United States Patent	12391049
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Hayashi; Masahiro et al.

Liquid consuming device including air tank and liquid tank each communicable with atmosphere when connected to liquid container

Abstract

A liquid consuming device includes a liquid container, an air tank, a liquid tank, and an ejection head. The liquid container is connectable to the air tank and the liquid tank. The air tank includes: an air flow path; an air chamber configured to communicate with a first storage chamber of the liquid container through the air flow path; and a first air communicating portion. The liquid tank includes: a liquid flow path; a second storage chamber configured to communicate with the first storage chamber through the liquid flow path; a liquid outlet port to allow liquid in the second storage chamber to flow out therefrom; and a second air communicating portion. The air flow path is configured to provide communication between the first storage chamber and the air chamber in a state where the liquid container is connected to the air tank and the liquid tank.

Inventors: **Hayashi; Masahiro (Nishio, JP), Okazaki; Naoya (Hashima, JP), Tanabe; Yuma (Nagoya, JP), Oki; Satoru (Nagoya, JP), Abe; Nanami (Niigata, JP), Fukuta; Yuji (Nagoya, JP)**

Applicant: **BROTHER KOGYO KABUSHIKI KAISHA** (Nagoya, JP)

Family ID: **1000008766431**

Assignee: **BROTHER KOGYO KABUSHIKI KAISHA (Nagoya, JP)**

Appl. No.: **18/167990**

Filed: **February 13, 2023**

Prior Publication Data

Document Identifier	Publication Date
US 20230311532 A1	Oct. 05, 2023

Foreign Application Priority Data

JP	2022-054896	Mar. 30, 2022

Publication Classification

Int. Cl.: **B41J2/175** (20060101)

U.S. Cl.:

CPC **B41J2/17556** (20130101); **B41J2/17503** (20130101); **B41J2/17509** (20130101); **B41J2/17523** (20130101); B41J2/175 (20130101)

Field of Classification Search

CPC: B41J (2/17556); B41J (2/17503); B41J (2/17509); B41J (2/17523); B41J (2/175)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
6520630	12/2002	Oda et al.	N/A	N/A
10618302	12/2019	Sato	N/A	B41J 2/17596
2019/0030910	12/2018	Tanabe et al.	N/A	N/A
2021/0300052	12/2020	Takei et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2001-187459	12/2000	JP	N/A
2019-25818	12/2018	JP	N/A
2021-151724	12/2020	JP	N/A

Primary Examiner: Mruk; Geoffrey S

Attorney, Agent or Firm: Merchant & Gould P.C.

Background/Summary

REFERENCE TO RELATED APPLICATIONS

(1) This application claims priority from Japanese Patent Application No. 2022-054896 filed on Mar. 30, 2022. The entire content of the priority application is incorporated herein by reference.

BACKGROUND ART

(2) There has been known a liquid supplying device including a liquid ejection head, a liquid storage tank in communication with the liquid ejection head, and a liquid cartridge attachable to and detachable from the liquid storage tank.

DESCRIPTION

(3) In this conventional liquid supplying device, the liquid storage tank is made in communication with the atmosphere through an air communicating portion, and the cartridge attached to the liquid storage tank is in air communication with the liquid storage tank through a second connecting portion. Hence, the cartridge is in communication with the atmosphere through the air communicating portion of the liquid storage tank.

(4) Accordingly, in this liquid supplying device, it is difficult to set a difference in flow resistance between during inflow of gas into the liquid storage tank and during inflow of gas into the cartridge, since the liquid storage tank and the cartridge are both in communication with the atmosphere through the single air communicating portion. Particularly, in a case where a semi-permeable membrane is provided at the air communicating portion, the semi-permeable membrane has a predominant influence on the flow resistance, and, hence, it becomes difficult to set the flow resistance during the inflow of gas into the liquid storage tank to be greater than the flow resistance during the inflow of gas into the cartridge.
(5) For example, liquid flows out of the liquid storage tank and the cartridge if a large amount of liquid is ejected through the liquid ejection head. If the amount of liquid following out of the cartridge is smaller than the amount of liquid flowing out of the liquid storage tank, the amount of the liquid stored in the liquid storage tank may decrease while liquid is ejected through the liquid ejection head, although liquid is still stored in the cartridge. On the other hand, if an air communicating portion is provided in the cartridge, the cartridge may have a complicated structure, and hence, the cartridge may become costly, and may have to be configured as a disposable cartridge.
(6) In view of the foregoing, it is an object of the disclosure to provide a liquid consuming device capable of easily setting a difference in flow resistance between a liquid container and a liquid tank while realizing a simple structure for the liquid container.
(7) In order to attain the above and other objects, according to one aspect, the disclosure provides a liquid consuming device including a liquid container, an air tank, a liquid tank, and an ejection head. The liquid container is connectable to the air tank and to the liquid tank. The liquid container includes a first storage chamber configured to store liquid therein. The air tank includes an air flow path, an air chamber, and a first air communicating portion. The air flow path is configured to communicate with the first storage chamber of the liquid container that is connected to the air tank. The air chamber is connected to the air flow path and is configured to communicate with the first storage chamber through the air flow path to provide airflow between the first storage chamber and the air chamber. The first air communicating portion is configured to allow the air chamber to communicate with an atmosphere. The liquid tank includes a liquid flow path, a second storage chamber, a liquid outlet port, and a second air communicating portion. The liquid flow path is configured to communicate with the first storage chamber of the liquid container that is connected to the liquid tank. The second storage chamber is connected to the liquid flow path and is configured to communicate with the first storage chamber through the liquid flow path to allow the liquid stored in the first storage chamber to flow into the second storage chamber. The liquid stored in the second storage chamber is configured to flow out therefrom through the liquid outlet port. The second air communicating portion is configured to allow the second storage chamber to communicate with the atmosphere. The ejection head is configured to eject the liquid supplied from the second storage chamber through the liquid outlet port. The air flow path is configured to provide communication between the first storage chamber and the air chamber in a state where the liquid container is connected to the air tank and the liquid tank.
(8) With this structure, since air flows into the first storage chamber from the first air communicating portion through the air chamber and the air flow path, the flow resistance of this passage of air can be set to an optimum value to allow the liquid stored in the first storage chamber to flow into the second storage chamber. On the other hand, the flow resistance of the second air communicating portion can also be set to an optimum value to allow the liquid in the second storage chamber to flow out therefrom through the liquid outlet port. Further, since no air communicating portion is necessary in the liquid container, the liquid container can have a simplified structure.
(9) According to another aspect, the disclosure also provides a liquid consuming device including a liquid container, an air flow path, an air chamber, a first air communicating portion, a liquid flow

path, a second storage chamber, a liquid outlet port, a second air communicating portion, and an ejection head. The liquid container includes a first storage chamber configured to store liquid therein. The air flow path is configured to communicate with the first storage chamber of the liquid container. The air chamber is connected to the air flow path and is configured to communicate with the first storage chamber through the air flow path to provide airflow between the first storage chamber and the air chamber. The first air communicating portion is configured to allow the air chamber to communicate with an atmosphere. The liquid flow path is configured to communicate with the first storage chamber of the liquid container. The second storage chamber is connected to the liquid flow path and is configured to communicate with the first storage chamber through the liquid flow path to allow the liquid stored in the first storage chamber to flow into the second storage chamber. The liquid stored in the second storage chamber is configured to flow out therefrom through the liquid outlet port. The second air communicating portion is configured to allow the second storage chamber to communicate with the atmosphere. The ejection head is configured to eject the liquid supplied from the second storage chamber through the liquid outlet port. The air flow path is configured to provide communication between the first storage chamber and the air chamber in a state where the first storage chamber is in communication with the second storage chamber. The second storage chamber and the air chamber are not in communication with each other in a state where the first communication chamber is not in communication with each of the second storage chamber and the air chamber. The air chamber has a volume which is smaller than a volume of the second storage chamber.

Description

(1) With this structure, since air flows into the first storage chamber from the first air communicating portion through the air chamber and the air flow path, the flow resistance of this passage of air can be set to an optimum value to allow the liquid stored in the first storage chamber to flow into the second storage chamber. On the other hand, the flow resistance of the second air communicating portion can also be set to an optimum value to allow the liquid in the second storage chamber to flow out therefrom through the liquid outlet port. Further, since no air communicating portion is necessary in the liquid container, the liquid container can have a simplified structure.
(2) FIG. **1**A is a perspective view of a multifunction device **10** according to one embodiment in a state where a cover **87** is at a closed position thereof.
(3) FIG. **1**B is a perspective view of the multifunction device **10** in a state where the cover **87** is at an open position thereof.
(4) FIG. **2** is a schematic vertical cross-sectional view illustrating an internal structure of a printer portion **11** of the multifunction device **10**.
(5) FIG. **3** is a perspective view illustrating an exterior of a cartridge receiving portion **110** as viewed from an opening **112** side thereof.
(6) FIG. **4** is a vertical cross-sectional view of the cartridge receiving portion **110**.
(7) FIG. **5** is a perspective view of an ink cartridge **30** as viewed from a rear side thereof.
(8) FIG. **6** is a vertical cross-sectional view of the ink cartridge **30**.
(9) FIG. **7** is a vertical cross-sectional view illustrating a state where the ink cartridge **30** is attached to the cartridge receiving portion **110**.
(10) FIG. **8** is a schematic view illustrating a positional relationship among the ink cartridge **30**, an ink tank **103**, and a buffer tank **130** of the cartridge receiving portion **110** in a state where the multifunction device is in a collapsed posture.
(11) FIG. **9** is a vertical cross-sectional view of a cartridge receiving portion **210** according to a first modification to the embodiment.

