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(54) Title: INK SUPPLY SYSTEM WITHOUT PUMP, FOR INK JET PRINTER WITH INK RECIRCULATION SYSTEM

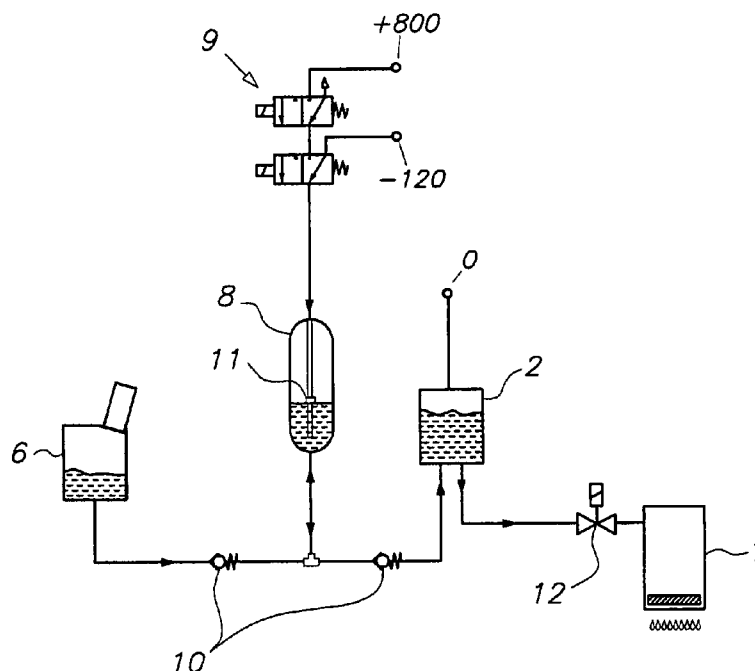


FIG. 2

(57) Abstract: An ink supply system for an industrial ink jet printer is provided making use of a least one buffer vessel (8) wherein ink at low pressure is isolated and pressurized to a high pressure suited for feeding the ink to the print-head (1). A recirculation ink supply system using plural buffer vessels is suited for repressurizing the ink without the use of a pump. The system avoids generation of gas bubbles due to cavitation which are present in systems using a pump for repressurizing ink.



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INK SUPPLY SYSTEM WITHOUT PUMP, FOR INK JET PRINTER WITH INK
RECIRCULATION SYSTEM

[DESCRIPTION]

5 FIELD OF THE INVENTION

The present invention relates to a method for supplying ink to an inkjet printhead in a inkjet apparatus.

More specifically the invention is related to method for supplying
10 ink to a printhead ink in an inkjet printer having a recirculation ink supply system.

BACKGROUND OF THE INVENTION

15 Nowadays a lot of printed matter is produced carrying a reproduction of a color image. A large part of these color prints in office and home environment are made using inkjet printers.

In an inkjet printer drops of ink are jetted out of nozzles of an inkjet printhead towards a receiving layer which may be e.g.
20 specially coated paper.

Usually an inkjet print head has an array of nozzles, each nozzle jetting ink to a different location possibly at the same time. The ink is jetted out of the nozzles by use of e.g. a thermal or piezoelectric actuators creating a pressure wave.

25 It is normally the intention that the size of the droplets can be kept constant or that there is a good control of the droplet size in printers capable of recording variable droplet sizes.

Inkjet printhead and ink pressure

30 One of the major parameters to ensure a constant drop size is that ink pressure at the printhead is stable and within a certain range suitable for the printhead used.

The pressure can be kept constant using several methods :

- For small inkjet printers often a negative pressure generating
35 member is present in the ink reservoir mounted on the shuttle carrying the printhead.

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- In larger printers and industrial inkjet printers an ink tank is often equipped with a system regulating and stabilizing the pressure in the tank by directly controlling the ink pressure or the pressure of the air (atmosphere) above the ink.

5

In the PCT application PCT/EP2005/056809 an ink supply system, depicted in figure 1, for an ink jet printer is disclosed, wherein one or more ink jet print heads 1 receive ink from an ink supply tank 2. The printhead is of a throughflow type and ink circulates
10 further to an ink return tank 3. The ink is pumped back to the ink supply tank 2 by a circulation pump 4 thereby passing through a degassing unit 5. If additional ink is required in this circuit, it is added from main ink tank 6 by the ink feed pump 7.

15 In figure 1 the circulation through the printhead is determined only by the pressure difference between the ink supply tank 2 and the ink return tank 3. This can be generated by keeping an exact ink level difference between the ink level in the supply tank 2, remaining at a higher ink level than the level in the return tank 3, as shown in
20 Fig. 1, or by providing a regulation system for providing regulated pressures in the supply and return tank. Another possibility is that the ink supply tank is mounted physically higher than the return tank whereby a level difference can be guaranteed.

