 211 based on the detection result of the

detection mechanism 228 (specifically, detection results of the sensors 240 to 242). In FIG. 14, only one detection mechanism 228 is shown.

[0158] Further, the printer 201 includes a maintenance unit 243 for preventing clogging of the plurality of nozzles of the head 203. The maintenance unit 243 is provided at a position outside a printing area where printing is performed on the medium 202 in the main scanning direction. The maintenance unit 243 includes a wiper member for wiping an ink discharge surface (lower surface) of the head 203, and an ink receiving container for receiving ink discharged from the head 203. In the maintenance unit 243, a cleaning operation of the head 203 is performed such that clogging does not occur in the plurality of nozzles of the head 203.

[0159] The cleaning operation of the head 203 includes a purging operation in which the pressure in the sub tank 211 is configured to be a positive pressure to forcibly discharge ink from the head 203. Further, the cleaning operation includes a wiping operation of wiping the ink discharge surface of the head 203 with the wiper member, and a flushing operation of driving the piezoelectric elements of the head 203 to forcibly discharge ink from the head 203. The cleaning operation is automatically executed by the control unit 217.

[0160] Further, the cleaning operation of the head 203 includes three types of cleaning operations, namely, a soft cleaning operation, a normal cleaning operation in which a quantity of ink discharged from the head 203 increases and a required time is longer compared to the soft cleaning operation, and a hard cleaning operation in which the quantity of ink discharged from the head 203 increases and the required time is longer than the normal cleaning operation. The soft cleaning operation is executed, for example, in the case of restoring the nozzles of the head 203, such as before performing printing on the medium 202. The normal cleaning operation is executed, for example, in the case of occurrence of a plurality of nozzle dropouts in which ink is not discharged from the nozzles despite driving the piezoelectric elements of the head 203. The hard cleaning operation is executed, for example, in the case of occurrence of nozzle clogging that cannot be resolved by the normal cleaning operation.

(Control Method of Inkjet Printer)

[0161] During printing on the medium 202, the control unit 217 drives the pump 214 with the opening and closing valves 223 and 224 opened and the opening and closing valve 225 closed to supply ink from the buffer tank 212 to the sub tank 211, based on the detection result of the detection mechanism 228. During printing on the medium 202, negative pressure is present in the sub tank 211. Since ink is supplied from the buffer tank 212 to the sub tank 211 during printing on the medium 202, even when ink runs out in the main tank 213 during printing on the medium 202 and a replacement work of the main tank 213 is performed, ink is supplied from the buffer tank 212 to the sub tank 211. The replacement work of the main tank 213 during printing on the medium 202 is performed after closing the opening and closing valve 223, and upon completion of the replacement work of the main tank 213, the opening and closing valve 223 is opened.

[0162] Further, in the printer 201, to suppress sedimentation of ink particles in the buffer tank 212, when the carriage 204 is stopped for a predetermined time or more without performing printing on the medium 202, ink is circulated between the main tank 213 and the buffer tank 212. Specifically, the control unit 217 closes the opening and closing valve 224 and opens the opening and closing valves 223 and 225 to form a circulation route of ink passing through the main tank 213 and the buffer tank 212, and then drives the pump 214 to circulate ink in such a circulation route. As described above, in the present embodiment, in a state where the piping side joint portion 235 and the tank side joint portion 236 are separated, the piping side joint portion 235 is sealed such that ink does not flow out from the piping side joint portion 235.

[0163] Therefore, for example, after ink runs out in the main tank 213 and the main tank 213 is replaced, if a connection failure occurs in the joint 234 in which the piping side joint portion 235 and the tank side joint portion 236 are not normally connected (that is, a connection failure in which the piping route 222 is not normally connected to the replaced main tank 213), when ink is to be circulated between the main tank 213 and the buffer tank 212, the pump 214 becomes unable to send ink, an excessive load acts on the pump 214, and the pump 214 may malfunction. Further, if a connection failure occurs in the joint 234, when ink is to be circulated between the main tank 213 and the buffer tank 212, the pressure inside the piping route 222 becomes excessively high, and ink may leak out from the piping route 222.

[0164] Therefore, in the present embodiment, the control unit 217 executes a predetermined operation for confirming whether the piping side joint portion 235 and the tank side joint portion 236 are normally connected, for example, after replacement of the main tank 213 or after startup of the printer 201. Specifically, the control unit 217 executes a confirmation operation CO in which, in a state where the quantity of ink in the sub tank 211 is set to a predetermined first reference quantity, the opening and closing valves 224 and 225 are opened and the pump 214 is driven at a constant speed for a predetermined first time, and it is determined whether the quantity of ink in the sub tank 211 exceeds a predetermined second reference quantity based on the detection result of the detection mechanism 228.

[0165] In the present embodiment, when the piping side joint portion 235 and the tank side joint portion 236 are normally connected, upon driving the pump 214 with the opening and closing valves 224 and 225 opened, the quantity of ink flowing from the buffer tank 212 to the main tank 213 is greater than the quantity of ink flowing from the buffer tank 212 to the sub tank 211. Specifically, the height of the liquid level of the ink in

the sub tank 211 and the height of the liquid level of the ink in the main tank 213 are higher than the height of the liquid level of the ink in the buffer tank 212, and the head difference of the sub tank 211 with respect to the buffer tank 212 is greater than the head difference of the main tank 213 with respect to the buffer tank 212. Therefore, when the piping side joint portion 235 and the tank side joint portion 236 are normally connected, upon driving the pump 214 with the opening and closing valves 224 and 225 opened, the quantity of ink flowing from the buffer tank 212 to the main tank 213 is greater than the quantity of ink flowing from the buffer tank 212 to the sub tank 211.

[0166] Therefore, in the present embodiment, if the piping side joint portion 235 and the tank side joint portion 236 are normally connected, in the confirmation operation, the quantity of ink flowing from the buffer tank 212 to the main tank 213 is greater than the quantity of ink flowing from the buffer tank 212 to the sub tank 211, and the quantity of ink in the sub tank 211 does not exceed the second reference quantity. In contrast, if the piping side joint portion 235 and the tank side joint portion 236 are not normally connected, since ink does not flow from the buffer tank 212 to the main tank 213, in the confirmation operation, the quantity of ink flowing from the buffer tank 212 to the sub tank 211 increases, and the quantity of ink in the sub tank 211 exceeds the second reference quantity. Accordingly, in the present embodiment, by executing the confirmation operation, it becomes possible to confirm whether the piping side joint portion 235 and the tank side joint portion 236 are normally connected.

[0167] In the present embodiment, the control unit 217 executes the confirmation operation during the cleaning operation. Specifically, the control unit 217 does not execute the confirmation operation during the cleaning operation performed in the middle of printing on the medium 202, but executes the confirmation operation during the cleaning operation performed before the start of printing or after the end of printing on the medium 202. Further, in the present embodiment, the procedures of the soft cleaning operation and the normal cleaning operation differ from the procedure of the hard cleaning operation. Hereinafter, the procedure of the confirmation operation will be described while sequentially describing the procedures of the soft cleaning operation and the normal cleaning operation, and the procedure of the hard cleaning operation.

(Soft Cleaning Operation and Normal Cleaning Operation)

[0168] FIG. 15 is a flowchart representing an example of procedures of the soft cleaning operation and the normal cleaning operation of the head 203 shown in FIG. 12.

[0169] Before the start of printing or after the end of printing on the medium 202, upon starting the soft cleaning operation or the normal cleaning operation of the head 203, first, the control unit 217 drives the pump 214 with the opening and closing valve 224 opened and the opening and closing valve 225 closed to supply ink from the buffer tank 212 to the sub tank 211 until the quantity of ink in the sub tank 211 reaches the second reference quantity (step S0).

[0170] Thereafter, the control unit 217 performs a purging operation (step S1). In step S1, the control unit 217 causes ink to be discharged from the head 203 until the quantity of ink in the sub tank 211 becomes the first reference quantity. That is, after the purging operation, the quantity of ink in the sub tank 211 becomes the first reference quantity. Further, in step S1, upon completion of the discharge of ink, the control unit 217 opens the sub tank 211 to the atmosphere to configure the pressure in the sub tank 211 to be atmospheric pressure, and then configures the pressure in the sub tank 211 to be a slightly negative pressure.

[0171] Thereafter, the control unit 217 determines whether it is required to execute the confirmation operation (step S2). In the present embodiment, in the case where the state of the joint 234 stored in the control unit 217 is an "unconfirmed state", the control unit 217 determines that it is required to execute the confirmation operation. Further, in the present embodiment, in the case where the cleaning operation is performed for the first time after the main tank 213 is replaced, in the case where the cleaning operation is performed for the first time after startup of the printer 201, and in the case where the "unconfirmed state" is stored in the control unit 217 in step S17 to be described later, the state of the joint 234 stored in the control unit 217 is the "unconfirmed state". On the other hand, in the case where the state of the joint 234 stored in the control unit 217 is not the "unconfirmed state", the control unit 217 determines that it is not required to execute the confirmation operation. The printer 201 includes a detection mechanism for detecting that the main tank 213 has been replaced, and the replacement of the main tank 213 is detected by such a detection mechanism.

[0172] In step S2, if it is not required to execute the confirmation operation, the control unit 217 drives the pump 214 at a constant speed with the opening and closing valve 224 opened and the opening and closing valve 225 closed to supply ink from the buffer tank 212 to the sub tank 211 until the quantity of ink in the sub tank 211 reaches the second reference quantity that is greater than the first reference quantity (step S3). That is, after the purging operation, the control unit 217 drives the pump 214 with the opening and closing valve 224 opened and the opening and closing valve 225 closed to supply ink to the sub tank 211 until the quantity of ink in the sub tank 211 reaches the second reference quantity. In step S3, the control unit 217 measures a second time, which is a time until the quantity of ink in the sub tank 211 reaches the second reference quantity.

[0173] The drive speed of the pump 214 in step S3 (specifically, the rotational frequency (rotational speed)

of the motor of the pump 214) is equal to the drive speed of the pump 214 when flowing ink from the buffer tank 212 toward the sub tank 211 with the opening and closing valve 224 opened and the opening and closing valve 225 closed during printing on the medium 202 by the printer 201. For example, the rotational frequency of the motor of the pump 214 in step S3 is 216 (rpm). Hereinafter, the drive speed of the pump 214 in step S3 (that is, the drive speed of the pump 214 when supplying ink to the sub tank 211 without executing the confirmation operation after the purging operation) will be referred to as "normal drive speed".

[0174] Thereafter, the control unit 217 determines whether the confirmation operation has been executed before executing step S3 (step S4). Specifically, in step S4, the control unit 217 determines whether at least steps S12 and S13 to be described later have been executed before executing step S3. In step S4, if the confirmation operation has not been executed before executing step S3, the control unit 217 stores the time measured in step S3 as the second time (step S5). When proceeding from step S2 to step S3, since the confirmation operation has not been executed before step S3 is executed, the control unit 217 stores the time measured in step S3 as the second time in step S5.

[0175] Thereafter, the control unit 217 sequentially executes a wiping operation and a flushing operation (steps S6 and S7). In step S7, upon completion of the flushing operation, the soft cleaning operation or the normal cleaning operation of the head 203 is completed.

