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# New method of large ink supply without long tubing system for wide-format inkjet printer


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## ABSTRACT

This paper explored the design of large ink supply system of ink-jet printer, which is in general installed in so-called wide format printer today. Subsequently, a new type of large ink supply system (LISS) was presented to fulfill the fundamental functions that ink in the reservoir could be automatically delivered into the print head of printer by means of capillary force in nature. Moreover, the new system was characterized with no traditional long tubing portions such that pressure loss or vibration, due to long ink passage of tubing, could be eliminated. To achieve the goal of removing traditional long tubing system, the ink reservoir width of system must be greater than the print width of printer. As a result, a stable back pressure of print head can be kept all the time no matter the printer is printing or not; it could also be more stable than before even if print head is moving in high speed. Hence, better print quality could be obtained in the printer equipped with the new system of paper.



**Keywords:** Ink supply system, Ink-jet printer, Pressure, Ink reservoir


## 1. INTRODUCTION

In the past over 10 years [1], many types of wide format printer (WFP) have already been successfully developed to print on different media with large width. Of course, both of sheet media and roll media can be alternatively used in the WFP. In general, the print width for those WFP could be 24 inches, 36 inches, 54 inches, or even possibly greater than 60 inches. It could easily found that most of WFP in common comprise of off-board ink supply system [2,3,4,5,6,7,8]. In addition, these ink supply system always use long and flexible tubes for delivering ink flow to the print head, so that two major problems may unfortunately exist thereof. One issue is pressure loss that may be caused by the movement of ink flow through the long tubing system; therefore, pressure wave could be induced as well at the same time. The loss might be expressed as equation (1) where L is the length of tube, V is the flow speed, and A is the cross sectional area of tube. It can be clearly understood from considering the effect of friction between the flow and tube. The other is pressure vibration that may mainly contribute from the movement of print head and tubing system. It can be simply described as equation (2) where L is the length of tube in moving and A is the cross sectional area of tube. Here, Newton's second law of force can explain well such an effect of unsteady pressure. In the mean time, it's noted as shown in Figure 1.0 that both of issues might be happening due to the long tubing system.

$$P_{loss} \propto \frac{L \times V}{A}, \tag{1}$$

$$\Delta P_{vibration} \propto L \times A, \tag{2}$$


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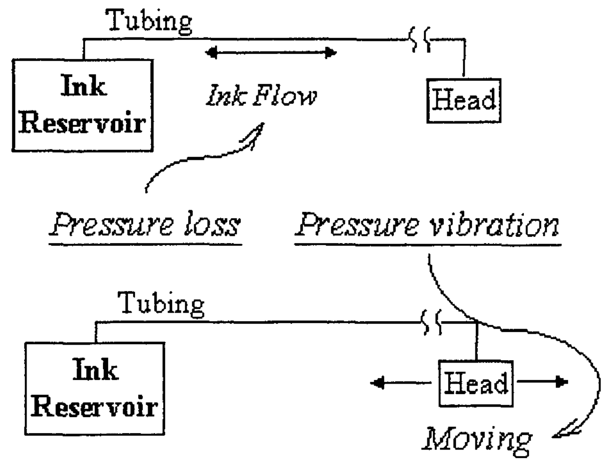


Fig. 1.0: Pressure loss and vibration due to the tubing system

General speaking, the pressure loss and vibration might be up to several centimeters of $H_2O$ under the normal operation of WFP, respectively. Both of them are not desirable because print quality might be badly unstable. However, it's obvious that reducing the length of tubing or further even removing the long tubing system could eliminate both.

## 2. NEW DESIGN OF SYSTEM

One new design of system for ink supply was presented to solve the above-mentioned issues. The mechanical configuration of design was clearly demonstrated in the following Figure 2.0 where key components of WFP were already set up, together with ink supply system thereof.

