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(54) Fluid system for multiple print heads

(57) A single fluid system (100) simultaneously and independently controls multiple print heads of a continuous ink jet printer. An ink reservoir supplies ink to the multiple print heads and a common vacuum system withdraws ink from the multiple print heads back to the ink reservoir. The system controls the concentration of ink to the multiple print heads and separately supplies ink to the multiple print heads. Multiple print heads are supported independently by this single fluid controller, allowing each print head to operate independently, as if it were controlled by its own fluid system. Hence, each one of the multiple print heads has the capability of cleaning, shutting down, and printing without any interference from the other, while sharing similar components.

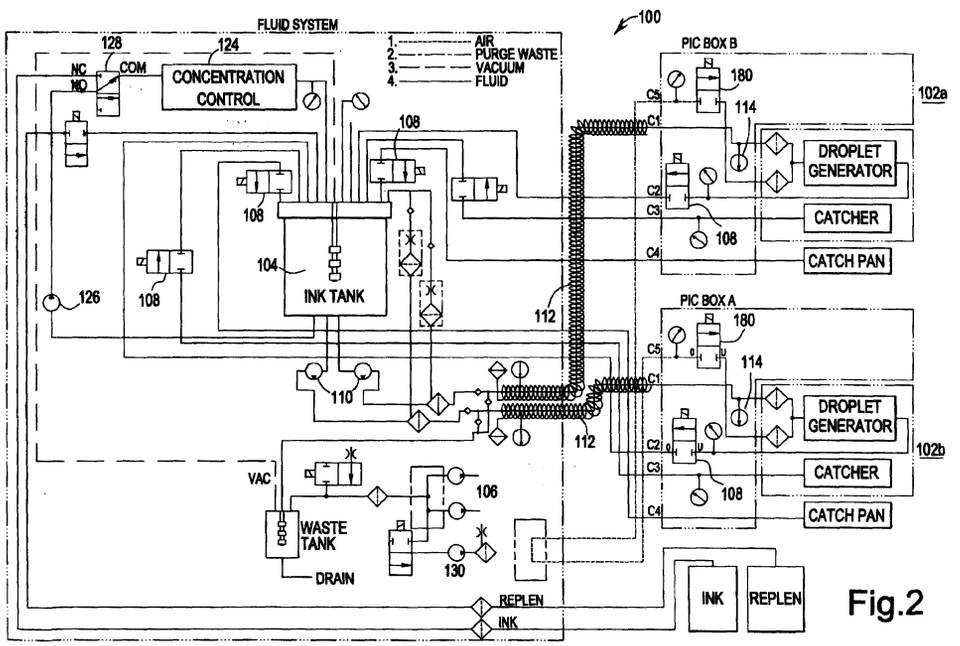

Fig.2

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Description

Technical Field

[0001] The present invention relates to continuous ink-jet printers and, more particularly, to the operation and control of multiple print heads from a single fluid controller for a continuous ink-jet printer.

Background Art

[0002] Prior art ink jet printers have typically consisted of two main components, a fluid system and a print head. The fluid system controls solenoid valves, pumps, and sensors to help clean, shutdown, and ready the print head for printing. All of the components are designated to a single print head as described in U.S. Patent Nos. 5,394,177 and 4,734,711, totally incorporated herein by reference.

[0003] In the field, it is typical to have either two or four print heads mounted side by side in order to achieve a full paper's width of printing. This, in turn, causes a need for two or four fluid systems, costing a customer both money and space.

[0004] During operation of the print heads the ink concentration can drift somewhat. This can lead to a drift in the darkness of the print. This drift of darkness is not noticeable by itself. However, if two print heads are printing side-by-side, the contrast differences can become noticeable.

[0005] Separate print heads are used for each color of ink used by the customer. As different print jobs may require different inks, customers may have more than one type or color of ink in their plant.

[0006] It is seen then that it would be desirable to be able to incorporate multiple print heads into a single fluid system, thereby addressing space constraint issues and decreasing financial costs.

[0007] It would further be desirable to eliminate the possibility of concentration differences for inks from adjacent print heads of the same color.

[0008] It is also seen that it would further be desirable to provide a means to ensure that ink type and ink color do not get inadvertently added to the fluid system in the middle of a print run.

Summary of the Invention

[0009] It is an object of the present invention to allow multiple print heads to be supported independently by a single fluid controller for a continuous ink jet printer. In accordance with the present invention, each print head operates independently, as if it were controlled by its own fluid system. This means that each one of the multiple print heads has the capability of cleaning, shutting down, and printing without any interference from the other, while sharing similar components.