[0176] On the other hand, in step S2, if it is required to execute the confirmation operation, the control unit 217 determines whether the second time is stored in the control unit 217 (step S9). In step S9, if the second time is not stored in the control unit 217, the process proceeds to step S3. When proceeding from step S9 to step S3, since the confirmation operation has not been executed before step S3 is executed, the control unit 217 stores the time measured in step S3 as the second time in step S5.

[0177] On the other hand, in step S9, if the second time is stored in the control unit 217, the control unit 217 calculates a first time for executing the confirmation operation (step S10). In step S10, the control unit 217 calculates the first time based on the second time stored in the control unit 217.

[0178] In the present embodiment, the drive speed of the pump 214 when executing the confirmation operation (specifically, the drive speed of the pump 214 in step S12 to be described later) is lower than the normal drive speed of the pump 214. For example, the rotational frequency of the motor of the pump 214 when executing the confirmation operation is approximately half the rotational frequency of the motor of the pump 214 driven at the normal drive speed. In step S10, the control unit 217 calculates the first time by multiplying the second time stored in the control unit 217 by a ratio of the drive speed of the pump 214 when executing the confirmation operation to the normal drive speed and a margin. The first time is longer than the second time. For example, the first time is approximately four times the second time.

[0179] Thereafter, the control unit 217 determines whether the first time calculated in step S10 exceeds a predetermined reference time (step S11). If the first time exceeds the reference time, the time of executing the confirmation operation becomes excessively long, and the cleaning time of the head 203 becomes excessively long. Therefore, if the first time exceeds the reference time in step S11, the process proceeds to step S3. When proceeding from step S11 to step S3, since the confirmation operation has not been executed before step S3 is executed, the control unit 217 stores the time measured in step S3 as the second time in step S5.

[0180] On the other hand, if the first time is less than the reference time in step S11, the control unit 217 opens the opening and closing valves 224 and 225 and drives the pump 214 at a constant speed to supply ink to the main tank 213 and the sub tank 211 (step S12). In step S12, the control unit 217 drives the pump 214 for the first time. As described above, the drive speed of the pump 214 in step S12 is lower than the normal drive speed of the pump 214.

[0181] Thereafter, the control unit 217 determines whether the quantity of ink in the sub tank 211 exceeds the second reference quantity based on the detection result of the detection mechanism 228 (step S13). In step S13, if the quantity of ink in the sub tank 211 exceeds the second reference quantity, the control unit 217 determines that the piping side joint portion 235 and the tank side joint portion 236 are not normally connected, and stores an "abnormal state" as the state of the joint 234 in the control unit 217 (step S14). Thereafter, the process proceeds to step S6.

[0182] On the other hand, in step S13, if the quantity of ink in the sub tank 211 is less than the second reference quantity, the control unit 217 determines whether the pump 214 has made an emergency stop in step S12 (step S15). For example, in the case where an abnormality occurs, such as the case where the replacement work of the main tank 213 is started during execution of step S12, the case where the printer 201 makes an emergency stop, or the case where an abnormality is detected in the pressure adjustment mechanism 226, in step S12, the pump 214 makes an emergency stop before driving for the first time. On the other hand, if the above-described abnormality does not occur, in step S12, the pump 214 continues to drive for the first time without making an emergency stop.

[0183] In step S15, if the pump 214 has not made an emergency stop, the control unit 217 determines that the piping side joint portion 235 and the tank side joint portion 236 are normally connected, and stores a "normal state" as the state of the joint 234 in the control unit 217 (step S16). Thereafter, the process proceeds to step S3. When proceeding from step S16 to step S3, since the confirmation operation is executed before step S3 is executed, the process proceeds from step S4 to step S6.

[0184] On the other hand, in step S15, if the pump 214

has made an emergency stop, since the control unit 217 cannot determine whether the piping side joint portion 235 and the tank side joint portion 236 are normally connected, the control unit 217 stores an "unconfirmed state" as the state of the joint 234 in the control unit 217 (step S17). Thereafter, the process proceeds to step S3. When proceeding from step S17 to step S3, since the confirmation operation has been executed before step S3 is executed, the process proceeds from step S4 to step S6.

[0185] In such a manner, in the present embodiment, the control unit 217 executes the confirmation operation if predetermined conditions are satisfied (specifically, if conditions are satisfied in steps S2, S9, and S11) after the purging operation in step S1. Further, in the present embodiment, in step S16, upon storing the "normal state" in the control unit 217, ink circulation is performed between the main tank 213 and the buffer tank 212 as described above. Further, in step S14, upon storing the "abnormal state" in the control unit 217, the control unit 217 executes a predetermined processing. Specifically, the control unit 217 executes a predetermined processing for preventing execution of the circulation operation of ink between the main tank 213 and the buffer tank 212. Further, in step S14, upon storing the "abnormal state" in the control unit 217, the control unit 217 displays a predetermined error message on a display unit 45 such as a display panel of the printer 201 connected to the control unit 217, for example.

(Hard Cleaning Operation)

[0186] FIG. 16 is a flowchart representing an example of a procedure of the hard cleaning operation of the head 203 shown in FIG. 12. In FIG. 16, steps similar to the steps shown in FIG. 15 are labeled with the same reference signs.

[0187] In the following description, the purging operation in the soft cleaning operation will be referred to as a "first purging operation", and the purging operation in the hard cleaning operation will be referred to as a "second purging operation". That is, the soft cleaning operation includes the first purging operation in which the pressure in the sub tank 211 is configured to be a positive pressure to discharge ink from the head 203, and the hard cleaning operation includes the second purging operation in which the pressure in the sub tank 211 is configured to be a positive pressure to discharge ink from the head 203. The quantity of ink discharged from the head 203 in the second purging operation is greater than the quantity of ink discharged from the head 203 in the first purging operation, and the time required for the second purging operation is longer than the time required for the first purging operation.

[0188] Before the start of printing or after the end of printing on the medium 202, upon starting the hard cleaning operation of the head 203, first, the control unit 217 drives the pump 214 with the opening and closing valve 224 opened and the opening and closing valve 225 closed to supply ink from the buffer tank 212 to the sub tank 211 until the quantity of ink in the sub tank 211 reaches the second reference quantity (step S21). In step S21, the control unit 217 configures the pressure in the sub tank 211 to be a slightly negative pressure. Thereafter, the control unit 217 determines whether it is required to execute the confirmation operation (step S22). Similar to step S2, in step S22, the control unit 217 determines whether it is required to execute the confirmation operation according to whether the state of the joint 234 stored in the control unit 217 is the "unconfirmed state".

[0189] In step S22, if it is not required to execute the confirmation operation, the control unit 217 executes the second purging operation (step S23). Further, in step S23, upon completion of the discharge of ink, the control unit 217 opens the sub tank 211 to atmosphere to configure the pressure in the sub tank 211 to be atmospheric pressure, and then configures the pressure in the sub tank 211 to be a slightly negative pressure. Thereafter, the control unit 217 drives the pump 214 with the opening and closing valve 224 opened and the opening and closing valve 225 closed to supply ink from the buffer tank 212 to the sub tank 211 until the quantity of ink in the sub tank 211 reaches the second reference quantity (step S24). Thereafter, the control unit 217 sequentially executes the wiping operation and the flushing operation (steps S25 and S26). In step S26, upon completion of the flushing operation, the hard cleaning operation of the head 203 is completed.

[0190] On the other hand, in step S22, if it is required to execute the confirmation operation, the control unit 217 performs the first purging operation (step S27). In step S27, the control unit 217 causes ink to be discharged from the head 203 until the quantity of ink in the sub tank 211 becomes the first reference quantity. Further, in step S27, upon completion of the discharge of ink, the control unit 217 opens the sub tank 211 to atmosphere to configure the pressure in the sub tank 211 to be atmospheric pressure, and then configures the pressure in the sub tank 211 to be a slightly negative pressure. Thereafter, the control unit 217 determines whether the second time is stored in the control unit 217 as described above (step S9). In step S9, if the second time is not stored in the control unit 217, the process proceeds to step S3.

[0191] Thereafter, the control unit 217 determines whether the confirmation operation has been executed before executing step S3 (step S4), and if the confirmation operation has not been executed before executing step S3, the control unit 217 stores the time measured in step S3 as the second time (step S5). When proceeding from step S9 to step S3, since the confirmation operation has not been executed before step S3 is executed, the control unit 217 stores the time measured in step S3 as the second time in step S5. Thereafter, the process proceeds to step S23.

[0192] On the other hand, in step S9, if the second time

is stored in the control unit 217, the control unit 217 calculates the first time (step S10). Thereafter, the control unit 217 determines whether the first time calculated in step S10 exceeds the reference time (step S11). In step S11, if the first time exceeds the reference time, the process proceeds to step S3. When proceeding from step S11 to step S3, since the confirmation operation has not been executed before step S3 is executed, the control unit 217 stores the time measured in step S3 as the second time in step S5.

[0193] On the other hand, in step S11, if the first time is less than the reference time, the control unit 217 opens the opening and closing valves 224 and 225 and drives the pump 214 at a constant speed to supply ink to the main tank 213 and the sub tank 211 (step S12). Thereafter, the control unit 217 determines whether the quantity of ink in the sub tank 211 exceeds the second reference quantity based on the detection result of the detection mechanism 228 (step S13). In step S13, if the quantity of ink in the sub tank 211 exceeds the second reference quantity, the control unit 217 stores the "abnormal state" as the state of the joint 234 in the control unit 217 (step S14). Thereafter, the process proceeds to step S23.

[0194] On the other hand, in step S13, if the quantity of ink in the sub tank 211 is less than the second reference quantity, the control unit 217 determines whether the pump 214 has made an emergency stop in step S12 (step S15). In step S15, if the pump 214 has not made an emergency stop, the control unit 217 stores the "normal state" as the state of the joint 234 in the control unit 217 (step S16), and then proceeds to step S3. When proceeding from step S16 to step S3, since the confirmation operation has been executed before step S3 is executed, the process proceeds from step S4 to step S23.

[0195] Further, in step S15, if the pump 214 has made an emergency stop, the control unit 217 stores the "unconfirmed state" as the state of the joint 234 in the control unit 217 (step S17), and then proceeds to step S3. When proceeding from step S17 to step S3, since the confirmation operation has been executed before step S3 is executed, the process proceeds from step S4 to step S23. In such a manner, in the present embodiment, in the case where the hard cleaning operation of the head 203 is executed, upon satisfying predetermined conditions, the control unit 217 executes the first purging operation in step S27 before executing the second purging operation in step S23, and the control unit 217 executes the confirmation operation upon satisfying predetermined conditions after the first purging operation, and then executes the second purging operation.

(Main Effects of Present Embodiment)

[0196] As described above, in the present embodiment, the control unit 217 executes the confirmation operation in which, in the state where the quantity of ink in the sub tank 211 is set to the first reference quantity, the opening and closing valves 224 and 225 are opened and the pump 214 is driven at a constant speed for the first time, and it is determined whether the quantity of ink in the sub tank 211 exceeds the second reference quantity based on the detection result of the detection mechanism 228.

[0197] Further, in the present embodiment, if the piping side joint portion 235 and the tank side joint portion 236 are normally connected, in the confirmation operation, the quantity of ink flowing from the buffer tank 212 to the main tank 213 is greater than the quantity of ink flowing from the buffer tank 212 to the sub tank 211, and the quantity of ink in the sub tank 211 does not exceed the second reference quantity. On the other hand, if the piping side joint portion 235 and the tank side joint portion 236 are not normally connected, since ink does not flow from the buffer tank 212 to the main tank 213, in the confirmation operation, the quantity of ink flowing from the buffer tank 212 to the sub tank 211 increases, and the quantity of ink in the sub tank 211 exceeds the second reference quantity.

