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### PRINTING APPARATUS AND INK QUANTITY DETECTION METHOD THEREOF

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#### Abstract

A printing apparatus according to this invention counts an ink quantity in an ink tank in accordance with consumption of ink from the ink tank, updates and holds a count value obtained by the count in a counter, and detects whether ink injection to the ink tank has been done before execution of sensing by a sensing unit configured to sense whether a predetermined quantity of ink is present in the ink tank. If sensing by the sensing unit is executed, the apparatus reads out a preceding sensing result from a memory that stores a sensing result of presence/absence of the ink by the sensing unit, verifies a transition between the preceding sensing result and a current sensing result, and controls operations of reset of the count value held by the counter and the count based on the transition and a result of the detection.

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## Background/Summary

### BACKGROUND OF THE INVENTION

#### Field of the Invention

[0001] The present invention relates to a printing apparatus and an ink quantity detection method thereof, and particularly to a printing apparatus configured to perform printing by discharging ink from a printhead in accordance with, for example, an inkjet method, and an ink quantity detection method thereof.

#### Description of the Related Art

[0002] Conventionally, for an inkjet printing apparatus (to be referred to as a printing apparatus hereinafter) including a refillable ink tank that a user can inject with ink via an inlet port, there has been proposed an arrangement for detecting, using a sensor in the ink tank, whether a predetermined ink quantity is present in the ink tank.

[0003] For example, Japanese Patent Laid-Open No. 2016-179677 discloses a printing apparatus having the following arrangement. That is, the printing apparatus includes a calculation unit configured to calculate an ink consumption quantity, a storage unit configured to store a count value updated based on the ink consumption quantity calculated by the calculation unit, and a pair of electrodes configured to detect whether ink is present at a predetermined position in an ink tank. A control unit measures a voltage across the pair of electrodes, thereby detecting the presence/absence of ink. Upon judging, before the count value is returned to an initial value, that the ink is present, the control unit controls to return the count value to the initial value.

[0004] However, the printing apparatus described in Japanese Patent Laid-Open No. 2016-179677 has the following problem. That is, if air in the ink tank expands/contracts due to a change in the atmospheric pressure or temperature in the ink tank, an ink liquid surface level changes, and the sensor reacts to the change, although the actual ink quantity does not change. As a result, an error occurs in the count value updated based on the ink consumption quantity.

### SUMMARY OF THE INVENTION

[0005] Accordingly, the present invention is conceived as a response to the above-described disadvantages of the conventional art.

[0006] For example, a printing apparatus and an ink quantity detection method thereof according to this invention are capable of accurately detecting an ink quantity in an ink tank regardless of a change in an environment.

[0007] According to one aspect of the present invention, there is provided a printing apparatus including an ink tank that contains ink injected from an inlet port, a printhead configured to print by discharging ink supplied from the ink tank, a sensing unit configured to sense whether a predetermined quantity of ink is present in the ink tank, comprising: a memory unit configured to

store a sensing result by the sensing unit; a counting unit configured to count an ink quantity in the ink tank in accordance with consumption of the ink from the ink tank; a first counter configured to update and hold a count value by the counting unit; a verification unit configured to, if sensing by the sensing unit is executed, read out a preceding sensing result from the memory unit and verify a transition between the preceding sensing result and a current sensing result; a detection unit configured to detect whether ink injection to the ink tank has been done before execution of sensing by the sensing unit; and a control unit configured to control operations of reset of the count value held by the first counter and count by the counting unit based on the transition obtained by the verification unit and a result of detection by the detection unit.

[0008] According to another aspect of the present invention, there is provided an ink quantity detection method of a printing apparatus including an ink tank that contains ink injected from an inlet port, a printhead configured to print by discharging ink supplied from the ink tank, and a sensing unit configured to sense whether a predetermined quantity of ink is present in the ink tank, comprising: counting an ink quantity in the ink tank in accordance with consumption of the ink from the ink tank; updating and holding a count value obtained by the counting in a counter; detecting whether ink injection to the ink tank has been done before execution of sensing by the sensing unit; if sensing by the sensing unit is executed, reading out a preceding sensing result from a memory that stores a sensing result of presence/absence of the ink by the sensing unit and verifying a transition between the preceding sensing result and a current sensing result; and controlling operations of reset of the count value held by the counter and the count based on the transition obtained in the verifying and a result of detection in the detecting.

[0009] According to still another aspect of the present invention, there is provided a printing apparatus comprising: a printhead configured to discharge ink; an ink tank configured to contain ink to be supplied to the printhead and including an inlet port from which the ink is injected; a cover configured to cover the inlet port; an open/close detection unit configured to detect open/close of the cover; a detection unit configured to detect whether a predetermined quantity of ink contained in the ink tank is present; a memory configured to store a preceding detection result by the detection unit; and a notification unit configured to notify a status of the apparatus, wherein if the preceding detection result by the detection unit is absence, and a current detection result is presence, the notification unit notifies that an ink quantity has increased in a case where the open/close detection unit detects that the cover is closed, and the notification by the notification unit is not made in a case where the open/close detection unit does not detect that the cover is closed.

[0010] The invention is particularly advantageous since the transition of a change between preceding ink presence/absence detection and current ink presence/absence detection is taken into consideration, it is possible to suppress an error between an actual ink quantity and a count value, and accurately grasp the ink quantity in an ink tank.