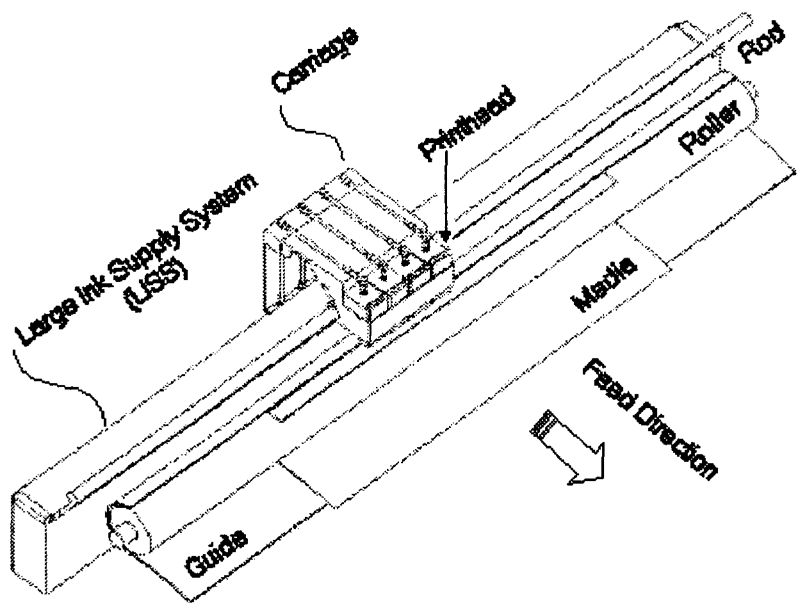


Fig. 2.0: A new design of large ink supply system (LISS) without long tubing

First of all, the print heads sitting at one carriage can be driven to horizontally move along a rod and make printing onto media that would be driven by the roller along a feed direction of guide, as shown in Figure 2.0. Therefore, the designed WFP prints similar as most regular ink-jet printers do. However, the large ink supply system (LISS) makes big difference that the system is wider than maximum print width of WFP. In addition, it comprises of no long tubing at all, unlike most regular ink-jet printer do today. Explosion view for details of system can be found in Figure 3.0.

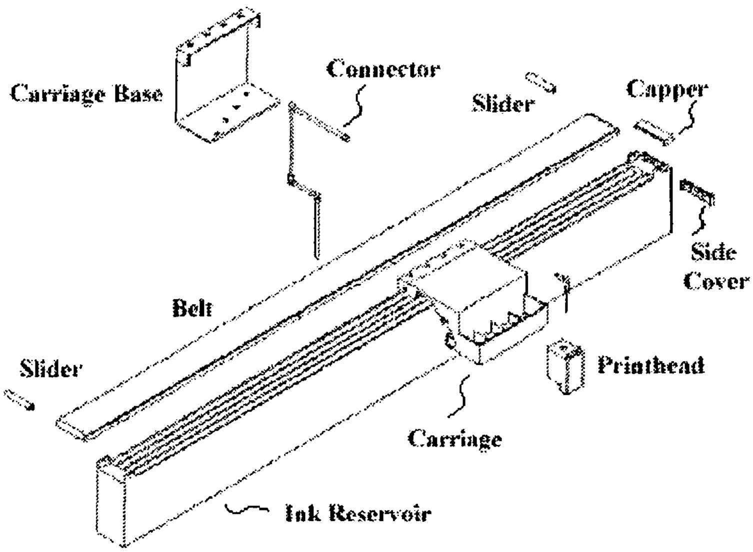


Fig. 3.0: Some key parts of LISS in explosion view

Meanwhile, the side view of WFP was also shown in Figure 4.0 that more clearly demonstrated the relative positions of parts in height.

