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(54) **LIQUID EJECTION SYSTEM AND COMPUTER PROGRAM**

(71) Applicant: **SEIKO EPSON CORPORATION**, Tokyo (JP)

(72) Inventors: **Shuichi KOGANEHIRA**, Matsumoto (JP); **Tsuyoshi HAYASHI**, Shiojiri (JP); **Yasuhiko KOSUGI**, Matsumoto (JP)

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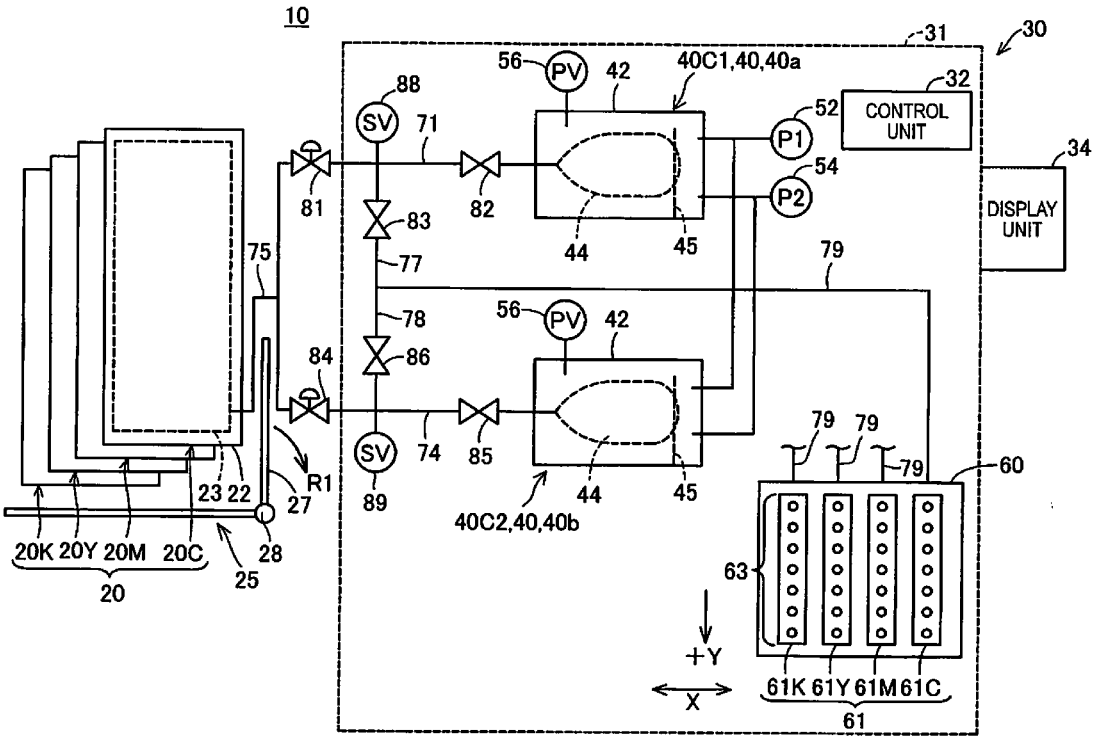
(57) **ABSTRACT**

The control unit, when a first condition in which a minimum value of a suppliable time that is a time it takes for an amount of liquid contained in each supply-side sub tank to reach an amount corresponding to a switching preparation time necessary for switching between the refill-side sub tank and the supply-side sub tank is less than or equal to a maximum value of a full refill refilling time that is a period from when refill processing for performing refilling of the liquid from the main tank is started in each of the plurality of refill-side sub tanks until a state is achieved in which the refill-side sub tank is fully re-filled with liquid and can supply the liquid is satisfied, the refill processing is performed on the plurality of refill-side sub tanks.



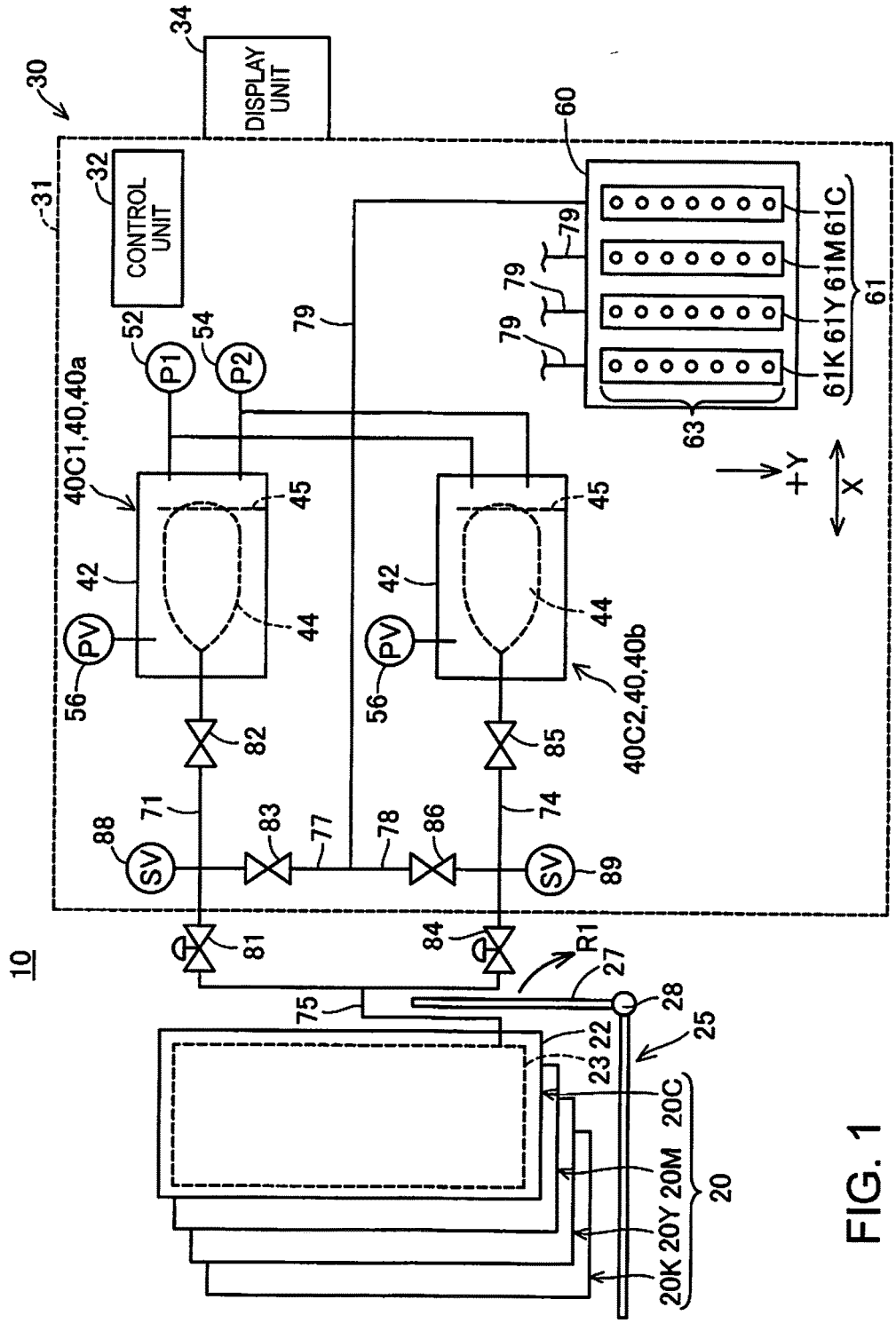

10
30
31
34
DISPLAY UNIT
32
CONTROL UNIT
60
61
61K 61Y 61M 61C
63
79
52
54
P1
P2
40C1,40,40a
40C2,40,40b
42
44
45
PV
56
82
85
71
74
88
83
77
78
86
89
SV
81
84
R1
27
28
25
75
22
23
20
20C
20M
20Y
20K
+Y
X

FIG. 1

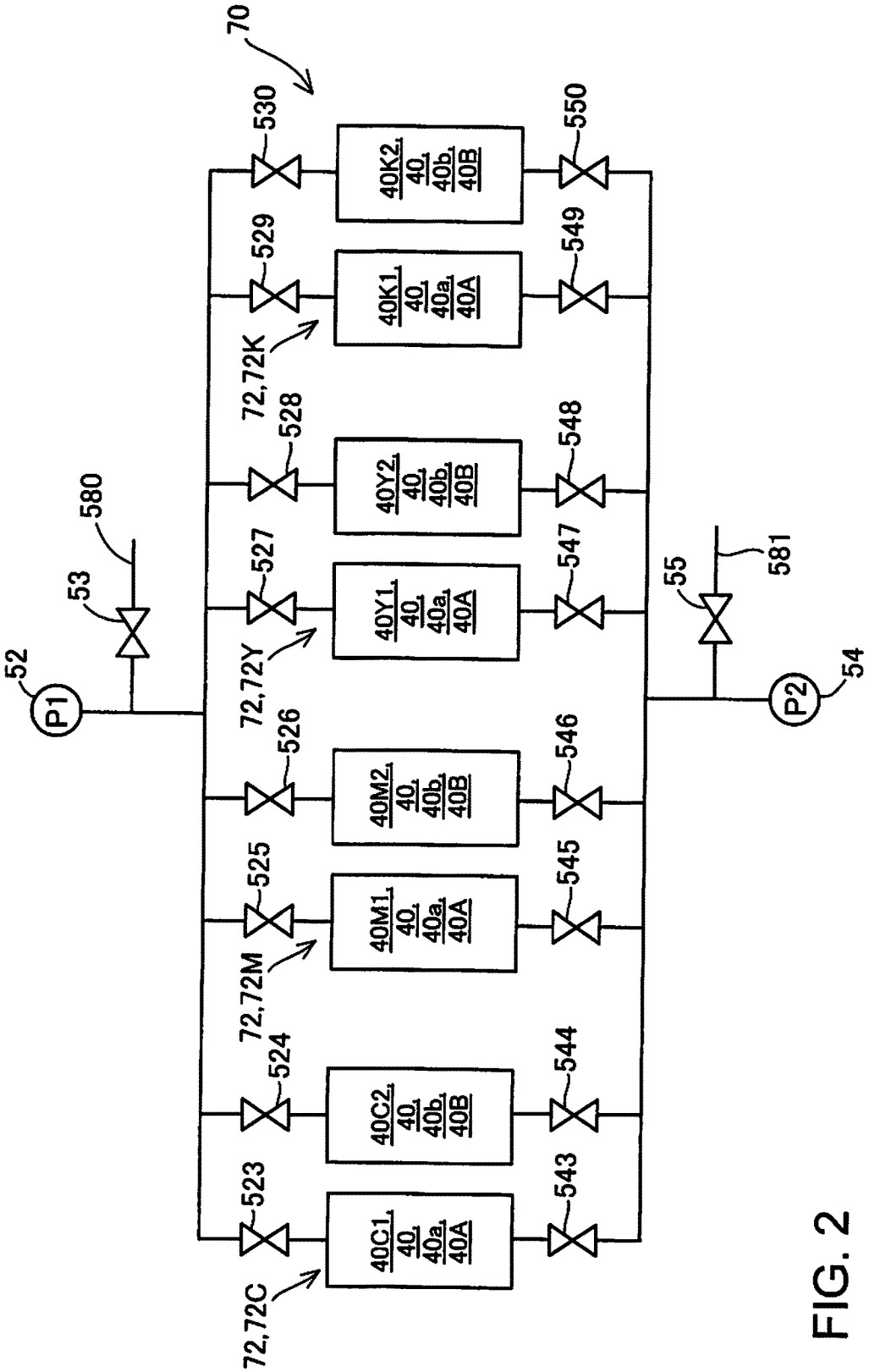

70
530
550
40K2, 40, 40b, 40B
529
549
40K1, 40, 40a, 40A
72,72K
528
548
40Y2, 40, 40b, 40B
580
527
547
40Y1, 40, 40a, 40A
581
53
55
52
72,72Y
P1
P2
54
526
546
40M2, 40, 40b, 40B
525
545
40M1, 40, 40a, 40A
72,72M
524
544
40C2, 40, 40b, 40B
523
543
40C1, 40, 40a, 40A
72,72C