As the "hydrostatic" or regulated pressure in the supply tank is
25 higher than that of the return tank, the ink supply tank 2 can be considered to be part of the "high" pressure section of the ink feed system while the ink return tank 3 is part of the low pressure section of the ink supply system.

As the ink flows continuously from the high pressure supply tank 2
30 to the low pressure return tank 3 the ink has to be re-pumped from the low pressure section to the high pressure section of the ink supply system by the circulation pump 4.

A disadvantage of this ink supply system is that gas bubbles may be
35 created in the ink due to cavitation phenomena in the circulation pump 4. If gas bubbles enter the print head 1, nozzles may be

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blocked, resulting in unreliable operation of the printer. The pump 4 may also introduce sudden level differences or pressure changes in the high pressure section.

- 5 It is clear that there is need for a method for pressurizing the ink in an inkjet printer during feeding or recirculation of the ink without the mentioned drawbacks caused by a pump.

SUMMARY OF THE INVENTION

10

The above-mentioned advantageous effects are realized by a method having the specific steps set out in claim 1. Specific features for preferred embodiments of the invention are set out in the dependent claims.

- 15 An ink supply system for using the method according to the present invention is claimed in claim 6.

Further advantages and embodiments of the present invention will become apparent from the following description and drawings.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a prior art ink supply system for an industrial printer using a circulation pump.

Fig. 2 shows the principle of supplying ink using a pressure vessel.

- 25 Fig. 3 shows a re-circulation type ink supply using a single re-pressurizing vessel.

Fig. 4 shows a re-circulation type ink supply system using two re-pressurizing vessels which can be used alternating.

- Fig. 5 shows a re-circulation type ink supply system using two re-pressurizing vessels, an ink supply vessel and a utility "in" vessel.
- 30

DETAILED DESCRIPTION OF THE INVENTION

- 35 Feeding the ink to a high pressure ink supply section without the aforementioned drawbacks is solved by a method for feeding ink in an

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ink jet printer wherein ink vessels are used for pressurizing ink instead of pumps. An advantage is that no gas bubbles due to pump cavitation will be created.

5 While the present invention will hereinafter be described in connection with preferred embodiments thereof, it will be understood that it is not intended to limit the invention to those specific embodiments.

10 The principle and its most simple embodiment is depicted in Fig 2. The printhead 1 used in Fig 2 is a printhead which is not based upon circulation through the printhead 1. This means the ink is fed once to the printhead 1 from e.g. a ink supply header tank 2 and the ink amount to be fed to the printhead 1 is the same as the total

15 consumption due to printing, spitting during maintenance, etc. No ink will return from the printhead 1 to the ink supply system during normal operation. We consider this feed system to be a high pressure ink supply section for the printhead 1 as the flow of ink is from the ink supply header tank 2 in the feed system to the printhead 1. This does however not mean that the "hydrostatic" pressure in the system elsewhere is always lower than the pressure in the header tank 2 which feeds ink to the printhead, it can
20 understood that e.g. the pressure in the printhead 1 can be higher due to a height difference, but the flow is always directed from the ink supply header tank 2 to the printhead 1.
25

Ink is fed by the system from a main ink tank 6 to counteract the consumption by the printhead 1.

In the ink supply section, a buffer tank 8 is provided coupled to a pressure regulation system 9 controlling the pressure in the buffer
30 tank 8.

Replenishment of ink to the system is done from an main ink tank 6 which can also be a small canister. The main ink tank 6 is normally at an ambient air pressure.

35 The feeding of the ink from the main ink tank 6 to the high pressure system is done using the method having the following steps :

- 5 -

- the ink at low pressure is isolated in a buffer vessel 8 which is separate from the high pressure ink supply section.
- the pressure inside the buffer vessel 8 is raised by the pressure regulation system 9 thereby pressurizing the ink contained in the buffer vessel 8.
- the buffer vessel 8 is then connected to the high pressure ink supply section
- the pressurized ink is fed to the high pressure ink supply section.

To isolate the ink in the buffer vessel 8 as mentioned in the first step, the ink has to enter the buffer vessel 8 which could be done using gravity making the ink flow into the buffer vessel 8. In figure 2 however the ink is drawn from the main ink tank 6 into the buffer vessel by providing a negative pressure using the pressure regulation system 9. The pressure used in this case is about -120 mbar. As a result the buffer tank 8 is slowly filled with ink. No reverse flow is possible as in this embodiment a check valve 10 is incorporated into the ink channel.

A system using e.g. a float 11 detects the level of ink into the buffer vessel 8 and the inflow of ink is stopped when a desired level is attained by disconnecting of the vessel 8 from the negative pressure resulting in raising of the internal pressure in the buffer vessel 8 or by use of an electronically controlled valve in the ink channel (not used in fig. 2). Such a valve could also replace the check valve 10 shown in Fig. 2.