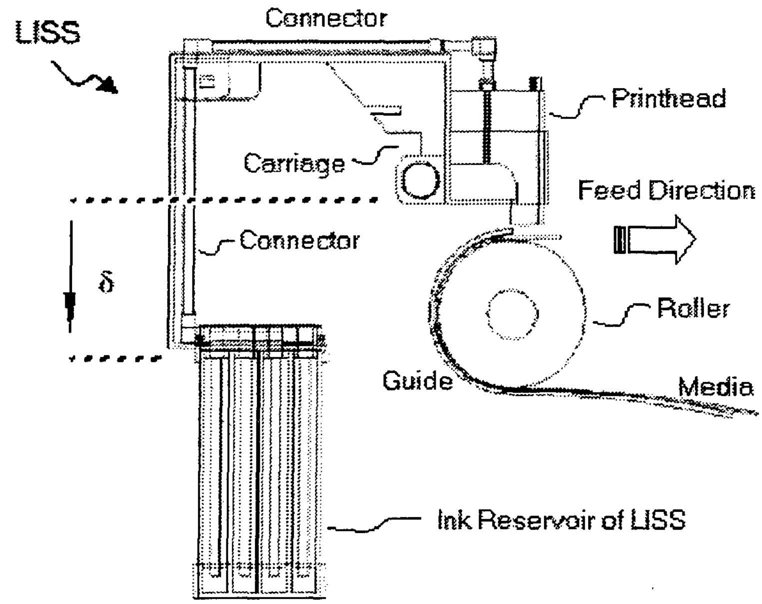


Fig. 4.0: The side view of WFP demonstrated relative positions of parts in height

## 3. DISCUSSION FOR LISS

### 3.1 Back Pressure of System

It's well known that a negative back pressure always needs be kept in the print head to prevent from drilling ink thereof. Note then that the ink reservoir of LISS presented here was open to its environmental air even although it's capped so closed with the belt, sliders, capper and side cover, shown in Figure 3.0. Since the new design used capillary action of ink to automatically and continuously supply the ink usage for the head, it is necessary that the top position of ink reservoir in LISS must be lower than the bottom position of print head, as shown in Figure 4.0. Mathematically, the relation was expressed as equation (3) where δ means the distance between the bottom position of print head and the top position of ink reservoir.

$$\delta \begin{cases} > 0\text{, at least} \\ \cong 2 \sim 4 \text{ cm} \end{cases}, \qquad (3)$$

Note that the δ must be greater than zero in order to keep a negative back pressure of print head. At the same time, values ranging from 2 cm to 4 cm were further preferred. It essentially depended on the character of print head.

### 3.2 Width of ink reservoir

Since no long tubing system was given in the design of LISS, it required that the ink reservoir was much wider than before. Here, first direction was defined as the feed direction of media so that the direction of width was vertical to it. Moreover, the width must be greater than print width of media in order to allow the print head go covering all margins of media. It might be mathematically described as equation (4) for details. Values of W were actually depending on the real print width of WFP.

$$W \begin{cases} > \text{Print Width of WFP} \\ \cong 30, 42, 60, \text{etc... inches} \end{cases}, \qquad (4)$$

