A New Ion-Jet Printing Head Controlled by A Low-Voltage Signal

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Abstract

The ion-jet printing method controls the ion flow directly to make an electrostatic latent image on an insulated layer. This printing method has several advantages over laser printing, such as high printing speed and simple maintenance. However, conventional ion-jet method poses a problem, particularly for office printer applications, because a high-voltage circuit is required to control the ion flow.

We developed the new ion-jet printing method to solve this problem. The new process uses a pre-charge to accelerate the ion flow to the insulated layer, and the high-voltage bias is eliminated from the head. So, the new ion-jet head permits controlling the ion flow by a low-voltage signal. Experimentally, we attained a printing speed of 20 ppm and a resolution of 400 dpi at the control voltage of -30 V, and succeeded in printing Chinese characters with 32 X 32 dots per 2-mm square.

keywords: ion-jet head, ion-jet printer, ion generator, ion flow, ozone, developing unit, transfer roller, pre-charge.

1. Introduction

The ion-jet printing methods have been reported by Delfax(1), Xerox(2), NTT(3) and other corporations. These methods have many features (Table 1); that is, high printing speed, and simple maintenance without a photoconductor and a mechanical optical scanner as for a laser printing method. However, these methods require a high-voltage circuit to control the ion flow, so it is not appropriate for office printer applications.

This paper reports on a new pre-charge process and a new ion-jet head. The new pre-charge process applies a uniform surface charge to the insulated image layer to accelerate the ion flow from the head, instead of the high bias voltage applied to the head. So, it becomes possible to use conventional low-voltage IC drivers to control the ion flow. Consequently, without a high-voltage circuit, we succeeded in printing Chinese characters by a printing speed of 20 ppm using the new pre-charge process and the new ion-jet head.

2. The New Ion-Jet Printer

In the new ion-jet printer (Fig. 1), an ion generator, the new ion-jet head, a developing unit, an electric transfer roller, and a cleaner unit are put around an imaging drum. The imaging drum is composed of an aluminum drum covered with an insulated layer. The ion generator pre-charges the insulated image layer up to -600 V. The surface potential accelerates the ion flow from the new ion-jet head. The new ion-jet head is able to control the ion flow by means of the low-voltage signal. The ion flow arrives at the insulated image layer, and erases the surface potential to form the reversal electrostatic latent image, in response to the voltage signal. A two-component developing unit with high-gamma characteristics is used to develop the latent image. A high bias voltage (-550 V) nearly equal to the surface potential is applied to the developing unit, which uses non-magnetic toner with a negative charge. The latent image is reversal-developed to form a normal image on the insulated image layer. An electric transfer roller (4) moves this toner image to a sheet of plain paper by means of a transfer bias voltage (+800 V). The transferred toner is melted by a fixing heater, and the toner image is fused to the plain paper. The remaining toner on the insulated image layer is wiped out by a cleaner to form the toner image again.

3. The Latent Image Formation

The insulated image layer charged up to -600 V moves under the new ion-jet head (Fig. 2). The high-density ion flow is continuously generated from the solid state ion generator of the head by the application of a high-frequency voltage (3 kVpp, 100 kHz). This solid state ion generator consists of an induction electrode and an ion electrode with an ion slit. An insulated glass layer is placed between these electrodes. Photograph 1 shows the solid state ion generator. The induction electrode is placed on the back of the glass layer. These components are mounted on a ceramic board using thick and thin film techniques suitable for mass production. On the other hand, a low-voltage signal (-30 V) is applied to the pair of control electrodes to generate a high electric field between the control electrodes. The ion flow is controlled with a high electric field, and passes through the through-hole of the pair of control electrodes. Thus, the new ion-jet head is able to control the ion flow by means of the low-voltage signal, so we can design a simple circuit using conventional low-voltage IC drivers. The controlled ion flow is accelerated by the surface potential, and erases this potential in response to the low-voltage signal. Consequently, an electrostatic latent image is formed on the insulated image layer. This latent image contrast potential must be kept below 300 V, which is lower than that in conventional electrophotography, in order to eliminate the

interaction between the ion flow and the electrostatic latent image.