FIG. 2

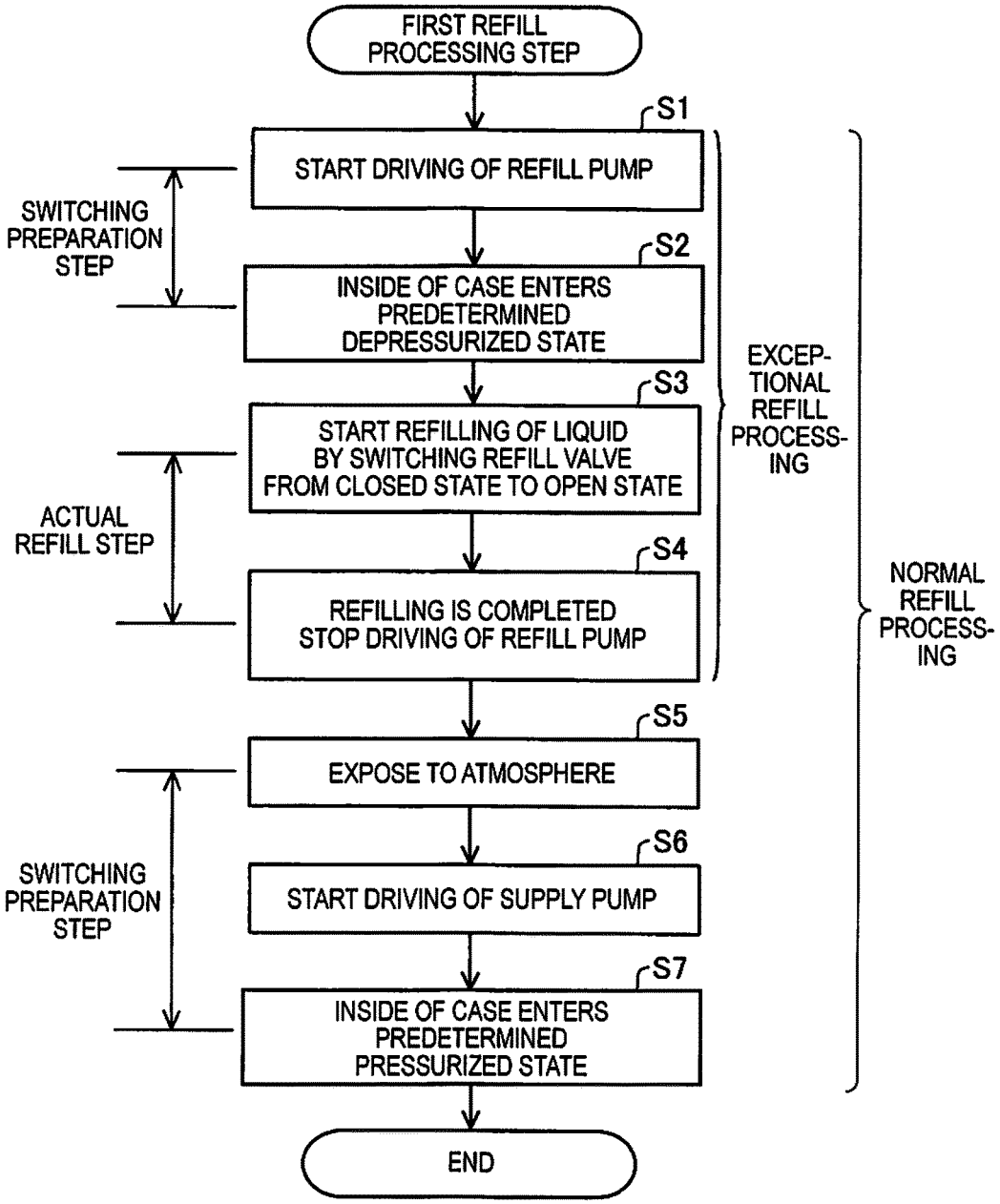

FIRST REFILL PROCESSING STEP
S1
START DRIVING OF REFILL PUMP
S2
INSIDE OF CASE ENTERS PREDETERMINED DEPRESSURIZED STATE
S3
START REFILLING OF LIQUID BY SWITCHING REFILL VALVE FROM CLOSED STATE TO OPEN STATE
S4
REFILLING IS COMPLETED STOP DRIVING OF REFILL PUMP
S5
EXPOSE TO ATMOSPHERE
S6
START DRIVING OF SUPPLY PUMP
S7
INSIDE OF CASE ENTERS PREDETERMINED PRESSURIZED STATE
END
SWITCHING PREPARATION STEP
ACTUAL REFILL STEP
SWITCHING PREPARATION STEP
EXCEP-TIONAL REFILL PROCESS-ING
NORMAL REFILL PROCESS-ING

FIG. 3

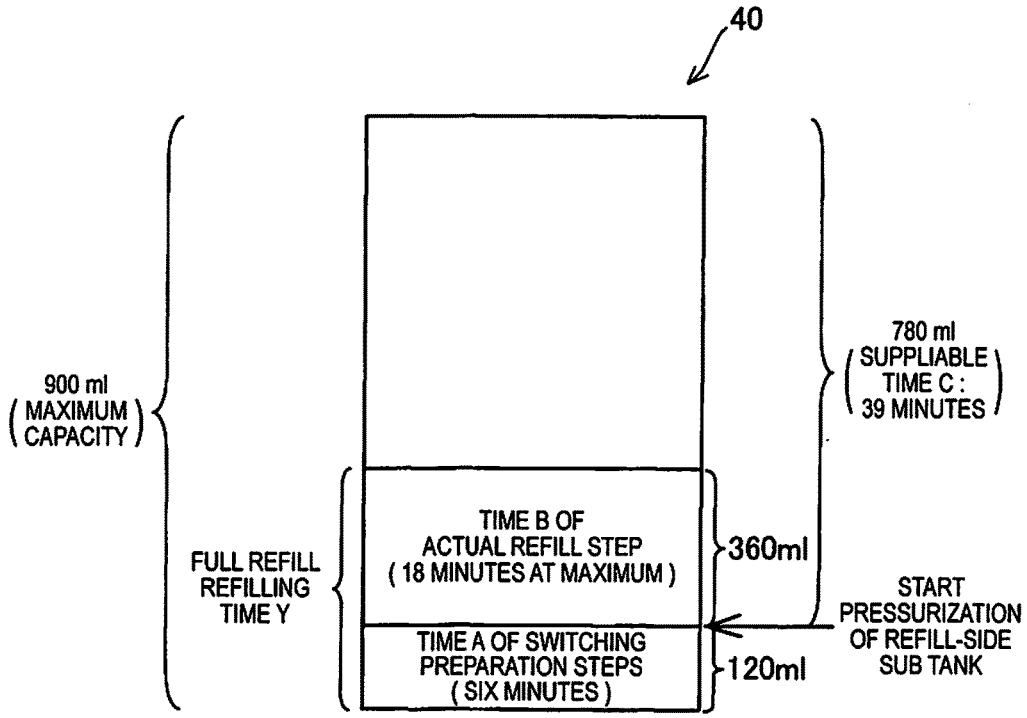
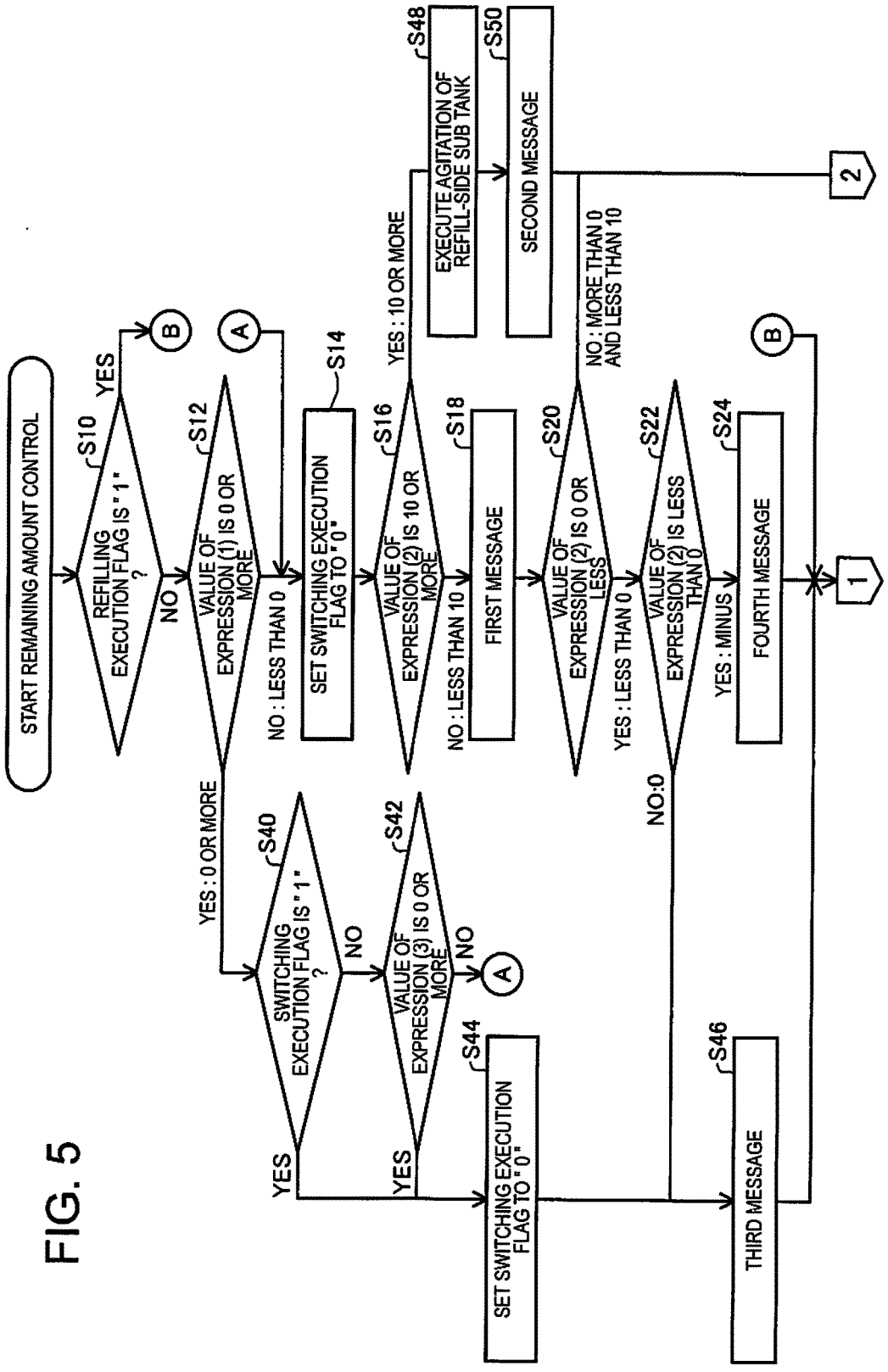

40
900 ml
(MAXIMUM CAPACITY)
780 ml
(SUPPLIABLE TIME C : 39 MINUTES)
FULL REFILL REFILLING TIME Y
TIME B OF ACTUAL REFILL STEP (18 MINUTES AT MAXIMUM)
360ml
START PRESSURIZATION OF REFILL-SIDE SUB TANK
TIME A OF SWITCHING PREPARATION STEPS (SIX MINUTES)
120ml

FIG. 4

FIG. 5


START REMAINING AMOUNT CONTROL
S10
REFILLING EXECUTION FLAG IS "1" ?
YES
NO
B
S12
VALUE OF EXPRESSION (1) IS 0 OR MORE
A
NO : LESS THAN 0
S14
SET SWITCHING EXECUTION FLAG TO "0"
YES : 0 OR MORE
S16
VALUE OF EXPRESSION (2) IS 10 OR MORE
YES : 10 OR MORE
S48
EXECUTE AGITATION OF REFILL-SIDE SUB TANK
S50
SECOND MESSAGE
2
NO : LESS THAN 10
S18
FIRST MESSAGE
S20
VALUE OF EXPRESSION (2) IS 0 OR LESS
NO : MORE THAN 0 AND LESS THAN 10
YES : LESS THAN 0
S22
VALUE OF EXPRESSION (2) IS LESS THAN 0
NO:0
S24
YES : MINUS
FOURTH MESSAGE
B
1
S40
SWITCHING EXECUTION FLAG IS "1" ?
NO
YES
S42
VALUE OF EXPRESSION (3) IS 0 OR MORE
NO
A
YES
S44
SET SWITCHING EXECUTION FLAG TO "0"
S46
THIRD MESSAGE