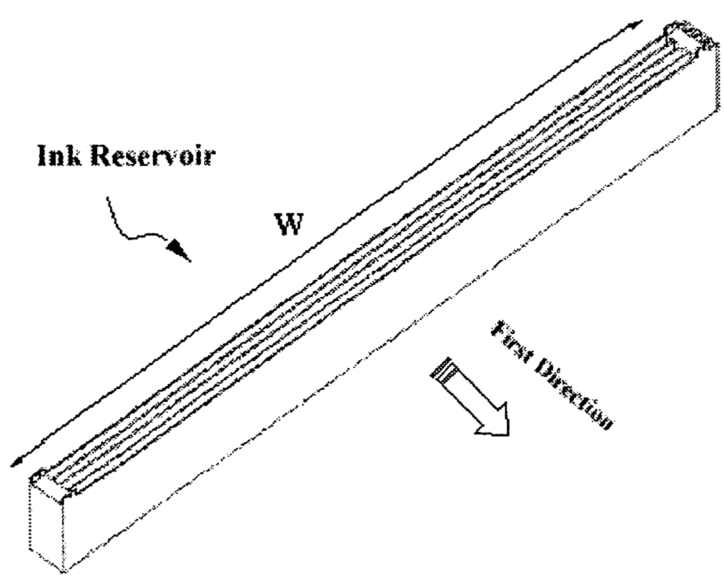


Fig. 5.1: The width of ink reservoir facing the first direction

### 3.3 Depth and height of ink reservoir

Except for the large width of ink reservoir, the depth and height were also characterized so different from before. Figure 5.2 clearly demonstrated the two dimensions. The ink reservoir here was partitioned into four individual chambers where four typical different colors of ink, such as black, cyan, yellow, and magenta, were contained thereof. Each chamber had the depth of d and the height of H. Thus the total depth of D in reservoir was roughly equal to four times of d. Meanwhile, it's noted that the volume V of ink reservoir was completely determined by three dimensions, i.e. the width W, depth d, and height H, shown in Figure 5.1 and 5.2. The exact relation could be expressed as V=W×d×H. In addition, the change of height may imply the change of back pressure of print head so that the height should be small enough to avoid large change of back pressure. In general, the amount less than 15 centimeters might be no problem for printing. Therefore, the height could be determined by previous expression if the volume of chamber was given. For example, supposed that one WFP with print width of 54 inches was designed to contain 500-cc ink in each chamber. Next, the width of chamber could be 60 inches and the height of chamber could be 10 centimeters. Thus we could obtain the individual depth d of 3.3 mm and total depth D of up to 20 mm as partition thickness counted too. Following the computational rules could easily yield more examples. Generally speaking, it's preferred that the specifications of WFP were holding as expressed in the following relationship (5).

$$\text{General rules,} \begin{cases} H > d \\ H \cong 5 \sim 15cm \\ d \geq 0.3cm \end{cases} , \tag{5}$$

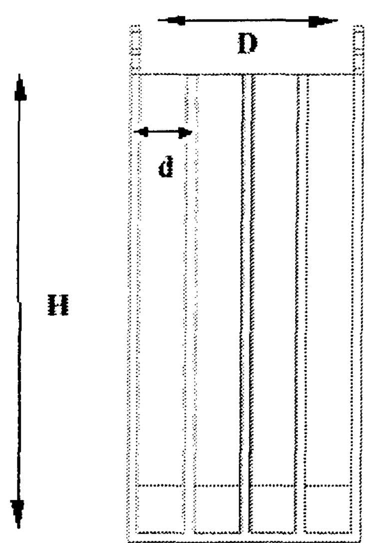


Fig. 5.2: The depth and height of ink reservoir

### 3.4 Clean and fill for ink reservoir

It's also necessarily considered in clean service and filling ink for the LISS. Fill ports were provided in the end of ink reservoir as required to fill ink; of course, each chamber of different ink had such an individual port to fill, respectively. At the same place, the clean ports of chambers were also designed for the service of clean when ink was refilled over time and time. Fill ports and clean ports should certainly at the top and bottom of chamber, respectively. Their corresponding capper and side cover would close them up tightly when the jobs were not requested. One embodiment of LISS was clearly illustrated in Figure 5.3 for details.

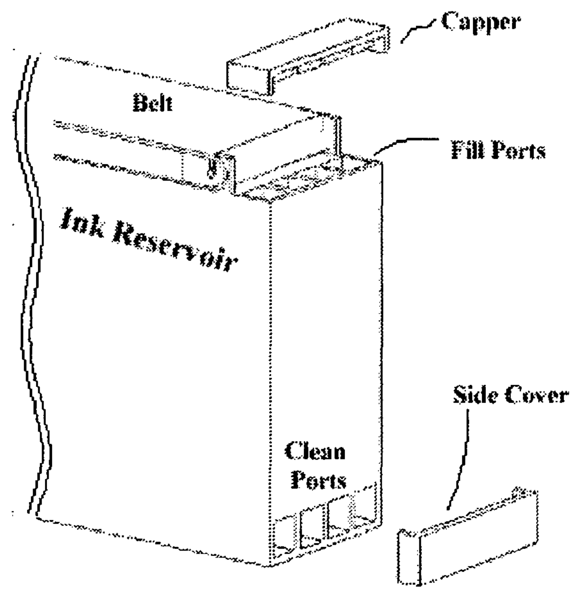


Fig. 5.3: Clean ports and fill ports in the system

### 3.5 Driven belt and slider

It's very necessary to close all chambers of ink reservoir up to prevent the volatility of ink into the air of environment. At the mean time, the ink path via the connector shown in Figure 3.0 and 4.0 should always keep go through from the reservoir to the print head. We noticed here that the print head was not still but movable as any print job been doing. For those purposes, an endless belt was provided in the system. The belt had four holes symbolized as YMCK, for example, to allow the construction of four different ink paths. The distance between any neighboring two was d' which was approximately equal to the depth d of chamber. Also it's flexible to form a closed loop that could be synchronically driven with ease by the carriage of print heads.