(12) FIG. **10** is a vertical cross-sectional view of a cartridge receiving portion **310** according to a second modification to the embodiment.
(13) FIG. **11** is a schematic view illustrating a positional relationship among the ink cartridge **30**, an ink tank **403**, and a buffer tank **430** of a cartridge receiving portion **410** according to a third modification to the embodiment.
(14) FIG. **12** is a schematic view illustrating a positional relationship among an ink cartridge **50**, an ink tank **550**, and a buffer tank **560** of a cartridge receiving portion **510** according to a fourth modification to the embodiment.
(15) FIG. **13** is a schematic view illustrating a positional relationship among a bottle **670**, an ink tank **780**, and a buffer tank **790** of a cartridge receiving portion **710** according to a fifth modification to the embodiment.

EMBODIMENT

(16) Hereinafter, one embodiment of the present disclosure will be described with reference to FIGS. **1** through **8**.
(17) Throughout the specification, a multifunction device **10** according to the embodiment will be described assuming that the multifunction device **10** is resting on a horizontal surface illustrated in FIG. **1**. Hereinafter, this posture of the multifunction device **10** illustrated in FIG. **1** will be referred to as an “operable posture”.
(18) Specifically, an up-down direction **7** will be defined based on the operable posture of the multifunction device **10**. A front-rear direction **8** will be referred to assuming that a surface of the multifunction device **10** at which an opening **13** is formed (the near side in FIG. **1**) is a front surface **14**A of the multifunction device **10** in the operable posture. A left-right direction **9** will be referred to assuming that the multifunction device **10** in the operable posture is viewed from its front side. In the present embodiment, in the operable posture of the multifunction device **10**, the up-down direction **7** corresponds to the vertical direction, and the front-rear direction **8** and the left-right direction **9** are both horizontal. The front-rear direction **8** and the left-right direction **9** are perpendicular to each other.
(19) <Overall Structure of Multifunction Device **10**>
(20) As illustrated in FIGS. **1**A and **1**B, the multifunction device **10** has a lower portion where a printer portion **11** is provided. The printer portion **11** is configured to form an image on a sheet **12** (see FIG. **2**) based on an inkjet recording system. The multifunction device **10** may have various other functions such as a facsimile function, a scanning function, and a copying function. The printer portion **11** includes a housing **14** having a generally rectangular parallelepiped shape. The housing **14** has a front surface **14**A formed with the opening **13**.
(21) As illustrated in FIG. **2**, a sheet tray **15**, a discharge tray **16**, a pick-up roller **23**, a pair of conveyor rollers **25**, a pair of discharge rollers **27**, a recording unit **24**, and a platen **26** are provided in an internal space of the housing **14**.
(22) <Sheet Tray **15**, Discharge Tray **16**, and Pick-Up Roller **23**>
(23) As illustrated in FIGS. **1**A and **1**B, the opening **13** is open on the front surface **14**A of the housing **14** at a generally center thereof in the left-right direction **9**. The sheet tray **15** is configured to be inserted into and removed from the housing **14** through the opening **13** in the front-rear direction **8**. The sheet tray **15** is configured to support a stack of sheets **12**. The discharge tray **16** is positioned above the sheet tray **15**. The discharge tray **16** is configured to support the sheet **12** discharged through a gap between the recording unit **24** and the platen **26** by the pair of discharge rollers **27**. The pick-up roller **23** is configured to be rotated by a motor (not illustrated) to feed each sheet **12** supported on the sheet tray **15** onto a conveying path **17**.
(24) <Conveying Path **17**>
(25) As illustrated in FIG. **2**, the conveying path **17** is a space defined mainly by guide members **18**, **19**, the recording unit **24**, and the platen **26**. In the printer portion **11**, the guide members **18** and **19** face each other with a predetermined gap therebetween and the recording unit **24** and the platen

26 face each other with a predetermined gap therebetween. The conveying path **17** extends upward from a rear end portion of the sheet tray **15**, makes a U-turn frontward, and extends through the gap between the recording unit **24** and the platen **26** to reach the discharge tray **16**. In FIG. **2**, a conveying direction of the sheet **12** (sheet conveying direction) is indicated by a dashed-dotted arrow in FIG. **2**.

(26) <Conveyor Rollers **25**>

(27) The pair of conveyor rollers **25** is positioned upstream of the recording unit **24** in the sheet conveying direction. The pair of conveyor rollers **25** includes a conveyor roller **25**A and a pinch roller **25**B opposing each other. The conveyor roller **25**A is configured to be driven by a motor (not illustrated). The pinch roller **25**B is configured to be rotated following the rotation of the conveyor roller **25**A. As the conveyor roller **25**A makes forward rotation in response to forward rotation of the non-illustrated motor, each sheet **12** is conveyed in the sheet conveying direction with the sheet **12** nipped between the conveyor roller **25**A and the pinch roller **25**B.

(28) <Discharge Rollers **27**>

(29) The pair of discharge rollers **27** is positioned downstream of the recording unit **24** in the sheet conveying direction. The pair of discharge rollers **27** includes a discharge roller **27**A and a spur **27**B opposing each other. The discharge roller **27**A is configured to be driven by the non-illustrated motor. The spur **27**B is configured to be driven following the rotation of the discharge roller **27**A. As the discharge roller **27**A makes forward rotation in response to the forward rotation of the non-illustrated motor, each sheet **12** is nipped between the discharge roller **27**A and the spur **27**B and is conveyed in the sheet conveying direction.

(30) <Recording Unit **24** and Platen **26**>

(31) As illustrated in FIG. **2**, the recording unit **24** and the platen **26** are positioned between the pair of conveyor rollers **25** and the pair of discharge rollers **27** in the sheet conveying direction. Specifically, the recording unit **24** and the platen **26** are positioned downstream of the pair of conveyor rollers **25** and upstream of the pair of discharge rollers **27** in the sheet conveying direction. Further, the recording unit **24** and the platen **26** are positioned to face each other in the up-down direction **7**.

(32) The recording unit **24** includes a carriage **22**, and an ejection head **21** mounted on the carriage **22**. The carriage **22** is reciprocally movable in the left-right direction **9** upon receipt of a driving force from a motor (not illustrated). The ejection head **21** has a lower surface where a plurality of nozzles **29** is formed. The ejection head **21** is configured to eject ink droplets from the nozzles **29** through oscillation of oscillating elements such as piezoelectric elements. The ejection head **21** ejects ink droplets from selected nozzles **29** onto the sheet **12** supported by the platen **26** while the carriage **22** moves, thereby forming an image on the sheet **12**.

(33) In the operable posture of the multifunction device **10**, the lower surface of the ejection head **21** is positioned higher than a level of ink stored in an ink cartridge **30** (described later) received in a cartridge receiving portion **110** (see FIG. **3**, described later) and a level of ink stored in an ink tank **103** (see FIG. **4**, described later). Further, in the operable posture of the multifunction device **10**, the ejection head **21** is positioned rearward of the cartridge receiving portion **110** in the front-rear direction **8**.

(34) A bundle of ink tubes (not illustrated) and a flexible flat cable (not illustrated) are connected to the carriage **22**. The ink tubes connect the cartridge receiving portion **110** to the ejection head **21**. Specifically, the ink tubes are configured to supply ink stored in each of the ink cartridges **30** received in the cartridge receiving portion **110** to the ejection head **21**. In the embodiment, a bundle of four ink tubes is provided to allow circulation of ink of four different colors of black, magenta, cyan, and yellow, respectively, from the respective ink cartridges **30** to the ejection head **21**. The flexible flat cable is configured to provide electrical connection between the ejection head **21** and a control board (not illustrated) configured to control operations of the multifunction device **10**.