4. Potential Distribution in the Head

Figure 3 shows the potential distribution in the new ion-jet head. When a high-frequency voltage (3 kVpp, 100 kHz) is applied to the ion generator, positive or negative ions are generated according to the polarity of the induction electrode. The induction electrode changes to the positive polarity (Fig. 3: solid line), then positive ions are generated over the glass layer of the ion-electrode slit. The ion electrode of the ion generator is maintained at earth potential. The positive ions can move from the ion generator to the first control electrode by the high potential on the glass layer of the ion generator. So, the first control electrode is kept to earth potential. A low-voltage signal (-30 V) is applied to the second control electrode, then a high electric field generates between the pair of control electrodes. The ion flow with positive polarity passes through the through-hole of pair of control electrodes, and arrives at the image layer with the high surface potential (-600 V). Then, the ion flow erases the surface potential to make the latent image. When the second control electrode is changed to earth potential, an electric field is eliminated between the first control electrode and the second control electrode. So, the ion flow is cut off. Otherwise, the induction electrode of the ion generator changes to negative polarity (Fig. 3: dotted line), negative ions are generated from the ion generator. However, the negative ions cannot flow to the image layer due to the negative surface potential on the insulated image layer. For this reason, only positive ions are used to form the electrostatic latent image.

5. The Structure of the New Ion-Jet Head

The new ion-jet head consists of a solid state ion generator, a sheet of control electrodes, and hybrid IC drivers. These components is integrated into one unit (Fig. 4) on a ceramic holder. The ion generator and the sheet of control electrodes are assembled at the edge of a ceramic holder, and hybrid IC drivers are arranged on both sides of this holder.

The sheet of control electrodes (Photo. 2) is composed of a first common electrode and the second separate electrodes which are placed on both sides of the resin thin film. The first control electrode and the second control electrode form a pair, and have a through-hole to pass the ion flow. Electric lead patterns from the second control electrodes are alternately arranged on right and left sides of the control electrode sheet, and the pairs of control electrodes are arranged on four lines.

6. Printing Results Using the New Ion-Jet Head

We succeeded in printing a Chinese character (Photo 3) by the printer using the new pre-charge process and the new ion-jet head. The Chinese character was printed with 32 X 32 dots per 2-mm square. This ion-jet printer has a 400-dpi resolution and 20-ppm printing speed. Furthermore, we found that the solid state ion generator generates less ozone than a conventional charger. In the next step, we would like to apply the new precharge process and the ion-jet head to an office printer and a half-tone image with the pulse width modulation.

7. Conclusion

Table 2 shows the characteristics of the new ion-jet printing method. We succeeded in designing a new ion-jet head with a resolution of 400 dpi and a printing speed of 20 ppm, controlled by a low-voltage signal (-30 V). The new pre-charge process accelerates the ion flow from the ion-jet head to the insulated image layer instead of the high bias voltage, and the new ion-jet head can control the high-density ion flow with a low-voltage signal. This head is composed of a solid state ion generator, a sheet of control electrodes, and conventional IC drivers. These components are integrated into one unit suitable for mass production. The new ion-jet printing method can make a toner image on plain paper, and is appropriate for office printers which should be low-cost, high reliability, and should generate less ozone.

8. References

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Table 1. Features of Conventional Ion-Jet Printer

	Delfax	Xerox	NTT
Ion Acceleration Method	Head Bias Voltage 1 kV	Head Bias Voltage + Air Blow	Head Bias Voltage 1 kV
Signal Voltage	High-Frequency Voltage (2 kVpp)	DC ~ 100V	DC ~ 150V
Printing speed	~ 300ppm	~ 40 ppm	~2 ppm
Resolution	250 dpi	~ 300 dpi	250 dpi

Table 2. Characteristics of New Ion-Jet Printer

Ion Acceleration Method	Pre-charge
Signal Voltage	30 V
Printing Speed	20 ppm
Resolution	400 dpi