As a result a quantity of ink is now isolated in the buffer vessel 8. During the second step the pressure in the vessel 8 is raised thereby pressurizing the ink inside. The positive pressure which is applied in this embodiment is about +800mbar.

During the third step the buffer vessel 8 is connected to the high pressure ink supply section. This can happen using e.g.

- an electronically controlled valve which can be e.g. controlled by the level of ink in the header tank 2

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- the opening of a check valve 10 between the buffer vessel 8 and the header tank 2 which opens at a certain pressure.

During the fourth step the pressurized ink is fed from the buffer vessel 8 to the high pressure ink supply section. It has to be
5 avoided that the pressure in the header tank 2, which is part of the high pressure ink supply section, is disturbed by the sudden flow of ink into the tank 2. This can be done by electronically controlling the valve when using a controlled valve to ensure that only a limited amount of ink flows into the header tank 2 supplying ink to
10 the printhead 1.

This limitation can also be obtained by the automatic closing of the check valve 10 as the pressure difference between the buffer vessel 8 and the header tank 2 lowers as the pressure of the buffer vessel 8 lowers below the +800mbar value, this lowering can be
15 caused by the outflow of ink from the buffer vessel 8 to the header tank 2 when the connection to the high pressure source is closed so that outflow of ink causes a pressure drop, or by a fast deliberate lowering the +800 mbar pressure inside the buffer vessel 8 by letting pressure escape from the buffer vessel.

20 When all the ink from the buffer tank 8 is fed slowly to the header tank 2, which means the same amount of ink has passed through the printhead 1, the pressure in the buffer vessel 8 can be lowered again to a negative value and new ink is drawn from the ink reservoir 6.

25

A second embodiment of the invention is illustrated by Fig. 3. The printer has here a recirculation ink supply system and uses e.g. a printhead which is of a throughflow type.

30 The printhead 1 is supplied with ink from the "high" pressure supply section of the ink supply system and only uses a part of the ink to record an image on a receiver, a large part of the ink delivered to the printhead flows back to the "low" pressure ink supply section for receiving ink from the printhead 1 and the ink is then reused.

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At the bottom right of fig. 3. the printhead 1 is shown which is coupled to the ink supply system of the shuttle which is connected to header tanks 2,3 for feeding ink to the shuttle/printhead and receiving reflow ink from the shuttle/printheads.

5 The same steps as in the first embodiment are used :

- the ink at low pressure is isolated in a buffer vessel 8 which is separate from the high pressure ink supply section.
- the pressure inside the buffer vessel 2 is raised using the pressure regulating system 9 thereby pressurizing the ink
- 10 contained in the buffer vessel 8.
- the buffer vessel 8 is then connected to the high pressure ink supply section.
- the pressurized ink is fed to the high pressure ink supply section.

15 An additional step is however present :

- draining low pressure ink from the low pressure ink supply section into the buffer vessel 8.

During this extra step the ink reflow from the shuttle which was collected in the ink return header tank 3 is, depending upon the ink level in the return header tank 3 drained into the buffer vessel 8 as follows. The ink return header subtank 3 is connected to the buffer vessel 8 by opening the controlled valve 12. As the pressure inside the buffer vessel 8 is set lower than the pressure in the

20 return header tank 3 the ink is drained from the tank 3 to the buffer vessel 8. When all ink is evacuated, the valve can be closed again. This evacuation action can be repeated until the buffer vessel 8 is full.

The further known steps are executed:

- 30 - The ink at low pressure is isolated into the buffer vessel 8 by the closing the valves.
- The pressure in the buffer vessel 8 is raised using the pressure regulating system 9 actuating the appropriate valves. The underpressure of -500 mbar on the buffer vessel 8 is replaced by a
- 35 positive pressure of 800 mbar.

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- the buffer vessel 8 is connected to the high pressure ink supply section by opening the appropriate valves, electronically controlled or by automatic opening when using a check valve 10,
- the pressurized ink from the buffer vessel 8 is fed to the high pressure ink supply section.

Using this method the ink is re-fed from the low pressure supply section to the high pressure supply section without the use of pumps. Afterwards the same routine is repeated.

- 10 Using a single buffer vessel 8 however may pose problems. No ink can be drawn from the ink return header tank 3 during the re-fed of the ink to the ink feed header tank 2 which may result in an overflow of the return tank 3 or the occurrence of ink level deviations which may cause problems. A strict design of the
- 15 different components may avoid such a situation. Using large ink header tanks 2,3 and a relative small buffer vessel 8 may solve such a problem.