(35) <Cover **87**>

(36) As illustrated in FIG. **1**B, the front surface **14**A of the housing **14** has a right end portion where an opening **85** is formed. The housing **14** includes a cover **87** for opening and closing the opening **85**. Specifically, the cover **87** is pivotable between a closed position (FIG. **1**A) where the cover **87** closes the opening **85** and an open position (FIG. **1**B) where the cover **87** opens the opening **85**. The cover **87** has a lower end supported by the housing **14** such that the cover **87** is pivotally movable about a pivot axis extending in the left-right direction **9**. To the rear beyond the opening **85** in the internal space of the housing **14**, an accommodation space **86** is provided to accommodate the cartridge receiving portion **110** therein.
(37) <Cartridge Receiving Portion **110**>
(38) As illustrated in FIGS. **3** and **4**, the cartridge receiving portion **110** includes a cartridge case **101**, four rods **125**, a locking portion **129**, four buffer tanks **130**, four ink tanks **103**, four pivot members **145**, and four liquid-level sensors **155**.
(39) Four ink cartridges **30** corresponding to the colors of cyan, magenta, yellow, and black can be accommodated in the cartridge receiving portion **110**. A set of one rod **125**, one buffer tank **130**, one ink tank **103**, one pivot member **145**, and one liquid-level sensor **155** is provided for each of the four ink cartridges **30**. Incidentally, the number of the ink cartridges **30** to be received in the cartridge receiving portion **110** need not be four. FIG. **3** illustrates a state where only one ink cartridge **30** is accommodated in a leftmost end space in the cartridge receiving portion **110**.
(40) The cartridge case **101** constitutes an outer shell of the cartridge receiving portion **110**. The cartridge case **101** has a box-like shape providing an internal space therein for accommodating the ink cartridges **30**. The cartridge case **101** has a rear end wall (without reference numeral) and a front open end defining an opening **112**. The opening **112** is thus opposite the rear end wall in the front-rear direction **8** and is exposed to an outside of the multifunction device **10** through the opening **85** of the housing **14** when the cover **87** is at the open position.
(41) The ink cartridges **30** are inserted rearward in the cartridge receiving portion **110** and are removed frontward from the cartridge receiving portion **110** through the opening **85** of the housing **14** and the opening **112** of the cartridge receiving portion **110**. The cartridge case **101** includes a bottom wall **117** where guide grooves **109** are formed for guiding the insertion and removal of the respective ink cartridges **30** in the front-rear direction **8**. The guide grooves **109** extend in the front-rear direction **8**, and are arranged in line in the left-right direction **9** at intervals. The guide grooves **109** receive lower end portions of the respective ink cartridges **30** to guide movements of the ink cartridges **30** in the front-rear direction **8**. Three plates **104** are provided in the internal space of the cartridge case **101** to partition the internal space into four individual spaces juxtaposed with one another in the left-right direction **9**. Each of the four spaces partitioned by the plates **104** is configured to receive one of the four ink cartridges **30** storing ink of four different colors.
(42) <Locking Portion **129**>
(43) As illustrated in FIGS. **3** and **4**, the locking portion **129** extends in the left-right direction **9** at a position adjacent to a top wall and the opening **112** of the cartridge case **101**. The locking portion **129** is a rod-like member extending in the left-right direction **9**. For example, the locking portion **129** is a solid cylindrical metal rod. The locking portion **129** has both end portions in the left-right direction **9** supported by respective side walls of the cartridge case **101**. The locking portion **129** extends through the four spaces each configured to accommodate one of the four ink cartridges **30**.
(44) The locking portion **129** is configured to retain each of the ink cartridges **30** accommodated in the cartridge receiving portion **110** at an attached position illustrated in FIG. **7**. At the attached position, the ink cartridge **30** is engaged with the locking portion **129**. In this way, the locking portion **129** can hold the ink cartridge **30** at the attached position against urging forces of coil springs **78**, **98** (see FIG. **6**, described later) to urge the ink cartridge **30** rearward.
(45) <Buffer Tank **130**>
(46) As illustrated in FIG. **4**, the buffer tanks **130** are positioned at an upper portion of the rear end wall of the cartridge case **101**. Further, each buffer tank **130** is positioned above a corresponding

connecting portion **107** (described later) provided at the rear end wall. Each buffer tank **130** is a box-like container molded integrally with the cartridge case **101**. The buffer tank **130** has an internal space serving as an air chamber **131**. Each buffer tank **130** includes a top wall **134** formed with an air communication port **132** penetrating the top wall **134** in the up-down direction **7** to be open upward thereon. A first semipermeable membrane **133** is affixed to an upper open end of the air communication port **132** to close the air communication port **132**. The first semipermeable membrane **133** allows air to flow therethrough, but interrupts ink from flowing therethrough.

(47) <Rod **125**>

(48) As illustrated in FIG. **4**, each rod **125** extends frontward from a front wall **135** of the corresponding buffer tank **130** at a lower end portion thereof. Each rod **125** is positioned above the corresponding connecting portion **107** (described later) provided at the rear end wall of the cartridge case **101**. The rod **125** has a tubular shape whose hollow space is in communication with the air chamber **131**. The rod **125** has a front end that is open frontward and upward. As will be described later, in the state where the ink cartridge **30** is accommodated in the cartridge receiving portion **110**, the rod **125** is inserted in an air valve chamber **36** (see FIG. **6**) of the ink cartridge **30** through an air communication opening **96** (see FIGS. **5** and **6**). As such, the air valve chamber **36** of the ink cartridge **30** is in communication with the air chamber **131** of the corresponding buffer tank **130**, and the hollow space of the rod **125** functions as a passage to provide airflow therethrough.

(49) <Ink Tank **103**>

(50) As illustrated in FIG. **4**, the ink tanks **103** are positioned rearward of the cartridge case **101**. Each ink tank **103** includes a front wall **142**, a rear wall **143**, a lower wall, and side walls. In these walls constituting the ink tank **103**, at least regions facing the liquid-level sensor **155** are light transmissive so that light outputted from the liquid-level sensor **155** can pass through these regions.

(51) Each ink tank **103** has a box-like shape defining a storage chamber **121** therein. The storage chamber **121** is independent from the buffer tank **130** and is not in communication with the buffer tank **130**. An outlet port **128** is provided at a position adjacent to the lower wall of each ink tank **103** and is connected to the corresponding ink tube. The outlet port **128** is positioned below the corresponding connecting portion **107**. Each ink tank **103** is thus in communication with the corresponding ink tube through the corresponding outlet port **128**. The ink stored in the storage chamber **121** can flow out therefrom through the outlet port **128** and is supplied to the ejection head **21** through the corresponding ink tube. The storage chamber **121** has an internal volume greater than an internal volume of the air chamber **131** of the corresponding buffer tank **130**.

(52) An air communication port **124** is formed at an upper end portion of the rear wall **143** of each storage chamber **121**. The air communication port **124** penetrates through the rear wall **143** in the front-rear direction **8**. The air communication port **124** is positioned higher than the light transmissive regions of the ink tank **103** facing the liquid-level sensor **155**. A second semipermeable membrane **127** is affixed to an open end of the air communication port **124** to close the open end. The second semipermeable membrane **127** interrupts ink flow therethrough but allows air to flow therethrough. The second semipermeable membrane **127** has a flow resistance R2 higher than a flow resistance R1 of the first semipermeable membrane **133** ($R1<R2$).

(53) <Connecting Portion **107**>

(54) As illustrated in FIGS. **3** and **4**, each connecting portion **107** includes: an ink needle **102** having a tubular shape and made from resin; and a guide portion **105**. The ink needle **102** extends frontward from the corresponding ink tank **103**. The ink needle **102** has a protruding end in which an opening **116** is formed. The ink needle **102** has an internal space in communication with the storage chamber **121**. Further, the ink needle **102** is at a position corresponding to the position of an ink supply portion **34** (see FIGS. **5** and **6**, described later) of the corresponding ink cartridge **30** accommodated in the cartridge receiving portion **110**. The front wall **142** of the ink tank **103** has a through-hole **126** which provides communication between the internal space of the ink needle **102**

and the storage chamber **121**.

(55) The guide portion **105** is a hollow cylindrical member positioned to surround the ink needle **102**. The guide portion **105** extends frontward from the ink tank **103**, and has a protruding end in which an opening is formed. The ink needle **102** is positioned at a diametrical center of the guide portion **105**. During the insertion of the ink cartridge **30** into the cartridge receiving portion **110**, the ink supply portion **34** moves into the guide portion **105**.

(56) In the internal space of the ink needle **102**, a valve **114** and a coil spring **115** are accommodated. In the internal space of the ink needle **102**, the valve **114** is movable in the front-rear direction **8** between a closed position where the valve **114** closes the opening **116** and an open position where the valve **114** opens the opening **116**. The coil spring **115** urges the valve **114** frontward, i.e., in a direction to move the valve **114** toward the closed position. When the valve **114** is at the closed position, a front end of the valve **114** protrudes further frontward relative to the opening **116**.

(57) <Pivot Member **145**>

(58) The pivot member **145** is positioned inside the storage chamber **121**. The pivot member **145** is pivotally movably supported by a support member (not illustrated) disposed in the storage chamber **121**. The pivot member **145** is pivotally movable in directions indicated by arrows **198**, **199** in FIG. **4**. Specifically, the pivot member **145** is pivotable between a first position depicted by a solid line in FIG. **4** and a second position depicted by a broken line in FIG. **4**. Further, the pivot member **145** at the first position is restricted from pivoting further in the direction of the arrow **198** by a non-illustrated stopper (for example, an inner surface of the storage chamber **121**).