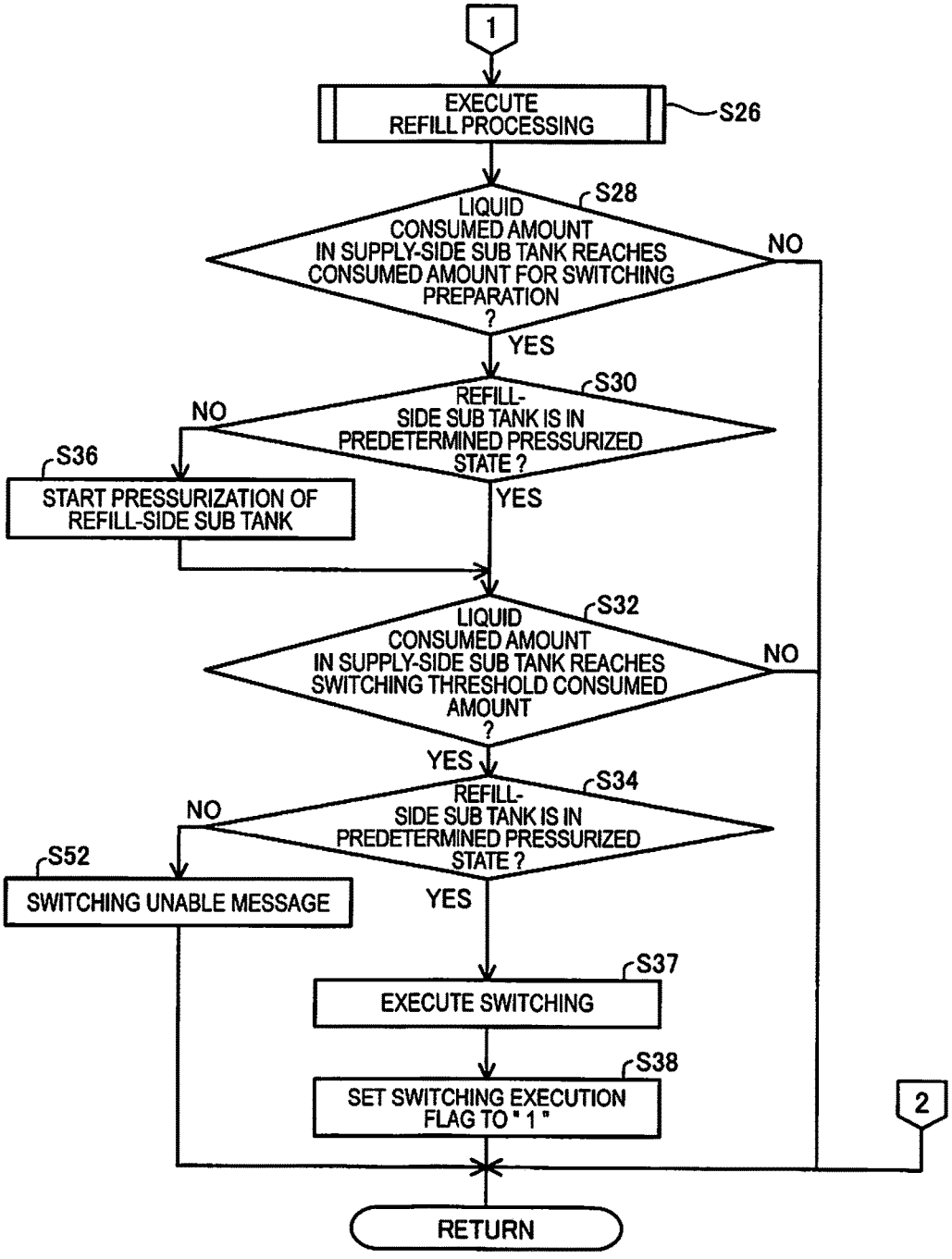

1
EXECUTE REFILL PROCESSING
S26
S28
LIQUID CONSUMED AMOUNT IN SUPPLY-SIDE SUB TANK REACHES CONSUMED AMOUNT FOR SWITCHING PREPARATION ?
NO
YES
S30
REFILL-SIDE SUB TANK IS IN PREDETERMINED PRESSURIZED STATE ?
NO
YES
S36
START PRESSURIZATION OF REFILL-SIDE SUB TANK
S32
LIQUID CONSUMED AMOUNT IN SUPPLY-SIDE SUB TANK REACHES SWITCHING THRESHOLD CONSUMED AMOUNT ?
NO
YES
S34
REFILL-SIDE SUB TANK IS IN PREDETERMINED PRESSURIZED STATE ?
NO
YES
S52
SWITCHING UNABLE MESSAGE
S37
EXECUTE SWITCHING
S38
SET SWITCHING EXECUTION FLAG TO " 1 "
2
RETURN

FIG. 6

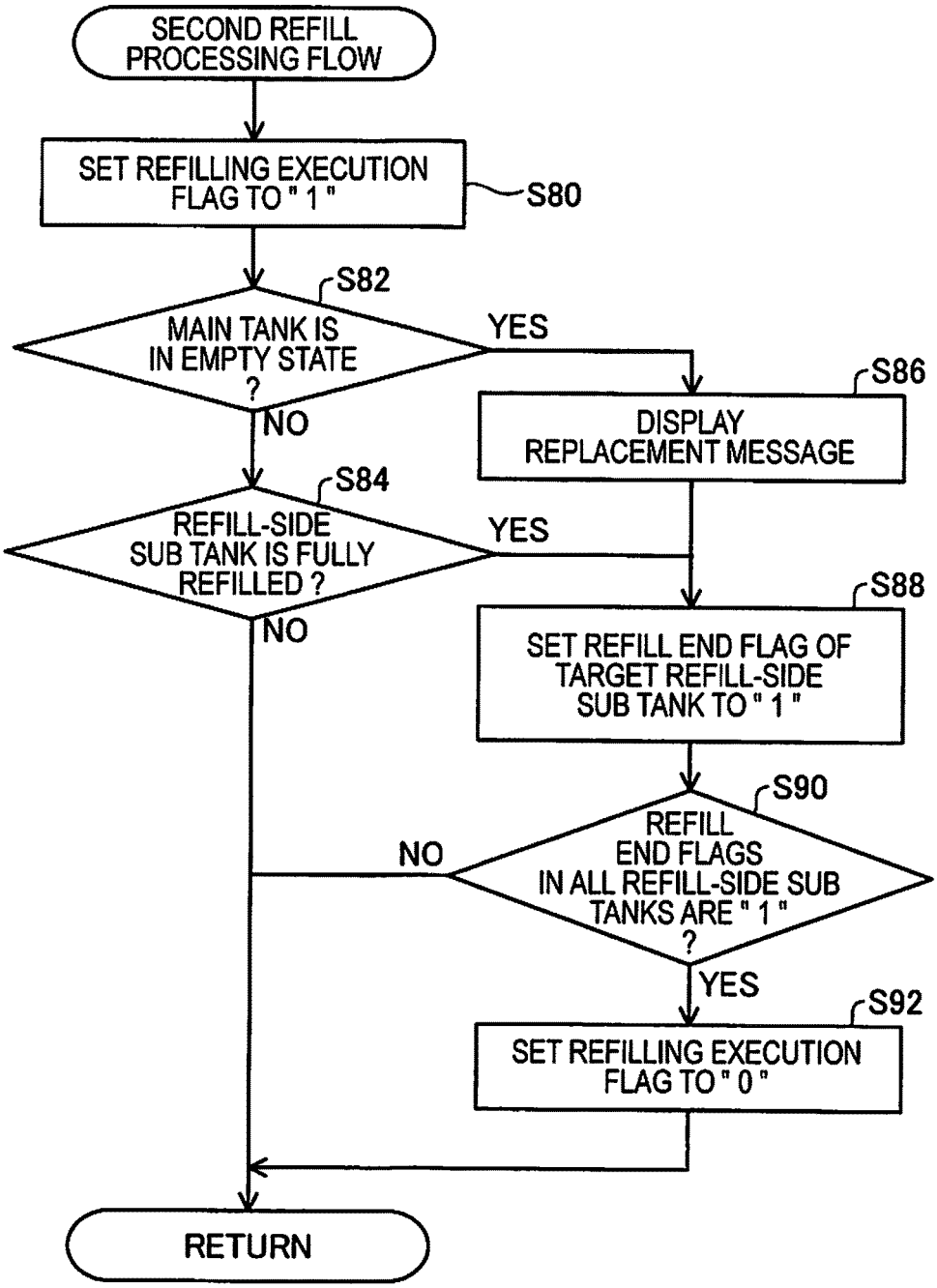

SECOND REFILL PROCESSING FLOW
SET REFILLING EXECUTION FLAG TO " 1 "
S80
S82
MAIN TANK IS IN EMPTY STATE ?
YES
NO
S86
DISPLAY REPLACEMENT MESSAGE
S84
REFILL-SIDE SUB TANK IS FULLY REFILLED ?
YES
NO
S88
SET REFILL END FLAG OF TARGET REFILL-SIDE SUB TANK TO " 1 "
S90
REFILL END FLAGS IN ALL REFILL-SIDE SUB TANKS ARE " 1 " ?
NO
YES
S92
SET REFILLING EXECUTION FLAG TO " 0 "
RETURN

FIG. 7

LIQUID EJECTION SYSTEM AND COMPUTER PROGRAM

BACKGROUND

[0001] Priority is claimed under 35 U.S.C. § 119 to Japanese Applications No. 2017-012630 filed on Jan. 27, 2017 which is hereby incorporated by reference in their entirety.

1. TECHNICAL FIELD

[0002] The present invention relates to techniques of liquid ejection systems.

2. RELATED ART

[0003] Heretofore, a technique is known in which, in a liquid ejection system including a sub tank between a head and a main tank that stores liquid, the main tank and the sub tank are connected by a liquid supply tube, and the sub tank can be refilled with the ink in the main tank (JP-A-2010-228112, f_{or} example). After the liquid in the main tank has been consumed, the main tank is replaced with a new main tank.

[0004] In the case where the head includes ejection outlets respectively corresponding to ink of a plurality of colors such that the head can eject ink of the plurality of colors, the liquid ejection system includes a plurality of sub tanks and main tanks respectively corresponding to the plurality of colors. Also, there are cases where a plurality of sub tanks are provided for each color. In this case, there is a risk that the control to switch between a sub tank that is refilled with liquid from a main tank and a sub tank that supplies liquid to the head will be complicated. Also, in this case, replacement of a main tank and refilling of ink from a main tank to a sub tank are desired to be performed at an appropriate timing. In the case where the refilling of ink from a main tank to a sub tank is executed many times more than necessary, inconveniences such as units of the printing device being damaged and the period of time during which printing cannot be performed becomes excessively long can occur. Also, in the case where the replacement of a main tank is performed many times more than necessary, there is a risk that a user who performs the replacement of the main tank will be heavily burdened.

[0005] The problem described above is not limited to the printing device, and is common among liquid ejection systems that include main tanks and sub tanks that contain various types of liquid and a head that ejects the various types of liquid.

SUMMARY

[0006] Advantages of some aspects of the invention are realized as the following embodiments and application examples.

[0007] (1) According to one aspect of the invention a liquid ejection device is provided. The liquid ejection device includes: a head including a plurality of types of ejection outlets for ejecting a plurality of types of liquid onto a medium; a sub tank unit including sub tank sets for the respective plurality of types of ejection outlets, each of the sub tank sets being constituted by a plurality of sub tanks that are in communication with the ejection outlet in parallel, and can contain the liquid to be supplied to the ejection outlet; main tanks that are provided for the respective sub tank sets, each of the main tanks being in communication with the plurality of sub tanks that constitute the sub tank set in parallel, and containing liquid to be supplied to the sub tanks; and a control unit that controls the operations of the liquid ejection system, and switches the sub tanks in each of the sub tank sets between one supply-side sub tank that can supply liquid to the ejection outlet and the other refill-side sub tank that can be refilled with liquid from the main tank. The control unit, when a first condition in which a minimum value of a suppliable time that is a time it takes for an amount of liquid contained in each supply-side sub tank to reach an amount corresponding to a switching preparation time necessary for switching between the refill-side sub tank and the supply-side sub tank is less than or equal to a maximum value of a full refill refilling time that is a period from when refill processing for performing refilling of the liquid from the main tank is started in each of the plurality of refill-side sub tanks until a state is achieved in which the refill-side sub tank is fully re-filled with liquid and can supply the liquid is satisfied, performs the refill processing on the plurality of refill-side sub tanks.