[0011] Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a perspective view showing the schematic arrangement of a printing apparatus including an inkjet printhead according to an exemplary embodiment of the present invention;

[0013] FIGS. 2A, 2B, and 2C are perspective views showing the outline of the internal mechanism of the printing apparatus shown in FIG. 1;

[0014] FIG. 3 is a sectional view schematically showing an example of the ink supply system of the printing apparatus shown in FIG. 1;

[0015] FIGS. 4A, 4B, and 4C are sectional views schematically showing an example of ink

injection of the printing apparatus shown in FIG. 1;  
[0016] FIG. 5 is a block diagram showing the control configuration of the printing apparatus shown in FIG. 1;  
[0017] FIG. 6 is a flowchart showing ink residual quantity detection processing according to the first embodiment;  
[0018] FIG. 7 is a flowchart showing predetermined ink quantity presence/absence detection processing according to the first embodiment;  
[0019] FIG. 8 is a view showing a display screen that displays an ink residual quantity state on a portable device according to the first embodiment;  
[0020] FIG. 9 is a flowchart showing ink residual quantity detection processing according to the second embodiment; and  
[0021] FIG. 10 is a flowchart showing ink residual quantity detection processing according to the third embodiment.

## DESCRIPTION OF THE EMBODIMENTS

[0022] Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention. Multiple features are described in the embodiments, but limitation is not made an invention that requires all such features, and multiple such features may be combined as appropriate. Furthermore, in the attached drawings, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.

[0023] In this specification, the terms “print” and “printing” not only include the formation of significant information such as characters and graphics, but also broadly includes the formation of images, figures, patterns, and the like on a print medium, or the processing of the medium, regardless of whether they are significant or insignificant and whether they are so visualized as to be visually perceivable by humans.

[0024] Also, the term “print medium” not only includes a paper sheet used in common printing apparatuses, but also broadly includes materials, such as cloth, a plastic film, a metal plate, glass, ceramics, wood, and leather, capable of accepting ink.

[0025] Furthermore, the term “ink” (to be also referred to as a “liquid” hereinafter) should be broadly interpreted to be similar to the definition of “print” described above. That is, “ink” includes a liquid which, when applied onto a print medium, can form images, figures, patterns, and the like, can process the print medium, and can process ink. The process of ink includes, for example, solidifying or insolubilizing a coloring agent contained in ink applied to the print medium.

[0026] Further, a “nozzle” (to be also referred to as “print element” hereinafter) generically means an ink orifice or a liquid channel communicating with it, and an element for generating energy used to discharge ink, unless otherwise specified.

[0027] An element substrate for a printhead (head substrate) used below means not merely a base made of a silicon semiconductor, but an arrangement in which elements, wirings, and the like are arranged.

[0028] Further, “on the substrate” means not merely “on an element substrate”, but even “the surface of the element substrate” and “inside the element substrate near the surface”. In the present invention, “built-in” means not merely arranging respective elements as separate members on the base surface, but integrally forming and manufacturing respective elements on an element substrate by a semiconductor circuit manufacturing process or the like.

Description of Outline of Printing Apparatus (FIGS. 1 to 4)

[0029] FIG. 1 is a perspective view showing the outline of the mechanism of a printing apparatus 10 that performs printing using an inkjet printhead (to be referred to as a printhead hereinafter) according to an exemplary embodiment of the present invention. As shown in FIG. 1, the printing apparatus 10 includes a printhead (not shown) detachably mounted on a carriage 104 and configured to discharge ink, a supply tube 111 configured to supply the ink to the printhead, and an

inktank that contains the ink.

[0030] As the inktank, the printing apparatus **10** includes four inktanks, that is, an inktank **105** that contains black ink, an inktank **106** that contains cyan ink, an inktank **107** that contains magenta ink, and an inktank **108** that contains yellow ink. The printing apparatus **10** also includes a first cover **109** that covers the inktank **105**, and a second cover **110** that covers the inktanks **106**, **107**, and **108**. The carriage **104** is supported to be reciprocally movable in an X direction along a guide rail installed in the printing apparatus **10**. When performing printing on a print medium, the carriage **104** reciprocally moves in a print region via a carriage belt (not shown) driven by a carriage motor (not shown).

[0031] In addition, the printing apparatus **10** includes a feeding unit **102** that feeds a print medium, a conveyance unit **103** that conveys the print medium in a Y direction orthogonal to the X direction, and a recovery mechanism **112** that performs a recovery operation to maintain the ink discharge performance of the printhead to hold the quality of a printed image. The recovery mechanism **112** is arranged outside the print region and inside the moving region of the carriage **104**.

[0032] Note that the printhead mounted on the carriage is a printhead according to an inkjet method of discharging ink using thermal energy, and includes a plurality of electrothermal transducers configured to generate the thermal energy. According to this method, thermal energy is generated by a pulse signal applied to the electrothermal transducers, film boiling is caused in ink by the thermal energy, and ink is discharged from orifices using the bubbling pressure of film boiling, thereby performing printing.

[0033] FIGS. 2A to 2C are external perspective views of the printing apparatus including the same internal mechanism as shown in FIG. 1.