(59) The pivot member **145** includes a float **146**, a shaft **147**, an arm **148**, and a detection-target portion **149**.

(60) The float **146** is made from a material having a specific gravity smaller than a specific gravity of the ink stored in the storage chamber **121**. The shaft **147** protrudes from right and left surfaces of the float **146** in the left-right direction **9**. In the operable posture of the multifunction device **10**, the left-right direction **9** is horizontal. Both ends of the shaft **147** are inserted in holes (not illustrated) formed in the non-illustrated support member. With this structure, the pivot member **145** is supported by the support member such that the pivot member **145** is pivotally movable about an axis of the shaft **147**.

(61) The arm **148** extends generally upward from the float **146**. The arm **148** has an upper end provided with the detection-target portion **149**. The detection-target portion **149** is a plate-like member extending in the up-down direction **7** and front-rear direction **8**. The detection-target portion **149** is made from a material (or is colored) capable of shielding light emitted from a light emitting portion of the liquid-level sensor **155**.

(62) In a case where a level of the ink stored in the storage chamber **121** is equal to or higher than a boundary position P1, the pivot member **145** is pivotally moved in the direction of the arrow **198** because of buoyancy acting on the float **146** and the pivot member **145** is maintained at the first position by the non-illustrated stopper. Accordingly, the detection-target portion **149** is kept at a detection position. On the other hand, in a case where the level of the ink becomes lower than the boundary position P1, the pivot member **145** is pivotally moved in the direction of the arrow **199** following the declining liquid surface of the ink. Hence, the detection-target portion **149** is displaced from the detection position. That is, the detection-target portion **149** moves to a position corresponding to an amount of the ink stored in the storage chamber **121**.

(63) The boundary position P1 is at a height equal to the position of the axis of the ink needle **102** in the up-down direction **7**, and also to the position of a center of an ink supply opening **71** (see FIGS. **5** and **6**, described later) of the corresponding ink cartridge **30** in the up-down direction **7**. The boundary position P1 is indicated by an imaginary line extending in the horizontal direction in FIG. **4**. However, the boundary position P1 need not be at the height indicated in FIG. **4**, provided that the boundary position P1 is higher than the outlet port **128** in the up-down direction **7**. For

example, the boundary position P1 may be at the same height as an upper end or a lower end of the internal space of the ink needle **102**, or may be at the same height as an upper end or a lower end of the ink supply opening **71**.

(64) In a case where the level of the ink stored in the storage chamber **121** is equal to or higher than the boundary position P1, the light emitted from the light emitting portion of the liquid-level sensor **155** is interrupted by the detection-target portion **149**. Hence, since the light emitted from the light emitting portion does not reach a light receiving portion of the liquid-level sensor **155**, the liquid-level sensor **155** outputs a low level signal to a controller (not illustrated) of the multifunction device **10**. On the other hand, in a case where the level of the ink is lower than the boundary position P1, the light emitted from the light emitting portion reaches the light receiving portion, and, hence, the liquid-level sensor **155** outputs a high level signal to the non-illustrated controller of the multifunction device **10**. In this way, the controller can determine whether the level of ink in the storage chamber **121** is at the boundary position P1 or higher based on the signals outputted from the liquid-level sensor **155**.

(65) <Ink Cartridge **30**>

(66) The ink cartridge **30** is a container configured to store ink therein. As illustrated in FIG. **5**, the ink cartridge **30** includes a casing **31**, the ink supply portion **34**, a protruding portion **43**, and an operating portion **90**.

(67) The casing **31** has a generally rectangular parallelepiped shape. The casing **31** has a generally flat shape such that dimensions thereof in the up-down direction **7** and in the front-rear direction **8** are greater than a dimension thereof in the left-right direction **9**. Incidentally, the ink cartridges **30** storing different colors of ink from one another may have the same outer shape as or may have different outer shapes from one another.

(68) The casing **31** includes a rear wall **40**, a front wall **41**, an upper wall **39**, a lower wall **42**, and a pair of side walls **37** and **38**.

(69) The rear wall **40** includes a first rear wall **40**A, a second rear wall **40**B, and a third rear wall **40**C. The first rear wall **40**A is positioned frontward of and above the second rear wall **40**B. The second rear wall **40**B is positioned rearward of and above the third rear wall **40**C. The third rear wall **40**C is positioned frontward of and below the first rear wall **40**A. The air communication opening **96** is formed at the first rear wall **40**A. The air communication opening **96** is positioned rearward of the ink supply opening **71** (described later) of the ink supply portion **34**. The ink supply portion **34** is provided at the third rear wall **40**C.

(70) As illustrated in FIG. **6**, the casing **31** of the ink cartridge **30** is roughly divided into a base part **48** and a protruding part **49**. The base part **48** is provided by, for example, a front portion of the upper wall **39**, the front wall **41**, the lower wall **42**, the third rear wall **40**C, and front portions of the side walls **37**, **38**. The protruding part **49** is provided by, for example, a rear portion of the upper wall **39**, the first rear wall **40**A, the second rear wall **40**B, and rear portions of the side walls **37**, **38**.

(71) The protruding part **49** protrudes rearward from a portion of the base part **48**. Specifically, the protruding part **49** protrudes rearward from an upper-rear portion of the base part **48**. A boundary between the base part **48** and the protruding part **49** in the front-rear direction **8** may be defined by, for example, an extension line from the first rear wall **40**A, or an extension line from the third rear wall **40**C, or an imaginary line connecting between a lower end of the first rear wall **40**A and an upper end of the third rear wall **40**C.

(72) The protruding portion **43** and the operating portion **90** are provided at the upper wall **39**. The protruding portion **43** protrudes upward from an outer surface of the upper wall **39** and extends in the front-rear direction **8**. The protruding portion **43** has a locking surface **62** facing frontward. The locking surface **62** is positioned above the upper wall **39**. The locking surface **62** is configured to abut on the locking portion **129** of the cartridge receiving portion **110** in a state where the ink cartridge **30** is attached to the cartridge receiving portion **110**. The abutment of the locking surface **62** on the locking portion **129** functions to maintain the ink cartridge **30** at the attached position

against the urging force of the coil springs **78** and **98**.
(73) The operating portion **90** is positioned frontward of the locking surface **62** on the upper wall **39**. The operating portion **90** has an operating surface **92**. In the state where the ink cartridge **30** is accommodated in the cartridge receiving portion **110**, the ink cartridge **30** is pivotally moved downward by user's depression of the operating surface **92** downward, which in turn moves the locking surface **62** downward relative to the locking portion **129**. The ink cartridge **30** is thus made removable from the cartridge receiving portion **110**.
(74) As illustrated in FIG. **6**, the casing **31** has an internal space which defines therein an upper storage chamber **32**, a lower storage chamber **33**, an ink valve chamber **35**, and the air valve chamber **36**. The upper storage chamber **32**, the lower storage chamber **33**, and the ink valve chamber **35** are configured to store ink therein. The air valve chamber **36** provides airflow between the upper storage chamber **32** and the air chamber **131** of the buffer tank **130**.
(75) The upper storage chamber **32** and the lower storage chamber **33** are positioned adjacent to each other in the up-down direction **7** and partitioned by a partitioning wall **45** in the internal space of the casing **31**. The partitioning wall **45** has a through-hole **47** allowing the upper storage chamber **32** and the lower storage chamber **33** to communicate with each other. The upper storage chamber **32** has an internal volume greater than a sum of internal volumes of the lower storage chamber **33** and the ink valve chamber **35**. The upper storage chamber **32** extends over the base part **48** and the protruding part **49** in the front-rear direction **8**.
(76) The upper storage chamber **32** and the air valve chamber **36** are positioned adjacent to each other in the up-down direction **7** and partitioned by a partitioning wall **44** in the internal space of the casing **31**. The partitioning wall **44** has a through-hole **46** allowing the upper storage chamber **32** and the air valve chamber **36** to communicate with each other. The lower storage chamber **33** is positioned frontward of the ink valve chamber **35**. The lower storage chamber **33** and the ink valve chamber **35** are in communication with each other by a through-hole **99**. The sum of the internal volumes of lower storage chamber **33** and the ink valve chamber **35** is smaller than the internal volume of the storage chamber **121** of the corresponding ink tank **103**. The internal volume of the air chamber **131** is smaller than the internal volume of the storage chamber **121**, as described earlier.
(77) The air valve chamber **36** functions as an airflow path positioned above the upper storage chamber **32**. A labyrinth channel or a semipermeable membrane may be provided in the air valve chamber **36**. A sealing member **94**, a valve **97** and the coil spring **98** are accommodated in the air valve chamber **36**. The sealing member **94** is a disc-like member having a through-hole which is in communication with the air communication opening **96**. The sealing member **94** is in close contact with the casing **31** around the air communication opening **96** to secure air-tight sealing around the air communication opening **96**. The through-hole of the sealing member **94** has an inner diameter slightly smaller than an outer diameter of the corresponding rod **125** of the cartridge receiving portion **110**.
(78) The valve **97** is movable in the front-rear direction **8** between a closed position where the valve **97** closes the through-hole of the sealing member **94** and an open position where the valve **97** opens the through-hole of the sealing member **94**. In other words, the valve **97** is movable between the closed position and the open position to close and open the air communication opening **96**. The coil spring **98** urges the valve **97** rearward, i.e., in a direction to move the valve **97** toward the closed position.
(79) In a process to attach the ink cartridge **30** to the cartridge receiving portion **110**, the rod **125** (see FIG. **7**) of the cartridge receiving portion **110** is inserted in the air valve chamber **36** through the air communication opening **96** and the through-hole of the sealing member **94**. The rod **125** inserted in the air valve chamber **36** moves the valve **97** at the closed position frontward against the urging force of the coil spring **98**, thereby moving the valve **97** to the open position. As a result, the air valve chamber **36** becomes communicated with the air chamber **131** through the internal space

of the rod **125**, and hence, the upper storage chamber **32** is allowed to communicate with the atmosphere through the air communication port **132** of the air chamber **131**.