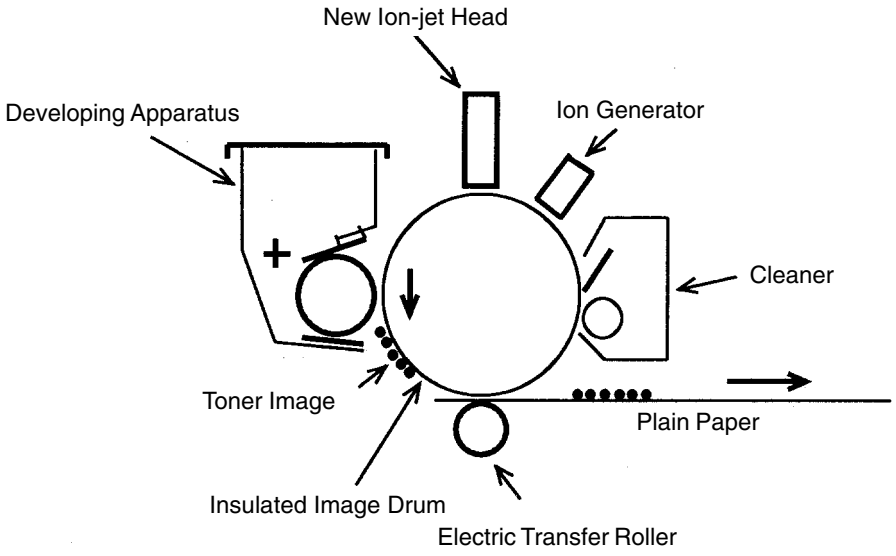


Figure 1. Ion-Jet Printer.

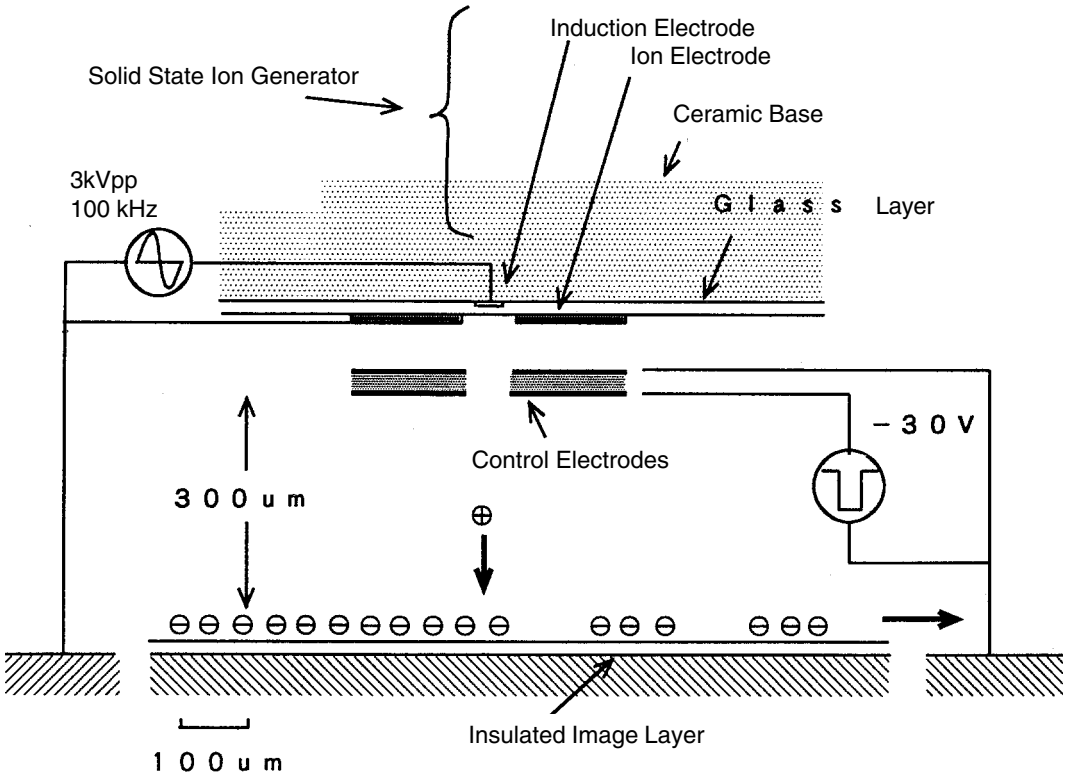


Figure 2. A Cross-Section of the Ion-jet Head.