[0008] According to this aspect, when the first condition is satisfied, all of the refill-side sub tanks including the refill-side sub tank whose full refill refilling time is the longest can be refilled with liquid. Accordingly, switching for causing the refill-side sub tanks for respective types of liquid to each function as the supply-side sub tanks can be performed at the same time, and therefore the possibility of the switching control becoming complicated can be reduced.

[0009] (2) In the aspect described above, the control unit may execute the refill processing until either of a condition in which all the refill-side sub tanks are each fully refilled with the liquid and a condition in which at least one of the plurality of main tanks has entered an empty state with respect to the liquid remaining amount and the refill-side sub tank that is refilled with the liquid from a main tank other than the main tank that has entered the empty state is fully refilled with the liquid is satisfied. According to the aspect, an increase in number of times the refill processing is performed can be suppressed.

[0010] (3) In the aspect described above, the control unit may, in a case where a second condition in which a minimum value of the suppliable time of each of the plurality of supply-side sub tanks is greater than or equal to a maximum refilling time that is a time it takes for the fully refilled refill-side sub tank that has entered an empty state with respect to liquid to enter a state of being filled again with the liquid and being able to supply the liquid, in either of a first case that is a state immediately after switching between the supply-side sub tank and the refill-side sub tank is performed and a second case in which, in the refill-side sub tank and the main tank for containing the same type of liquid, the liquid consumed amount when the refill-side sub tank functioned as the supply-side sub tank is greater than or equal to the liquid remaining amount in the main tank, execute refill processing for performing refilling of the liquid from the main tank regardless of whether or not the first condition is satisfied. According to the aspect, because the refill-side sub tank immediately after the switching is performed can be refilled with liquid, all the sub tanks can be fully refilled with liquid at an earlier time. Also, according to the aspect, as a result of executing the refill processing when the liquid consumed amount in the refill-side sub tank is larger than the liquid remaining amount in the main tank, the liquid in the main tank **20** can be completely consumed at an earlier time before the first condition is satisfied. Accordingly, a user can be prompted to replace the main tank with a new main tank before executing the refill processing when the first condition is satisfied.

[0011] (4) In the aspect described above, the control unit may, in a case where the second condition is satisfied and the refill processing is executed in the second case, execute preparation urging processing for prompting the preparation of a new main tank, before the refill processing is executed, or while the refill processing is being executed, in order to replace the main tank corresponding to the second case with the new main tank. According to this aspect, when the main tank has entered an empty state with respect to the liquid remaining amount, a user can smoothly perform replacement with a new main tank.

[0012] (5) In the aspect described above, the control unit may not determine whether or not the first condition is satisfied in a period during which the refill processing is executed. According to the aspect, the possibility of the refill processing being stopped midway can be reduced.

[0013] (6) In the aspect described above, the control unit may, when at least one main tank among the plurality of main tanks enters an empty state with respect to the liquid remaining amount in a period during which the refill processing is executed, executes the replacement urging processing for prompting a user to replace the main tank that has entered an empty state with a new main tank after the refill processing ends. According to this aspect, the replacement of the main tank in a period during which the refill processing is executed can be suppressed.

[0014] Note that the invention can be achieved in various modes, and may be achieved not only as a liquid ejection system, but also in modes such as a control methods of a liquid ejection system, a computer program for controlling a liquid ejection system, and a storage medium storing the computer program.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

[0016] FIG. **1** is a schematic diagram of a liquid ejection system serving as an embodiment of the invention.

[0017] FIG. **2** is a diagram for describing a connection state of sub tanks, a supply pump, and a refill pump.

[0018] FIG. **3** is a flow diagram for describing a first refill processing step performed on a sub tank.

[0019] FIG. **4** is a diagram for describing a relationship between refilling of and supply from a sub tank.

[0020] FIG. **5** is a first flow diagram of a remaining amount control step executed by a control unit.

[0021] FIG. **6** is a second flow diagram of the remaining amount control step executed by the control unit.

[0022] FIG. **7** is a flow diagram of a second refill processing step, which is one process of the remaining amount control step.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

A. Embodiment

[0023] A-1: Configuration of Liquid Ejection System:

[0024] FIG. **1** is a schematic diagram of a liquid ejection system serving as an embodiment of the invention. FIG. **2** is a diagram for describing a connection state of sub tanks, a supply pump, and a refill pump, and is a control diagram of air pressure.

[0025] A liquid ejection system **10** includes main tanks **20** and a liquid ejection device **30**. The main tanks **20** are arranged outside a housing of the liquid ejection device **30**. Each main tank **20** can be replaced with a new main tank **20** by a user. When the four main tanks **20** are distinguished therebetween, reference signs "**20**C", "**20**M", "**20**Y", and "**20**K" are used. The four main tanks **20**C to **20**K respectively contain (are filled with) liquid of different types. In the present embodiment, yellow (Y) ink, magenta (M) ink, cyan (C) ink, and black (K) ink are respectively contained in the main tanks **20**C to **20**K, which are different from each other. The main tank **20**C contains cyan liquid. The main tank **20**M contains magenta liquid. The main tank **20**Y contains yellow liquid. The main tank **20**K contains black liquid. Each main tank **20** can contain a larger amount of liquid than a later-described sub tank **40**. The liquid contained in the main tank **20** is ink containing a precipitation component (pigment), for example. The main tank **20** includes a container body **22** and a main liquid containing portion **23** housed in the container body **22**. The main liquid containing portion **23** is a flexible bag member, and the volume decreases as the liquid is consumed.

[0026] One main tank **20** is provided for each of later-described sub tank sets **72**C to **72**K (FIG. **2**), and is in communication with a plurality of sub tanks **40** in parallel that constitute a corresponding one of the sub tank sets **72**C to **72**K. The main tank **20** contains liquid to be supplied to the sub tanks **40**.

[0027] The main tanks **20** (FIG. **1**) are placed in a tank placement portion **25**. Specifically, the main tanks **20** are placed on a bottom wall **26** of the tank placement portion **25**. A liquid supply portion of the main tank **20** is exposed to the outside as a result of pivoting a main tank lever **27** that stands upward from the bottom wall **26** in an arrow R**1** direction around a fulcrum **28**. The liquid supply portion of the main tank **20** is a portion for supplying the liquid in the main liquid containing portion **23** to a connection member of a later-described liquid ejection device **30**. A user pivots the main tank lever **27** in the arrow R**1** direction so as to open the tank placement portion **25**, and thereafter removes the connection member of the liquid ejection device **30** from the liquid supply portion of the main tank **20**. The user raises the main tank **20** from which the connection member has been removed, and removes the main tank **20** from the tank placement portion **25**. Thereafter, the user places a new main tank **20** on the bottom wall **26** of the tank placement portion **25**. Then, after connecting the liquid supply portion of the new main tank **20** and the connection portion of the liquid ejection device **30**, the user closes the tank placement portion **25** by pivoting the main tank lever **27** in the direction opposite to the arrow R**1** direction. Accordingly, the user can replace the main tank **20** with a new main tank **20**.

[0028] The liquid ejection device **30** is an inkjet printer that performs recording (printing) by ejecting ink, which is an example of liquid, onto a medium such as paper. The liquid ejection device **30** includes an outer shell **31** that forms an outer surface, a control unit **32**, a head **60**, and a sub tank unit **70** (FIG. **2**). The control unit **32** is arranged inside the outer shell **31**, and controls the operations of the liquid ejection device **30**.

[0029] The sub tank unit **70** is arranged inside the outer shell **31**. The sub tank unit **70** includes, for each of a later-described plurality of types of ejection outlets **63** included in the head **60**, a plurality of (two, in the present embodiment) sub tanks **40** that are in communication with the ejection outlets **63** in parallel. The sub tank set **72** is constituted by a plurality of sub tanks **40** that can contain liquid to be supplied to the ejection outlets **63**. The sub tank unit **70** includes the sub tank sets **72** respectively corresponding to the plurality of types of ejection outlets **63**. The

sub tank set **72** that is in communication with ejection outlets **63** that eject cyan liquid is referred to as a sub tank set **72**C as well, and the sub tank set **72** that is in communication with ejection outlets **63** that eject magenta liquid is referred to as a sub tank set **72**M as well. Also, the sub tank set **72** that is in communication with ejection outlets **63** that eject yellow liquid is referred to as a sub tank set **72**Y as well, and the sub tank set **72** that is in communication with ejection outlets **63** that eject black liquid is referred to as a sub tank set **72**K as well.

[0030] Two sub tanks **40** are provided for each of the main tanks **20**C to **20**K. Two sub tanks **40**C**1** and **40**C**2**, out of the plurality of sub tanks **40**, corresponding to the main tank **20**C that contains cyan liquid are illustrated in FIG. **1**. In addition to the two sub tanks **40**C**1** and **40**C**2**, two sub tanks **40**M**1** and **40**M**2** corresponding to the main tank **20**M that contains magenta liquid, two sub tanks **40**Y**1** and **40**Y**2** corresponding to the main tank **20**Y that contains yellow liquid, and two sub tanks **40**K**1** and **40**K**2** corresponding to the main tank **20**K that contains black liquid are arranged inside the outer shell **31**, as shown in FIG. **2**. When the plurality of sub tanks **40**C**1** to **40**K**2** are not distinguished, they are referred to as "sub tanks **40**". Out of the two sub tanks **40** for each of the plurality of types of liquid, one sub tank **40** is referred to as a first sub tank **40***a* as well, and the other sub tank **40** is referred to as a second sub tank **40***b* as well.

[0031] The head **60** is reciprocally moved along a predetermined direction (X direction in FIG. **1**) by a drive mechanism (not shown). The head **60** includes nozzle lines **61** that eject liquid onto a medium. Four nozzle lines **61** are provided. When the four nozzle lines **61** are distinguished therebetween, reference signs "**61**C", "**61**M", "**61**Y", and "**61**K" are used. Each of the nozzle lines **61**C to **61**K includes a plurality of ejection outlets **63**. The nozzle line **61**C ejects cyan liquid that is supplied from one of the two sub tanks **40**C**1** and **40**C**2**. The nozzle line **61**M ejects magenta liquid that is supplied from one of the two sub tanks **40**M**1** and **40**M**2**. The nozzle line **61**Y ejects yellow liquid that is supplied from one of the two sub tanks **40**Y**1** and **40**Y**2**. The nozzle line **61**K ejects black liquid that is supplied from one of the two sub tanks **40**K**1** and **40**K**2**. When recording (printing) is performed by ejecting liquid onto a medium, the head **60** is reciprocally moved along the X direction, and the medium is moved inside the outer shell **31** along a +Y direction orthogonally intersecting the X direction by a conveyance mechanism (not shown). Note that, in another embodiment, the head **60** may be a line head whose position is fixed without being reciprocally moved.

[0032] As described above, the head **60** includes the plurality of types of ejection outlets **63** for ejecting the plurality of types (cyan, magenta, yellow, and black colors) of liquid onto a medium. The plurality of types of ejection outlets **63** are respectively formed in the nozzle lines **61**C to **61**K, and eject different types of liquid.

[0033] Each sub tank **40** includes a case **42**, a sub liquid containing portion **44** arranged inside the case **42**, and a pressure sensor **56** that detects pressure inside the case **42**. The case **42** is a housing substantially in the shape of a rectangular parallelepiped, and houses the sub liquid containing portion **44**. The sub liquid containing portion **44** contains ink to be supplied to the head **60**. The sub liquid containing portion **44** is a flexible bag member, and the volume decreases as the liquid is consumed. The pressure sensor **56** detects the pressure inside the case **42**, and transmits a detection result to the control unit **32**.