[0010] In accordance with one aspect of the present invention, a single fluid system simultaneously and independently controls multiple print heads of a continuous ink jet printer. An ink reservoir supplies ink to the multiple print heads and a common vacuum system withdraws ink from the multiple print heads back to the ink reservoir. The system controls the concentration of ink to the multiple print heads and separately supplies ink to the multiple print heads.

[0011] Other objects and advantages of the present invention will be apparent from the following description and the appended claims.

Brief Description of the Drawings

[0012]

Fig. 1 is a schematic illustration of a prior art fluid system; and

Fig. 2 is a schematic illustration of a fluid system in accordance with the present invention, capable of supporting multiple print heads.

Detailed Description of the Invention

[0013] Referring to the drawings, in Fig. 1 a block diagram of a prior art fluid system 10 is illustrated. The fluid system 10 is attached to the print head 12 by means of a flexible umbilical 14. The umbilical 14 connection carries fluid to and from the print head 12. The umbilical 14 also carries electrical signals to and from a control means 16, such as a computer, that controls the print head 12 functions.

[0014] The print head functions that are controlled include operation of a retractable catch pan or "eyelid" 18 for startup and shutdown. The eyelid 18, operated by a solenoid 19, seals the print head 12 so that ink from an orifice plate of a resonator 20 goes only to a catcher 22 during startup. The eyelid 18 also allows jets, once formed, to flow into the catcher 22 such that a charge plate 24 of the ink jet printer does not get wet. The print head 12 functions that are controlled also include proper fluid pressure, stimulation voltage, and charge voltage, as well as ink heating during startup, and catcher 22 and charge plate 24 heating to remove condensation at the catcher 22. Finally, the print head 12 communicates with the control means 16 during printing to control these functions.

[0015] Continuing with Fig. 1, prior art fluid system 10 includes a pressure control means associated with the control means 16 to increase or decrease voltage to an ink pump 26. The pressure control means is necessary for printing, as well as other pressure levels during startup and shutdown. The pressure control means includes a pressure transducer 28 located at the print head 12 for providing the control means 16 with a voltage level, preferably between 0.5 and 4.5 volts, that corresponds to the actual ink pressure at the print head 12. A comparison means associated with the control means 16

then compares the actual ink pressure with a desired ink pressure and provides a comparison value. This comparison value is used by the computer 16 to adjust a pulse-width-modulated voltage to the ink pump 26 to attain the desired ink pressure. If the actual ink pressure is high or low in comparison to the desired ink pressure, then the computer 16 adjusts the pulse width modulated voltage to the ink pump 26 accordingly. This correction can occur almost continuously, on the order of up to forty times per second.

[0016] The fluid system 10 includes an optical concentration sensor 30, whereby ink from an ink supply 44 or a replenishment supply 48 is added to a fluid supply 46 to provide the proper dye level. An ink temperature control means comprises an ink temperature sensor 50, an ink heater 52 and an ambient temperature sensor 54 associated with the control means 16 for controlling ink temperature. The ink temperature control is provided mainly for the purpose of accomplishing the startup process required to startup the fluid system 10. The ink temperature control means comprises means for heating the ink sufficiently to place condensation on the charge plate 24 leads, to wash any ink left from the startup procedure down to the catcher 22. By the time the print head 12 is ready to print, the ink in the system 10 has returned to its nominal temperature level, typically a few degrees above ambient.

[0017] The fluid system 10 also includes a vacuum control means 56 for controlling vacuum during startup, shutdown, and printing. A vacuum transducer 58 is located in the fluid system 10 which measures vacuum level. This information is provided to the control means 16 to control the vacuum. The vacuum control 56 is preferably provided by a stepper motor 60 which effectively controls flow into a secondary or bypass line 74 attached to an ambient air inlet 76 of a vacuum pump 78. This, in turn, changes the system 10 vacuum to the desired value.

[0018] Referring now to Fig. 2, a single fluid system 100 according to the present invention is illustrated, capable of independently and simultaneously controlling the integration of multiple print heads. The integration of two print heads supported by one fluid system involves both shared and additional components from the existing fluid system, and new components which enable the operation of the system.

[0019] In Fig. 2, each print head is controlled by a separate print head interface controller (PIC) box 102a and 102b, and share a common ink reservoir or ink tank 104. The ink tank is under vacuum supplied by regulated vacuum systems means. Regulated vacuum system means could be of the type described in patent 5,394,177 or, in a preferred embodiment, as described in co-pending, commonly assigned patent application Serial No. _____ , (Attorney Docket No. SDP231PA).