[0034] FIG. 2A shows a state in which the printing apparatus **10** is provided with an access cover **301** in which a scanner unit including a read unit (ADF) capable of reading images of stacked originals is mounted. The access cover **301** is axially supported to be opened/closed with respect to the main body of the printing apparatus **10**. The printing apparatus **10** includes, on the front surface, an operation unit **4** on which the user can perform an operation such as instruction input to the printing apparatus **10**. The operation unit **4** includes a display panel capable of displaying an error in the printing apparatus **10** or the ink quantity in the inktank **105**. FIG. 2B shows a state when the access cover **301** is opened, and the user injects ink. The access cover **301** is synchronized with an open/close sensing sensor (not shown) configured to sense the open/close of the access cover **301**. When the user opens the access cover **301**, the sensor reacts and determines that ink can be injected. FIG. 2C shows a state in which the first cover **109** that covers an inktank cap **211** of the inktank **105**, and the second cover **110** that covers a cap **212** of the inktank **106**, a cap **213** of the inktank **107**, and a cap **214** of the inktank **108** are provided. That is, the second cover **110** integrally covers the caps provided on the plurality of inktanks. Note that the access cover **301** in which the scanner unit is not mounted is also possible.

[0035] When injecting ink into the inktank, the user needs to perform an operation of raising (opening) the first cover **109** and the second cover **110**, as shown in FIG. 2C. The user can inject ink by detaching the cap of each inktank.

[0036] FIG. 3 is a sectional view schematically showing the structure of the main part of the ink supply system of the printing apparatus. A description will be made here using an example applied to black ink (BK), and the same structure is assumed to be provided for the remaining inks.

[0037] As shown in FIG. 3, a printhead **100** communicates, via the supply tube **111**, with the inktank **105** that contains black ink. The inktank **105** contains black ink inside, and an air communication tube **201** that forms an air communication path connected to an air communication port **202** configured to make the inside communicate with air is attached to the inktank **105**. The supply tube **111** and the air communication tube **201** are made of a flexible material such as elastomer. An ink filling port **210** configured to inject ink is provided in the upper portion of the inktank **105**. In addition, the tank cap **211** used to seal the inlet port is attached to the ink filling

port **210**. Furthermore, the first cover **109** that covers the tank cap **211** is attached.

[0038] A valve unit **209** that blocks communication of ink and air is provided on the supply tube **111** and the air communication tube **201**. The valve unit **209** is interlocked with the first cover **109**. When the user opens the first cover **109**, a closed state in which the supply tube **111** and the air communication tube **201** are closed (blocked) is obtained. When the user removes the tank cap **211**, it is possible to inject ink from the ink filling port **210** into the ink tank **105**. To the contrary, when the user closes the first cover **109**, the valve unit **209** is set in an open state, and the supply tube **111** and the air communication tube **201** are opened.

[0039] As the black ink is consumed from an orifice array **101BK** formed from a plurality of orifices configured to discharge the black ink, an ink liquid surface **205** in the ink tank **105** lowers. Two electrodes **203** and **204** used to detect the ink residual quantity are provided in the ink tank **105**. These electrodes are also called residual detection pins. A voltage value obtained by supplying a weak current across the two electrodes is detected, and the voltage value is A/D-converted to obtain a digital value. It is detected based on the digital value, whether the ink liquid surface **205** in the ink tank **105** is located under a vertical-direction (Z-direction) position indicated by Lin FIG. 3. Note that the position L shown in FIG. 3 corresponds to the position of the lower ends of the two electrodes **203** and **204**.

[0040] More specifically, in a case in which the ink liquid surface **205** in the ink tank **105** is located at the same position as the position L or above it, when a weak current is supplied across the two electrodes **203** and **204**, the current flows via the ink. Hence, the detected voltage value at that time is low, and the digital value is small. On the other hand, in a case in which the ink liquid surface **205** in the ink tank **105** is located under the position L, no current flows across the two electrodes **203** and **204** via the ink. Hence, the detected voltage value at that time of weak current supply is high, and the obtained digital value is large.

[0041] In this way, it is possible to detect whether the ink liquid surface **205** in the ink tank **105** is located under the position L. That is, with this arrangement, it is possible to detect whether the ink quantity contained in the ink tank **105** is less than a predetermined quantity. Such a detection operation will be referred to as an ink residual quantity detection or residual detection hereinafter. The sensing result will also be referred to as a residual sensing result. In addition, the position L will also be referred to as a residual detection position.

[0042] The position L is set at a height from a position E defined such that the ink residual quantity becomes equal to/more than “a quantity consumed by a recovery operation (refresh operation) to fill the supply tube **111** and the printhead **100** with the ink”. For this reason, if the ink liquid surface **205** is at a position under the position L, and the ink residual quantity is determined to be less than the ink consumption quantity in the refresh operation, the recovery operation cannot be executed. However, a printing operation or a recovery operation whose ink consumption quantity is less than that in the refresh operation can be executed.

[0043] In addition, the position E is a height defined such that the ink residual quantity becomes equal to/more than a minimum ink quantity needed to prevent air from entering from a gas-liquid replacement portion **207** of the ink tank **105** into an ink supply channel when consuming the ink. If the ink is continuously supplied in a state in which the ink in the ink tank **105** is absent, air is mixed into the ink supply channel including the supply tube **111**. When the air enters the printhead **100** via the supply tube **111** and reaches the orifice **101BK**, the ink cannot be discharged, and a discharge failure occurs.

[0044] To prevent this, in this embodiment, the ink residual quantity located under the position L is managed by a counter that counts the ink consumption quantity, and when the counter reaches a threshold, an operation concerning ink consumption such as a printing operation or a recovery operation is paused. In this case, when the user performs ink injection such that the ink liquid surface **205** is located above the position L, or the user cancels the pause at any desired timing, the printing operation or the recovery operation can be resumed.