(80) The air communication opening **96** is positioned rearward of the ink supply opening **71**. The tip end of the rod **125** and the tip end of the ink needle **102** are generally aligned with each other (generally at the same position as each other) in the front-rear direction **8**. Therefore, the rod **125** can be inserted in the air communication opening **96** to establish communication with the air valve chamber **36** before communication of the ink needle **102** with the ink valve chamber **35** is established by insertion of the ink needle **102** in the ink supply opening **71**.

(81) The ink supply portion **34** protrudes rearward from the third rear wall **40**C. Specifically, the ink supply portion **34** is positioned below the lower end of the protruding part **49**, and preferably at a surface of the base part **48** facing rearward. The ink supply portion **34** has a hollow cylindrical shape whose internal space provides the ink valve chamber **35**. The ink supply portion **34** has a protruding end that is open to the outside of the ink cartridge **30**. The second rear wall **40**B is positioned further rearward of the protruding end of the ink supply portion **34**. A sealing member **76**, a valve **77**, and the coil spring **78** are accommodated in the ink valve chamber **35**.

(82) The sealing member **76** is provided at the open protruding end of the ink supply portion **34**. The sealing member **76** has a generally disc-like shape having a through-hole at a diametrical center thereof. The through-hole of the sealing member **76** functions as the ink supply opening **71** of the ink supply portion **34**. The ink supply opening **71** has an inner diameter slightly smaller than an outer diameter of the ink needle **102**. The valve **77** is movable in the front-rear direction **8** inside the ink valve chamber **35** between a closed position where the valve **77** is in abutment with the sealing member **76** to close the ink supply opening **71** and an open position where the valve **77** is separated from the sealing member **76** to open the ink supply opening **71**. The coil spring **78** urges the valve **77** rearward to move the valve **77** to the closed position.

(83) <Ink Flow and Air Flow>

(84) As illustrated in FIG. **7**, the ink cartridge **30** can be attached to the cartridge receiving portion **110** by being moved rearward in the front-rear direction **8**, and can be detached from the cartridge receiving portion **110** by being moved frontward in the front-rear direction **8**. In the process to attach the ink cartridge **30** to the cartridge receiving portion **110**, the ink needle **102** of the cartridge receiving portion **110** is inserted into the ink valve chamber **35** of the ink cartridge **30** through the ink supply opening **71**. At this time, the ink needle **102** closely contacts the ink supply opening **71** (the inner peripheral surface of the sealing member **76** defining the ink supply opening **71**) to provide light-tight sealing therebetween, while elastically deforming the sealing member **76**. In accordance with further insertion of the ink cartridge **30** into the cartridge receiving portion **110**, the ink needle **102** moves the valve **77** to the open position against the urging force of the coil spring **78**. Further, the valve **77** moves the valve **114**, which protrudes out through the opening **116** of the ink needle **102**, to the open position against the urging force of the coil spring **115**.

(85) As illustrated in FIG. **7**, ink is allowed to circulate between the ink valve chamber **35** of the ink supply portion **34** and the internal space of the ink needle **102** when the ink supply opening **71** is opened and the air valve chamber **36** is made to communicate with the atmosphere through the air communication port **132** of the air chamber **131**. As a result, the ink stored in the upper storage chamber **32** and the lower storage chamber **33** flows into the storage chamber **121** of the ink tank **103** due to water head difference through the ink supply portion **34** and the connecting portion **107** connected to each other. The ink flowing out of the storage chamber **121** into the ejection head **21** through the outlet port **128** is configured to be ejected from the nozzles **29** in the state where the ink cartridge **30** is connected to the ink tank **103** and the buffer tank **130**.

(86) In the operable posture of the multifunction device **10** illustrated in FIG. **1**A, the ink cartridge **30** and the ink tank **103** are in the state illustrated in FIG. **7**. The multifunction device **10** can perform various operations such as image recording operations in the operable posture.

(87) Hereinafter, description will be made on a case where a new ink cartridge **30** is attached to a

brand-new multifunction device **10**. In the new ink cartridge **30**, a maximum amount of ink is stored in the upper storage chamber **32**, the lower storage chamber **33**, and the ink valve chamber **35**. Further, in the unused multifunction device **10**, no ink is stored in the storage chamber **121** of the ink tank **103**. Here, “no ink is stored in the storage chamber **121**” implies a state where the ink in the ink cartridge **30** has not been flowed into the storage chamber **121**. That is, the “ink stored in the storage chamber **121**” does not mean such ink left in the storage chamber **121** as a result of execution of the inspection of the multifunction device **10** at the time of manufacture thereof (the ink may be temporarily stored in the storage chamber **121** and then removed therefrom in the inspection of the multifunction device **10**).

(88) Immediately after the attachment of the new ink cartridge **30** to the unused multifunction device **10**, that is, in a state where the ink in the ink cartridge **30** has not yet flowed into the storage chamber **121** of the ink tank **103**, the level of ink stored in the ink cartridge **30** in the up-down direction **7** is shown by a level P2 as indicated by a two-dotted chain line in FIG. **7**.

(89) As illustrated in FIG. **7**, upon attachment of the ink cartridge **30** to the cartridge receiving portion **110**, the ink supply opening **71** is opened and the air valve chamber **36** is open to the atmosphere through the air communication port **132** of the air chamber **131**, so that the ink can flow into the ink valve chamber **35** of the ink supply portion **34** and the internal space of the ink needle **102**. Accordingly, the ink stored in the upper storage chamber **32** and the lower storage chamber **33** flows into the storage chamber **121** of the ink tank **103** due to water head difference through the ink supply portion **34** and the connecting portion **107** connected to each other. The ink flow between the upper and lower storage chambers **32**,**33** and the storage chamber **121** is terminated when the level of ink stored in the upper and lower storage chambers **32**, **33** becomes equal to the level of ink stored in the storage chamber **121**, that is, when the water head difference between the storage chamber **121** and the upper and lower storage chambers **32**,**33** disappears. The level of ink in the storage chamber **121** at this time (when the water head difference disappears after attachment of the new ink cartridge **30** to the unused multifunction device **10**) is a level P3 indicated by two-dotted chain line in FIG. **7**.

(90) As illustrated in FIG. **7**, the air communication port **132** of the buffer tank **130** is positioned higher than each of the level P2 and the level P3 of the ink stored in the ink cartridge **30**. Further, the air communication port **124** of the ink tank **103** is positioned higher than each of the level P2 and the level P3 of the ink stored in the ink cartridge **30**. Hence, in the state illustrated in FIG. **7**, the ink does not contact the first semipermeable membrane **133** and the second semipermeable membrane **127**.

(91) As the ink flows into the storage chamber **121** in response to attachment of the new ink cartridge **30** to the brand-new multifunction device **10**, the ink is to be stored in the storage chamber **121** to elevate the ink level in the storage chamber **121**. In the ink cartridge **30**, in response to the outflow of the ink therefrom, air flows into the upper storage chamber **32** through the first semipermeable membrane **133** covering the air communication port **132**, the air chamber **131**, the internal space of the rod **125**, the air valve chamber **36**, and the through-hole **46**. On the other hand, in the ink tank **103**, air in the storage chamber **121** flows out of the storage chamber **121**, in response to the inflow of ink into the storage chamber **121**, through the second semipermeable membrane **127** covering the air communication port **124**.

(92) In the state illustrated in FIG. **7**, the ink stored in the storage chamber **121** of the ink tank **103** flows into the ejection head **21** through the outlet port **128** in accordance with the ejection of ink from the ejection head **21**. The level of ink in the storage chamber **121** is lowered down, and ambient air of a certain volume is taken into the storage chamber **121** through the second semipermeable membrane **127** and the air communication port **124**, the certain volume being equivalent to a volume of the ink flowing out of the storage chamber **121**.