[0198] Furthermore, in the present embodiment, when the quantity of ink in the sub tank 211 exceeds the second reference quantity in the confirmation operation, the control unit 217 stores the "abnormal state" as the state of the joint 234 in the control unit 217, and executes a predetermined processing for preventing execution of the circulation operation of ink between the main tank 213 and the buffer tank 212. Therefore, in the present embodiment, when a connection failure occurs in the joint 234, execution of the circulation operation of ink can be prevented between the main tank 213 and the buffer tank 212.

[0199] Further, in the present embodiment, when the quantity of ink in the sub tank 211 exceeds the second reference quantity in the confirmation operation, since the control unit 217 executes a predetermined error processing such as displaying a predetermined error message on the display unit 45, an operator can be enabled to easily recognize that a connection failure occurs in the joint 234.

[0200] Particularly, in the present embodiment, since the main tank 213 is capable of being removed from the printer 201 and replaced, the possibility of occurrence of a connection failure in the joint 234 after replacement of the main tank 213 becomes high. However, in the present embodiment, even if a connection failure occurs in the joint 234, execution of the circulation operation of ink can be prevented between the main tank 213 and the buffer tank 212. Further, even if a connection failure occurs in the joint 234, it becomes possible to enable an operator to easily recognize that a connection failure occurs in the joint 234.

[0201] In the present embodiment, the drive speed of the pump 214 when executing the confirmation operation is lower than the normal drive speed of the pump 214. According to studies by the inventors of the present application, in the case where the drive speed of the pump 214 when executing the confirmation operation

is equal to or higher than the normal drive speed, even if the piping side joint portion 235 and the tank side joint portion 236 are normally connected, ink flows easily from the buffer tank 212 to the sub tank 211 upon driving the pump 214 with the opening and closing valves 224 and 225 opened. Therefore, in such a case, even if the piping side joint portion 235 and the tank side joint portion 236 are normally connected, the quantity of ink in the sub tank 211 may still exceed the second reference quantity in the confirmation operation.

[0202] In this regard, according to the studies by the inventors of the present application, in the case where the drive speed of the pump 214 when executing the confirmation operation is lower than the normal drive speed, if the piping side joint portion 235 and the tank side joint portion 236 are normally connected, it becomes difficult for ink to flow from the buffer tank 212 to the sub tank 211 upon driving the pump 214 with the opening and closing valves 224 and 225 opened. In the present embodiment, since the drive speed of the pump 214 when executing the confirmation operation is lower than the normal drive speed, in the case where the piping side joint portion 235 and the tank side joint portion 236 are normally connected, the quantity of ink in the sub tank 211 can be prevented from exceeding the second reference quantity in the confirmation operation.

[0203] In the present embodiment, after the purging operation in the soft cleaning operation or the normal cleaning operation of the head 203 is executed, or after the first purging operation in the hard cleaning operation of the head 203 is executed, the quantity of ink in the sub tank 211 becomes the first reference quantity, and the control unit 217 executes the confirmation operation upon satisfying predetermined conditions after the purging operation. Therefore, in the present embodiment, it is not required to discharge ink from the head 203 until the quantity of ink in the sub tank 211 becomes the first reference quantity solely for executing the confirmation operation. Accordingly, in the present embodiment, even in executing the confirmation operation, wasteful consumption of ink is suppressed.

[0204] In the present embodiment, after the purging operation in the soft cleaning operation or the normal cleaning operation of the head 203 is executed, or after the first purging operation in the hard cleaning operation of the head 203 is executed, the control unit 217 drives the pump 214 with the opening and closing valve 224 opened and the opening and closing valve 225 closed to supply ink to the sub tank 211 until the quantity of ink in the sub tank 211 reaches the second reference quantity, and measures the second time, which is the time until the quantity of ink in the sub tank 211 reaches the second reference quantity. Further, in the present embodiment, in the case of not executing the confirmation operation after the purging operation, the control unit 217 stores the measured latest second time and calculates the first time based on the second time.

[0205] Therefore, in the present embodiment, even if the state of the supply route of ink from the buffer tank 212 to the sub tank 211 changes over time, it is possible to accurately determine whether the quantity of ink in the sub tank 211 exceeds the second reference quantity in the confirmation operation. For example, even if the filter 215 becomes clogged and it gradually becomes difficult for ink to flow from the buffer tank 212 to the sub tank 211 over time, it becomes possible to accurately determine whether the quantity of ink in the sub tank 211 exceeds the second reference quantity in the confirmation operation.

[0206] In the present embodiment, in the case where the hard cleaning operation is executed, the control unit 217 executes the first purging operation before executing the second purging operation upon satisfying predetermined conditions, executes the confirmation operation upon satisfying predetermined conditions after the first purging operation, and thereafter executes the second purging operation. Therefore, in the present embodiment, it becomes possible to shorten the time required for the confirmation operation compared to the case of executing the confirmation operation when the predetermined conditions are satisfied after the second purging operation.

(Other Embodiments)

[0207] The above-described embodiment is an example of a suitable embodiment of the present invention, but the present invention is not limited thereto, and various modifications may be implemented within the scope that does not change the gist of the present invention.

[0208] In the above-described embodiment, the hard cleaning operation of the head 203 may be the same operation as the soft cleaning operation and the normal cleaning operation of the head 203. That is, the hard cleaning operation of the head 203 may be executed according to the procedure represented in the flowchart of FIG. 15. Further, in the above-described embodiment, the drive speed of the pump 214 when executing the confirmation operation may also be equal to or higher than the normal drive speed. Furthermore, in the above-described embodiment, the second time may also be a fixed value that is not updated.

[0209] In the above-described embodiment, the confirmation operation may also be executed during the cleaning operation performed in the middle of printing on the medium 202. Further, in the above-described embodiment, it is also possible that the confirmation operation is not executed during the cleaning operation. For example, the confirmation operation may also be executed immediately after the main tank 213 is replaced or immediately after the printer 201 is started up. Furthermore, in the above-described embodiment, the detection mechanism 228 may also be a detection mechanism other than a liquid level detection mechanism. Further, in the above-described embodiment, at least any one of the opening and closing valves 223 to 225 may also be a

manual valve with which opening and closing operations are performed manually. Further, in the above-described embodiment, it is also possible that the buffer tank 212 is not an ink pack.

[0210] In the above-described embodiment, the printer 201 may also include a pump provided in the piping route 22219. In such a case, ink is supplied from the main tank 213 to the buffer tank 212 by such a pump. Further, in the above-described embodiment, the printer 201 is an apparatus for performing printing on the medium 202, but the printer 201 may also be used for applications other than printing on the medium 202. For example, the printer 201 may also be a 3D printer for forming three-dimensional shaped objects. Further, the printer 201 may also be an inkjet printer for general consumers.

Reference Signs List

[0211]

1 printer (inkjet printer)
5 head (inkjet head)
11 sub tank
15 opening and closing valve (second opening and closing valve)
17 main tank
18 buffer tank
19 pump
20 check valve
21 opening and closing valve
22 opening and closing valve (third opening and closing valve)
23 detection mechanism
101 printer (inkjet printer)
103 head (inkjet head)
111 sub tank
112 buffer tank (supplied side tank)
113 main tank
114 pump
115 filter (ink filter)
116 detection mechanism
117 control unit
119 piping route (first piping route)
122 piping route (fourth piping route)
124 opening and closing valve (first opening and closing valve)
125 opening and closing valve (second opening and closing valve)
130 connection spot
131 piping route (third piping route)
132 piping route (second piping route)
M1 reference quantity (first reference quantity)
M2 reference quantity (second reference quantity)
M3 reference quantity (third reference quantity)
T1 specific time (first specific time)
T2 specific time (second specific time)
201 printer (inkjet printer)
203 head (inkjet head)
211 sub tank
212 buffer tank
213 main tank
214 pump
217 control unit
221 piping route (first piping route)
222 piping route (second piping route)
224 opening and closing valve (first opening and closing valve)
225 opening and closing valve (second opening and closing valve)
228 detection mechanism
230 connection spot
234 joint
235 piping side joint portion
236 tank side joint portion
243 maintenance unit

Claims

1. An inkjet printer comprising:

an inkjet head discharging an ink;
a sub tank accommodating the ink to be supplied to the inkjet head;
a main tank accommodating the ink to be supplied to the sub tank;
a buffer tank provided in a piping route between the sub tank and the main tank and accommodating the ink;
a pump provided in a piping route between the sub tank and the buffer tank; and
a check valve provided in parallel with the buffer tank in a piping route between the main tank and the pump and allowing a flow of the ink only in a direction from the main tank toward the pump.

2. The inkjet printer according to claim 1, further comprising an opening and closing valve provided in a piping route between the main tank and the buffer tank.

3. The inkjet printer according to claim 1 or 2, wherein the ink is supplied from the main tank to the buffer tank using a head difference.

4. The inkjet printer according to claim 1 or 2, wherein the buffer tank is an ink pack formed in a bag shape.

5. The inkjet printer according to claim 1, further comprising:

a second opening and closing valve provided in a piping route between the sub tank and the pump; and
a third opening and closing valve provided in a piping route that has one end connected to a piping route between the second opening and

closing valve and the pump and has another end connected to the main tank.

6. The inkjet printer according to claim 5, further comprising an opening and closing valve provided in a piping route between the main tank and the buffer tank.

7. The inkjet printer according to claim 1 or 2, further comprising a detection mechanism for detecting a volume of the ink accommodated in the main tank, wherein
a volume of the ink accommodated in the buffer tank is indirectly detected by the detection mechanism.

8. An inkjet printer comprising an inkjet head discharging an ink, the inkjet printer comprising:

a main tank accommodating the ink;
a supplied side tank provided closer to the inkjet head side than the main tank in a piping route between the main tank and the inkjet head and accommodating the ink supplied from the main tank;
a pump for circulating the ink between the main tank and the supplied side tank;
a first piping route, which is a piping route for supply through which the ink flows from the main tank toward the supplied side tank;
a second piping route, which is a piping route for circulation in which the pump is provided and through which the ink flows from the supplied side tank toward the main tank;
a detection mechanism for detecting a quantity of the ink accommodated in the main tank; and
a control unit for controlling the inkjet printer, wherein
the control unit is configured to:

calculate an increase quantity of the ink over a predetermined first specific time in the main tank at intervals of the first specific time based on a detection result of the detection mechanism during ink circulation in which the pump is driven to circulate the ink between the main tank and the supplied side tank, and execute a predetermined error processing in a case where the calculated increase quantity is equal to or greater than a predetermined first reference quantity consecutively for a plurality of times, and calculate a variation quantity of the ink over a predetermined second specific time in the main tank at intervals of the second specific time based on the detection result of the detection mechanism during the ink circulation, calculate an ink variation quantity difference, which is a difference between a variation quantity of the ink over the second specific time in the main tank calculated a previous time and the variation quantity of the ink over the second specific time in the main tank calculated this time, at intervals of the second specific time, store a quantity of the ink in the main tank as an ink initial quantity in a case where an absolute value of the calculated ink variation quantity difference is equal to or less than a predetermined second reference quantity, which is less than the first reference quantity, consecutively for a plurality of times, and thereafter execute the error processing also in a case where an increase quantity of the ink in the main tank from the stored ink initial quantity is a predetermined third reference quantity, which is greater than the first reference quantity.