A more preferred embodiment, which avoids such problems is shown in

20 Fig 4. where 2 buffer vessels 8a,8b and a dedicated ink supply vessel 13 are available. As in the previous embodiment, the ink reflow from the shuttle is collected in the ink return header subtank 3 of which the ink level guarded. When this ink level reaches a specific height, the ink is evacuated as follows. The ink

25 return header subtank 3 is connected to the first buffer vessel 8a by opening the appropriate valve 12. The first buffer vessel 8a is at -500 mbar, so that ink flows from the ink return header subtank 3 to the first buffer vessel 8a until a desired low level in the ink return header subtank is reached. Then, the connection to the first

30 buffer vessel 8a is closed by closing the appropriate valve 12. This evacuation action can be repeated until the first buffer vessel 8a is full or has reached a desired level. After this , excess ink from ink return header subtank 3 is evacuated to the second buffer vessel 8b instead of the first buffer vessel 8a, and

35 in the mean time, by using the appropriate pressure regulating sytem 9, the underpressure of -500 mbar on the first buffer vessel 8a is

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replaced by a pressure of +800 mbar and the first buffer vessel 8a is emptied into a dedicated ink supply vessel 13, without the use of pumps. If, after some time, the second buffer vessel 8b is full, a switch from the second to the first buffer vessel 8a occurs, so that
5 excess ink is now evacuated again to the first buffer vessel 8a, and in the mean time the second buffer vessel 8b can be emptied into the ink supply vessel 13.

This dedicated ink supply vessel 13 is at a constant pressure of +500mbar so ink can be fed at all times to the ink supply header
10 tank 2 which is e.g. at ambient pressure (0 mbar) depending upon the level of the supply header tank 2. This is controlled by an intervening electronically controlled valve 12.

By having an ink supply system having at least two buffer vessels 8a,8b, at least two different steps can be done simultaneously using
15 the different buffer vessels 8a,8b.

Using this method it is possible to obtain a continuous recirculation of the ink by using the different buffer vessels 8a,8b alternating so continuously ink can be drawn from the low pressure
20 ink supply section and ink is fed to the high pressure ink supply section.

The step of isolating the ink at low pressure in at least one buffer vessel separated from the high pressure ink supply section
25 preferably comprises the closing of valves in between the connection of the buffer vessel and the high and low pressure ink supply sections by controlled closing of electronically controlled valves 12 or the automatic closing of check valves 10.

When ink is to be supplied from the main ink reservoir 6 at the left
30 due to consumption of ink during printing, an ink feed pump 7 can be used. This is not a problem as there is less risk for cavitation and a very low risk that air bubbles will reach the printhead 1. The circulation pump 4 in the prior art, which has to pump the ink
35 from the return header tank 3 to the header feed tank 2 had however

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to suck ink at a already a low pressure (e.g. -120 mbar), which meant there was quite a risk for cavitation.

Therefore, in the present invention, this pump is replaced by the system of ink vessels at fixed and changing pressures.

5

The embodiment of Fig. 5 includes an additional utility in vessel 14 from which the shuttle is fed. Dedicated header supply and reflow tanks are omitted and can be located elsewhere on the shuttle itself.

10 Reflow of the shuttle is received directly in the two return vessels 8a, 8b.

Having described in detail preferred embodiments of the current invention, it will now be apparent to those skilled in the art that
15 numerous modifications can be made therein without departing from the scope of the invention as defined in the appending claims.

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Reference numbers

1. inkjet printhead
2. ink supply (header) tank
- 5 3. ink return (header) tank
4. circulation pump
5. Degassing unit
6. Main ink tank
7. ink feed pump
- 10 8,8a,8b. buffer vessel
9. pressure regulating system
10. check valve
11. float
12. controlled valve
- 15 13. ink supply vessel
14. utility in vessel

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[CLAIMS]

1. Method for feeding ink in a ink supply system of an inkjet printer having a high pressure ink supply section for feeding ink to a printhead (1) characterized in that the method comprises the steps of:
 - isolating ink at a low pressure in at least one buffer vessel(8,8a,8b) separated from the high pressure ink supply section,
 - raising the pressure in the buffer vessel(8,8a,8b) thereby pressurizing the ink contained in the buffer vessel(8,8a,8b) ,
 - connecting the buffer vessel(8,8a,8b) with the pressurized ink to the high pressure ink supply section, and
 - feeding the pressurized ink from the buffer vessel(8,8a,8b) to the high pressure ink supply section.
2. The method according to claim 1 wherein the printer has a recirculation ink supply system, also having a low pressure ink supply section for receiving ink from the printhead, further comprising the step of
 - draining low pressure ink from said low pressure ink supply section into the buffer vessel(8,8a,8b) .
3. The method according to claim 2 wherein the ink supply system has at least 2 buffer vessels(8a,8b) and wherein at least two different steps can be done simultaneously using different buffer vessels(8a,8b) .
4. The method according to claim 3 wherein the different buffer vessels(8a,8b) are used alternating to obtain a continuous recirculation of the ink.
5. The method according to any one of the claims 1 to 3 wherein the step of isolating ink at low pressure in at least one buffer vessel(8,8a,8b) separated from the high pressure ink supply section comprises the closing of valves(11,12) in between the

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connection of the buffer vessel(8,8a,8b) and the high pressure ink supply section.