(93) Further, the ink stored in the upper storage chamber **32** and lower storage chamber **33** of the ink cartridge **30** flows into the storage chamber **121** through the ink needle **102**. The level of ink in

the upper storage chamber **32** is lowered down, and a certain volume of ambient air (corresponding to the volume of the ink flowing out of the upper storage chamber **32**) flows into the upper storage chamber **32** through the first semipermeable membrane **133**, the air communication port **132**, the air chamber **131**, and the air valve chamber **36**. Since the flow resistance R2 of the second semipermeable membrane **127** is greater than the flow resistance R1 of the first semipermeable membrane **133** (R1<R2), the flow rate of the ink flowing out of the outlet port **128** from the lower storage chamber **33** of the ink cartridge **30** through the storage chamber **121** is higher than the flow rate of the ink flowing out of the outlet port **128** from the storage chamber **121**, in accordance with the ejection of ink from the ejection head **21**. That is, the ink stored in the lower storage chamber **33** is more likely to flow out of the outlet port **128** than the ink stored in the storage chamber **121** of the ink tank **103** flows out of the outlet port **128**.

(94) FIG. **8** illustrates a state where the multifunction device **10** is turned into an abnormal posture (referred to as “collapsed posture”) for some reason. In the collapsed posture of the multifunction device **10**, the ink cartridge **30** connected to the ink tank **103** and the buffer tank **130** is positioned above the ink tank **103** and the buffer tank **130**. In the collapsed posture, the rear surface of the multifunction device **10** (rear wall **40**) comes to the bottom, and the front surface of the multifunction device **10** (front wall **41**) comes to the top. In the collapsed posture, ambient air can flow into the upper storage chamber **32** and the lower storage chamber **33** through the first semipermeable membrane **133**, the air communication port **132**, the air valve chamber **36**, and the through-hole **46**.

(95) In the collapsed posture, the second semipermeable membrane **127** contacts the ink in the storage chamber **121**, since the air communication port **124** and the second semipermeable membrane **127** are provided at the rear wall **143** of the ink tank **103**. That is, ambient air cannot pass through the second semipermeable membrane **127**. Accordingly, in the operable posture, the ink in the lower storage chamber **33** of the ink cartridge **30** does not continuously flow into the storage chamber **121** of the ink tank **103**.

Operational and Technical Advantages According to the Embodiment

(96) According to the above-described embodiment, in the state where the ink cartridge **30** is connected to the ink tank **103** and the buffer tank **130**, ambient air passing through the first semipermeable membrane **133** covering the air communication port **132** flows into the upper storage chamber **32** through the airflow path including the air chamber **131**, the internal space of the rod **125**, and the first semipermeable membrane **133**. As such, the flow resistance for this airflow path can be set to an optimum value to realize the ink flow from the upper storage chamber **32** and the lower storage chamber **33** into the storage chamber **121**. On the other hand, since the ambient air passing through the second semipermeable membrane **127** covering the air communication port **124** flows into the storage chamber **121**, the flow resistance for the airflow through the second semipermeable membrane **127** can be set to an optimum value for enabling the ink stored in the storage chamber **121** to flow out of the outlet port **128**. Further, the structure of the ink cartridge **30** can be simplified, since no air communicating portion is necessary in the ink cartridge **30**.

(97) Further, in the collapsed posture, air communication between the storage chamber **121** and the atmosphere is interrupted, since the second semipermeable membrane **127** covering the air communication port **124** is closed or plugged by the ink stored in the storage chamber **121**. With this configuration, due to the interruption of airflow into the storage chamber **121**, the ink in the storage chamber **121** is less likely to flow out therefrom into the ejection head **21** through the outlet port **128**.

(98) Further, the air communication opening **96** of the ink cartridge **30** is positioned rearward of the ink supply opening **71**, and the rod **125** is inserted in the air communication opening **96** to provide communication of air between the air chamber **131** and the air valve chamber **36** before the ink needle **102** is inserted in the ink supply opening **71** to provide communication of ink between the

storage chamber **121** and the ink valve chamber **35**. Accordingly, the communication between the ink needle **102** and the ink valve chamber **35** is established after the air layer in the upper storage chamber **32** of the ink cartridge **30** becomes the atmospheric pressure. This configuration can restrain abrupt outflow of ink from the ink cartridge **30** and abrupt outflow of ink from the ink tank **103** into the ink cartridge **30** upon attachment of the ink cartridge **30** to the cartridge receiving portion **110**.
(99) Further, the flow resistance R2 of the second semipermeable membrane **127** is greater than the flow resistance R1 of the first semipermeable membrane **133** (R1<R2). In accordance with the ejection of ink from the ejection head **21**, the ink stored in the ink tank **103** and the ink stored in the ink cartridge **30** decrease. Since the flow resistance R2 is higher than the flow resistance R1, ambient air tends to flow into the ink cartridge **30**, rather than into the ink tank **103**. This means that the level of ink in the ink cartridge **30** is more likely to be lowered, compared to the level of ink in the ink tank **103**. That is, with respect to the amount of ink flowing into the ejection head **21**, the ratio of the ink coming from the ink cartridge **30** to the ejection head **21** is higher than the ratio of the ink coming from the ink tank **103** to the ejection head **21**.
(100) Accordingly, in a case where a large amount of ink is ejected from the ejection head **21** (such as photo-printing and a maintenance checkup to the ejection head **21**), the level of ink in the ink tank **103** is less likely to decrease relative to the level of ink in the ink cartridge **30**. Hence, the ink level in the ink tank **103** hardly becomes lower than the boundary position P1 to make the liquid-level sensor **155** output a high level signal, despite the fact that the ink level in the ink cartridge **30** is still higher than the boundary position P1. Thus, the liquid-level sensor **155** can accurately detect the amount of ink left in the storage chamber **121** of the ink tank **103**. Further, the ink level in the ink cartridge **30** can be lower than the ink level in the ink tank **103** upon termination of an image recording operation. As such, after the image recording operation, the ink in the ink cartridge **30** does not flow into the ink tank **103**, and the level of ink in the ink tank **103** does not go up.
(101) Further, since the level of ink in the ink cartridge **30** can be lower than the level of ink in the ink tank **103**, the lower storage chamber **33** of the ink cartridge **30** becomes empty before the liquid surface of the ink in the ink tank **103** reaches the boundary position P1. Thereafter, as the ink is further ejected from the ejection head **21**, ambient air is introduced into the storage chamber **121** of the ink tank **103** through the first semipermeable membrane **133** and the second semipermeable membrane **127**. Since the flow resistance R2 is higher than the flow resistance R1, ambient air tends to be introduced into the storage chamber **121** of the ink tank **103** through the ink cartridge **30**. Hence, ink is unlikely to remain in the ink cartridge **30**, thereby promoting use up of the ink in the ink cartridge **30**.
Modifications
(102) While the invention has been described in conjunction with various example structures outlined above and illustrated in the figures, various alternatives, modifications, variations, improvements, and/or substantial equivalents, whether known or that may be presently unforeseen, may become apparent to those having at least ordinary skill in the art. Accordingly, the example embodiments of the disclosure, as set forth above, are intended to be illustrative of the invention, and not limiting the invention. Various changes may be made without departing from the spirit and scope of the disclosure. Therefore, the disclosure is intended to embrace all known or later developed alternatives, modifications, variations, improvements, and/or substantial equivalents. Some specific examples of potential alternatives, modifications, or variations in the described invention are provided below:
(103) For example, in the above-described embodiment, the boundary position P1 is at the same height as the axis of the ink needle **102** and also at the same height as the center of the ink supply opening **71** in the up-down direction **7**. However, the boundary position P1 may be higher than or lower than the axis of the ink needle **102**.
(104) As an example, FIG. **9** illustrates a cartridge receiving portion **210** according to a first

modification to the embodiment where the boundary position P1 is set to be higher than the axis of the ink needle **102** in the up-down direction **7**. With this structure, air is less likely to flow into the ink tank **103** from the ink cartridge **30** when the level of ink reaches the boundary position P1. Hence, air bubbles are less likely to adhere to the pivot member **145**, and the pivotal movement of the pivot member **145** is less likely to be impeded by the air bubbles when the level of ink reaches the boundary position P1.

(105) Alternatively, FIG. **10** illustrates a cartridge receiving portion **310** according to a second modification where the boundary position P1 is set at a position lower than the axis of the ink needle **102** in the up-down direction **7**. With this configuration, the lower storage chamber **33** of the ink cartridge **30** becomes empty before the level of ink in the ink tank **103** reaches the boundary position P1; and thereafter the ink and air bubbles remaining in the lower storage chamber **33** and the upper storage chamber **32** flow into the ink tank **103** as time elapses. In this way, the ink left in the ink cartridge **30** can fully move into the ink tank **103** before the level of ink in the ink tank **103** reaches the boundary position P1.