9. The inkjet printer according to claim 8, wherein
the main tank is capable of being removed from the inkjet printer and replaced.

10. The inkjet printer according to claim 9, further comprising:

a sub tank accommodating the ink to be supplied to the inkjet head;
a buffer tank serving as the supplied side tank accommodating the ink to be supplied to the sub tank and supplied from the main tank;
a first opening and closing valve; and
a second opening and closing valve, wherein
a connection spot is provided midway in a piping route connecting the buffer tank and the sub tank, and a piping route having one end connected to the main tank has another end connected to the connection spot,
the second piping route is constituted by a third piping route, which is a piping route between the buffer tank and the connection spot, and a fourth piping route, which is a piping route between the connection spot and the main tank,
the pump is provided in the third piping route,
the first opening and closing valve is provided in a piping route between the connection spot and the sub tank,
the second opening and closing valve is provided in the fourth piping route,
upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, the ink flows from the buffer tank toward the main tank, and
upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, the ink flows from the buffer tank toward the sub tank.

11. The inkjet printer according to claim 10, further comprising an ink filter provided in the third piping route, wherein
the ink is supplied from the main tank to the buffer tank using a head difference.

12. A method for controlling an inkjet printer, the inkjet printer comprising:

an inkjet head discharging an ink;
a main tank accommodating the ink;
a supplied side tank provided closer to the inkjet head side than the main tank in a piping route between the main tank and the inkjet head and accommodating the ink supplied from the main tank;
a pump for circulating the ink between the main tank and the supplied side tank;
a first piping route, which is a piping route for supply through which the ink flows from the main tank toward the supplied side tank;
a second piping route, which is a piping route for circulation in which the pump is provided and through which the ink flows from the supplied side tank toward the main tank; and
a detection mechanism for detecting a quantity of the ink accommodated in the main tank,
the method for controlling an inkjet printer comprising:

calculating an increase quantity of the ink over a predetermined first specific time in the main tank at intervals of the first specific time based on a detection result of the detection mechanism during ink circulation in which the pump is driven to circulate the ink between the main tank and the supplied side tank, and executing a predetermined error processing in a case where the calculated increase quantity is equal to or greater than a predetermined first reference quantity consecutively for a plurality of times, and calculating a variation quantity of the ink over a predetermined second specific time in the main tank at intervals of the second specific time based on the detection result of the detection mechanism during the ink circulation, calculating an ink variation quantity difference, which is a difference between a variation quantity of the ink over the second specific time in the main tank calculated a previous time and the variation quantity of the ink over the second specific time in the main tank calculated this time, at intervals of the second specific time, storing a quantity of the ink in the main tank as an ink initial quantity in a case where an absolute value of the calculated ink variation quantity difference is equal to or less than a predetermined second reference quantity, which is less than the first reference quantity, consecutively for a plurality of times, and thereafter executing the error processing also in a case where an increase quantity of the ink in the main tank from the stored ink initial quantity is a predetermined third reference quantity, which is greater than the first reference quantity.

13. An inkjet printer comprising an inkjet head discharging an ink, the inkjet printer comprising:

a sub tank accommodating the ink to be supplied to the inkjet head;
a buffer tank accommodating the ink to be supplied to the sub tank;
a main tank accommodating the ink to be supplied to the buffer tank;
a pump provided in a piping route between the buffer tank and the sub tank;
a first piping route, which is a piping route connecting the pump and the sub tank;
a second piping route, which is a piping route connecting the first piping route and the main tank;
a joint having a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected;
a first opening and closing valve provided in a piping route between the sub tank and a connection spot connecting the first piping route and the second piping route;
a second opening and closing valve provided in the second piping route;
a detection mechanism for detecting a quantity of the ink accommodated in the sub tank; and
a control unit for controlling the inkjet printer, wherein
upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, the ink flows from the buffer tank toward the main tank,
upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, the ink flows from the buffer tank toward the sub tank,
upon driving the pump with the first opening and closing valve and the second opening and closing valve opened in a case where the piping side joint portion and the tank side joint portion are normally connected, a quantity of the ink flowing from the buffer tank to the main tank is greater than a quantity of the ink flowing from the buffer tank to the sub tank,
with the piping side joint portion and the tank side

joint portion separated, the piping side joint portion is sealed such that the ink does not flow out, and

the control unit is configured to execute a confirmation operation in which, in a state where the quantity of the ink in the sub tank is set to a predetermined first reference quantity, the first opening and closing valve and the second opening and closing valve are opened and the pump is driven at a constant speed for a predetermined first time, and it is determined whether the quantity of the ink in the sub tank exceeds a predetermined second reference quantity based on a detection result of the detection mechanism.

14. The inkjet printer according to claim 13, wherein
the main tank is capable of being removed from the inkjet printer and replaced.

15. The inkjet printer according to claim 13 or 14, wherein
a drive speed of the pump during executing the confirmation operation is lower than a drive speed of the pump during printing by the inkjet printer in which the pump is driven with the first opening and closing valve opened and the second opening and closing valve closed and the ink flows from the buffer tank toward the sub tank.

16. The inkjet printer according to claim 13 or 14, further comprising a maintenance unit with which a cleaning operation of the inkjet head is performed for preventing clogging of a plurality of nozzles of the inkjet head, wherein
the control unit is configured to execute the confirmation operation during the cleaning operation.

17. The inkjet printer according to claim 16, wherein

the cleaning operation comprises a purging operation in which pressure in the sub tank is configured to be a positive pressure to discharge the ink from the inkjet head,

after the purging operation, the quantity of the ink in the sub tank becomes the first reference quantity, and

the control unit is configured to execute the confirmation operation upon satisfying predetermined conditions after the purging operation.

18. The inkjet printer according to claim 17, wherein
the control unit is configured to:

drive the pump with the first opening and closing valve opened and the second opening and closing valve closed after the purging operation to supply the ink to the sub tank until the quantity of the ink in the sub tank reaches the second reference quantity, and

measure a second time, which is a time until the quantity of the ink in the sub tank reaches the second reference quantity, store the measured latest second time in a case where the confirmation operation is not executed after the purging operation, and calculate the first time based on the second time.

19. The inkjet printer according to claim 18, wherein
a drive speed of the pump during executing the confirmation operation is lower than a drive speed of the pump during supplying the ink to the sub tank without executing the confirmation operation after the purging operation.

20. The inkjet printer according to claim 16, wherein

the cleaning operation comprises a soft cleaning operation and a hard cleaning operation in which a quantity of discharging the ink from the inkjet head increases and a required time is longer compared to the soft cleaning operation,

the soft cleaning operation comprises a first purging operation in which pressure in the sub tank is configured to be a positive pressure to discharge the ink from the inkjet head,

the hard cleaning operation comprises a second purging operation in which pressure in the sub tank is configured to be a positive pressure to discharge the ink from the inkjet head,

a quantity of the ink discharged from the inkjet head in the second purging operation is greater than a quantity of the ink discharged from the inkjet head in the first purging operation,

a time required for the second purging operation is longer than a time required for the first purging operation,

after the first purging operation, the quantity of the ink in the sub tank becomes the first reference quantity, and

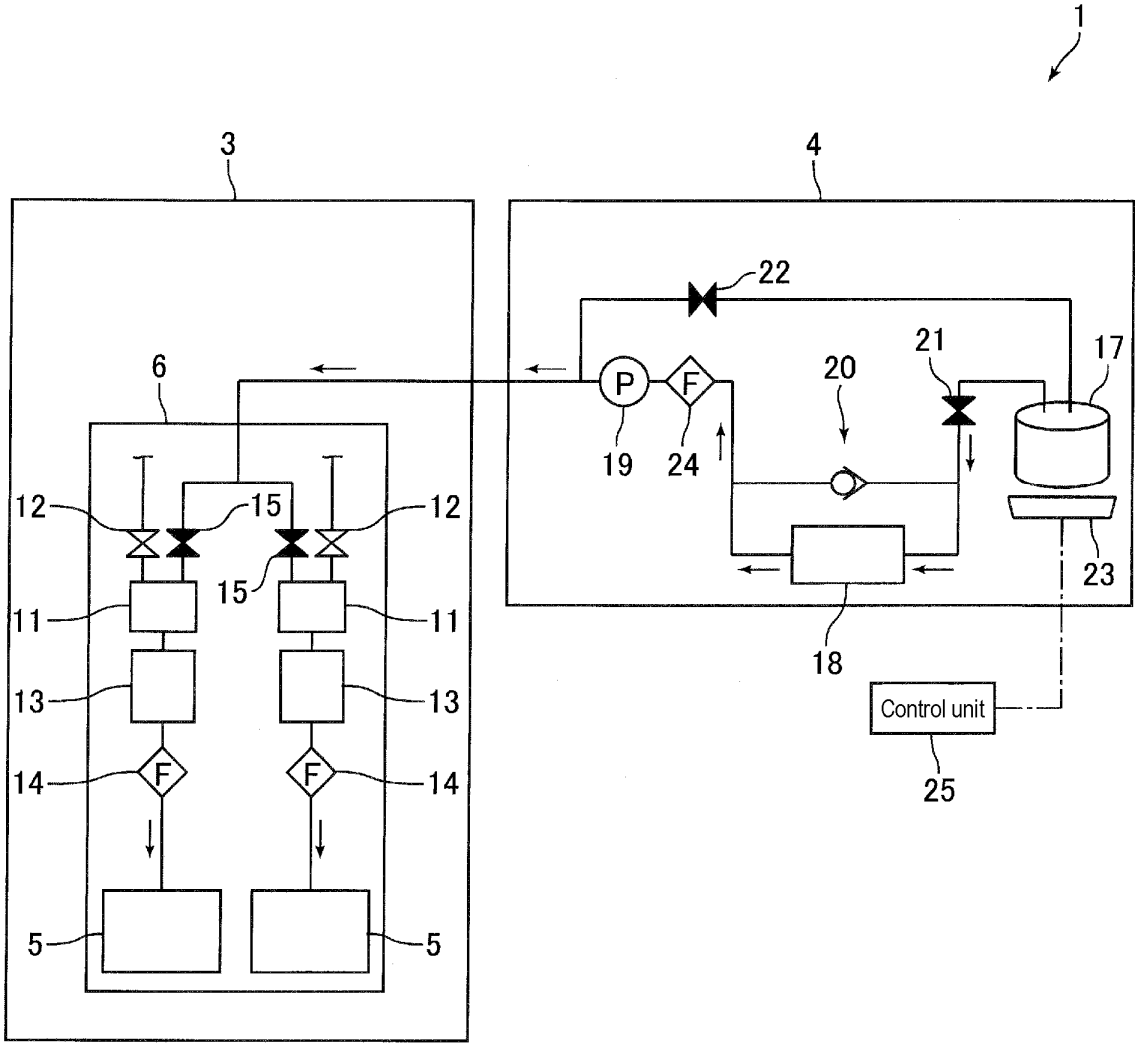
the control unit is configured to execute the first purging operation before executing the second purging operation upon satisfying predetermined conditions in a case where the hard cleaning operation is executed, execute the confirmation operation upon satisfying predetermined conditions after the first purging operation, and thereafter execute the second purging operation.