6. Ink supply system of an inkjet printer wherein ink is recirculated by repressurizing ink in the system comprising

5 - a high pressure ink supply section for feeding ink to a throughflow printhead (1),

- at least one throughflow printhead (1) for jetting ink to a receiver, the inkjet printhead being fed by the high pressure ink supply section, and having a high and a low pressure end,

10 - a low pressure ink supply section for receiving ink from the throughflow printhead(1),

- at least one buffer vessel(8,8a,8b) for draining low pressure ink from the low pressure ink supply section and isolating this ink at low pressure from the high pressure ink supply section,

15 - pressurizing means for pressurizing the ink in the buffer vessel(8,8a,8b).

7. An ink supply system according to claim 6 wherein the high pressure supply section comprises a high pressure header tank(2) and low pressure supply section comprises a low pressure header tank(3).

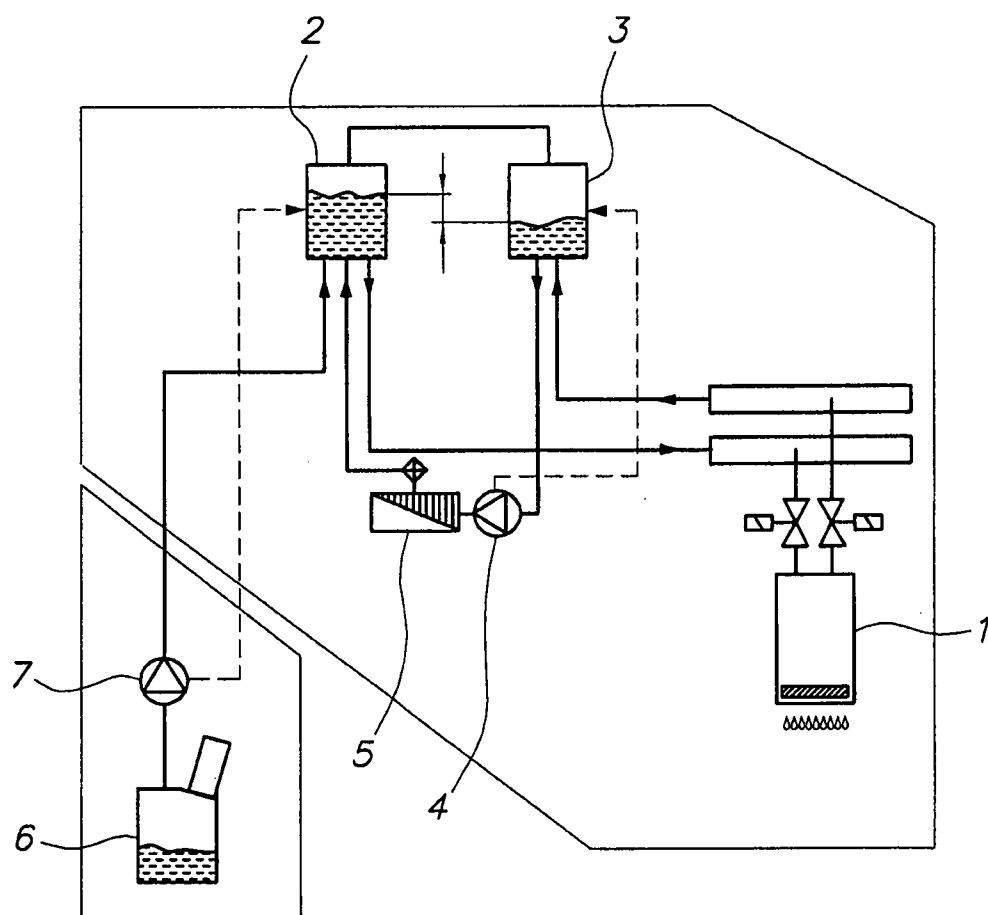
8. An ink supply system according to claim 6 or 7 further comprising an ink supply vessel(13)