(106) Incidentally, in the above-described embodiment, the pivot member **145** is provided in the storage chamber **121**, and the liquid-level sensor **155** is configured to detect the detection-target portion **149** of the pivot member **145**. However, a conventional structure may be used instead of the pivot member **145**. For example, a prism may be provided on an inner surface of the rear wall **143** of the ink tank **103** at the same height as the boundary position P1 in the up-down direction **7**. The prism is configured to provide different reflection coefficients with respect to light depending on whether or not the ink contacts the prism, and the liquid-level sensor **155** may be configured to detect the light reflected by the prism. Alternatively, instead of the pivot member **145**, a pair of electrodes may be disposed in the storage chamber **121**. Whether or not current flows between the two electrodes may be detected depending on whether the electrodes are in contact with the ink or not.

(107) Further, in the above-described embodiment, the air communication port **124** is provided on the rear wall **143** of the ink tank **103**. However, the air communication port **124** may be provided on the upper wall or the side wall of the ink tank **103**, instead of the rear wall **143**. In a case where the air communication port **124** is positioned on the upper wall or the side wall, preferably, the air communication port **124** be at a position rearward (toward the bottom in the collapsed posture) relative to a front-rear center of the upper wall or the side wall with respect to the front-rear direction **8**.

(108) Further, instead of the first semipermeable membrane **133** and the second semipermeable membrane **127**, foamed resin members (which allow airflow therethrough) may be provided at the air communication port **124** and the air communication port **132**, respectively, to close the same.

(109) Incidentally, the air communication opening **96** of the ink cartridge **30** may be opened and closed through a structure other than the valve mechanism described in the above-described embodiment. For example, an elastic member may be provided to seal the air communication opening **96**, and the rod **125** may have a pointed tip end to penetrate the elastic member.

(110) Still further, while the ink tank **103** and the buffer tank **130** of the above-described embodiment are respectively different products made from resin, the ink tank **103** and the buffer tank **130** may be integral with each other as an integral resin molded product.

(111) For example, FIG. **11** illustrates a cartridge receiving portion **410** according to a third modification to the embodiment where an ink tank **403** (corresponding to the ink tank **103**) and a buffer tank **430** (corresponding to the buffer tank **130**) are made integral with each other. In the cartridge receiving portion **410**, an air communication port **424** of the ink tank **403** and an air communication port **432** of the buffer tank **430** are formed in respective upper walls of the ink tank **403** and the buffer tank **430**, and a single semipermeable membrane **436** covers both of the air communication ports **424** and **432**. It should be noted here that, although the single semipermeable membrane **436** covers both of the air communication ports **424** and **432** at the same time in this

example, the buffer tank **430** and the ink tank **403** respectively define independent chambers (the air chamber **131** and storage chamber **121**) which are not in communication with each other. The internal volume of the air chamber **131** is smaller than the internal volume of the storage chamber **121**, as in the embodiment.

(112) In the described embodiment, the ink cartridge **30** is configured to be attached to and detached from the cartridge receiving portion **110** by being moved in the front-rear direction **8**. However, the ink cartridge **30** need not be moved in the front-rear direction **8**. For example, FIG. **12** illustrates a configuration according to a fourth modification where an ink cartridge **50** is configured to be attached to and detached from a cartridge receiving portion **510** in the up-down direction **7**.

(113) Specifically, referring to FIG. **12**, the ink cartridge **50** includes a casing **51** having an internal space divided into an ink storage chamber **53** and an air chamber **54** by a partition wall **52**. A through-hole **56** is formed in an upper end portion of the partition wall **52** to provide communication of air between the ink storage chamber **53** and the air chamber **54**.

(114) The casing **51** has a lower wall provided with connecting portions **57**, **58**. Although not illustrated in detail in FIG. **12**, the connecting portion **57** has a structure the same as that of the ink supply portion **34**. The connecting portion **57** has an opening through which the ink in the ink storage chamber **53** can flow out, and a valve is provided for opening and closing the opening. The connecting portion **58** has a structure the same as that of the air valve chamber **36**. The connecting portion **58** has an opening in communication with the air chamber **54**, and a valve is provided for opening and closing the opening.

(115) The cartridge receiving portion **510** includes an ink tank **550** having a generally L-shape in a side view. The ink tank **550** has a first upper wall formed with an air communication port **551** which is covered with a second semipermeable membrane **552**. The ink tank **550** has an internal space functioning as a storage chamber **553** for storing ink. The ink tank **550** has a second upper wall **554** lower than the first upper wall, and an ink needle **555** extends upward from the second upper wall **554**. The ink needle **555** has an internal space in communication with the ink storage chamber **553**. The ink needle **555** can be inserted in the connecting portion **57** of the ink cartridge **50**. The storage chamber **553** has an outlet opening **556** through which the ink in the storage chamber **553** is configured to flow out to the ejection head **21**.

(116) A buffer tank **560** is positioned frontward of the ink tank **550**. The buffer tank **560** has a box-like shape whose internal space functions as an air chamber **561**. The buffer tank **560** has an upper wall formed with an air communication port **562** which is closed by a first semipermeable membrane **563**. A rod **564** extends upward from the upper wall of the buffer tank **560**. The rod **564** has a hollow cylindrical shape whose hollow space is in communication with the air chamber **561**. The rod **564** can be inserted in the connecting portion **58** of the ink cartridge **50**. In this example, since the buffer tank **560** is a separate member from the ink tank **550**, the air chamber **561** in the buffer tank **560** and the storage chamber **553** in the ink tank **550** are respectively independent chambers which are not in communication with each other. The air chamber **561** has an internal volume which is smaller than an internal volume of the storage chamber **553**, as in the embodiment.

(117) As illustrated in FIG. **12**, the ink cartridge **50** is connected to the ink tank **550** and the buffer tank **560** by being moved downward toward the ink tank **550** and the buffer tank **560**. In a process to move the ink cartridge **50** downward, the ink needle **555** is inserted in the connecting portion **57** of the ink cartridge **50**, and the rod **564** is inserted in the connecting portion **58** of the ink cartridge **50**. Hence, the ink storage chamber **53** of the ink cartridge **50** is communicated with the atmosphere through the air chamber **54**, the air chamber **561** and the air communication port **562**. Accordingly, the ink stored in the ink storage chamber **53** of the ink cartridge **50** can flow into the storage chamber **553** of the ink tank **550** due to the water head difference.

(118) FIG. **13** illustrates another configuration according to a fifth modification to the embodiment

where a bottle **670** (instead of the ink cartridge **30**) is configured to be attached to and detached from a cartridge receiving portion **710**. Specifically, the bottle **670** is connectable to an ink tank **780** and a buffer tank **790** of the cartridge receiving portion **710**. The bottle **670** includes a casing **671** and a partition wall **672** dividing an internal space of the casing **671** into a storage chamber **673** and an air chamber **674**. The partition wall **672** has an upper end portion formed with a through-hole **675**. The through-hole **675** allows circulation of air between the storage chamber **673** and the air chamber **674**.

(119) The casing **671** has a bottom wall provided with connecting portions **676** and **677**. Although not illustrated in detail in FIG. **13**, the connecting portion **676** has a structure the same as that of the ink supply portion **34**. The connecting portion **676** has an opening through which the ink in the storage chamber **673** can flow out therefrom, and a valve is provided for opening and closing the opening. The connecting portion **677** has a structure the same as that of the air valve chamber **36**. The connecting portion **677** has an opening in communication with the air chamber **674** and a valve is provided for opening and closing the opening.

(120) The ink tank **780** has a generally L-shape in a side view. The ink tank **780** has an upper wall formed with an air communication port **781** which is covered with a second semipermeable membrane **782**. The ink tank **780** has an internal space functioning as a storage chamber **783** for storing ink. An ink needle **785** extends upward from the upper wall of the ink tank **780**. The ink needle **785** has an internal space in communication with the storage chamber **783**. The ink needle **785** can be inserted in the connecting portion **676** of the bottle **670**. The storage chamber **783** has an outlet opening **786** through which the ink in the storage chamber **783** is configured to flow out to the ejection head **21**.

(121) The buffer tank **790** is positioned rearward of and above the ink tank **780**. The buffer tank **790** has a box-like shape whose internal space functions as an air chamber **791**. That is, the air chamber **791** is an independent space that is not in communication with the storage chamber **783**. The buffer tank **790** has a rear wall formed with an air communication port **792** which is closed by a first semipermeable membrane **793**. A rod **794** extends upward from the upper wall of the buffer tank **790**. The rod **794** has a hollow cylindrical shape whose hollow space is in communication with the air chamber **791**. The rod **794** can be inserted in the connecting portion **677** of the bottle **670**. In this example as well, the air chamber **791** has an internal volume that is smaller than an internal volume of the storage chamber **783**.

(122) As illustrated in FIG. **13**, the bottle **670** is connectable to the ink tank **780** and the buffer tank **790** by being moved downward toward the ink tank **780** and the buffer tank **790**. The bottle **670** is for replenishing ink therein to the storage chamber **783** of the ink tank **780**, and, hence, the bottle **670** is not always connected to the ink tank **780** and the buffer tank **790**. Accordingly, the ejection head **21** can eject the ink flowing out of the storage chamber **783** in a state where the bottle **670** is not connected to the ink tank **780** and the buffer tank **790**.