21. A method for controlling an inkjet printer, the inkjet printer comprising:

an inkjet head discharging an ink;

a sub tank accommodating the ink to be supplied to the inkjet head;

a buffer tank accommodating the ink to be supplied to the sub tank;
a main tank accommodating the ink to be supplied to the buffer tank;
a pump provided in a piping route between the buffer tank and the sub tank;
a first piping route, which is a piping route connecting the pump and the sub tank;
a second piping route, which is a piping route connecting the first piping route and the main tank;
a joint having a piping side joint portion attached to an end of the second piping route and a tank side joint portion attached to the main tank and to which the piping side joint portion is connected;
a first opening and closing valve provided in a piping route between the sub tank and a connection spot connecting the first piping route and the second piping route;
a second opening and closing valve provided in the second piping route; and
a detection mechanism for detecting a quantity of the ink accommodated in the sub tank, wherein
upon driving the pump with the second opening and closing valve opened and the first opening and closing valve closed, the ink flows from the buffer tank toward the main tank,
upon driving the pump with the first opening and closing valve opened and the second opening and closing valve closed, the ink flows from the buffer tank toward the sub tank,
upon driving the pump with the first opening and closing valve and the second opening and closing valve opened in a case where the piping side joint portion and the tank side joint portion are normally connected, a quantity of the ink flowing from the buffer tank to the main tank is greater than a quantity of the ink flowing from the buffer tank to the sub tank, and
with the piping side joint portion and the tank side joint portion separated, the piping side joint portion is sealed such that the ink does not flow out,
the method for controlling an inkjet printer comprising:
executing a confirmation operation in which, in a state where the quantity of the ink in the sub tank is set to a predetermined first reference quantity, the first opening and closing valve and the second opening and closing valve are opened and the pump is driven at a constant speed for a predetermined first time, and it is determined whether the quantity of the ink in the sub tank exceeds a predetermined second reference quantity based on a detection result of the detection mechanism.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Control unit
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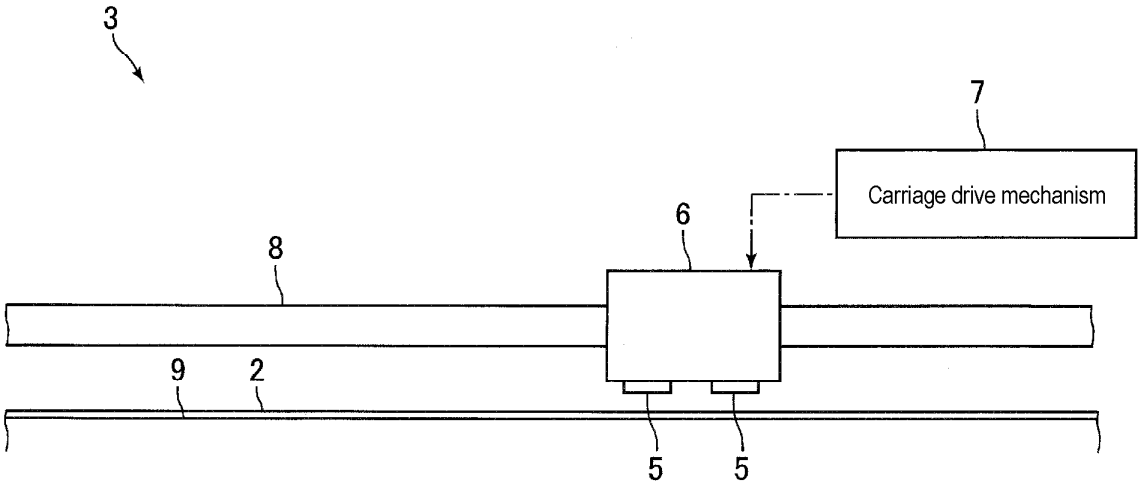
FIG. 1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Carriage drive mechanism
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FIG. 2