[0034] The sub tank **40** further includes agitation rollers **45** inside the case **42**. Two agitation rollers **45** are provided so as to sandwich the sub liquid containing portion **44** (only one of them is shown in FIG. **1**). According to an instruction from the control unit **32**, the two agitation rollers **45** stir the liquid inside the sub liquid containing portion **44** by moving in a left and right direction in FIG. **1** while sandwiching the sub liquid containing portion **44**.

[0035] The control unit **32** switches each of the plurality of (two, in the present embodiment) sub tanks **40***a* and **40***b* of each sub tank set **72** between a supply-side sub tank **40**B in a state in which liquid can be supplied to the ejection outlets **63** and a refill-side sub tank **40**A in a state in which the sub tank can be refilled with the liquid from the main tank **20**. At a predetermined timing, the refill-side sub tank **40**A is switched to the supply-side sub tank **40**B, and the pre-switching supply-side sub tank **40**B is switched to the refill-side sub tank **40**A. Here, the plurality (two, in the present embodiment) of sub tanks **40** included in each sub tank set **72** are controlled such that, in a period during which one sub tank **40** (first sub tank **40***a*, for example) supplies liquid to the ejection outlets **63** in a period before the switching is executed, the remaining sub tank **40** (second sub tank **40***b*, for example) does not supply liquid to the ejection outlets **63**.

[0036] The liquid ejection device **30** further includes a first refilling flow passage **71** and a second refilling flow passage **74** for bringing the main liquid containing portion **23** of the main tank **20** and the sub liquid containing portion **44** of the corresponding sub tank **40** into communication, and a first supply flow passage **77**, a second supply flow passage **78**, and a merged supply flow passage **79** for bringing the sub liquid containing portion **44** and the head **60** into communication. The first refilling flow passage **71** and the second refilling flow passage **74** branch from a connection flow passage **75**.

[0037] Four of each of the flow passages **71**, **74**, **75**, **77**, **78**, and **79** are provided corresponding to the four main tanks **20**C to **20**K. Note that only the flow passages **71**, **74**, **75**, **77**, **78**, and **79** that are provided corresponding to the main tank **20**C are shown in FIG. **1**. The flow passages **71**, **74**, **77**, **78**, and **79** provided corresponding to each of the other main tanks **20**M, **20**Y, and **20**K are also similarly configured.

[0038] The connection flow passage **75** includes, at one end portion, a connection portion (not shown) that is detachably connected to the liquid supply portion of the main tank **20**. The other end portion of the connection flow passage **75** branches into the first refilling flow passage **71** and the second refilling flow passage **74**.

[0039] The first refilling flow passage **71** brings the main liquid containing portion **23** of the main tank **20** and the sub liquid containing portion **44** of the first sub tank **40***a* into communication via the connection flow passage **75**. The first refilling flow passage **71** is a flow passage for refilling the first sub tank **40***a* with the liquid in the main tank **20**. A first open/close valve **81** and a first refill valve **82** are arranged in the middle of the first refilling flow passage **71**. The first open/close valve **81** is arranged outside the outer shell **31**, and can be operated by a user. The first open/close valve **81** opens and closes the first refilling flow passage **71**. For example, when the main tank **20** is to be replaced, a user removes the main tank **20** from the first refilling flow passage **71** after closing the first open/close valve **81**, and then opens the first open/close valve **81** after connecting a new main tank **20** to the first refilling flow passage **71**. Also, the first open/close valve **81** can be opened and closed according to an instruction from the control unit **32**. The first

refill valve **82** opens and closes according to an instruction from the control unit **32**, and opens and closes the first refilling flow passage **71**.

[0040] The second refilling flow passage **74** brings the main liquid containing portion **23** of the main tank **20** and the sub liquid containing portion **44** of the second sub tank **40***b* into communication via the connection flow passage **75**. The second refilling flow passage **74** is a flow passage for refilling the second sub tank **40***b* with the liquid in the main tank **20**. A second open/close valve **84** and a second refill valve **85** are arranged in the middle of the second refilling flow passage **74**. The second open/close valve **84** is arranged outside the outer shell **31**, and can be operated by a user. For example, when the main tank **20** is to be replaced, a user removes the main tank **20** from the second refilling flow passage **74** after closing the second open/close valve **84**, and then opens the second open/close valve **84** after connecting a new main tank **20** to the second refilling flow passage **74**. Also, the second open/close valve **84** can be opened and closed according to an instruction from the control unit **32**. The second refill valve **85** opens and closes according to an instruction from the control unit **32**, and opens and closes the second refilling flow passage **74**.

[0041] The first supply flow passage **77** is a flow passage that is connected to a portion of the first refilling flow passage **71** between the first refill valve **82** and the first open/close valve **81**. A first supply valve **83** is arranged in the middle of the first supply flow passage **77**. The first supply valve **83** opens and closes according to an instruction from the control unit **32**.

[0042] The second supply flow passage **78** is a flow passage that is connected to a portion of the second refilling flow passage **74** between the second refill valve **85** and the second open/close valve **84**. A second supply valve **86** is arranged in the middle of the second supply flow passage **78**. The second supply valve **86** opens and closes according to an instruction from the control unit **32**.

[0043] The merged supply flow passage **79** is a flow passage to which the first supply flow passage **77** and the second supply flow passage **78** merge. The merged supply flow passage **79** is in communication with the head **60** (specifically, corresponding nozzle line **61**).

[0044] When the first sub tank **40***a* is refilled with liquid from the main tank **20**, the first open/close valve **81** enters an open state, the first supply valve **83** enters a closed state, and the first refill valve **82** enters an open state. This state of open and closed states of the valves is referred to as a first refillable state. Accordingly, the first sub tank **40***a* can be refilled with the liquid from the main tank **20** via the first refilling flow passage **71**. When the second sub tank **40***b* is refilled with liquid from the main tank **20**, the second open/close valve **84** enters an open state, the second supply valve **86** enters a closed state, and the second refill valve **85** enters an open state. This state of open and closed states of the valves is referred to as a second refillable state. Accordingly, the second sub tank **40***b* can be refilled with the liquid from the main tank **20** via the second refilling flow passage **74**.

[0045] When liquid is supplied from the first sub tank **40***a* to the head **60**, the first open/close valve **81** enters a closed state, the first refill valve **82** enters an open state, and the first supply valve **83** enters an open state. This state of open and closed states of the valves is referred to as a first suppliable state. Accordingly, liquid can be supplied from the first sub tank **40***a* to the head **60** via a portion of the first refilling flow passage **71**, the first supply flow passage **77**, and the merged supply flow passage **79**. When liquid is supplied from the second sub tank **40***b* to the head **60**, the second open/close valve **84** enters a closed state, the second refill valve **85** enters an open state, and the second supply valve **86** enters an open state. This state of open and closed states of the valves is referred to as a second suppliable state. Accordingly, liquid can be supplied from the second sub tank **40***b* to the head **60** via a portion of the second refilling flow passage **74**, the second supply flow passage **78**, and the merged supply flow passage **79**.

[0046] A first flow passage pressure sensor **88** is arranged in a first connection portion between the first refilling flow passage **71** and the first supply flow passage **77**. The first flow passage pressure sensor **88** detects the flow passage pressure of the first connection portion, and transmits a detection result to the control unit **32**. A second flow passage pressure sensor **89** is arranged in a second connection portion between the second refilling flow passage **74** and the second supply flow passage **78**. The second flow passage pressure sensor **89** detects the flow passage pressure of the second connection portion, and transmits a detection result to the control unit **32**.

[0047] The liquid ejection device **30** further includes a refill pump **52** and a supply pump **54**, as shown in FIG. **2**. The refill pump **52** and the supply pump **54** are shared between the plurality of sub tanks **40**C**1** to **40**K**2**. The refill pump **52** and the supply pump **54** are controlled by the control unit **32**.

[0048] In order to refill a sub tank **40** with liquid from the main tank **20**, the refill pump **52** reduces the pressure inside the case **42** of the sub tank **40** that is the refill target to a predetermined pressure. In order to supply liquid from a sub tank **40** to the head **60**, the supply pump **54** is used to increase the pressure inside the case **42** of the sub tank **40** that is a supply source to a predetermined pressure. Refill open/close valves **523** to **530** are arranged in the middle of respective flow passages that bring the refill pump **52** and the sub tanks **40** into communication. Also, supply open/close valves **543** to **550** are arranged in the middle of respective flow passages that bring the supply pump **54** and the sub tanks **40** into communication. The refill open/close valves **523** to **530** and the supply open/close valves **543** to **550** are controlled by the control unit **32**. Also, a flow passage **580** that is branched from a flow passage that is located between the refill pump **52** and the refill open/close valves **523** to **530** is provided. The flow passage **580** is in communication with the atmosphere. An open/close valve **53** is arranged in the middle of the flow passage **580**. Also, a flow passage **581** that is branched from a flow passage that is located between the supply open/close valves **543** to **550** and the supply pump **54** is provided. This flow passage **581** is in communication with the atmosphere. An open/close valve **55** is arranged in the middle of the flow passage **581**. The open/close valves **53** and **55** are controlled by the control unit **32**. The open/close valve **55** enters an open state only when the liquid ejection device **30** is turned off, in principle.

[0049] The liquid ejection device **30** further includes a display unit **34** that is arranged such that a user can view it, as shown in FIG. **1**. The display unit **34** displays information such as a message according to a request from a user.

[0050] A-2. Sub Tank Refilling Step:

[0051] FIG. **3** is a flow diagram for describing a first refill processing step performed on a sub tank **40**. FIG. **4** is a diagram for describing a relationship between refilling of and supply from a first sub tank **40***a* and a second sub tank **40***b*.

[0052] Also, in the present embodiment, the maximum capacity of a sub tank **40** is 900 ml, the liquid refilling speed

from the main tank **20** to the refill-side sub tank **40**A is 50 ml/min at the slowest including tolerance, and the maximum supply speed from the supply-side sub tank **40**B to the head **60** is 20 ml/min at the fastest including tolerance. The maximum supply speed is the liquid supply speed from the supply-side sub tank **40**B to the head **60** when single color solid printing is performed on a medium.

[0053] As shown in FIG. **3**, the control unit **32** starts driving of the refill pump **52** after bringing the open/close valves **523** to **530** between the refill pump **52** and the refill-side sub tanks **40**A into an open state (step S**1**). For example, when the first sub tanks **40***a* of the respective colors are each the refill-side sub tank **40**A, the control unit **32** brings the open/close valves **523**, **525**, **527**, and **529** shown in FIG. **2** into an open state, brings the open/close valves **524**, **526**, **528**, and **530** into a closed state, and brings the open/close valve **53** into a closed state, and thereafter starts driving of the refill pump **52**. On the other hand, in order to cause each of the second sub tanks **40***b* of the respective colors to function as the supply-side sub tank **40**B, the control unit **32** brings the open/close valves **544**, **546**, **548**, and **550** shown in FIG. **2** into an open state, brings the open/close valves **543**, **545**, **547**, and **549** into a closed state, and brings the open/close valve **55** into a closed state, and thereafter supplies liquid to the head **60** by driving the supply pump **54**.

[0054] After step S**1**, the control unit **32** drives the refill pump **52** until the inside of the case **42** of the refill-side sub tank **40**A enters a predetermined depressurized state (step S**2**). The predetermined depressurized state is a state in which the pressure inside the case **42** is at a predetermined negative pressure in order to take in the liquid in the main tank **20**. The control unit **32** detects the pressure inside the case **42** using the pressure sensor **56** of the refill-side sub tank **40**A. The control unit **32** drives the refill pump **52** so as to maintain the predetermined depressurized state until the refilling of the refill-side sub tank **40**A is completed.

[0055] Next, the control unit **32** switches the first refill valve **82** (FIG. **1**) from a closed state to an open state, and starts refilling of the refill-side sub tanks **40**A with the liquid from the respective main tanks **20** (step S**3**). In step S**3**, the first open/close valve **81** (FIG. **1**) is set to an open state. As a result of switching the first refill valve **82** from a closed state to an open state, the sub liquid containing portion **44** of the refill-side sub tank **40**A takes in the liquid in the main liquid containing portion **23** via the first refilling flow passage **71**.