[0045] Additionally, in the printing apparatus **10**, to prevent the ink from leaking from the orifice **101BK** of the printhead **100**, the gas-liquid replacement portion **207** of the ink tank **105** is provided at a position lower than the orifice **101BK** of the printhead **100** by a height H in the vertical direction (Z direction). That is, an arrangement for applying a negative pressure by a head difference corresponding to the height H to the orifice **101BK** is employed. Note that the gas-liquid replacement portion **207** is formed with an opening area that keeps the meniscus of ink. In addition, a buffer chamber **206** is provided under the ink tank **105**. The buffer chamber **206** can contain the ink that is pushed out when air in an ink containing chamber **208** containing ink expands due to an atmospheric pressure variation, a temperature change, or the like and breaks the meniscus in the gas-liquid replacement portion **207**. This prevents the ink from leaking from the ink tank **105** via the tube **201** of the air communication path.

[0046] FIGS. **4A** to **4C** are sectional views schematically showing an operation of injecting ink into the ink tank.

[0047] A description will be made here using an example applied to black ink (BK), and the same structure is assumed to be provided for the remaining inks.

[0048] As shown in FIG. **4A**, the ink filling port **210** is divided into two channels, that is, an ink inlet path and an air outlet path. As shown in FIG. **4B**, when an ink bottle **305** with black ink is inserted, the ink in the ink bottle **305** flows into the ink containing chamber **208** via the ink inlet path. In addition, air in the ink containing chamber **208** flows out to the ink bottle **305** via the air outlet path. That is, the ink is supplied to the ink tank **105** by gas-liquid replacement that replaces the air in the ink containing chamber **208** of the ink tank **105** with the black ink in the ink bottle **305**. When ink injection progresses, the port of the air outlet path is closed by the ink liquid surface **205**, as shown in FIG. **4C**. Hence, the air cannot flow out from the ink tank **105** to the ink bottle **305**, and gas-liquid replacement stops. For this reason, when the ink liquid surface **205** reaches a position F in the vertical direction (Z direction), ink injection automatically stops, and an ink filled-up state is obtained. Note that the position F is indicated by an alternate long and short dashed line in FIG. **3** as well.

[0049] A structure in which the ink tank is fixed to the printing apparatus, and ink is supplied via the tube has been described above as an example. However, the embodiment can also be applied to a so-called on-carriage structure in which an ink tank is mounted on a carriage together with a printhead. That is, the ink filling port may be provided in the ink tank mounted on the carriage, and the user may inject ink from the ink tank.

[0050] FIG. **5** is a block diagram showing the control configuration of the printing apparatus shown in FIG. **1**.

[0051] Referring to FIG. **5**, a host computer (to be referred to as a host hereinafter) **450** is an information processing apparatus such as a PC or a portable device, and for example, is connected from a PC to the printing apparatus **10** via a USB interface or the like. A printer driver **451** is software installed in the host **450**, and corresponds to various functions and specifications provided in the printing apparatus **10**. The printer driver **451** generates print data based on a user-desired document or image data of a photo or the like in accordance with a print instruction by the user, and transmits the print data to the printing apparatus **10**.

[0052] A reception buffer **401** is a buffer configured to hold print data or the like transmitted from the host **450** to the printing apparatus **10**. The print data or the like held in the reception buffer **401** is transferred to a RAM **403** by a CPU **402** and temporarily stored.

[0053] The printing apparatus **10** includes a counter that counts an ink quantity consumed by a recovery operation or discharge from an orifice array based on a recovery consumption quantity or a value obtained by multiplying the number of discharged ink droplets by a volume per droplet. The CPU **402** also executes count of the number of ink discharges by the counter or control based on the count value.

[0054] In addition, a ROM **404** stores programs, fixed data, and the like necessary for various kinds

of control of the printing apparatus **10**. An NVRAM **405** is a non-volatile memory configured to store information that should be held even if the printing apparatus **10** is powered off. The count value obtained by the counter is written and saved into the NVRAM **405** at a timing such as every time a print medium is discharged, after a cleaning sequence, or after soft-off.

[0055] A head driver **406** is a driver configured to drive the printhead **100**. A motor driver **407** is a driver configured to drive various kinds of motors **417** such as a carriage motor, a conveyance motor, and a motor used to move the cap in the vertical direction. A sensor controller **408** is a controller configured to control the operations of various kinds of sensors **418** including the open/close sensing sensor of the access cover **301**. A UI controller **409** is a controller configured to control a UI (user-interface) portion **419** of the printing apparatus **10**. The UI portion **419** includes a display panel (display unit) formed by an LED or an LCD configured to display various kinds of information, and an operation unit **4** configured to accept an operation from the user. The CPU **402** executes various kinds of operations such as calculation, control, judgment, and setting in cooperation with the RAM **403**, the ROM **404**, the NVRAM **405**, and other constituent elements.

[0056] Several embodiments of ink residual quantity detection processing executed by a printing apparatus having the above-described arrangement will be described next.

#### First Embodiment

[0057] FIG. **6** is a flowchart showing processing of ink residual quantity detection according to the first embodiment. Note that since the structure of the ink tank, the ink supply mechanism, and ink residual detection are common to all inks, as described above, processing of only one ink tank (an ink tank **105** containing black ink) will be described here.

[0058] In the first embodiment, a counter A and a counter B are used as two counters in association with ink residual quantity detection. The counter A is used for count when it is determined that a predetermined ink quantity or more is “present” in the ink tank **105** until an ink liquid surface **205** is located at a position L shown in FIG. **3** in accordance with the ink consumption quantity, and it is determined that a predetermined ink quantity or more is absent. On the other hand, the counter B is used to count the ink consumption quantity when it is determined that a predetermined ink quantity or more is “absent” in the ink tank **105** until the ink liquid surface **205** moves from the vicinity of the position L to the vicinity of a position E shown in FIG. **3** in accordance with the ink consumption quantity.