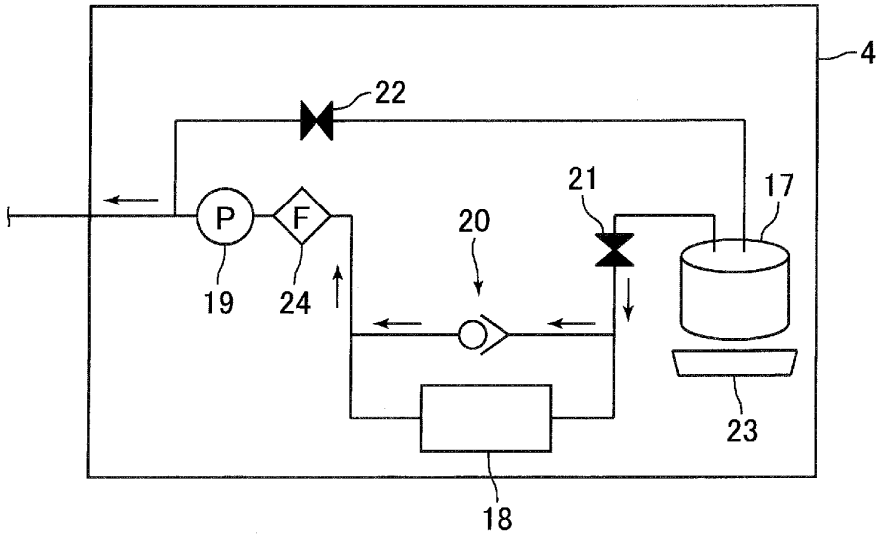

FIG. 3

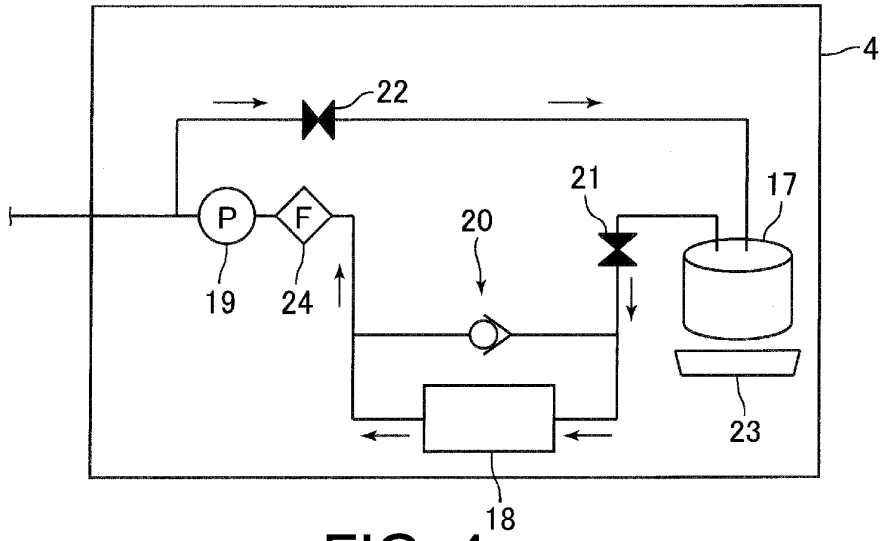

FIG. 4

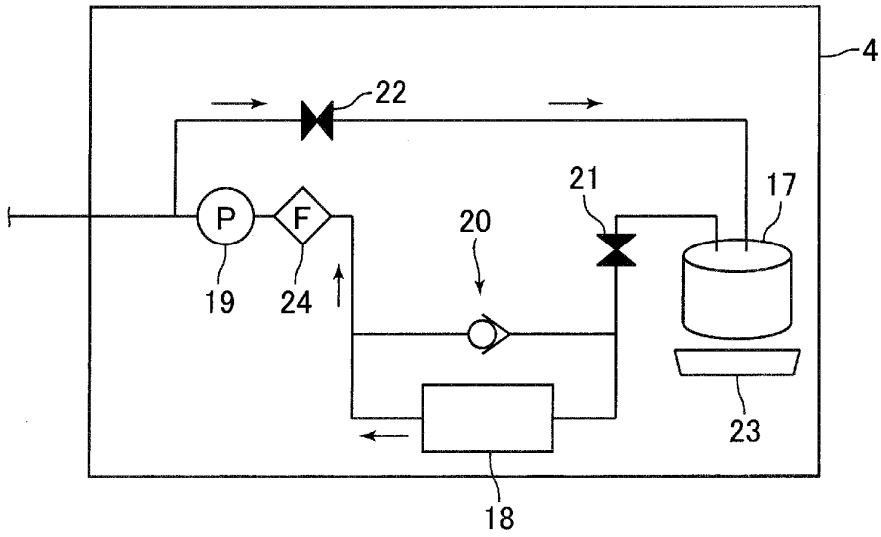

FIG. 5

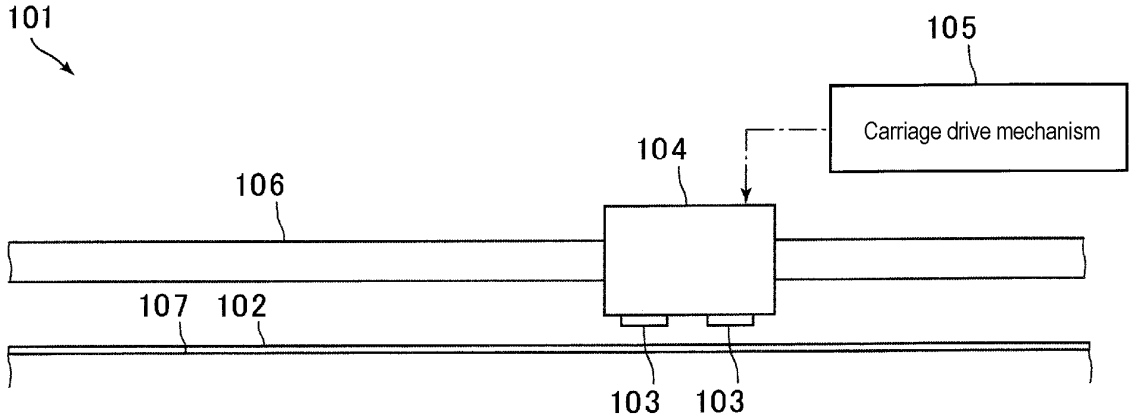

FIG. 6

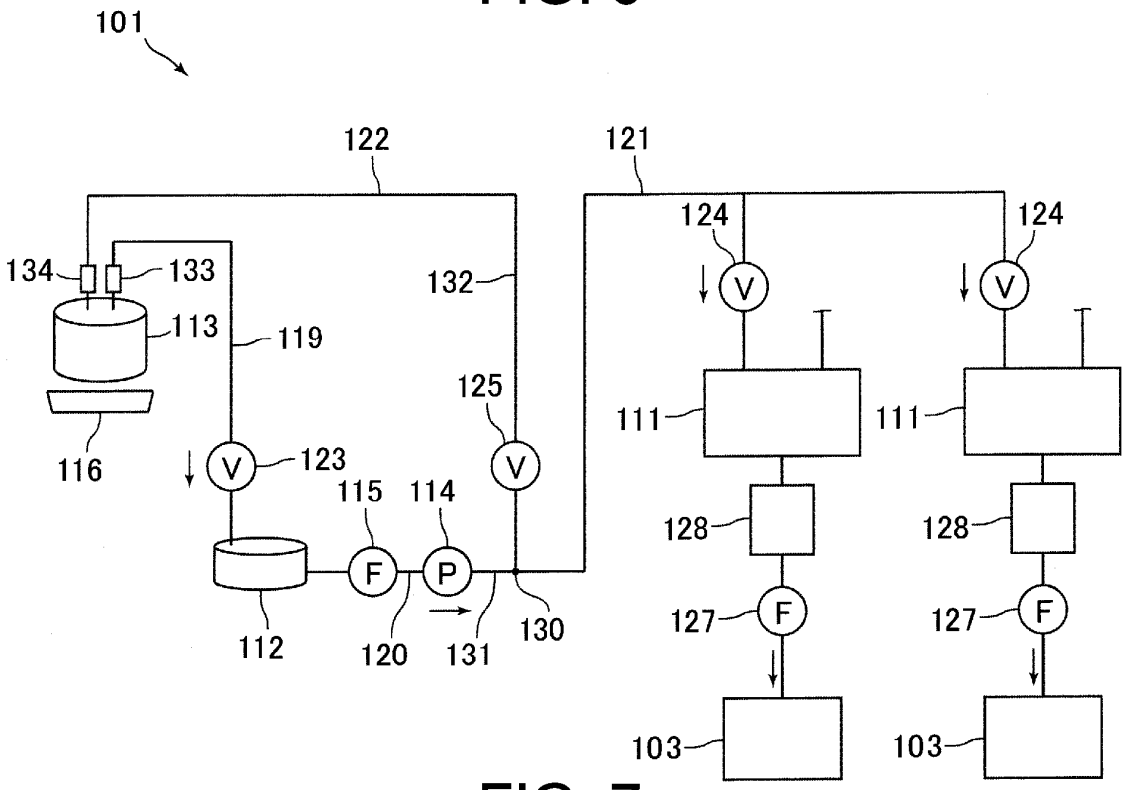

FIG. 7

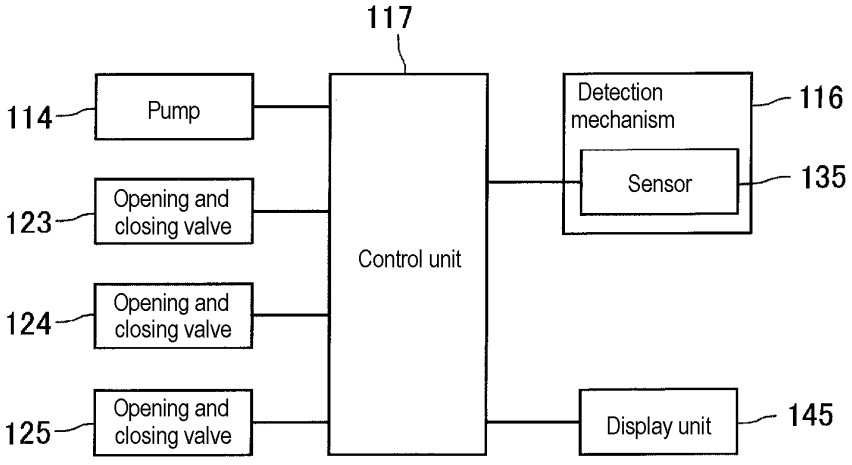

FIG. 8

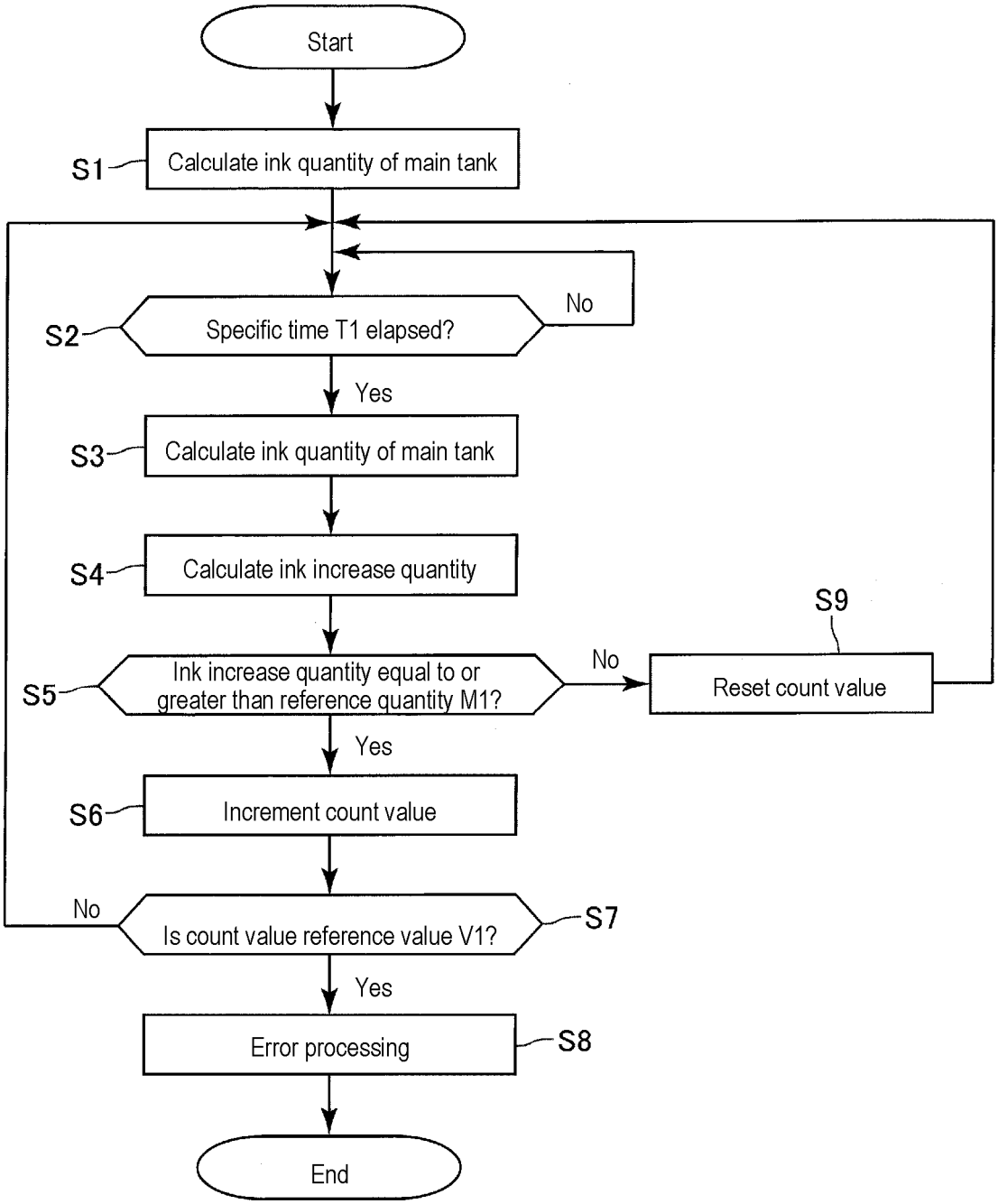
Start
S1
Calculate ink quantity of main tank
S2
Specific time T1 elapsed?
No
Yes
S3
Calculate ink quantity of main tank
S4
Calculate ink increase quantity
S5
Ink increase quantity equal to or greater than reference quantity M1?
No
S9
Reset count value
Yes
S6
Increment count value
No
Is count value reference value V1?
S7
Yes
Error processing
S8
End

FIG. 9

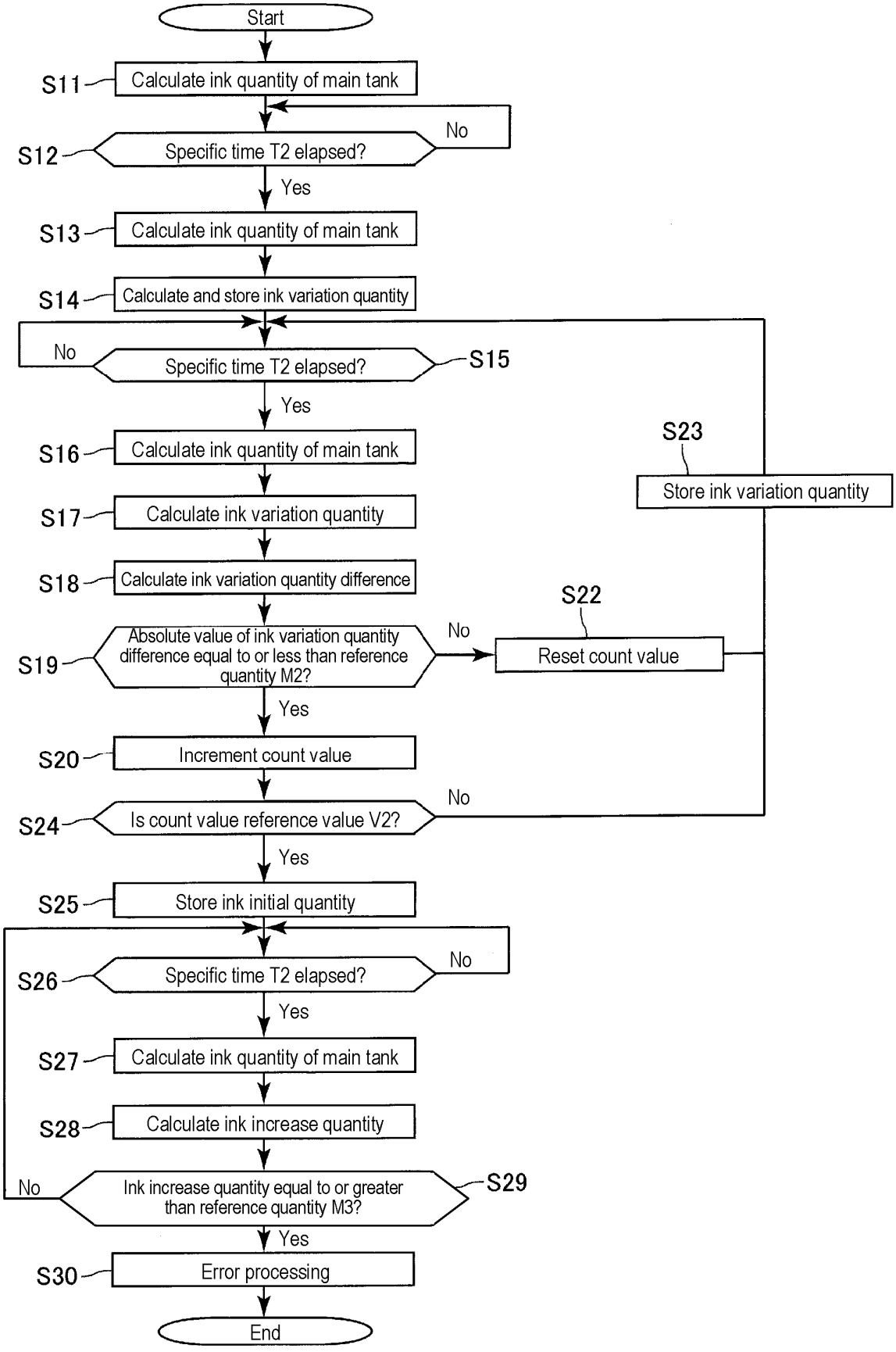
Start
S11
Calculate ink quantity of main tank
S12
Specific time T2 elapsed?
No
Yes
S13
Calculate ink quantity of main tank
S14
Calculate and store ink variation quantity
No
Specific time T2 elapsed?
S15
Yes
S16
Calculate ink quantity of main tank
S17
Calculate ink variation quantity
S18
Calculate ink variation quantity difference
S19
Absolute value of ink variation quantity difference equal to or less than reference quantity M2?
No
S22
Reset count value
S23
Store ink variation quantity
Yes
S20
Increment count value
S24
Is count value reference value V2?
No
Yes
S25
Store ink initial quantity
S26
Specific time T2 elapsed?
No
Yes
S27
Calculate ink quantity of main tank
S28
Calculate ink increase quantity
No
Ink increase quantity equal to or greater than reference quantity M3?
S29
Yes
S30
Error processing
End