9. An ink jet printing apparatus having an ink supply system according to any one of the claim 6 to 8.

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*FIG. 1 – PRIOR ART*

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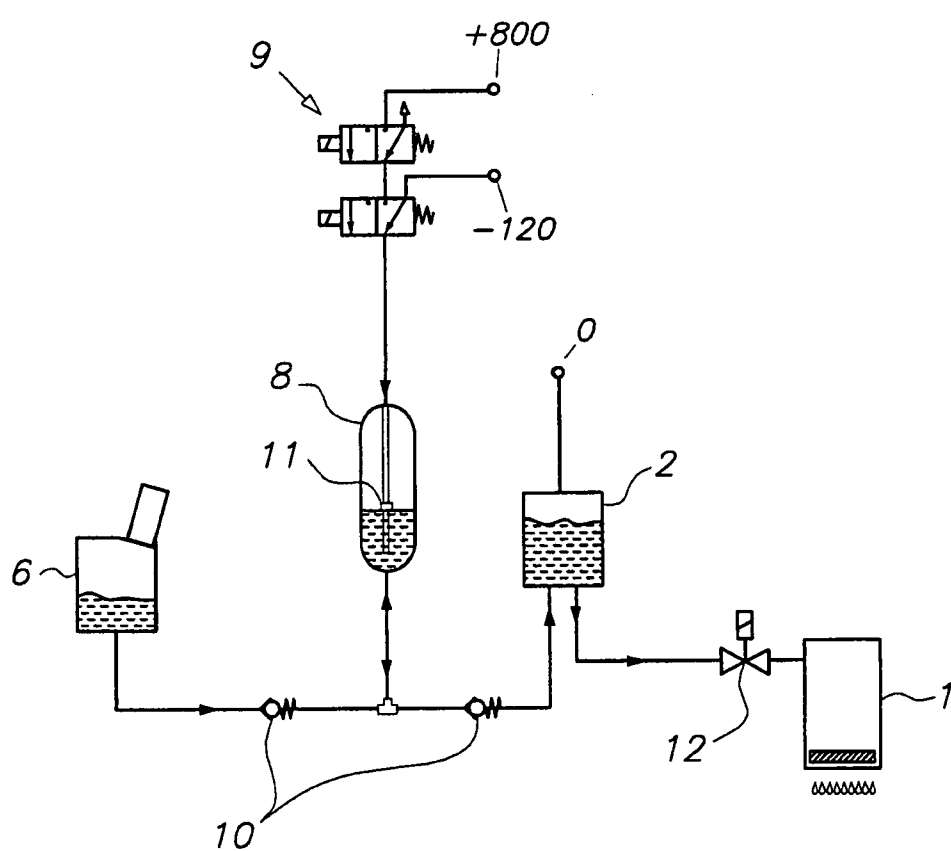
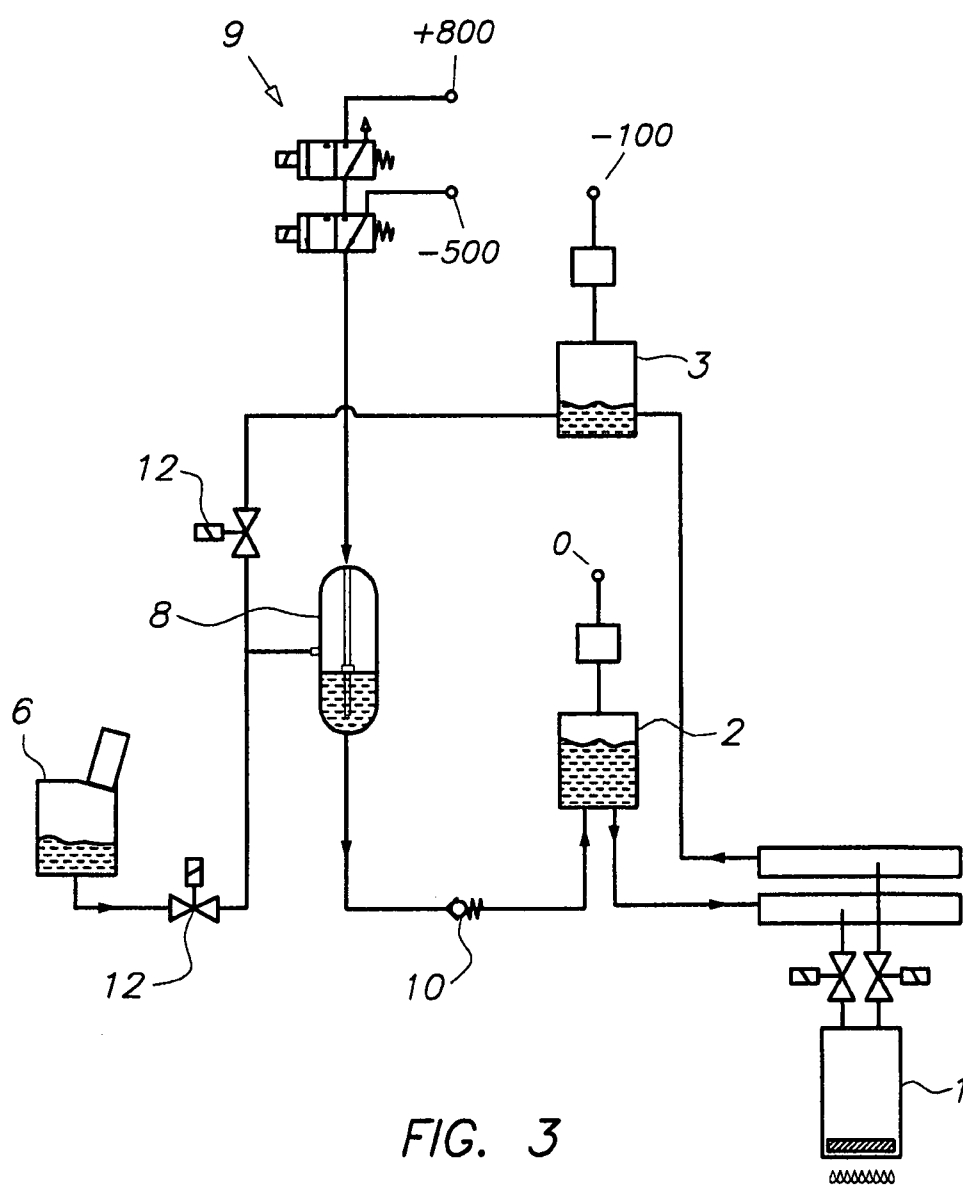