[0056] After the refilling of the refill-side sub tank **40**A is completed, the control unit **32** stops driving of the refill pump **52** (step S**4**). Also, in step S**4**, the control unit **32** switches the first refill valve **82** from an open state to a closed state. Note that the actual refilling time of the refill-side sub tank **40**A with liquid from a state in which the liquid remaining amount is zero to the maximum capacity (900 ml) is 18 minutes in the present embodiment. The steps S**3** and S**4** are collectively referred to as an actual refill step. Note that, in a later-described exceptional refilling, the first refill processing step is ended after step S**4** without performing step S**5** onward.

[0057] After step S**4**, exposure to the atmosphere is performed on the refill-side sub tank **40**A (step S**5**). The exposure to the atmosphere is a state in which the refill pump **52** and the supply pump **54** are not driven with respect to the refill-side sub tank **40**A, and is a step in which the pressure inside the case **42**, which is a negative pressure, is increased to the atmospheric pressure. The change in pressure from the negative pressure to the atmospheric pressure is realized by taking in ambient air into the case **42** via the flow passage **580** as a result of bringing the atmosphere exposure valve **53** into an open state, which is described in FIG. **2** and is located between the refill pump **52** and the open/close valves **523** to **530**. The control unit **32** ends step S**5** at a point in time when the pressure inside the case **42** detected by the pressure sensor **56** reaches the atmospheric pressure. Note that the time it takes to bring the depressurized state inside the case **42** to an atmospheric pressure state is several seconds, and this time is included in the execution time of a later-described switching preparation step.

[0058] After step S**5**, the control unit **32** starts driving of the supply pump **54** after bringing the open/close valves **543**, **545**, **547**, and **549** between the supply pump **54** and the refill-side sub tanks **40**A into an open state (step S**6**). The control unit **32** drives the supply pump **54** until the inside of the case **42** of each refill-side sub tank **40**A enters a predetermined pressurized state (step S**7**). The predetermined pressurized state is a pressure state for supplying liquid to the head **60**, and is a state in which the pressure inside the case **42** is a predetermined pressure higher than the atmospheric pressure. Accordingly, the refill-side sub tank **40**A is switched to the supply-side sub tank **40**B, and a state in which liquid can be supplied to the head **60** is achieved. In actuality, as a result of performing control such that the first open/close valve **81** enters a closed state, the first refill valve **82** enters an open state, and the first supply valve **83** enters an open state, the refill-side sub tank **40**A is switched to the supply-side sub tank **40**B, and the supply of liquid to the head **60** is started.

[0059] Here, steps S**1** and S**2**, and steps S**5** to S**7** are steps in which refilling of liquid from the main tank **20** and supply of liquid to the head **60** are not performed, and can be said to be steps necessary for performing pressure control in order to switch between the refill-side sub tank **40**A that can be refilled with the liquid from the main tank **20** and the supply-side sub tank **40**B. Therefore, steps S**1** and S**2** and steps S**5** to S**7** are also referred to as switching preparation steps.

[0060] First refill processing in refill processing that is executed when a later-described Expression (2) is less than or equal to zero is normal refill processing, and steps S**1** to S**7** are executed. On the other hand, first refill processing in refill processing that is executed when a later-described Expression (1) is greater than or equal to zero is exceptional refill processing, and steps S**1** to S**5** are executed.

[0061] As shown in FIG. **4**, in the present embodiment, the execution time (also referred to as "switching preparation time A") of the switching preparation steps is six minutes, and the execution time B of the actual refill step is 18 minutes at the maximum. The switching preparation time A is the time necessary for switching between the refill-side sub tank **40**A and the supply-side sub tank **40**B, and is the time in which pressure control for switching is performed. The time from the start to the end of the refilling step (full refill refilling time Y) is 24 minutes at the maximum, and liquid of an amount that is more than the amount that the supply-side sub tank **40**B can supply to the head **60** during this 24 minutes needs to be contained in the supply-side sub tank **40**B. That is, unless 480 ml or more of liquid is contained in the supply-side sub tank **40**B, it is possible that the liquid in the supply-side sub tank **40**B will be completely consumed in the middle of the first refilling step. Also, the suppliable time C (that is, printable time) during which the supply-side sub tank **40**B can supply liquid to the ejection outlets **63** excluding the time A (six minutes) of the switch-

ing preparation step of the refill-side sub tank **40**A is 39 minutes (**780120**) at the maximum.

[0062] A-3. Remaining Amount Control Step:

[0063] FIG. **5** is a first flow diagram of a remaining amount control step executed by the control unit **32**. FIG. **6** is a second flow diagram of the remaining amount control step executed by the control unit **32**. FIG. **7** is a flow diagram of a second refill processing step, which is one process of the remaining amount control step. The second refill processing step in FIG. **7** is executed while the actual refill step in the first refill processing step in FIG. **3** is executed. Also, various flags (refilling execution flag and switching execution flag, for example) that appear in the following description are stored in the control unit **32**.

[0064] The remaining amount control step is executed every time when any of the nozzle lines **61**C to **61**K of the head **60** has consumed a predetermined amount of liquid. The predetermined amount is 0.2 ml in the present embodiment. First, the control unit **32** determines whether or not the refilling execution flag is "1" (step S**10**). If the refilling execution flag is "1" (step S**10**: YES), the refill processing is being executed (step S**26** in FIG. **6**).

[0065] If the refilling execution flag is "0" instead of "1" (step S**10**: NO), the control unit **32** executes step S**12**. Step S**12** is a step for determining whether or not the value of Expression (1) is greater than or equal to zero. The maximum value (maximum refilling time) of the full refill refilling time Y is the time it takes for the refill-side sub tank **40**A in a state of the liquid remaining amount being zero to be refilled with liquid to the maximum capacity (900 ml) as shown in FIG. **4**, and is a fixed value.

minimum value of suppliable times C of respective plurality (colors) of supply-side sub tanks **40**B−maximum refilling time Expression (1):

[0066] Here, the maximum refilling time is a time it takes, when the first refill processing is executed on the refill-side sub tank **40**A in an empty state, for the refill-side sub tank **40**A to be fully refilled with liquid so as to be able to supply liquid, and is a fixed value of 24 minutes, in the present embodiment. The sum of the time needed to achieve a predetermined depressurized state from the atmospheric pressure state (including pressurized state) and the time needed to achieve a predetermined pressurized state from the atmospheric pressure state (including depressurized state) is the switching preparation time A (six minutes at the maximum). Also, in the case where the refill-side sub tank **40**A in an empty state and the predetermined depressurized state is started to be refilled with liquid, since the maximum refilling speed is 50 ml/minute, the refill-side sub tank **40**A can enter a fully refilled state in 18 minutes at the maximum. Therefore, the full refill refilling time Y in the present embodiment is 24 minutes. That is, if the refill-side sub tank **40**A starts the first refill processing at the point in time when liquid of an amount that is more than the amount that may be consumed in 24 minutes remains in the supply-side sub tank **40**B, the refill-side sub tank **40**A can be brought into the predetermined pressurized state until the supply-side sub tank **40**B enters the empty state. However, in the case where the maximum suppliable time C is estimated with reference to 900 ml, which is the maximum capacity of the supply-side sub tank **40**B, the point in time when the pressurization of the refill-side sub tank **40**A is started becomes uncertain. Therefore, in the present embodiment, the maximum suppliable time C is estimated with reference to 780 ml.

[0067] In step S**12**, if the value of Expression (1) is less than zero (step S**12**: NO), the control unit **32** sets the switching execution flag to "0" (step S**14**). The switching execution flag to be set in the control unit **32** is a flag for determining whether or not switching of the two sub tanks **40** provided for each of the liquid colors between the refill-side sub tank **40**A and the supply-side sub tank **40**B has been executed in the previous routine. If the switching between the refill-side sub tank **40**A and supply-side sub tank **406** has not been performed in the previous routine, the switching execution flag in the control unit **32** is set to "0". In the case where the supply-side sub tank **40**B has been switched to the refill-side sub tank **40**A and the refill-side sub tank **40**A has been switched to the supply-side sub tank **40**B in the previous routine, the switching execution flag in the control unit **32** is set to "1".

[0068] After step S**14**, the control unit **32** determines whether or not the value of the following Expression (2) is greater than or equal to ten (step S**16**). Here, ten (minutes) is the estimated maximum time it takes for a user to perform an agitation operation on the main tank **20**, but this value may be another value.

minimum value of suppliable times C of respective plurality (colors) of supply-side sub tanks **40**B−maximum value of full refill refilling times Y of respective plurality (cyan, magenta, yellow, and black) of refill-side sub tanks **40**A Expression (2):

[0069] In step S**16**, if the value of Expression (2) is less than 10 (step S**16**: NO), the control unit **32** displays a first message notifying the user that the user should not open the main tank lever **27**, in the display unit **34** (step S**18**). The first message is "Do not open the main tank lever in order to continue printing", for example.

[0070] After step S**18**, the control unit **32** determines whether or not the value of Expression (2) is less than or equal to zero (step S**20**). If the value of Expression (2) (step S**20**: NO) is larger than zero, this routine is ended. That is, in the case where the value of Expression (2) is larger than zero, printing can be performed for a time that is longer than the full refill refilling times Y of the refill-side sub tanks **40**A of respective colors using the supply-side sub tanks **40**B of respective colors, at the current point in time.

[0071] If the value of Expression (2) is less than or equal to zero (step S**20**: YES), the control unit **32** determines whether or not the value of Expression (2) is less than zero (step S**22**). If the value of Expression (2) is less than zero (step S**22**: YES), the control unit **32** displays a fourth message notifying that printing may stop, in the display unit **34**. The fourth message is "Printing may stop midway", for example. That is, if "YES" in step S**22**, there is a risk that the refill-side sub tank **40**A cannot be switched to the supply-side sub tank **40**B before the liquid in any of the supply-side sub tanks **40**B of respective colors is totally consumed. After step S**24**, the control unit **32** executes the refill processing (step S**26** in FIG. **6**).

[0072] In step S**22**, if the value of Expression (2) is not less than zero, that is, if the value is zero (step S**22**: NO), the control unit **32** displays a third message notifying the user that the refill processing will be executed in the display unit **34** (step S**46**). The third message is "Refilling in progress. Do not open the main tank lever during refilling.", for example. Then, after step S**46**, the control unit **32** executes the refill processing (step S**26** in FIG. **6**).

[0073] If the value of Expression (2) is greater than or equal to ten in step S**16** (step S**16**: YES), the control unit **32** executes stirring of the refill-side sub tank **40**A (step S**48**). Specifically, the control unit **32** stirs the liquid in the sub liquid containing portion **44** included in the refill-side sub tank **40**A by moving the agitation rollers **45**. Also, the control unit **32** displays a second message notifying the user

that the liquid in the main tank **20** should be stirred, in the display unit **34** (step S**50**). The second message is "After agitating the main tank, immediately install the main tank and close the main tank lever.", for example. That is, in the case where enough of the liquid in the supply-side sub tank **40**B remains so that immediate refilling of the refill-side sub tank **40**A is not required, stirring of liquid in the refill-side sub tank **40**A and the main tank **20** is performed. Accordingly, the possibility that unevenness occurs in the concentration distribution in the liquid in the refill-side sub tank **40**A and the main tank **20** can be reduced.

[0074] In step S**12**, if the value of Expression (1) is greater than or equal to zero (step S**12**: YES), the control unit **32** determines whether or not the switching execution flag is "1" (step S**40**). If the switching execution flag is "1" (step S**40**: NO), the control unit **32** sets the switching execution flag to "0" (step S**44**), and displays the third message in the display unit **34** (step S**46**). Then, the control unit **32** executes the refill processing (step S**26** in FIG. **6**).

[0075] If the switching execution flag is not "1" and is "0" (step S**40**: NO), the control unit **32** determines whether or not the value of Expression (3) is greater than or equal to zero (step S**42**).

liquid consumed amount in refill-side sub tank **40**A−
liquid remaining amount in main tank **20** Expression (3):

[0076] Here, in Expression (3), the refill-side sub tank **40**A and the main tank **20** are a refill-side sub tank **40**A and a main tank **20** that contain the same type (color) of liquid. The liquid consumed amount in refill-side sub tank **40**A is estimated by the control unit **32**. The control unit **32** counts the number of dots that have been ejected from the head while the refill-side sub tank **40**A functioned as the supply-side sub tank **40**B, and estimates the liquid consumed amount based on the liquid amount consumed per dot and the number of counted dots. Also, the liquid remaining amount in the main tank **20** is estimated by the control unit **32** based on the sum of time during which the first refill valve **82** or the second refill valve **85** are in an open state while the refill processing is executed, and the refilling speed (50 ml/min).