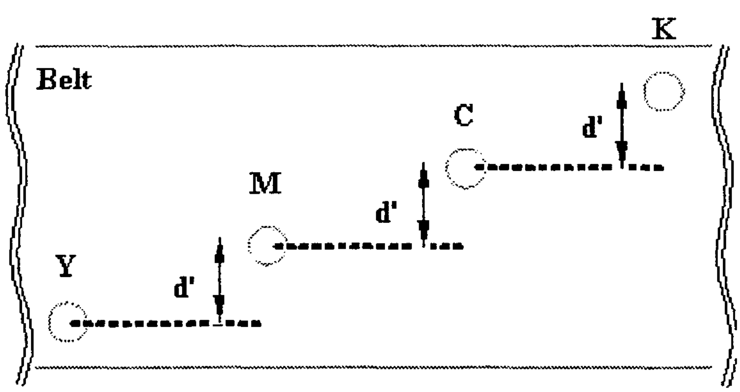


Fig. 5.4: A driven belt with four holes symbolized as Y, M, C, and K

In the two ends of ink reservoir, two sliders were installed as illustrated in Figure 3.0 and 5.3. Their rotation easily allows the belt to move as being driven. Each slider had the width of D', shown in Figure 5.5, that approximately equaled the depth D of reservoir; in addition, the radii of slider could have no limit, but small one in general was preferred.

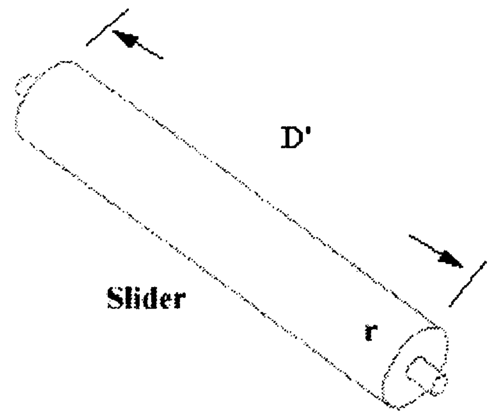


Fig. 5.5: A driven slider with width of D' and radii of r

# 4. CONCLUSION AND FUTURE WORK

## 4.1 Conclusion

A new method and design of large ink supply system (LISS) without long tubing system for wide format inkjet printer (WFP) was presented in the paper. By replacing long tubing with wider ink reservoir, the traditional pressure loss and pressure vibration could be eliminated a lot. The embodiment of new LISS design was summarized as below-

- **Back pressure of system**: the capillary action was applied to automatically supply the ink for the print head. Therefore, placing the ink reservoir in the position lower than that of the print head could easily set up a negative back pressure. In general, it's preferred to set the distance $\delta$ as equal to 2 ~ 4 centimeters.
- **Width of ink reservoir**: the width W of reservoir must be greater than the print width of WFP in order to go through all margins of media. For examples, the values of W could be 30 inches, 42 inches, and 60 inches for print width of 24 inches, 36 inches, and 52 inches, respectively.
- **Depth and height of ink reservoir**: the depth d and height H for each chamber of reservoir could be obtained by the relation $V=W\times d\times H$ where the symbol V means the required volume of chamber. Here, general rules were given with $H > d$, $H\cong 5\sim15$ centimeters, and $d \geq 0.3$ centimeters.
- **Clean and refill**: the capability of cleaning chamber and filling ink over time to time were owned in the system by offering clean ports and fill ports, respectively.
- **Driven belt and slider**: the endless and flexible belt was used to close the ink reservoir up since the volatility of ink in the reservoir must kept as low as possible. In addition, it can synchronically move driven by the print head, via the sliders at the time of movement of the print head.

## 4.2 Future work

Further work may be explored to know how the LISS system performs in the future. What we concern may be several fluid dynamic behaviors of ink in the reservoir, supplying speed of ink, availability of printing speed, Bernoulli effect, and so on. Two approaches of the dynamic simulation/computation and the real experiment of system would be recommended. Their results might further improve the future design presented in the study.

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