FIG. 2

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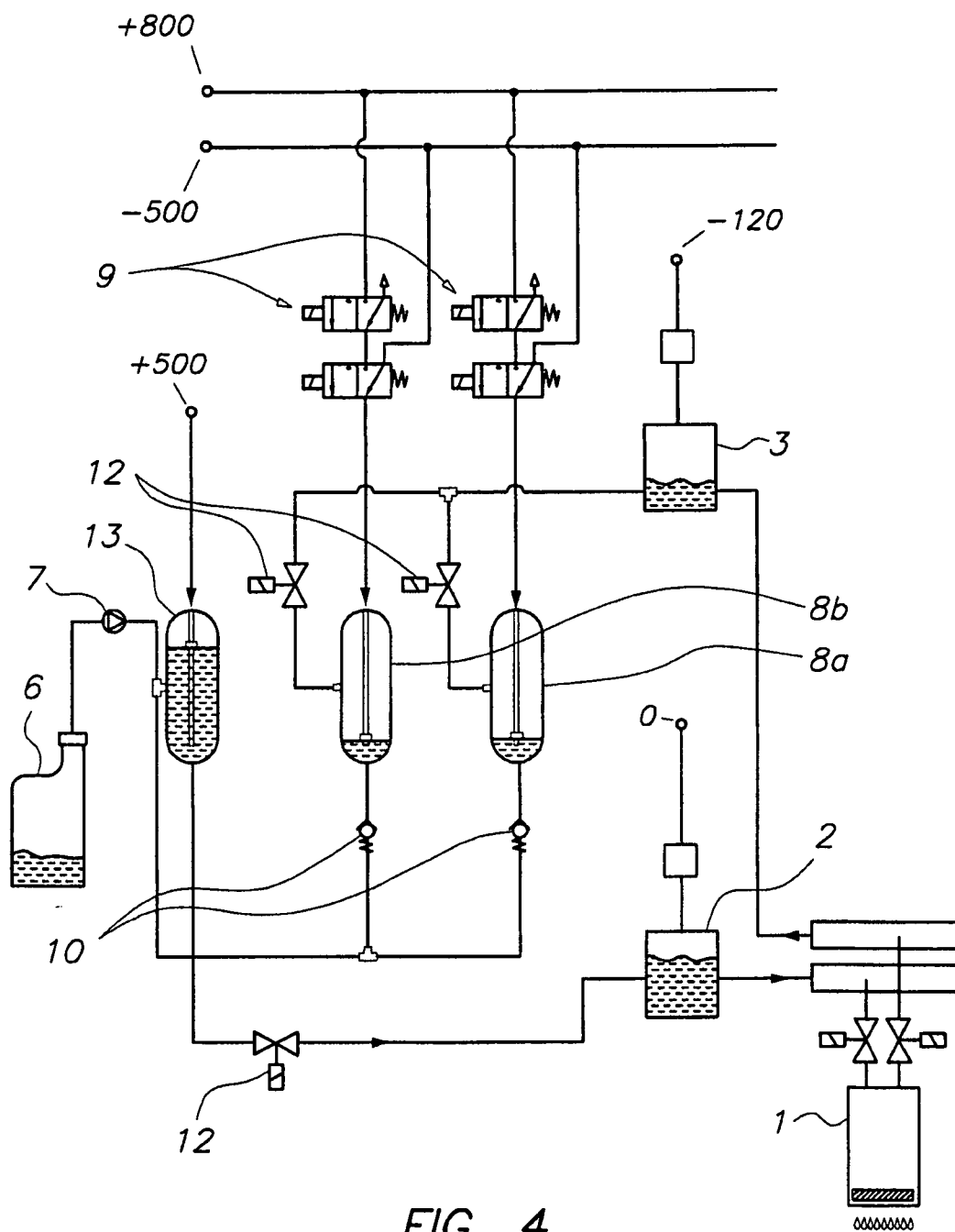