FIG. 10

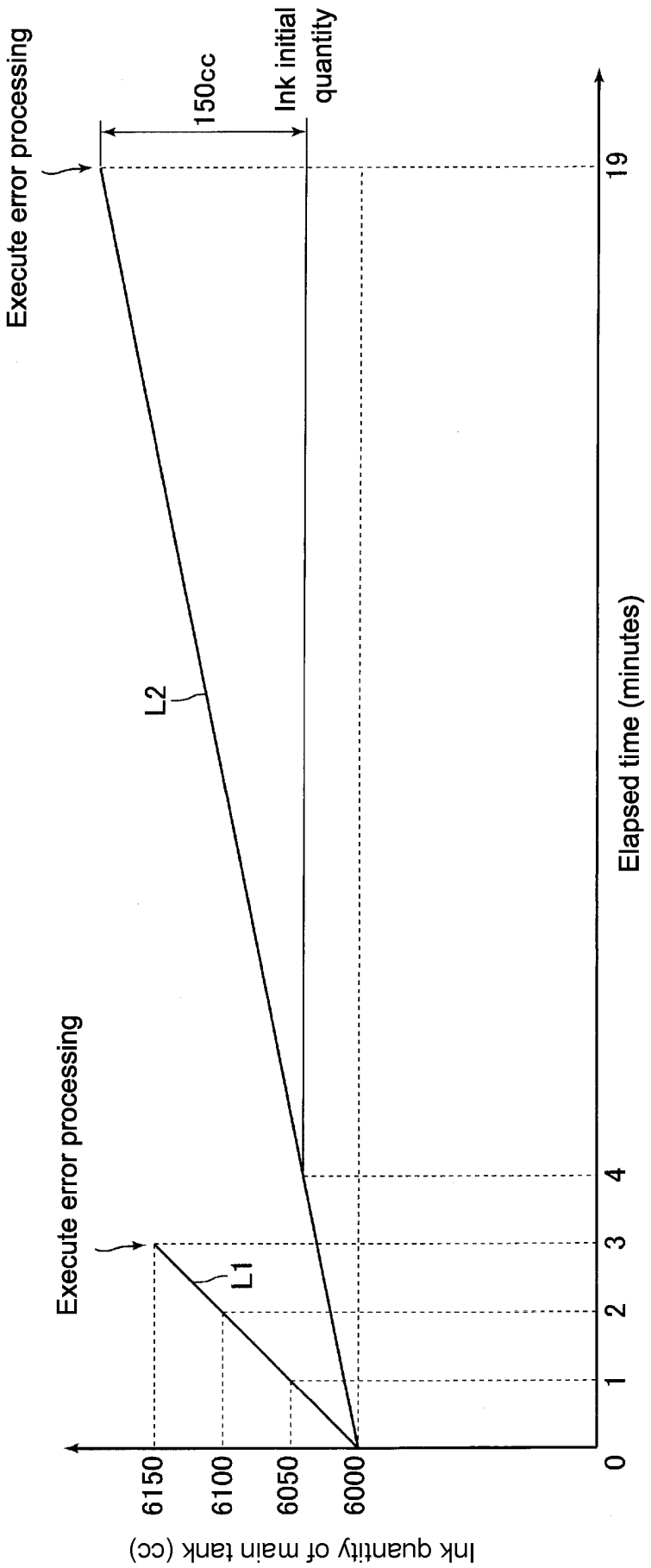
Execute error processing
150cc
Ink initial quantity
L2
L1
Execute error processing
Elapsed time (minutes)
0
1
2
3
4
19
6150
6100
6050
6000
Ink quantity of main tank (cc)

FIG. 11

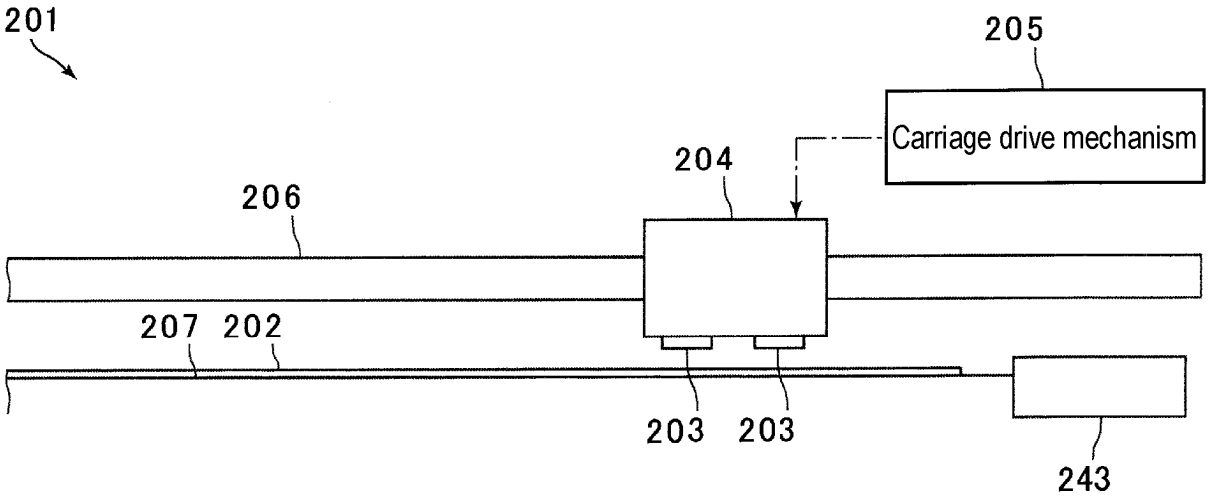
201
205
Carriage drive mechanism
204
206
207
202
203
203
243

FIG. 12

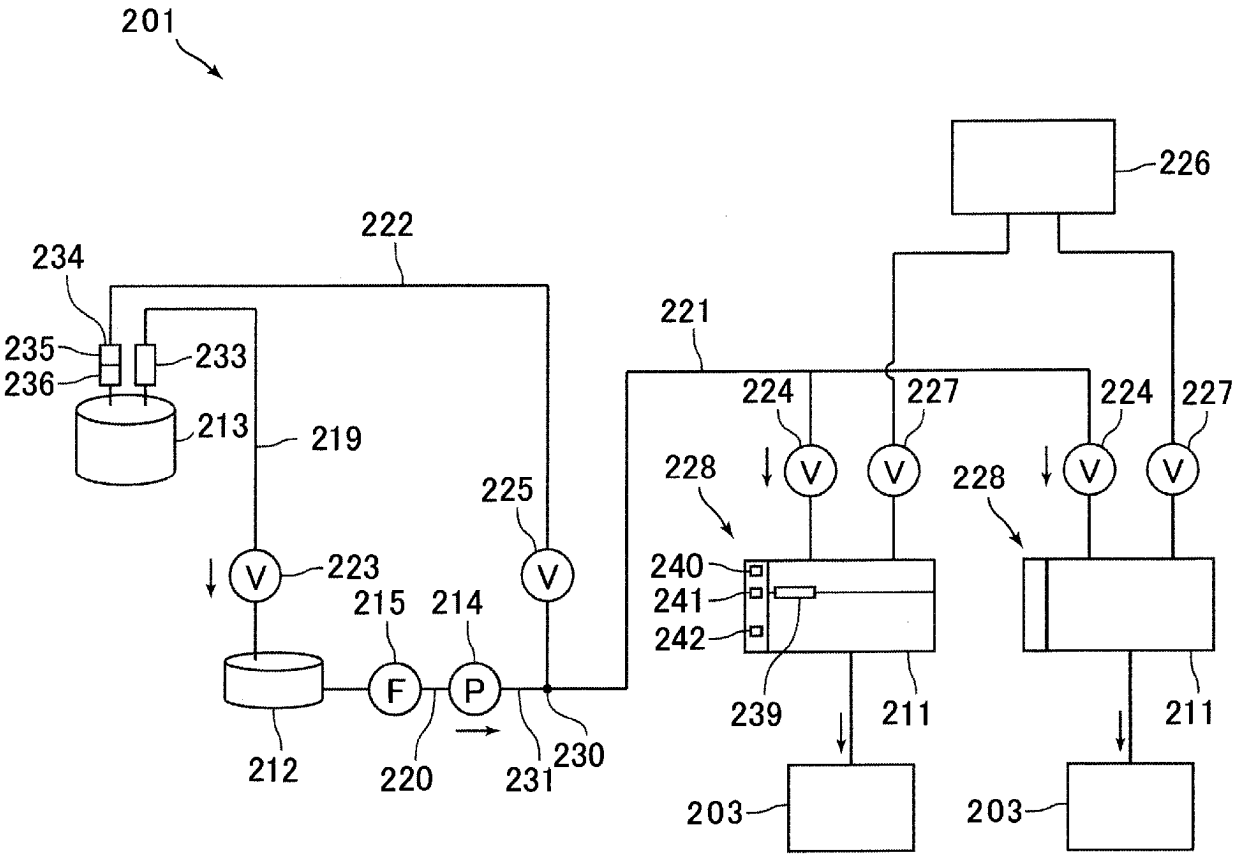
201
226
222
234
221
235
236
233
213
219
224
227
224
227
228
V
V
V
V
228
225
V
223
V
240
241
242
215
214
F
P
239
211
211
212
220
231
230
203
203

FIG. 13

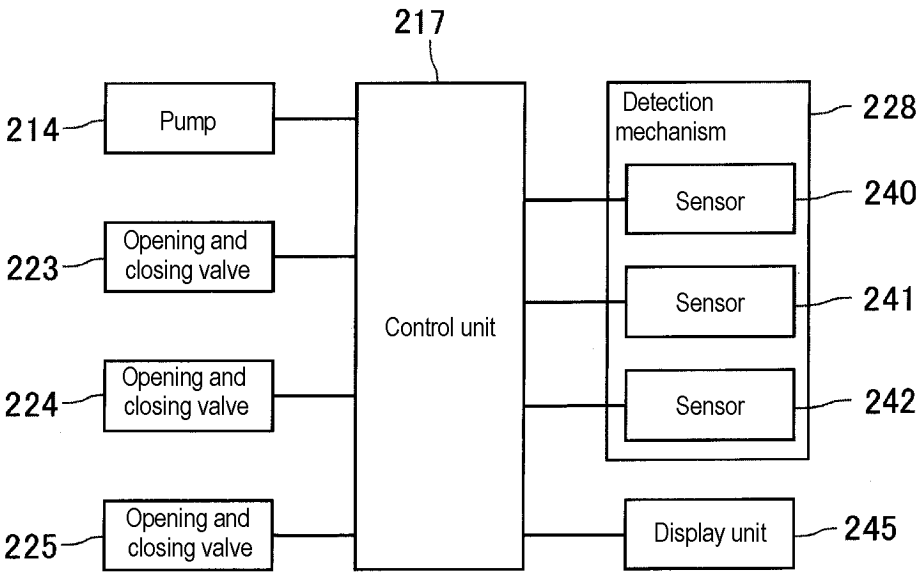
217
214
Pump
223
Opening and closing valve
224
Opening and closing valve
225
Opening and closing valve
Control unit
Detection mechanism
228
Sensor
240
Sensor
241
Sensor
242
Display unit
245