[0020] Ink is withdrawn from the ink tank 104 by ink pumps 110, each of which supply ink to a single print heads. Each pump 110 is driven by a variable speed brushless VDC motor which allows control of the flow rate to each print head, similar to the existing fluid system. It is important to note that with the addition of variable flow controlled solenoid valves, one ink pump would be sufficient to supply ink to both print heads. However, other design parameters may require each print head to be assigned its own ink pump.

[0021] In addition to the ink pumps 110, each print head also has an individual ink heater of any suitable type, such as a heated umbilical 112, as is described and claimed in commonly assigned, copending patent application Serial No. _____ , (Attorney Docket No. SDP211PA). A common heater controller means is used to control the two ink heaters. This controller monitors the ink temperature in each print head by means of separate temperature sensors 114 and energizes and deenergizes the ink heaters by means of separate heater control relays (not shown) to provide separate servo control of the ink temperature for the two print heads. To minimize the electromagnetic emissions, the switching of the heater power is done at the cross-over points of the AC sine wave. Since each ink heater consumes a large amount of power, the common heater controller ensures that both heaters are not energized at the same time. Rather it shares the heater power in a ping-pong fashion between the two heaters. Furthermore, during the start up sequence it is desirable for the ink temperature in the print head to rise rapidly to produce the condensation needed for cleaning the charge plate. To provide the desired rapid temperature the system controller staggers the startup sequence for the two print heads so that the heater controller can supply full power to a single heater for the time required to get the desired condensation before switching the power to the next heater to produce the desired condensation for the next print head. In this manner, the single common heater controller for the two print heads, can significantly reduce the peak current requirements for a multiple print head system. The separate ink heaters have separate thermostats (not shown) which protect the system from overheating, these thermostats are not used for temperature control.

[0022] A concentration control sensor 124, disclosed and claimed in commonly assigned, copending patent application Serial No. _____ , (Attorney Docket No. SDP215PA), monitors the ink concentration. Ink is circulated through the concentration sensor from the ink tank by a small separate fluid pump 126. In this way, the flow through the sensor is independent of the flow to either of the print heads. The concentration control system is configured such that when the fluid system 100 fills with fresh ink, ink passes through a valve 128 at the inlet of the concentration sensor and passes through the sensor. In this way, the sensor can be calibrated against fresh ink.

[0023] The fluid system control electronics monitors the output of this sensor and the output of the ink tank level sensors as it controls the addition of ink or a re-

plenishment fluid to the ink tank, similar to the existing fluid system.

[0024] Checking the concentration of make up ink with the concentration sensor as the ink is added to the fluid system can also provide a failsafe test to prevent the wrong type or color of ink from being added to the fluid system.

[0025] An addition to the existing fluid system is the use of a positive air pump 130. Positive air pumps have been employed in existing products to help keep dust and debris out of the print head. In the present invention, the positive air pump supplies clean air not to the enclosed print head, but into the fluid lines. The positive air pump in fluid system 100 provides clean air through air valves 180 to each droplet generator to help remove ink from the print heads during shutdown of both print heads. The function of this air pump is described in more detail in commonly assigned, copending patent application Serial No._____, (Attorney Docket No. SDP217), totally incorporated herein by reference.

[0026] The independent and simultaneous operation of multiple print heads from one fluid system in a continuous ink-jet printer gives the ability to print wide swath high quality images, saving both cost and space from the existing fluid system, as well as maintaining a consistent concentration of ink for the two print heads.

[0027] The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that modifications and variations can be effected within the spirit and scope of the invention. In particular, it will be recognized while the detailed description described a system having two print heads supplied by a single fluid system, that this invention could be extended to include fluid systems which supply more than two print heads.

Claims

1. A single fluid system for simultaneously and independently controlling multiple print heads of a continuous ink jet printer comprising:

   an ink reservoir for supplying ink to the multiple print heads;
   a common vacuum system to withdraw ink from the multiple print heads back to the ink reservoir;
   means for controlling concentration of ink to the multiple print heads; and
   means to separately supply ink to the multiple print heads.

2. A single fluid system claimed in claim 1 further comprising common controller means for controlling means to separately supply ink, the common vacuum system and the means for controlling concentration of ink.

3. A single fluid system as claimed in claim 1 further comprising a concentration sensor for monitoring concentration of ink as the ink is added to the fluid system.

4. A single fluid system as claimed in claim 1 wherein the means to separately supply ink to the multiple print heads further comprises separate ink pumping and flow control means for each of the multiple print heads.

