High Resolution Long Array Ink-Jet Printer

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Introduction

Scitex Digital Printing, Inc., has been involved with continuous binary ink-jet since the early 70's. The early effort was a research project at Mead Paper Company's Central Research Laboratory in Chillicothe, Ohio. In 1976, we introduced its first commerical product, the 2800 printer. To improve print quality of these printers, we recently introduced 3500 printers. The 3500 printer can print variable information at speeds up to 520 feet per minute with a resolution of 240 dots per inch. The printer prints 17" wide swath using four printheads of 4-1/4" width each. The printheads are based on the binary continuous ink-jet technology originally developed for the Dijit 1 office printer.

This paper describes extension of the 3500 printer that can print up to 1000 feet per minute. Specifically, we will describe the printing technology and the printing system.

Printing Technology

The 4-1/4" 240 jpi printhead uses continuous ink-jet technology, and is based on extension of processes developed for 64 jets, 300 jpi Dijit office printer. Here an array of 1028 jets is operated in the continuous mode printing binary information. Continuous mode means that ink flows constantly in each jet and drops are generated at a fixed rate. The drops are then switched to either print on the paper or are intercepted by a catcher. Binary mode means that each picture element or pixel on the paper is either printed or not printed. The print state is defined as a single print ink drop of fixed size addressed to that pixel and just covering it.

As shown in Figure 1, the printhead is composed of two basic parts: a resonator to produce an array of jets formed into uniform drops and a drop controlling device to remove the drops that are not printed.

The resonator (drop generator) contains a pressurized fluid cavity connected to an orifice plate which contains a row of 1028 very small, precise orifices (Figure 1). A very fine filament or jet of fluid is formed at each orifice. Since this cylinder of fluid is mechanically unstable, it always breaks up into small drops of ink. Drop formation can be made regular by a vibration of the orifice plate (called stimulation of the jets). The vibration is sinusoidal at an ultrasonic frequency determined by the orifice diameter, pressure, and physical properties of the ink. The size of the ink drops are chosen to produce dots of the proper size on the paper. For 1000 feet per minute printers, drops along the array are formed simultaneously at a rate of 96 kHz. The nominal orifice size is 1.4 mils and 14 psi operation pressure for water-based inks. These parameters give drop size to get full coverage with 1 drop per pixel.

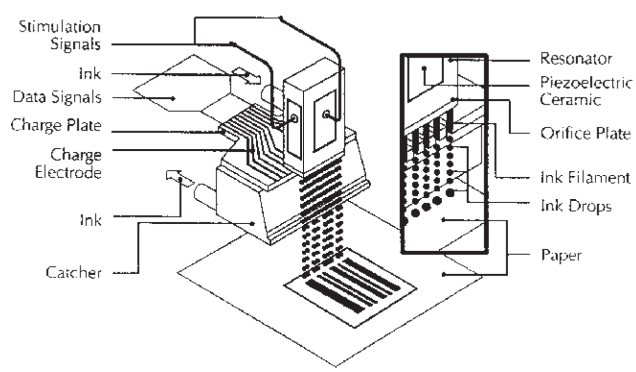

Figure 1.

The stimulation is provided by an ultrasonic transducer designed to be operated near a resonance to achieve sufficient vibrational amplitude. This system uses a slotted rectangular block of steel vibrated in a longitudinal mode near the first resonance. The slots are used to reduce the effect of other vibrational modes on stimulation. The resonant frequency in this mode is approximately given by $f = \frac{v}{2h}$ where v is the velocity of sound in steel and h is the height of the resonator. The fluid cavity is formed in one end of the block and the orifice plate is bonded to the block to form one side of the cavity. Piezoelectric ceramic plates bonded to the sides of the block cause it to vibrate when driven with a sinusoidal voltage. The voltage is adjusted to cause all the jets in the array to break up properly at a uniform distance from the orifice plate producing drops simultaneously in all jets. The level of stimulation is sensed using an extra transducer on the stimulator block. This allows to

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monitor the stimulation and allow to maintain stimulation amplitude constant at all times by a feedback circuit.