[0059] First, in step **S101**, when ink residual quantity detection starts, it is checked whether a predetermined ink quantity or more is present or absent in the ink tank. This is called predetermined ink quantity presence/absence detection. Details of predetermined ink quantity presence/absence detection will be described later with reference to FIG. **7**.

[0060] Next, in step **S102**, a preceding predetermined ink quantity presence/absence sensing result is read out from an NVRAM **405**, and it is checked whether the result is “absence” (predetermined ink quantity absence). Here, if the preceding result is “absence” (YES), the process advances to step **S103**. If the result is “presence” (NO), the process advances to step **S104**. In both step **S103** and step **S104**, it is checked whether the current predetermined ink quantity presence/absence sensing result executed in step **S101** is “presence”.

[0061] In step **S103**, if the current result is “presence” (YES), the process advances to step **S105** to check whether the access cover **301** was closed immediately before sensing. If the access cover **301** was closed (YES), a CPU **402** determines that the user has opened the access cover **301** and injected ink into the ink tank, and the process advances to step **S107**. In step **S107**, the counter A is reset to the initial value (the residual quantity is 100%, and the ink liquid surface **205** is at a position F), and count by the counter A is started. On the other hand, if the access cover **301** is not closed immediately before sensing (NO), the CPU **402** determines that air in the ink tank **105** has contracted due to a change in the temperature or atmospheric pressure, and the ink liquid surface **205** has risen, and the process advances to step **S108**. In step **S108**, the counter B is reset to the initial value (the ink liquid surface **205** is at the position L), and count by the counter B is started.



[0062] In step **S103**, if the current result is “absence” (NO), the CPU **402** determines that the ink in the ink tank **105** has been consumed, and the process advances to step **S106** to continue count by the counter B.

[0063] In step **S104**, if the current result is “presence” (YES), the process advances to step **S109** to continue count by the counter A. On the other hand, if the current result is “absence” (NO), the process advances to step **S108** to reset the counter B to the initial value and start count by counter B.

[0064] After one of the processes of steps **S106** to **S109** is executed, in step **S110**, the current predetermined ink quantity presence/absence sensing result is saved into the NVRAM **405**. In step **S111**, ink residual indication is changed in response to the count value, and the processing is ended.

[0065] FIG. 7 is a flowchart showing detailed processing of predetermined ink quantity presence/absence detection shown in step **S101** of FIG. 6.

[0066] First, in step **S201**, a digital value (AD value) obtained by detection by the residual detection pins and A/D conversion is obtained. Next, in step **S202**, it is checked whether the obtained AD value is equal to/more than a threshold (TH).

[0067] Here, if the AD value  $\geq$  TH (YES), the process advances to step **S203** to determine that a predetermined ink quantity is “absent”. On the other hand, if the AD value  $<$  TH (NO), the process advances to step **S204** to determine that a predetermined ink quantity is “present”.

[0068] FIG. 8 is a view showing a display screen of an ink residual quantity displayed on a portable device when the printing apparatus and the portable device serving as a host are connected via the Internet.

[0069] FIG. 8 shows a state in which an ink residual quantity is displayed stepwise as an estimated ink quantity level in accordance with a count value. Here, the residual quantity is 100% when the ink liquid surface **205** is at the position F shown in FIGS. 3, and 0% at the position E. “BK” represents a state in which a sufficient quantity of black ink exists. At this time, the counter A has the initial value (the residual quantity is 100%), and a rectangular bar indicating the ink residual quantity is colored black. When a state in which the ink is lower than the residual detection pins changes to a state in which the access cover is opened to inject ink into the ink tank, and the ink comes into contact with the residual detection pins (step **S107**), the bar indicating the ink residual quantity changes to a state in which the bar is colored black in step **S111**. This allows a printing apparatus **10** to notify the user that the residual quantity “has increased”.

[0070] As described above, the printing apparatus **10** also has a display control function of causing the display screen of a portable device or the like held by the user to display the ink residual quantity. Note that FIG. 8 shows a form in which the ink residual quantity is displayed on the display screen of a mobile phone. However, the form is not limited to this, and the ink residual quantity may be displayed on the display panel of an operation unit **4** of the printing apparatus **10**. In addition, not display but a voice or the like may be used to notify the user of the ink residual quantity.

[0071] “C” represents that cyan ink may have decreased to the vicinity of the position E, and the “x” mark makes a warning. At this time, the counter B reaches the threshold. “M” represents that a half or more of magenta ink has been consumed, and the half of the bar is colored black. This is a state in which the count value of the counter A has progressed to less than 50% of the whole. “Y” represents that the residual quantity of yellow ink is small. In a state in which the counter B has progressed to an ink quantity less than, for example, 10%, an attention of the user is aroused by an exclamation mark “!”.

[0072] In this embodiment, ink residual quantity detection is executed at the following timings. That is, the detection is executed: [0073] (a) at the time of soft power-on; [0074] (b) after cover close; [0075] (c) after a cleaning sequence; [0076] (d) immediately after suction recovery by a pump during the cleaning sequence; [0077] (e) before execution of cleaning; [0078] (f) after capping; and [0079] (g) every time a print medium is discharged.