[0077] If the value of Expression (3) is greater than or equal to zero (step S**42**: YES), the control unit **32** executes the refilling step (step S**26** in FIG. **6**) after executing steps S**44** and S**46**. If the value of Expression (3) is less than zero (step S**42**: NO), the control unit **32** executes processing in step S**14** and onward.

[0078] Next, the switching processing between the refill-side sub tank **40**A on which the refill processing in step S**26** has been completed and the supply-side sub tank **40**B will be described based on FIG. **6**. The switching processing is processing in which the current refill-side sub tank **40**A is switched to the supply-side sub tank **40**B for supplying liquid to the head **60**, and the current supply-side sub tank **40**B is switched to the refill-side sub tank **40**A that is to be refilled with liquid from the main tank **20**.

[0079] After step S**26**, the control unit **32** determines whether or not the liquid consumed amount in any of the supply-side sub tanks **40**B of the plurality of supply-side sub tanks **40**B (four supply-side sub tanks **40**B provided for respective colors, in the present embodiment) has reached the consumed amount for switching preparation (step S**28**). The consumed amount for switching preparation is a value obtained by subtracting the maximum liquid amount (120 ml in the present embodiment) that the supply-side sub tank **40**B supplies to the head **60** in the period (six minutes in present embodiment) of the switching preparation step of the refill-side sub tank **40**A from the maximum capacity (900 ml, in the present embodiment) of the supply-side sub tank **40**B, and is 780 ml in the present embodiment. That is, the consumed amount for switching preparation is the amount of liquid that the supply-side sub tank **40**B can consume before starting the switching preparation step. If the liquid consumed amount in each of the supply-side sub tanks **40**B does not reach the consumed amount for switching preparation (step S**28**: NO), the present routine is ended.

[0080] On the other hand, if the liquid consumed amount in any of the supply-side sub tanks **40**B reaches the consumed amount for switching preparation (step S**28**: YES), the control unit **32** determines whether or not the inside of the case **42** of the refill-side sub tank **40**A is in the predetermined pressurized state (step S**30**). If the inside of the case **42** is in the predetermined pressurized state (step S**30**: YES), the control unit **32** determines whether or not the liquid consumed amount in the supply-side sub tank **40**B has reached a switching threshold consumed amount (step S**32**). The switching threshold consumed amount is the liquid amount when all of the liquid of the maximum capacity (900 ml, in the present embodiment) of the supply-side sub tank **40**B is consumed, and is 900 ml in the present embodiment. If the inside of the case **42** is not in the predetermined pressurized state (step S**30**: NO), the control unit **32** starts pressurization by driving the supply pump **54** such that the inside of the case **42** of the refill-side sub tank **40**A enters the predetermined pressurized state (step S**36**). The control unit **32** executes step S**32** after step S**36**.

[0081] If the liquid consumed amount in the supply-side sub tank **40**B has not reached the switching threshold consumed amount (step S**32**: NO), the control unit **32** ends the present routine. On the other hand, if the liquid consumed amount in the supply-side sub tank **40**B has reached the switching threshold consumed amount (step S**32**: YES), the control unit **32** again determines whether or not the inside of the case **42** of the refill-side sub tank **40**A is in the predetermined pressurized state (step S**34**). If the inside of the case **42** is not in the predetermined pressurized state (step S**34**: NO), the control unit **32** displays a switching unable message that indicates that the switching between the refill-side sub tank **40**A and the supply-side sub tank **40**B is not possible, in the display unit **34**. That is, if the determination in step S**34** is "NO", even if the refill-side sub tank **40**A is switched to the supply-side sub tank **40**B, there is a risk that the supply-side sub tank **40**B after switching cannot supply enough liquid for printing to the head **60**. Therefore, the control unit **32** displays the switching unable message in the display unit **34**. In step S**38**, the switching execution flag is set to "1", and the atmosphere exposure valve **55** (FIG. **2**) that is located between the supply pump **54** and the open/close valves **543** to **550** is brought into an open state. Accordingly, the supply-side sub tank **40**B is exposed to the atmosphere via the flow passage **581**. The time required to switch the pressurized state to the atmospheric pressure state is several seconds, and is included in the execution time (switching preparation time A) of the switching preparation time.

[0082] On the other hand, if the inside of the case **42** is in the predetermined pressurized state (step S**34**: YES), the control unit **32** executes switching (step S**37**) by controlling various valves (first supply valve **83** and second supply valve **86** in FIG. **1**) such that the refill-side sub tank **40**A functions as the supply-side sub tank **40**B and the supply-side sub tank **40**B functions as the refill-side sub tank **40**A. The control unit **32** sets the switching execution flag to "1" after step S**37**, and ends the present routine.

[0083] Next, a second refill processing flow will be described using FIG. **7**. The second refill processing flow in FIG. **7** is repeatedly executed at predetermined time intervals during the actual refill step shown in FIG. **3**. If the refilling execution flag is "0", the control unit **32** sets the refilling execution flag to "1" (step S**80**). Next, whether or not the liquid remaining amount has reached zero (empty state) in at least one of the plurality of main tanks **20**C, **20**M, **20**Y, and **20**K is determined (step S**82**). If the liquid remaining amount is not zero in each of the main tanks **20**C, **20**M, **20**Y, and **20**K (step S**82**: NO), the control unit **32** determines whether or not at least one of the plurality of refill-side sub tanks **40**A (of respective colors) is fully refilled to the maximum capacity (900 ml) (step S**84**). In this determination, first, the current liquid remaining amount (maximum capacity−estimated liquid consumed amount) is calculated from the liquid consumed amount estimated by the dot count immediately before the second refill processing flow is started (that is, the supply-side sub tank **40**B before switching). Then, the liquid amount refilled during the actual refill step is added to the calculated liquid remaining amount, and when the added result reaches the maximum capacity (900 ml), the refill-side sub tank **40**A is determined to have been fully refilled to the maximum capacity. Also, the determination target in step S**84** is the refill-side sub tank **40**A, out of the plurality of the refill-side sub tanks **40**A, in which a later-described refill end flag is set to "0".

[0084] If each of the plurality of refill-side sub tanks **40**A (of respective colors) is not filled to the maximum capacity (900 ml) (step S**84**: NO), the second refill processing flow is again executed. On the other hand, if at least any one of the plurality of refill-side sub tanks **40**A (of respective colors) is filled to the maximum capacity (900 ml) (step S**84**: YES), the refill end flag is set to "1" in the refill-side sub tank **40**A with respect to which "YES" was determined in step S**84** (step S**88**). The refill end flag set to "1" indicates that the refill-side sub tank **40**A to which the flag is set is fully refilled with liquid to the maximum capacity. After step S**88**, the control unit **32** determines whether or not the refill end flags in all of the (cyan, magenta, yellow, and black) refill-side sub tanks **40**A are set to "1" (step S**90**). If the refill end flags in all of the refill-side sub tanks **40**A are set to "1", the refilling execution flag is set to "0" (step S**92**). As a result of the refilling execution flag being changed from "1" to "0", the actual refill step (FIG. **3**) is ended. On the other hand, if the refill end flag in any of the refill-side sub tanks **40**A is not set to "1" (step S**90**: NO), the second refill processing is again executed.

[0085] Also, in step S**82**, if the liquid remaining amount is zero (empty state) in at least one of the plurality of main tanks **20**C, **20**M, **20**Y, and **20**K (step S**82**: YES), the control unit **32** displays a replacement message for prompting a user to replace the main tank **20** whose liquid remaining amount is zero, in the display unit **34** (step S**86**). The replacement message is a message indicating the color (cyan, magenta, yellow, black) of the replacement-target main tank **20** along with a message "Replace the main tank after completion of the refill processing for the next refill", for example. Also, the refill end flag of the refill-side sub tank **40**A with respect to which "YES" was determined in step S**82** is set to "1" (step S**88**).

[0086] In the present embodiment, as described above, when the first condition in which the minimum value of the suppliable time C is less than or equal to the maximum value of the full refill refilling time Y (Expression (2) is less than or equal to zero) is satisfied, the control unit **32** executes refill processing on the plurality of (cyan, magenta, yellow, and black) refill-side sub tanks **40**A (step S**20** in FIG. **2**: YES, step S**26** in FIG. **6**). The minimum value of the suppliable time C is the minimum value of time it takes for the amount of liquid contained in each of the plurality of (cyan, magenta, yellow, and black) supply-side sub tanks **40**B to reach the amount corresponding to the time A of the switching preparation step necessary for switching between a refill-side sub tank **40**A and a supply-side sub tank **40**B. The maximum value of the full refill refilling time Y is the maximum value of the time from when the refill processing for refilling each of the plurality of (cyan, magenta, yellow, and black) refill-side sub tanks **40**A with liquid from the main tank **20** is started until the refill-side sub tank **40**A is fully refilled with the liquid and the refill-side sub tank **40**A enters a state in which the liquid is suppliable.

[0087] For example, when the suppliable time C of each of the three supply-side sub tanks **40**B that respectively contain cyan liquid, magenta liquid, and yellow liquid is 24 minutes, and the suppliable time C of the supply-side sub tank **40**B that contains black liquid is nine minutes, the minimum value of the suppliable time C is nine minutes. Also, when the full refill refilling time Y of each of the three refill-side sub tank **40**A that respectively contain cyan liquid, magenta liquid, and yellow liquid is 24 minutes, and the full refill refilling time Y of the refill-side sub tank **40**A that contains black liquid is nine minutes, the maximum value of the full refill refilling time Y is 24 minutes. Also, in this case, because the first condition in which Expression (2) is less than or equal to zero is satisfied, the refill processing (normal refill processing) is executed in each of the plurality of refill-side sub tanks **40**A. Accordingly, all the refill-side sub tanks **40**A including the supply-side sub tank **40**B whose suppliable time C is the minimum value among the plurality of supply-side sub tanks **40**B can be refilled with liquid. Accordingly, switching for causing the refill-side sub tanks **40**A for respective types of liquid to each function as the supply-side sub tank **40**B can be performed at the same time, and therefore the possibility of the switching control becoming complicated can be reduced.

[0088] Also, according to the embodiment described above, the control unit **32** executes the refill processing until either of the first refilling end condition and the second refilling end condition is satisfied. The first refilling end condition is a condition in which all the refill-side sub tanks **40**A are fully refilled with liquid. The second refilling end condition is a condition in which the liquid remaining amount is in an empty state with respect to at least one of the plurality of main tanks **20**C, **20**M, **20**Y, and **20**K, and refill-side sub tanks **40**A that are respectively refilled with liquid from the main tanks **20** other than the main tank **20** that has entered an empty state are fully refilled. Specifically, the first refilling end condition is a condition in which the flow from "step S**82**: NO" to "step S**84**: YES", "step S**88**", and "step S**90**: YES" in FIG. **7** is realized. Also, specifically, the second refilling end condition is a condition in which "step S**90**: YES" is satisfied via "step S**82**: YES" in FIG. **7**. In this way, an increase in number of times the refill processing is performed can be suppressed. Also, the refill processing includes the process in which the inside of the sub tank **40** is pressurized and depressurized (switching preparation step in FIG. **3**). When the pressurization and depressurization of the inside of the sub tank **40** are repeatedly executed, the deterioration of the case **42** and the sub liquid containing portion **44** may progress due to the stress caused by the pressurization and depressurization. However, since the number of executions of the refill processing can be suppressed in the embodiment described above, the

progress of deterioration of the case **42** and the sub liquid containing portion **44** can be suppressed.