The drop controlling apparatus consists of a charge plate and a catcher as shown in Figure 1. The charge plate is an array of electrodes with spacing equal to that of the jets. The voltage on each electrode can be controlled individually. When not printing, a DC voltage is applied to each electrode which causes the jet aligned with that electrode to be charged by induction. The ink filament is electrically conducting and is a ground potential since the resonator and orifice plate are grounded. A positive voltage on an electrode induces a negative charge on the ink filament in front of that electrode and as each drop breaks off, a well defined charge is trapped on it. Charged drops are deflected by the electric field in front of the charge plate and impacted on the catcher face. To print a dot on the paper, the charge voltage on the electrode controlling the appropriate jet is switched off during the time in which the next drop breaks off. This allows that drop to be uncharged. It is not deflected and follows a straight line trajectory to impact on the paper. A data system controls the voltage on the charging electrode.

The charging electrodes are about 2 mils wide. The thickness of the charge plate is about 40 mils, i.e., the lead length is 40 mils. This length is found sufficient to charge and deflect the drop. The catcher is composed of a metal with a smooth, flat face parallel to the plane of the jet array and offset to allow print drops to hit the paper. Charged catch drops impact at very small angles to the face and merge into a sheet of fluid which flows down the face and around a curved corner into a fluid removal system. A low vacuum on the catcher fluid return line is used to remove the deflected ink.

The Printing System and Operation

A fluid system provides the fluid and all the electronics controls for the operation of the printhead. For the start-up and the shutdown of the printhead, we use the eyelid concept. Here the eyelid seals against the catcher pan defining the catcher throat (Figure 2).

With the eyelid closed, the fluid system controller automatically brings printhead to a ready state by going through various stages of bring-up table (one button start). The ink during the bring up is evacuated via a catcher throat. When the jets are in catch, the eyelid is open and the printhead prints when data is transmitted to the printhead. For shut-down, eyelid is closed, fluid flow is stopped and the residual ink is again evacuated through the catcher throat.

To print 17 inch swath, four printheads staggered in two rows are used. Each printhead contains an independent fluid system. The printhead position along x-axis (i.e., along the paper) can be adjusted by using a lead screw. The y-axis position (along the paper motion direction) is adjusted by data delay and a fine screw mechanism.

The data system developed for the 3500 system can provide variable information up to a speed of 1000 feet per minute. The high data rate is transmitted to the printhead using fiber-optic cable. Commercially available roll-to-roll web paper transport is used to feed paper at 1000 feet per minute. Drying of the ink is achieved by a commercially available infrared drier.

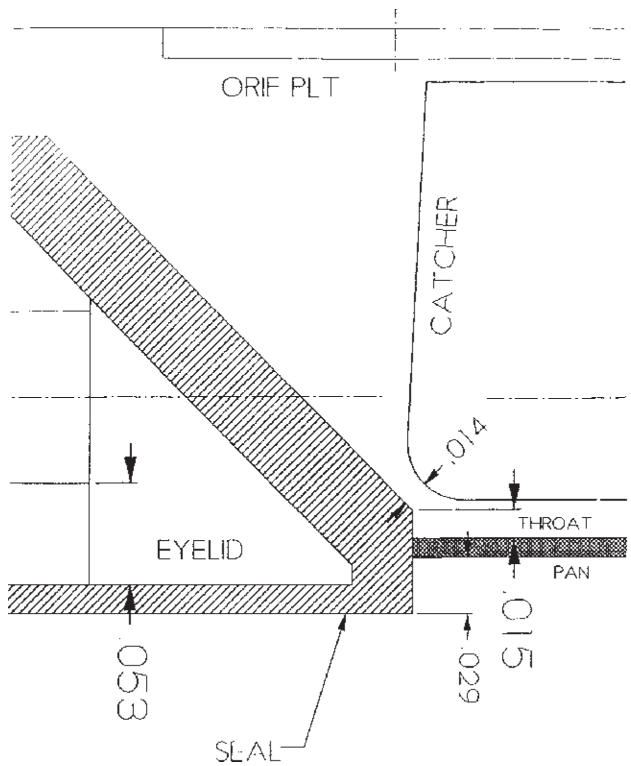

Figure 2.