[0080] For example, in a state in which the residual sensing result “(f) after capping” is saved as “absence” in the NVRAM **405**, the printing apparatus **10** is set in a soft-off state. In the soft-off state (in a hard-on state in which the power supply is connected), when the user opens the access cover **301** to inject ink into the ink tank up to the position F and then closes the access cover **301**, ink residual detection at the timing (b) cannot be performed because the soft-off state. However, since the sensor of the access cover **301** is operating, “cover close” can be detected. When the user performs soft-on after that, a state of “(a) at the time of soft power-on” is obtained. Hence, ink residual quantity detection is executed. In this case, the sensing result at the timing (f) in the preceding predetermined ink quantity presence/absence detection is “absence”, and the sensing result at the timing (a) in the current predetermined ink quantity presence/absence detection is “presence”. Furthermore, the cover is closed during soft-off immediately before sensing. Hence, according to the flowchart shown in FIG. **6**, in step **S107**, the counter A is reset to the initial value, and count by the counter A is started.

[0081] A case will be examined, in which in a state in which the residual sensing result “(f) after capping” is saved as “absence” in the NVRAM **405**, the printing apparatus **10** is set in a soft-off state, the air temperature lowers during soft-off, air in an ink containing chamber **208** contracts, and the ink liquid surface **205** rises. In a case in which the ink liquid surface **205** is higher than the position L, if the user performs soft-on, and ink residual detection is executed, the following processing is performed. That is, the sensing result at the timing (f) in the preceding predetermined ink quantity presence/absence detection is “absence”, and the sensing result at the timing (a) in the current predetermined ink quantity presence/absence detection is “presence”. Here, close of the access cover **301** is not detected by the sensor immediately before sensing. Hence, according to the flowchart shown in FIG. **6**, in step **S108**, the counter B is reset to the initial value, and count by the counter B is started.

[0082] Hence, according to the above-described embodiment, even if the atmospheric pressure or temperature in the ink tank changes, the air in the ink tank expands/contracts, and the ink level changes although the actual ink quantity does not change, it is possible to suppress the error between the actual ink quantity and the count value.

#### Second Embodiment

[0083] In the first embodiment, two counters A and B are provided to count the consumed ink quantity. An example in which ink residual quantity detection is performed using one counter will be described here.

[0084] FIG. **9** is a flowchart showing processing of ink residual quantity detection according to the second embodiment. Note that the same step numbers as described in the first embodiment with reference to FIG. **6** denote the same processing steps in FIG. **9**, and a description thereof will be omitted. The second embodiment is different from the first embodiment only in that ink residual quantity detection is performed using one counter. Hence, as is apparent from comparison between FIG. **9** and FIG. **6**, steps **S101** to **S105** are similarly executed in the second embodiment as well. As a processing portion for storing an ink residual quantity sensing result in the counter, steps **S106'** to **S109'** are executed in the second embodiment in place of steps **S106** to **S109** in the first embodiment.

[0085] That is, if the preceding predetermined ink quantity presence/absence sensing result is “absence”, and the current sensing result is “absence”, in step **S106'**, count by the counter is continued. If the preceding predetermined ink quantity presence/absence sensing result is “absence”, the current sensing result is “presence”, and an access cover **301** was closed immediately before sensing, a CPU **402** determines that the user has opened the access cover **301** and injected ink into the ink tank. In step **S107'**, the counter is reset to the initial value, and count by the counter is started.

[0086] If the preceding predetermined ink quantity presence/absence sensing result is “absence”, the current sensing result is “presence”, and the access cover **301** was not closed immediately

before sensing, the CPU **402** determines that air in the inktank has contracted due to a change in the temperature or atmospheric pressure, and an ink liquid surface **205** has risen. In step **S108'**, the counter is set to a value "X", and count by the counter is started. Here, the count value "X" is a count value corresponding to an ink quantity at a position L in the inktank.

[0087] Furthermore, if the preceding predetermined ink quantity presence/absence sensing result is "presence", and the current sensing result is "absence", the CPU **402** determines that the ink has been consumed. In step **S108'**, the counter is set to the value "X", and count by the counter is started.

[0088] Finally, if the preceding predetermined ink quantity presence/absence sensing result is "presence", and the current sensing result is "presence", in step **S109'**, count by the counter is continued.

[0089] Note that after one of the processes of steps **S106'** to **S109'** is executed, steps **S110** and **S111** are executed, and the processing is ended, as in the first embodiment.

[0090] Hence, according to the above-described embodiment, it is possible to detect the accurate ink residual quantity presence/absence as in the first embodiment using one counter.

### Third Embodiment

[0091] In the first and second embodiments, using a counter configured to count a consumed ink quantity, management is performed based on a count value in both a case in which a predetermined ink quantity is "present" and a case in which a predetermined ink quantity is "absent". In the third embodiment, an example will be described in which management is not performed based on a count value if a predetermined ink quantity is "present", and a counter starts count from a state in which an ink liquid surface **205** is lower than a position L, and a predetermined ink quantity is "absent".

[0092] FIG. **10** is a flowchart showing processing of ink residual quantity detection according to the third embodiment. Note that the same step numbers as described in the first and second embodiments with reference to FIGS. **6** and **9** denote the same processing steps in FIG. **10**, and a description thereof will be omitted.

[0093] As is apparent from comparison between FIG. **10** and FIGS. **6** and **9**, steps **S101** to **S105** are similarly executed in the third embodiment as well. As a processing portion for storing an ink residual quantity sensing result in the counter, steps **S107''** to **S109''** are executed in the third embodiment in place of steps **S107'** to **S109'** in the second embodiment.