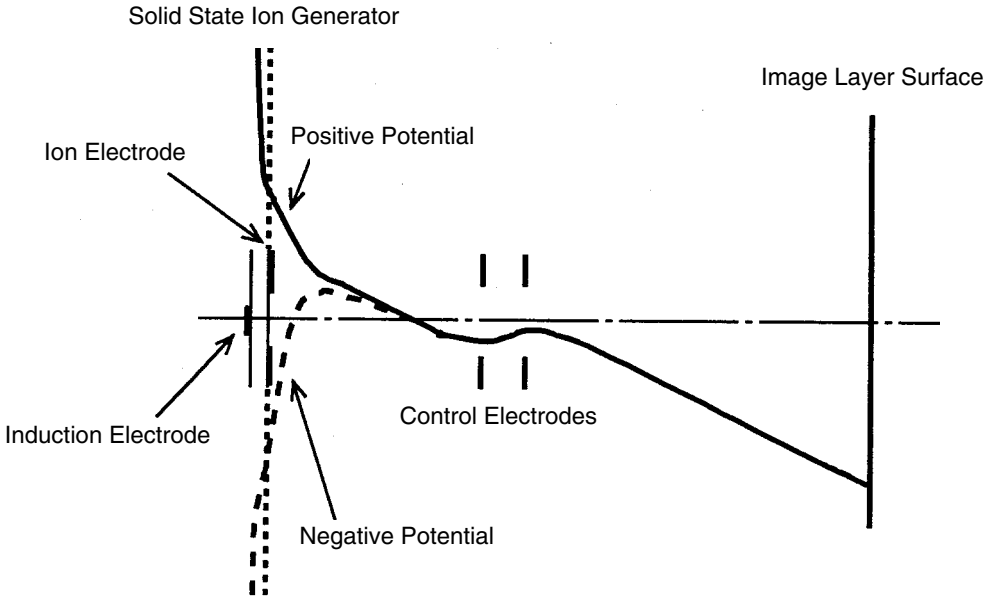


Figure 3. Potential Distribution in the Ion-jet Head.

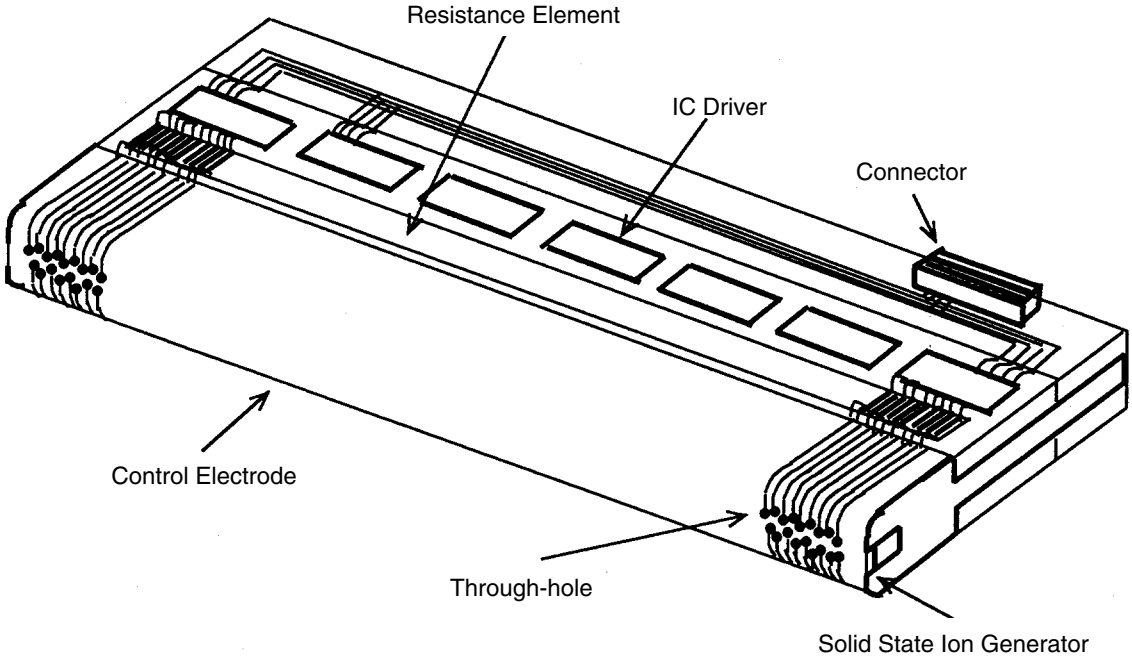
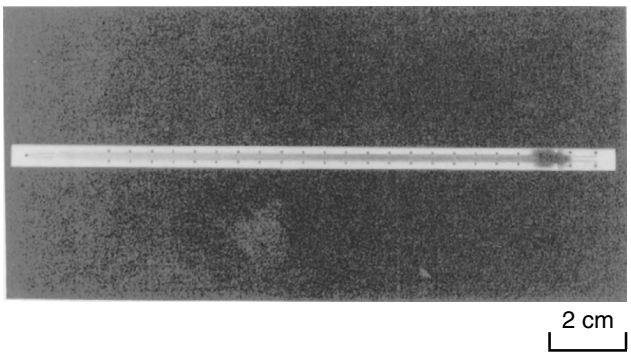
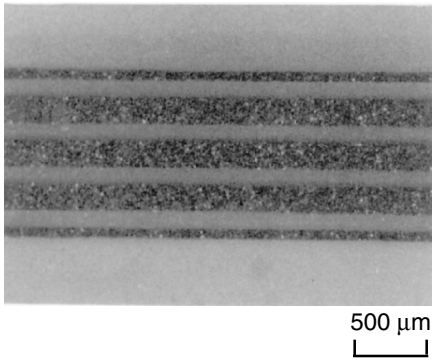