5. A single fluid system as claimed in claim 1 further comprising means to separately heat the ink to the multiple print heads.

6. A single fluid system as claimed in claim 5 wherein the separate means to heat the ink further comprises a heater control means for controlling heating of the ink.

7. A single fluid system as claimed in claim 6 wherein the heater control means comprises means for alternately sequencing power supplied to the heater control means to limit peak power requirements.

8. A single fluid system as claimed in claim 6 wherein the heater control means comprises means for staggering a startup sequence for the multiple print heads to supply full power to a single heater to get a desired condensation before switching power to a next heater to produce a desired condensation for the next print head.

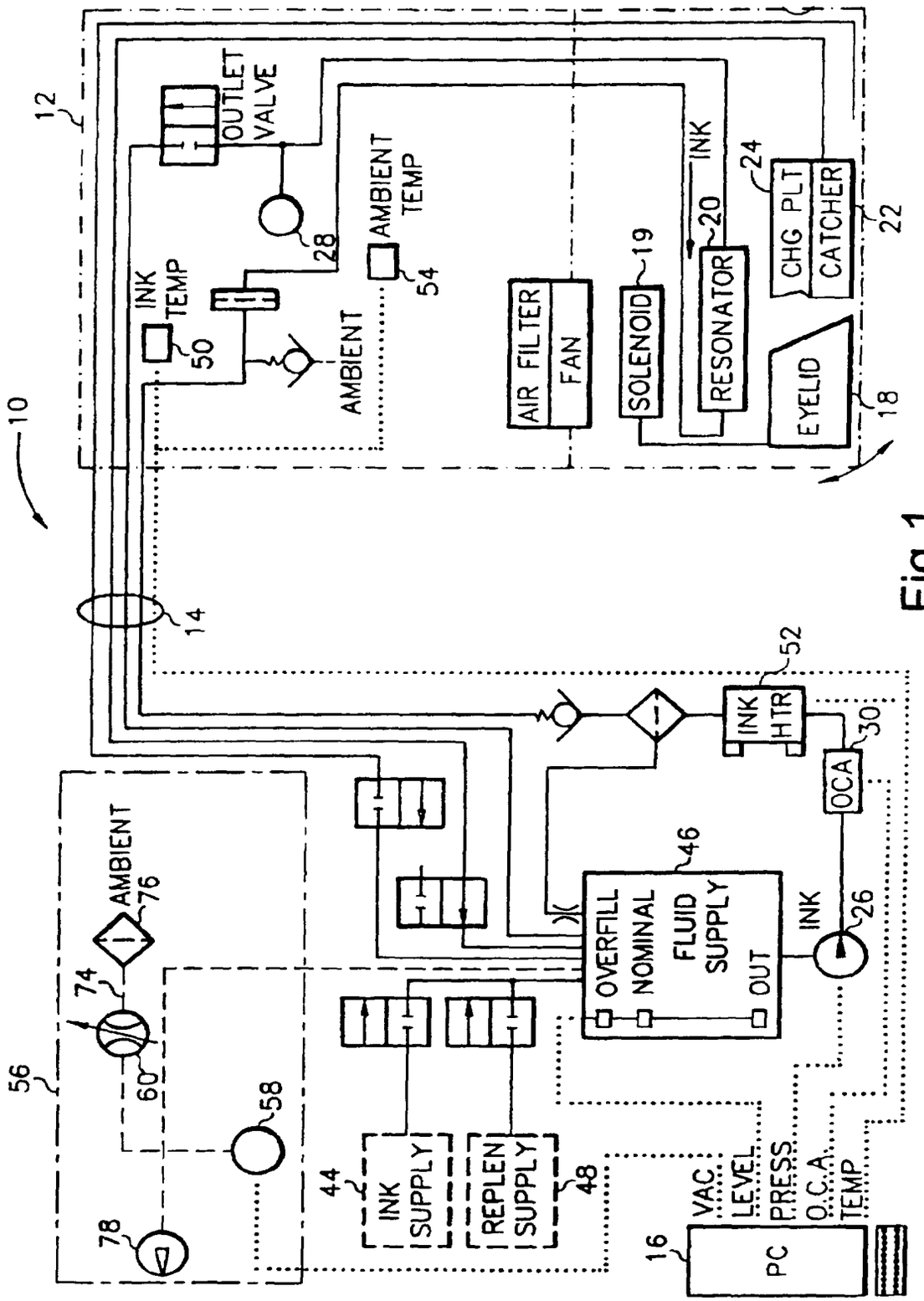

Fig.1
PRIOR ART

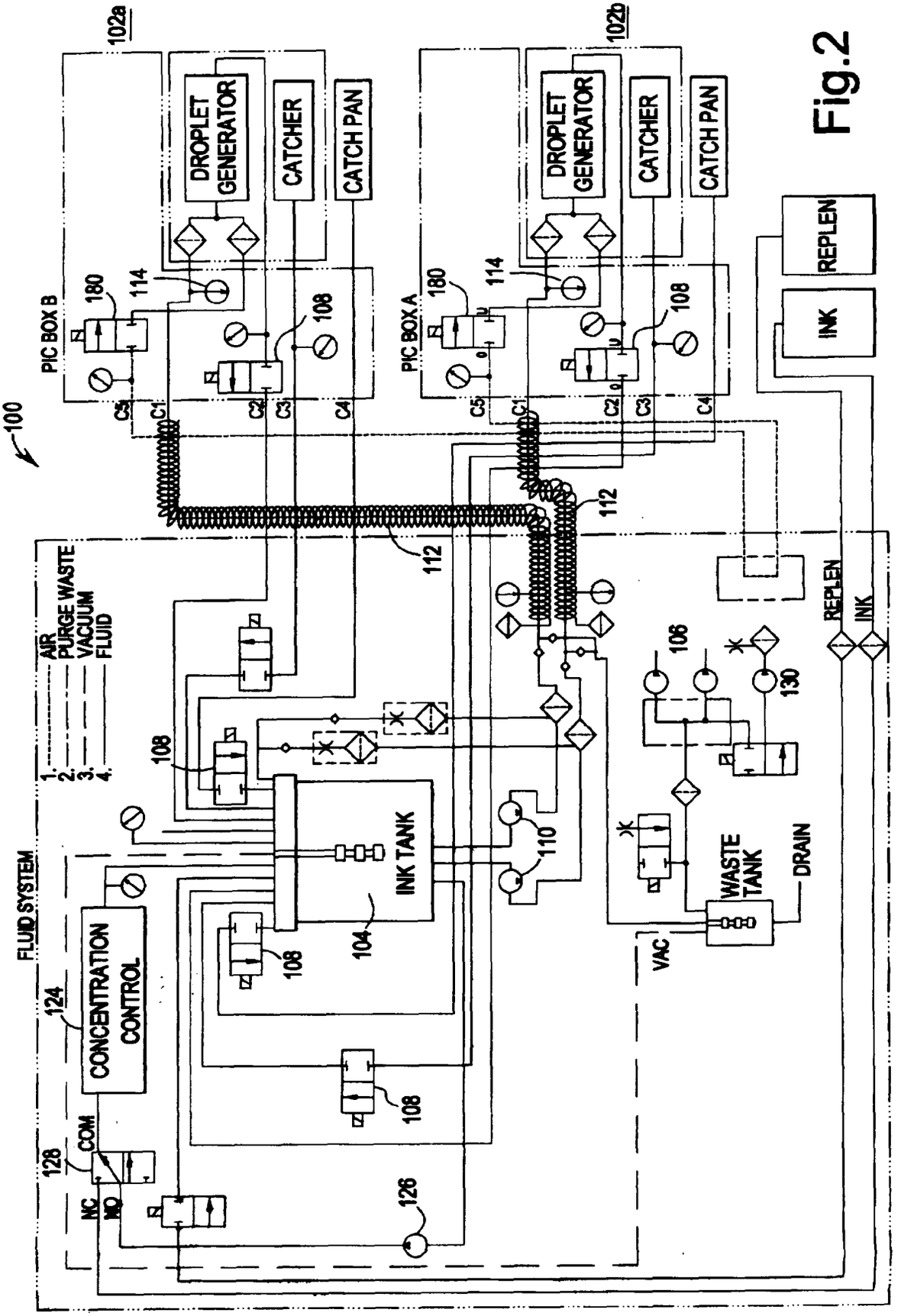
100
102a
102b
DROPLET GENERATOR
CATCHER
CATCH PAN
PIC BOX B
PIC BOX A
180
114
108
112
C1
C2
C3
C4
C5
AIR
PURGE WASTE
VACUUM
FLUID
1.
2.
3.
4.
FLUID SYSTEM
INK TANK
104
110
106
130
WASTE TANK
DRAIN
VAC
REPLEN
INK
CONCENTRATION CONTROL
124
COM
NC
NO
128
126

Fig.2