[0094] If the preceding predetermined ink quantity presence/absence sensing result is "absence", the current sensing result is "presence", and an access cover **301** was closed immediately before sensing, a CPU **402** determines that the user has opened the access cover **301** and injected ink into the inktank. In step **S107''**, count by the counter is stopped.

[0095] If the preceding predetermined ink quantity presence/absence sensing result is "absence", the current sensing result is "presence", and the access cover **301** was not closed immediately before sensing, the CPU **402** determines that air in the inktank has contracted due to a change in the temperature or atmospheric pressure, and the ink liquid surface **205** has risen. In step **S108''**, the counter is reset to the initial value, and count by the counter is started.

[0096] Furthermore, if the preceding predetermined ink quantity presence/absence sensing result is "presence", and the current sensing result is "absence", the CPU **402** determines that the ink has been consumed. In step **S108''**, the counter is reset to the initial value, and count by the counter is started.

[0097] Note that the initial value mentioned in step **S108''** indicates a count value representing a state in which the ink liquid surface **205** is located at the position L, unlike the initial value mentioned in the first and second embodiments.

[0098] Finally, if the preceding predetermined ink quantity presence/absence sensing result is "presence", and the current sensing result is "presence", in step **S109''**, count by the counter is kept stopped.

[0099] Note that after one of the processes of steps S106' and S107'' to S109'' is executed, step S110 is executed, and the processing is ended, as in the first embodiment.

[0100] Note that in this embodiment, since the counter operates only after the ink liquid surface 205 is located under the position L corresponding to the lower end portions of residual detection pins, synchronization with a residual indication bar as shown in FIG. 8 is not performed. If it is determined based on the count result by the counter that the ink liquid surface 205 may have lowered to the vicinity of a position E, a "x" mark is displayed on, for example, an ink indication screen of a portable device or a display panel of a printing apparatus. This warns the user that the ink residual quantity is small.

[0101] Hence, according to the above-described embodiment, for example, it is possible to use one counter as in the second embodiment and detect the accurate ink residual quantity presence/absence as in the first embodiment while decreasing the number of count processes.

[0102] According to the above-described embodiments, the transition between the result of predetermined ink quantity presence/absence detection executed at a certain timing and the result of detection executed at a timing immediately before the detection is verified. If it is determined that a change from a state in which a predetermined ink residual quantity is "absent" to a state in which a predetermined ink quantity is "present" has occurred, and ink injection was possible immediately before the detection, it is determined to do ink injection, and control is performed to initialize the count value and return the count to an ink filled-up state. This can suppress the error between the actual ink quantity and the count value.

[0103] Note that in the above-described embodiments, to determine whether ink injection from the inlet port is possible, a sensor that detects open/close of the access cover is used. However, the present invention is not limited to this. For example, sensors that detect open/close of the first cover 109 and the second cover 110 used to cover the inlet ports of the inktanks may be used, or a sensor that directly detects open/close of the tank cap for the inlet port may be used.

[0104] In the above-described embodiments, a pair of electrode pins are used to detect predetermined ink quantity presence/absence. However, the present invention is not limited to this. For example, an optical method of detecting the liquid level of ink from a reflected state of a light beam by an optical sensor and a prism may be used. Any other detection method can be used as long as it is possible to detect the liquid level position in a state in which a predetermined ink quantity remains in the inktank.

[0105] Furthermore, in the above-described embodiments, an example in which the ink residual quantity is displayed stepwise on the display screen to improve visibility for the user has been described. However, stepwise display need not always be performed. Warning display may be done when the ink residual quantity becomes a predetermined criterion or less.

[0106] Also, in the above-described embodiments, as the timing of executing ink residual quantity detection, the seven timings (a) to (g) are used. However, the timings are not limited the above seven timings. For example, residual quantity detection need only be executable before and after an event that consumes ink, and may be performed during a printing operation.

[0107] In addition, the present invention is applicable not only to an inkjet printing apparatus having a single function but also to a facsimile apparatus, a copying machine, a word processor, or a multifunction peripheral using the inkjet printing apparatus as a print unit. Furthermore, the printing apparatus may use not only a serial method of scanning a printhead on a print medium and conveying the print medium in a direction orthogonal to a scan direction to perform printing but also a method of performing printing only by conveying a print medium using a full-line printhead having a print width corresponding to the width of the print medium.