Figure 4. A schematic of the Ion-jet Head.

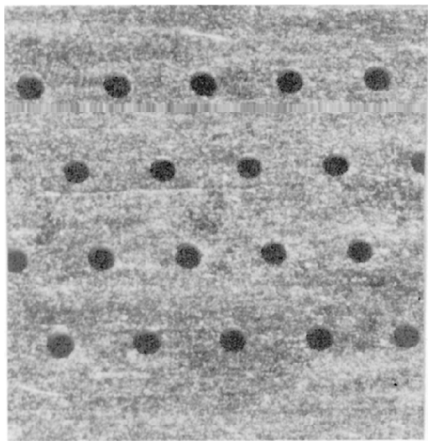


(1a) Ion Generator

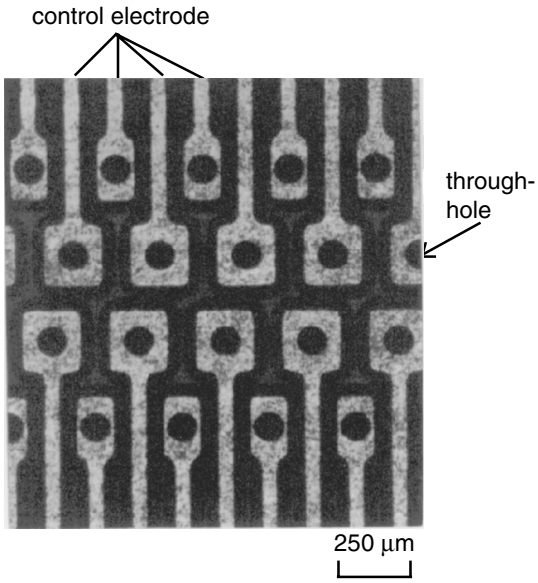


(1b) Magnificaiton Photograph

Photo 1. Solid State Ion Generator



(2a) First Electrode Magnification Photograph



(2b) Second Electrodes Magnification Photograph

Photo 2. Sheet of Control Electrodes

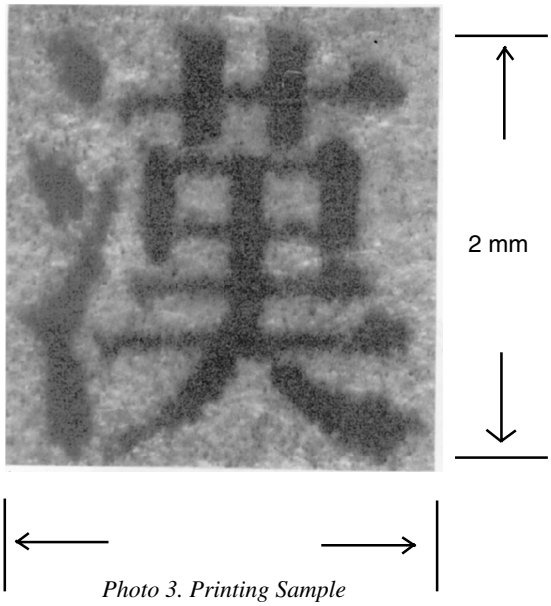


Photo 3. Printing Sample