(123) In a process to move the bottle **670** downward, the ink needle **785** is inserted in the connecting portion **676** of the bottle **670**, and the rod **794** is inserted in the connecting portion **677** of the bottle **670**. Accordingly, the storage chamber **673** of the bottle **670** is communicated with the atmosphere through the air chamber **674**, the air chamber **791** and the air communication port **792**. The ink stored in the storage chamber **673** of the bottle **670** can thus flow into the storage chamber **783** of the ink tank **780** due to the water head difference.

(124) [Remarks]

(125) The multifunction device **10** is an example of a liquid consuming device. The ink cartridges **30**, **50** and the bottle **670** are examples of a liquid container. The buffer tanks **130**, **430**, **560**, **790** are examples of an air tank. The ink tanks **103**, **403**, **550**, **780** are examples of a liquid tank. The ejection head **21** is an example of an ejection head. The upper storage chamber **32**, the lower storage chamber **33** and the ink valve chamber **35** are an example of a first storage chamber of the liquid container. The ink storage chamber **53** and storage chamber **673** are other examples of the

first storage chamber of the liquid container. The rods **125**, **564**, **794** are examples of an air flow path. The air chambers **131**, **561**, **791** are examples of an air chamber. The air communication ports **132**, **432**, **562**, **792** are examples of a first communicating portion. The ink needles **102**, **555**, **785** are examples of liquid flow path. The storage chambers **121**, **553**, **783** are examples of a second storage chamber. The outlet port **128** is an example of a liquid outlet port. The air communication ports **124**, **424**, **551**, **781** are examples of a second air communicating portion. The air communication opening **96** is an example of an air communication opening. The ink supply opening **71** is an example of a liquid communication opening. The first semipermeable membranes **133**, **563**, **793** are examples of a first semipermeable membrane. The second semipermeable membranes **127**, **552**, **782** are examples of a second semipermeable membrane. The liquid-level sensor **155** and pivot member **145** are an example of a detector. The rearward direction is an example of a first direction, and the frontward direction is an example of a second direction. The air valve chamber **36** is an example of a container air chamber. The valve **97** is an example of a valve, and the coil spring **98** is an example of a spring in the container air chamber.

Claims

1. A liquid consuming device comprising: a liquid container comprising a first storage chamber configured to store liquid therein; an air tank to which the liquid container is connectable, the air tank comprising: an air flow path configured to communicate with the first storage chamber of the liquid container that is connected to the air tank; an air chamber connected to the air flow path and configured to communicate with the first storage chamber through the air flow path to provide airflow between the first storage chamber and the air chamber; and a first air communicating portion configured to allow the air chamber to communicate with an atmosphere; a liquid tank to which the liquid container is connectable, the liquid tank comprising: a liquid flow path configured to communicate with the first storage chamber of the liquid container that is connected to the liquid tank; a second storage chamber connected to the liquid flow path and configured to communicate with the first storage chamber through the liquid flow path to allow the liquid stored in the first storage chamber to flow into the second storage chamber; a liquid outlet port through which the liquid stored in the second storage chamber is configured to flow out therefrom; and a second air communicating portion configured to allow the second storage chamber to communicate with the atmosphere; and an ejection head configured to eject the liquid supplied from the second storage chamber through the liquid outlet port, wherein the air flow path is configured to provide communication between the first storage chamber and the air chamber in a state where the liquid container is connected to the air tank and the liquid tank.
2. The liquid consuming device according to claim 1, wherein the ejection head is configured to consume the liquid in the state where the liquid container is connected to the air tank and the liquid tank.
3. The liquid consuming device according to claim 1, wherein the liquid container is configured to be moved in a first direction crossing a vertical direction to be connected to the air tank and the liquid tank, and wherein the liquid container is configured to be moved in a second direction opposite to the first direction to be removed from the air tank and the liquid tank.
4. The liquid consuming device according to claim 3, wherein the liquid container has: an air communication opening connectable to the air flow path; and a liquid communication opening connectable to the liquid flow path, the air communication opening being positioned further in the first direction relative to the liquid communication opening.
5. The liquid consuming device according to claim 4, wherein the liquid communication opening is configured to be connected to the liquid flow path after the air communication opening is connected to the air flow path in a process that the liquid container is moved in the first direction to be connected to the air tank and the liquid tank.

6. The liquid consuming device according to claim 1, wherein the first air communicating portion has an opening that is open to the atmosphere, and wherein, in the state where the liquid container is connected to the air tank and the liquid tank, the opening of the first air communicating portion is positioned above a level of the liquid stored in the first storage chamber.
7. The liquid consuming device according to claim 1, wherein the second air communicating portion has an opening that is open to the atmosphere, and wherein, in the state where the liquid container is connected to the air tank and the liquid tank, the opening of the second air communicating portion is positioned above a level of the liquid stored in the first storage chamber.
8. The liquid consuming device according to claim 7, wherein the liquid consuming device is in a collapsed posture when the liquid container connected to the air tank and the liquid tank is positioned above the air tank and the liquid tank, and wherein, in a state where the liquid consuming device is in the collapsed posture, the opening of the second air communicating portion is positioned at a bottom of the second storage chamber.
9. The liquid consuming device according to claim 1, wherein the ejection head is configured to consume the liquid in the second storage chamber in a state where the liquid container is disconnected from the air tank and the liquid tank.
10. The liquid consuming device according to claim 1, further comprising: a first semipermeable membrane provided to close the first air communicating portion and configured to allow air to flow through the first semipermeable membrane; and a second semipermeable membrane provided to close the second air communicating portion and configured to allow air to flow through the second semipermeable membrane.
11. The liquid consuming device according to claim 10, wherein the first semipermeable membrane has a flow resistance that is lower than a flow resistance of the second semipermeable membrane.
12. The liquid consuming device according to claim 1, wherein the air tank and the liquid tank are integral with each other as an integral resin molded product.
13. The liquid consuming device according to claim 1, wherein the air tank and the liquid tank are resin molded products independent of each other.
14. The liquid consuming device according to claim 1, further comprising a detector configured to detect whether a level of the liquid stored in the liquid tank is below a threshold liquid level.
15. The liquid consuming device according to claim 1, wherein the air chamber has a volume which is smaller than a volume of the second storage chamber.
16. The liquid consuming device according to claim 1, wherein the liquid container further comprises a container air chamber in communication with the first storage chamber, and wherein the air flow path is configured to provide communication between the first storage chamber and the air chamber via the container air chamber in the state where the liquid container is connected to the air tank and the liquid tank.
17. The liquid consuming device according to claim 16, wherein the liquid container has an air communication opening through which the container air chamber is configured to communicate with the atmosphere, wherein the liquid container further comprises: a valve provided in the container air chamber and movable between a closed position where the valve closes the air communication opening and an open position where the valve opens the air communication opening; and a spring urging the valve toward the closed position in the container air chamber, and wherein the valve is at the open position in the state where the liquid container is connected to the air tank and the liquid tank.
18. A liquid consuming device comprising: a liquid container comprising a first storage chamber configured to store liquid therein; an air flow path configured to communicate with the first storage chamber of the liquid container; an air chamber connected to the air flow path and configured to communicate with the first storage chamber through the air flow path to provide airflow between the first storage chamber and the air chamber; a first air communicating portion configured to allow the air chamber to communicate with an atmosphere; a liquid flow path configured to communicate

with the first storage chamber of the liquid container; a second storage chamber connected to the liquid flow path and configured to communicate with the first storage chamber through the liquid flow path to allow the liquid stored in the first storage chamber to flow into the second storage chamber; a liquid outlet port through which the liquid stored in the second storage chamber is configured to flow out therefrom; a second air communicating portion configured to allow the second storage chamber to communicate with the atmosphere; and an ejection head configured to eject the liquid supplied from the second storage chamber through the liquid outlet port, wherein the air flow path is configured to provide communication between the first storage chamber and the air chamber in a state where the first storage chamber is in communication with the second storage chamber, wherein the second storage chamber and the air chamber are not in communication with each other in a state where the first storage chamber is not in communication with each of the second storage chamber and the air chamber, and wherein the air chamber has a volume which is smaller than a volume of the second storage chamber.

19. The liquid consuming device according to claim 18, wherein the liquid container further comprises a container air chamber in communication with the first storage chamber, and wherein the air flow path is configured to provide communication between the first storage chamber and the air chamber via the container air chamber in the state where the first storage chamber is in communication with the second storage chamber.

20. The liquid consuming device according to claim 19, wherein the liquid container has an air communication opening through which the container air chamber is configured to communicate with the atmosphere, wherein the liquid container further comprises: a valve provided in the container air chamber and movable between a closed position where the valve closes the air communication opening and an open position where the valve opens the air communication opening; and a spring urging the valve toward the closed position in the container air chamber, and wherein the valve is at the open position in the state where the first storage chamber is in communication with the second storage chamber.