[0108] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

## Claims

1. A printing apparatus including an ink tank that contains ink injected from an inlet port, a printhead configured to print by discharging ink supplied from the ink tank, a sensing unit configured to sense whether a predetermined quantity of ink is present in the ink tank, comprising: a memory unit configured to store a sensing result by the sensing unit; a counting unit configured to count an ink quantity in the ink tank in accordance with consumption of the ink from the ink tank; a first counter configured to update and hold a count value by the counting unit; a verification unit configured to, if sensing by the sensing unit is executed, read out a preceding sensing result from the memory unit and verify a transition between the preceding sensing result and a current sensing result; a detection unit configured to detect whether ink injection to the ink tank has been done before execution of sensing by the sensing unit; and a control unit configured to control operations of reset of the count value held by the first counter and count by the counting unit based on the transition obtained by the verification unit and a result of detection by the detection unit.
2. The apparatus according to claim 1, further comprising a memory control unit configured to store the current sensing result in the memory unit.
3. The apparatus according to claim 1, further comprising a cover configured to cover the inlet port of the ink tank, wherein the detection unit detects open/close of the cover.
4. The apparatus according to claim 1, wherein the transition includes: a first change indicating that the preceding sensing result is ink absence, and the current sensing result is ink absence; a second change indicating that the preceding sensing result is ink absence, and the current sensing result is ink presence; a third change indicating that the preceding sensing result is ink presence, and the current sensing result is ink absence; and a fourth change indicating that the preceding sensing result is ink presence, and the current sensing result is ink presence.
5. The apparatus according to claim 4, wherein the control unit controls to cause the counting unit to perform count if the transition is one of the first change and the fourth change, to reset the count value held by the first counter to an initial value and cause the counting unit to start count if the transition is the second change, and it is detected by the detection unit that the ink injection has been done, and to reset the count value held by the first counter to a predetermined value and cause the counting unit to start count if the transition is the second change, and it is detected by the detection unit that the ink injection has not been done, and if the transition is the third change.
6. The apparatus according to claim 5, wherein the initial value is a count value representing a state in which the ink tank is filled up with the ink, and the predetermined value is a count value representing a state in which the predetermined quantity of ink is contained in the ink tank.
7. The apparatus according to claim 4, wherein the counting unit starts count if it is sensed by the sensing unit that the predetermined quantity of ink is absent, and the control unit controls to cause the counting unit to perform count if the transition is the first change, to stop count by the counting unit if the transition is the second change, and it is detected by the detection unit that the ink injection has been done, to reset the count value held by the first counter and cause the counting unit to start count if the transition is the second change, and it is detected by the detection unit that the ink injection has not been done, and if the transition is the third change, and not to perform count by the counting unit if the transition is the fourth change.
8. The apparatus according to claim 7, wherein reset of the count value indicates returning the count value to a count value representing a state in which the predetermined quantity of ink is contained in the ink tank.
9. The apparatus according to claim 4, further comprising a second counter configured to update and hold the count value by the counting unit, wherein the first counter is used until it is

determined by the sensing unit that a state in which the predetermined quantity of ink is present in the ink tank has changed to a state in which the predetermined quantity of ink is absent, and the second counter is used after it is determined by the sensing unit that the predetermined quantity of ink is absent in the ink tank.

**10.** The apparatus according to claim 9, wherein the control unit controls to cause the counting unit to perform count and cause the second counter to hold a result of the count if the transition is the first change, to reset the count value of the first counter to an initial value and cause the counting unit to start count if the transition is the second change, and it is detected by the detection unit that the ink injection has been done, to reset the count value of the second counter to an initial value and cause the counting unit to start count if the transition is the second change, and it is detected by the detection unit that the ink injection has not been done, and if the transition is the third change, and to cause the counting unit to continue count and cause the first counter to hold a result of the count if the transition is the fourth change.

**11.** The apparatus according to claim 10, wherein the initial value of the first counter is a count value representing a state in which the ink tank is filled up with the ink, and the initial value of the second counter is a count value representing a state in which the sensing result by the sensing unit changes from ink presence to ink absence.

**12.** The apparatus according to claim 1, further comprising a display control unit configured to display the ink quantity in the ink tank on a display screen.

**13.** The apparatus according to claim 1, wherein the sensing unit includes two electrodes provided in the ink tank, detects a voltage value when a current is supplied across the two electrodes, and senses, based on the detected voltage value, whether the predetermined quantity of ink is present in the ink tank.

**14.** An ink quantity detection method of a printing apparatus including an ink tank that contains ink injected from an inlet port, a printhead configured to print by discharging ink supplied from the ink tank, and a sensing unit configured to sense whether a predetermined quantity of ink is present in the ink tank, comprising: counting an ink quantity in the ink tank in accordance with consumption of the ink from the ink tank; updating and holding a count value obtained by the counting in a counter; detecting whether ink injection to the ink tank has been done before execution of sensing by the sensing unit; if sensing by the sensing unit is executed, reading out a preceding sensing result from a memory that stores a sensing result of presence/absence of the ink by the sensing unit and verifying a transition between the preceding sensing result and a current sensing result; and controlling operations of reset of the count value held by the counter and the count based on the transition obtained in the verifying and a result of detection in the detecting.

**15.** A printing apparatus comprising: a printhead configured to discharge ink; an ink tank configured to contain ink to be supplied to the printhead and including an inlet port from which the ink is injected; a cover configured to cover the inlet port; an open/close detection unit configured to detect open/close of the cover; a detection unit configured to detect whether a predetermined quantity of ink contained in the ink tank is present; a memory configured to store a preceding detection result by the detection unit; and a notification unit configured to notify a status of the apparatus, wherein if the preceding detection result by the detection unit is absence, and a current detection result is presence, the notification unit notifies that an ink quantity has increased in a case where the open/close detection unit detects that the cover is closed, and the notification by the notification unit is not made in a case where the open/close detection unit does not detect that the cover is closed.

**16.** The apparatus according to claim 15, wherein the notification unit includes a display unit configured to display an ink quantity in the ink tank, and if the preceding detection result by the detection unit is absence, and the current detection result is presence, display of the ink quantity by the display unit is changed in the case where the open/close detection unit detects that the cover is closed.

**17.** The apparatus according to claim 16, wherein if the preceding detection result by the detection unit is absence, and the current detection result is presence, display of the ink quantity by the display unit is not changed in the case where the open/close detection unit does not detect that the cover is closed.

**18.** The apparatus according to claim 15, wherein the cover is axially supported to be opened/closed with respect to the printing apparatus.

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