[0089] Also, according to the embodiment described above, if the second condition (step S**12** in FIG. **5**) is satisfied (step S**12**: YES), the control unit **32** executes the refill processing in which refilling of liquid from the main tank **20** is performed in either of a first case (step S**40** in FIG. **5**: YES) and a second case (step S**42**: YES) regardless of the first condition (Expression (2) is less than or equal to zero) being satisfied or not. The first case is a state immediately after the switching between the supply-side sub tank **40**B and the refill-side sub tank **40**A is performed. The second case is a case where, in the refill-side sub tank **40**A and the main tank **20** for containing the same type of liquid, the liquid consumed amount when the refill-side sub tank **40**A functioned as the supply-side sub tank **40**B is greater than or equal to the liquid remaining amount in the main tank **20**. The state immediately after the switching is performed indicates that the control unit **32** performed switching between the refill-side sub tank **40**A and the supply-side sub tank **40**B in the previous routine of controlling the remaining amount. The second condition is a condition in which the minimum value of the suppliable time C in each of the plurality of supply-side sub tanks **40**B is greater than or equal to the time (maximum refilling time) it takes for the refill-side sub tank **40**A in an empty state to enter a state of being fully refilled with liquid and being able to supply the liquid by executing the refill processing. Accordingly, because the refill-side sub tank **40**A immediately after the switching is performed can be refilled with liquid, all of the sub tanks **40** can be fully refilled with liquid at an earlier time. Also, as a result of executing the refill processing when the liquid consumed amount in the refill-side sub tank **40**A is larger than the liquid remaining amount in the main tank **20**, the liquid in the main tank **20** can be completely consumed by being supplied to the sub tank **40** at an earlier time before the first condition is satisfied. Accordingly, a user can be prompted to replace the main tank **20** to a new main tank **20** before executing the refill processing when the first condition is satisfied.

[0090] Here, the control unit **32** may execute the following processing, in the case where the second condition is satisfied and the refill processing is executed in the second case, before the refill processing is executed, or while the refill processing is being executed. That is, the control unit **32** may execute preparation urging processing for prompting a user to prepare a new main tank **20** in order to replace the main tank **20** that corresponds to the second case with the new main tank **20**. The preparation urging processing is processing in which a message notifying the user that a new main tank **20** should be prepared, in the display unit **34**. Also, the preparation urging processing is not limited thereto, and may be performed by outputting sound or lighting a lamp. The state before executing the refill processing is in a period after "YES" is determined in step S**42** until step S**26** in FIG. **6** is executed, for example. Also, the period during which the refill processing is executed may be a period between step S**80** and step S**82** in FIG. **7**, for example, or another period. In this way, when the main tank **20** enters an empty state with respect to the liquid remaining amount, a user can smoothly perform replacement with a new main tank **20**.

[0091] Also, according to the embodiment described above, the control unit **32** does not determine whether or not the first condition is satisfied in a period during which the refill processing is executed (step S**10**: YES). With this, the possibility of stopping the refill processing midway can be reduced. For example, the stopping of refill processing in the case where the minimum value of the suppliable time C is larger than the maximum value of the full refill refilling time Y (step S**20**: NO) in a period during which the refill processing is executed can be suppressed.

[0092] Also, according to the embodiment described above, when at least one main tank **20** among the plurality of main tanks **20** enters an empty state with respect to the liquid remaining amount in a period during which the refill processing is executed, the control unit **32** executes the replacement urging processing (step S**86** in FIG. **7**) for prompting a user to replace the main tank **20** that has entered an empty state with a new main tank **20** after the refill processing ends. Accordingly, the replacement of the main tank **20** in a period during which the refill processing is executed can be suppressed.

B. Modifications

[0093] Note that this invention is not limited to the above examples and embodiment, and may be implemented in various modes without departing from the gist of the invention. For example, the following modifications are also possible.

[0094] B-1. First Modification:

[0095] In the embodiment described above, the empty state with respect to the liquid remaining amount is a state in which the amount of liquid is zero, but is not limited thereto, and may be a state in which the liquid remaining amount is almost zero. Also, in the embodiment described above, the refill-side sub tank **40**A being fully refilled with liquid means that the refill-side sub tank **40**A is filled with the liquid to the maximum capacity thereof, but is not limited thereto, and may mean that the refill-side sub tank **40**A may be filled with the liquid to an amount close to the maximum capacity thereof.

[0096] B-2. Second Modification:

[0097] In the embodiment described above, the sub tank sets **72**C to **72**K each include two sub tanks **40**, but may include three or more sub tanks **40**. In this case, the switching is executed such that liquid is supplied to the ejection outlet **63** as a result of one of the three or more sub tanks **40** functioning as the supply-side sub tank **40**B, and the remaining sub tank **40** each functions as the refill-side sub tank **40**A.

[0098] B-3. Third Modification:

[0099] In the embodiment described above, the liquid contained in the main tanks **20** and the sub tanks **40** is ink including a precipitation component (pigment, for example), but the liquid may be a liquid that does not include a precipitation component (dye ink, for example).

[0100] B-4. Fourth Modification:

[0101] The invention can be applied to, not limited to an ink-jet printer, and a sub tank and a main tank for supplying ink to the ink-jet printer, any liquid ejection device that ejects liquid other than ink and a sub tank and a main tank for containing such liquid. For example, the invention can be applied to the following various liquid ejection devices and the liquid containers.

[0102] (1) Image recording apparatuses such as a facsimile apparatus

[0103] (2) Color material ejection recording apparatuses used to manufacture color filters for image display apparatuses such as a liquid crystal display

[0104] (3) Electrode material ejection apparatuses used to form electrodes for organic EL (Electro Luminescence) displays, field emission displays (FED), or the like

[0105] (4) Liquid consuming apparatuses that eject liquid containing biological organic matter used to manufacture biochips

[0106] (5) Sample ejection apparatuses serving as precision pipettes

[0107] (6) Lubricating oil ejection apparatuses

[0108] (7) Resin solution ejection apparatuses

[0109] (8) Liquid consuming apparatuses that perform pinpoint ejection of lubricating oil to precision machines such as a watch and a camera

[0110] (9) Liquid consuming apparatuses that eject transparent resin solution such as UV-cured resin solution onto substrates in order to form micro-hemispherical lenses (optical lenses) or the like used in optical communication elements or the like

[0111] (10) Liquid consuming apparatuses that eject acid or alkaline etchant in order to etch substrates or the like

[0112] (11) Liquid consuming apparatuses that include liquid consumption heads for discharging a very small amount of any other kinds of droplet.

[0113] Note that the "droplet" refers to a state of the liquid discharged from liquid consuming recording apparatuses or liquid consuming apparatuses, and includes droplets having a granular shape, a tear-drop shape, and a shape with a thread-like trailing end. The "Liquid" mentioned here need only be a material, the liquid state of which can be ejected by liquid consuming recording apparatuses or liquid consuming apparatuses. For example, the "liquid" need only be a material in a state where a substance is in a liquid phase, and a liquid material having a high or low viscosity, sol, gel water, and other liquid materials such as inorganic solvent, organic solvent, solution, liquid resin, and liquid metal (metallic melt) are also included as a "liquid". Furthermore, the "liquid" is not limited to being a single-state substance, and also includes particles of a functional material made from solid matter, such as pigment or metal particles, that are dissolved, dispersed, or mixed in a solvent, or the like. Representative examples of the liquid include ink such as that described in the above embodiment, liquid crystal, or the like. Here, the "ink" encompasses general water-based ink and oil-based ink, as well as various types of liquid compositions such as gel ink and hot melt ink.

[0114] The invention is not limited to the above embodiment and modifications, and can be achieved by various configurations without departing from the gist thereof. For example, the technical features in the embodiment and modifications that correspond to the technical features in the modes described in the summary of the invention can be replaced or combined as appropriate in order to solve some or all of the problems described above, or in order to achieve some or all of the above-described effects. A technical feature that is not described as essential in the specification can be deleted as appropriate.

What is claimed is:

1. A liquid ejection system comprising:

a head including a plurality of types of ejection outlets for ejecting a plurality of types of liquid onto a medium;

a sub tank unit including sub tank sets for the respective plurality of types of ejection outlets, each of the sub tank sets being constituted by a plurality of sub tanks that are in communication with the ejection outlet in parallel, and can contain the liquid to be supplied to the ejection outlet;

main tanks that are provided for the respective sub tank sets, each of the main tanks being in communication with the plurality of sub tanks that constitute the sub tank set in parallel, and containing liquid to be supplied to the sub tanks; and

a control unit that controls the operations of the liquid ejection system, and switches the sub tanks in each of the sub tank sets between one supply-side sub tank that can supply liquid to the ejection outlet and the other refill-side sub tank that can be refilled with liquid from the main tank,

wherein the control unit, when a first condition in which a minimum value of a suppliable time that is a time it takes for an amount of liquid contained in each supply-side sub tank to reach an amount corresponding to a switching preparation time necessary for switching between the refill-side sub tank and the supply-side sub tank is less than or equal to a maximum value of a full refill refilling time that is a period from when refill processing for performing refilling of the liquid from the main tank is started in each of the plurality of refill-side sub tanks until a state is achieved in which the refill-side sub tank is fully re-filled with liquid and can supply the liquid is satisfied, performs the refill processing on the plurality of refill-side sub tanks.

2. The liquid ejection system according to claim **1**,

wherein the control unit executes the refill processing until either of a condition in which all the refill-side sub tanks are each fully refilled with the liquid and a condition in which at least one of the plurality of main tanks has entered an empty state with respect to the liquid remaining amount and the refill-side sub tank that is refilled with the liquid from a main tank other than the main tank that has entered the empty state is fully refilled with the liquid is satisfied.

3. The liquid ejection system according to claim **1**,

wherein the control unit,

in a case where a second condition in which a minimum value of the suppliable time of each of the plurality of supply-side sub tanks is greater than or equal to a maximum refilling time that is a time it takes for the fully refilled refill-side sub tank that has entered an empty state with respect to liquid to enter a state of being filled again with the liquid and being able to supply the liquid,

in either of a first case that is a state immediately after switching between the supply-side sub tank and the refill-side sub tank is performed and a second case in which, in the refill-side sub tank and the main tank for containing the same type of liquid, the liquid consumed amount when the refill-side sub tank functioned as the supply-side sub tank is greater than or equal to the liquid remaining amount in the main tank, executes refill processing for performing refilling of the liquid from the main tank regardless of whether or not the first condition is satisfied.

4. The liquid ejection system according to claim **3**,

wherein the control unit, in a case where the second condition is satisfied and the refill processing is executed in the second case, executes preparation urging processing for prompting the preparation of a new main tank, before the refill processing is executed, or while the refill processing is being executed, in order to replace the main tank corresponding to the second case with the new main tank.

5. The liquid ejection system according to claim **1**,

wherein the control unit does not determine whether or not the first condition is satisfied in a period during which the refill processing is executed.

6. The liquid ejection system according to claim **1**,

wherein the control unit, when at least one main tank among the plurality of main tanks enters an empty state with respect to the liquid remaining amount in a period during which the refill processing is executed, executes the replacement urging processing for prompting a user to replace the main tank that has entered an empty state with a new main tank after the refill processing ends.

7. A computer program for controlling a liquid ejection system that includes a head including a plurality of types of ejection outlets for ejecting a plurality of types of liquid onto a medium; a sub tank unit including sub tank sets for the respective plurality of types of ejection outlets, each of the sub tank sets being constituted by a plurality of sub tanks that are in communication with the ejection outlet in parallel, and can contain the liquid to be supplied to the ejection outlet; main tanks that are provided for the respective sub tank sets, each of the main tanks being in communication with the plurality of sub tanks that constitute the sub tank set in parallel, and containing liquid to be supplied to the sub tanks, the computer program causing a computer to realize

a function of switching the sub tanks in each of the sub tank sets between one supply-side sub tank that can supply liquid to the ejection outlet and the other refill-side sub tank that can be refilled with liquid from the main tank, and

a function of determining whether or not a first condition in which a minimum value of a suppliable time that is a time it takes for an amount of liquid contained in each supply-side sub tank to reach an amount corresponding to a switching preparation time necessary for switching between the refill-side sub tank and the supply-side sub tank is less than or equal to a maximum value of a full refill refilling time that is a period from when refill processing for performing refilling of the liquid from the main tank is started in each of the plurality of refill-side sub tanks until a state is achieved in which the refill-side sub tank is fully re-filled with liquid and can supply the liquid is satisfied,

wherein the function of switching is executed when the first condition is satisfied.

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