FIG. 4

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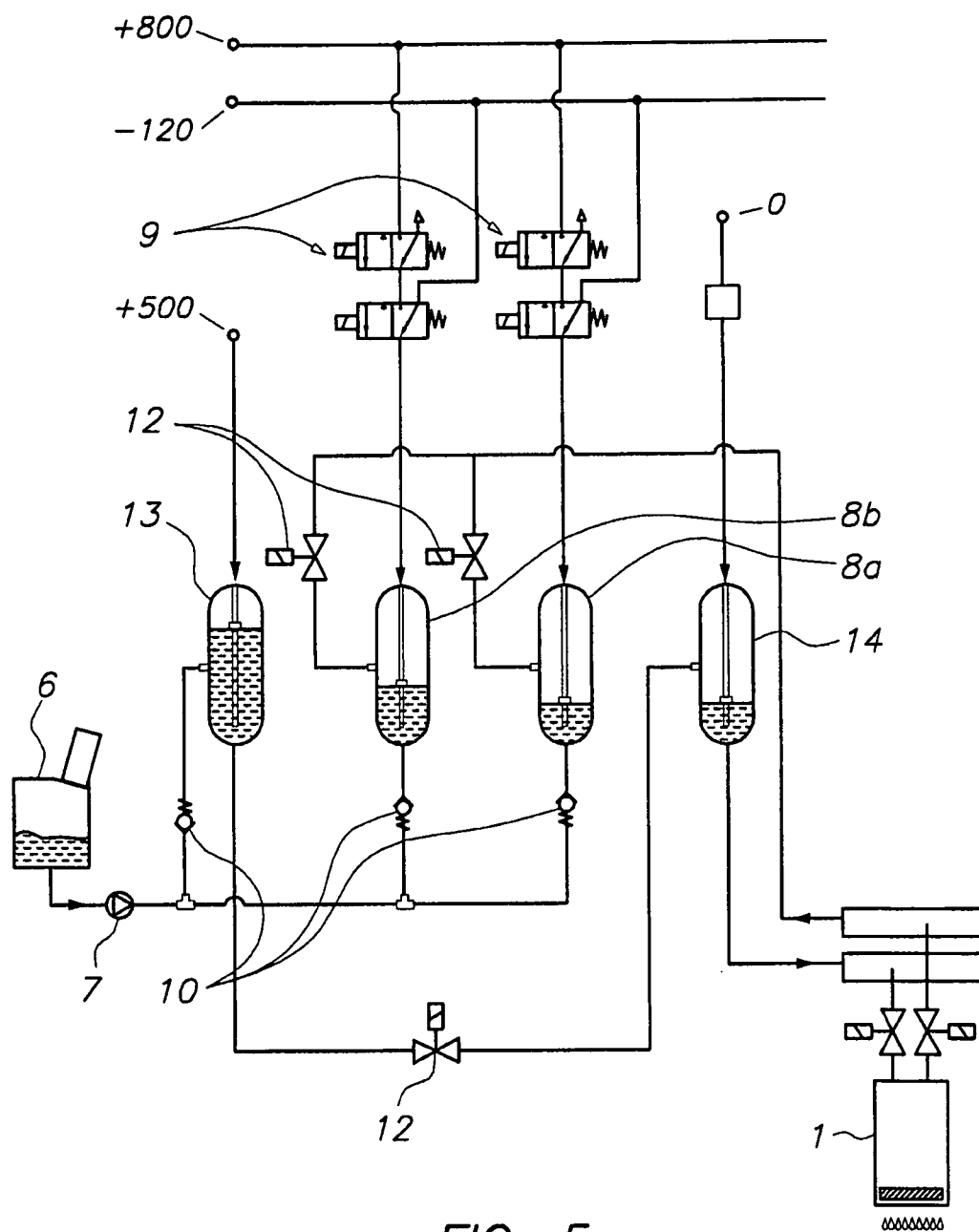


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/001429

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41J2/175 B41J2/18

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 58 219069 A (MATSUSHITA ELECTRIC IND CO LTD) 20 December 1983 (1983-12-20) abstract; figure 4	1-9
X	US 2007/268346 A1 (NISHIDA KATSUNORI [JP]) 22 November 2007 (2007-11-22) claims 1,2,4 paragraph [0034]; figures 2a,2b	1,5
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A	WO 2005/002860 A (OSIRIS TECHNOLOGY B V [NL]; MORSKATE BERNARDUS PETRUS PAUL [NL]) 13 January 2005 (2005-01-13) page 10 - page 11; figure 1	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

12 May 2009

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/001429

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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