FIG. 14

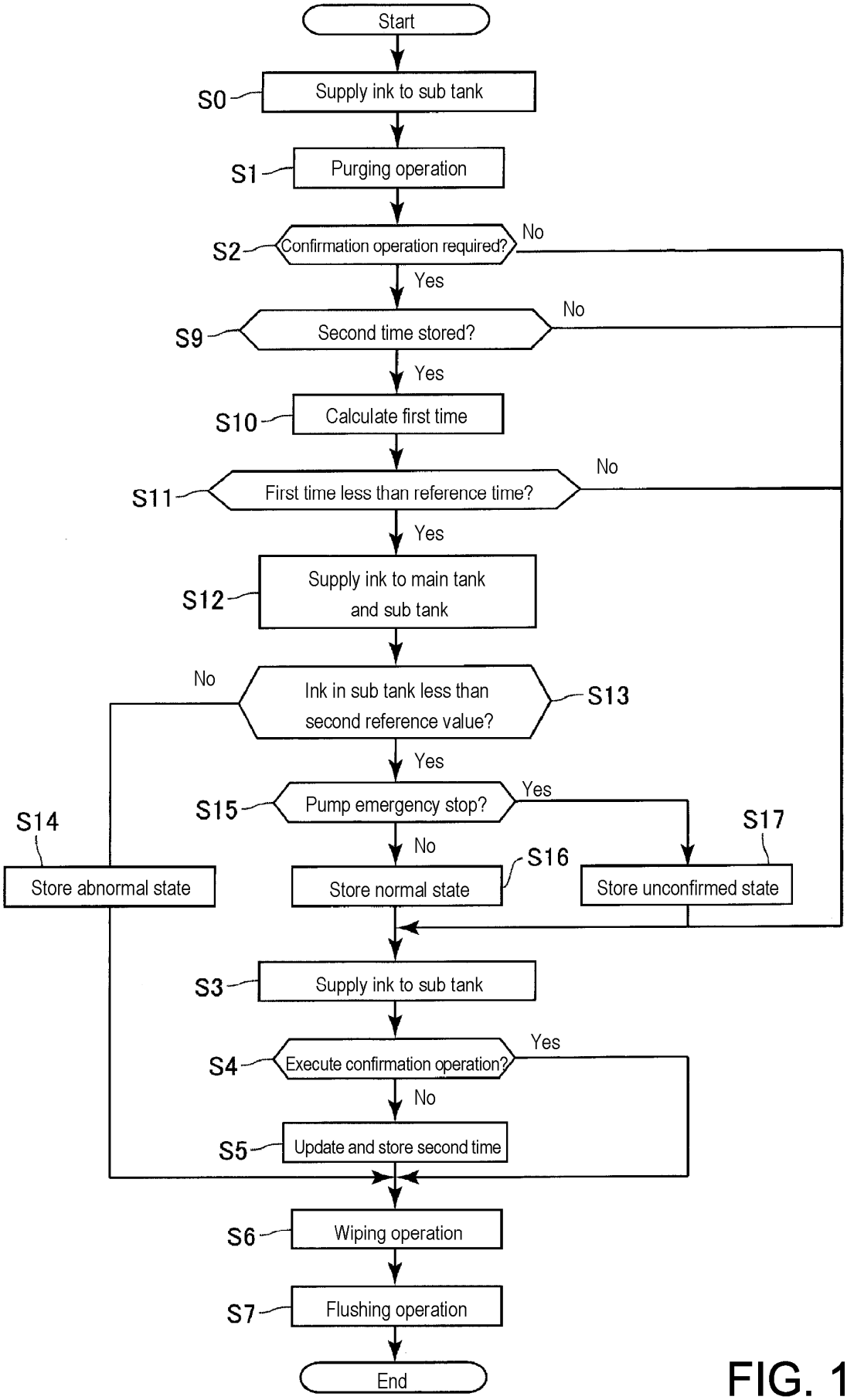
Start
S0
Supply ink to sub tank
S1
Purging operation
S2
Confirmation operation required?
No
Yes
S9
Second time stored?
No
Yes
S10
Calculate first time
S11
First time less than reference time?
No
Yes
S12
Supply ink to main tank and sub tank
No
Ink in sub tank less than second reference value?
S13
Yes
S15
Pump emergency stop?
Yes
No
S14
Store abnormal state
S16
Store normal state
S17
Store unconfirmed state
S3
Supply ink to sub tank
S4
Execute confirmation operation?
Yes
No
S5
Update and store second time
S6
Wiping operation
S7
Flushing operation
End

FIG. 15

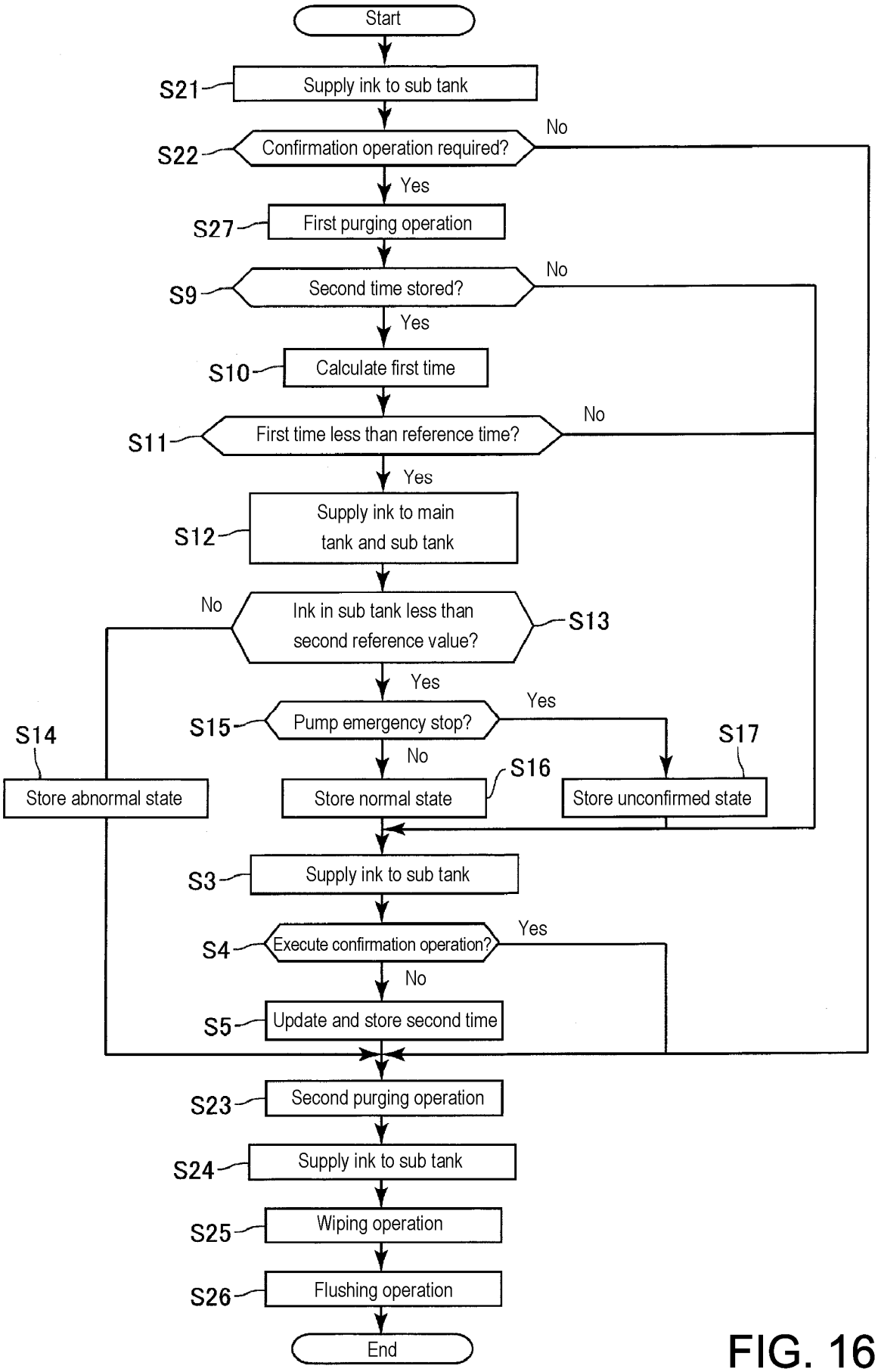
Start
S21
Supply ink to sub tank
S22
Confirmation operation required?
No
Yes
S27
First purging operation
S9
Second time stored?
No
Yes
S10
Calculate first time
S11
First time less than reference time?
No
Yes
S12
Supply ink to main tank and sub tank
No
Ink in sub tank less than second reference value?
S13
Yes
S15
Pump emergency stop?
Yes
S14
S17
No
S16
Store abnormal state
Store normal state
Store unconfirmed state
S3
Supply ink to sub tank
S4
Execute confirmation operation?
Yes
No
S5
Update and store second time
S23
Second purging operation
S24
Supply ink to sub tank
S25
Wiping operation
S26
Flushing operation
End

FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/030933

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/18(2006.01)i; ***B41J 2/01***(2006.01)i; ***B41J 2/165***(2006.01)i; ***B41J 2/175***(2006.01)i
FI: B41J2/18; B41J2/175 121; B41J2/175 113; B41J2/175 503; B41J2/01 451; B41J2/175 143; B41J2/175 115; B41J2/01 401; B41J2/165 207; B41J2/175 501; B41J2/175 119

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B41J2/18; B41J2/01; B41J2/165; B41J2/175

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2024
Registered utility model specifications of Japan 1996-2024
Published registered utility model applications of Japan 1994-2024

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2023-047194 A (SCREEN HOLDINGS CO., LTD.) 05 April 2023 (2023-04-05) entire text, all drawings	1-21
A	JP 2019-059046 A (TOSHIBA TEC KABUSHIKI KAISHA) 18 April 2019 (2019-04-18) entire text, all drawings	1-21
A	JP 2012-218302 A (SEIKO I INFOTECH INC.) 12 November 2012 (2012-11-12) entire text, all drawings	1-21
A	JP 11-042771 A (CANON KABUSHIKI KAISHA) 16 February 1999 (1999-02-16) entire text, all drawings	1-21

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 October 2024	**12 November 2024**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/030933

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2023-047194 A	05 April 2023	WO 2023/047781 A1	
		EP 4406745 A1	
JP 2019-059046 A	18 April 2019	US 2019/0092034 A1	
		EP 3459746 A1	
		CN 109551897 A	
JP 2012-218302 A	12 November 2012	WO 2012/137523 A1	
JP 11-042771 A	16 February 1999	(Family: none)	

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2020116813 A **[0007]**
- JP 2023007061 A **[0007]**
- JP 2010083021 A **[0007]**