

Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 0 890 439 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
13.01.1999 Bulletin 1999/02

(51) Int. Cl.⁶: **B41J 2/05**

(21) Application number: **98112684.0**

(22) Date of filing: **09.07.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **11.07.1997 US 891522**

(71) Applicant:
Lexmark International, Inc.
Lexington, Kentucky 40550 (US)

(72) Inventors:
• **Anderson, Frank Edward**
Sadleville, Kentucky 40370 (US)
• **Edwards, Mark Joseph**
Lexington, Kentucky 40515 (US)
• **Gibson, Bruce David**
Lexington, Kentucky 40514 (US)
• **Parish, George Keith**
Winchester, Kentucky 40391 (US)

(74) Representative:
Dr. Weitzel & Partner
Friedenstrasse 10
89522 Heidenheim (DE)

(54) **Ink jet printhead with an integral substrate heater driver**

(57) The invention is directed to an ink jet printer including an electrical circuit providing an output signal. A printhead includes a substrate, a nozzle plate having a plurality of ink emitting orifices, a plurality of jetting heaters respectively associated with the plurality of ink emitting orifices, and at least one substrate heater associated with the substrate. A substrate heater driver is located on and integral with the printhead. The substrate heater driver includes at least one input and at least one energizable output. The at least one input is connected with the electrical circuit and receives a signal corresponding to the output signal from the electrical circuit. One of the energizable outputs is coupled with at least one of the substrate heaters. The substrate heater driver is configured to selectively actuate the at least one substrate heater, dependent upon the received signal.

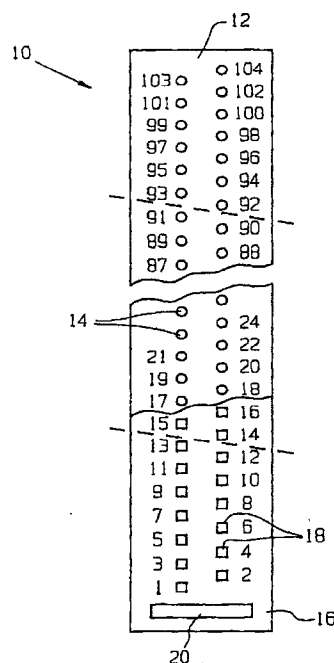


Fig. 1

EP 0 890 439 A2

Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to ink jet printers, and, more particularly, to ink jet printers including a printhead with a plurality of jetting heaters and at least one substrate heater.

DESCRIPTION OF THE RELATED ART

An ink jet printer typically includes a printhead having a nozzle plate which is connected to and mounted in spaced apart relationship relative to a substrate. The nozzle plate includes a plurality of ink emitting orifices which are respectively disposed in association with a plurality of jetting heaters mounted on the substrate. When a particular jetting heater is actuated or fired, ink disposed adjacent thereto rapidly expands to form a vapor bubble. Ink is expelled through the ink emitting orifice by the bubble and is jetted onto the print medium.

During use, selective actuation of the plurality of jetting heaters within the printhead causes the operating temperature of the printhead to increase. The increased operating temperature of the printhead in turn causes the temperature of the ink disposed within the printhead to correspondingly increase. A change in the temperature of the ink results in a change of the physical properties of the ink, such as viscosity, surface tension, etc. It has been found that the drop mass and velocity of the ink droplets which are jetted onto the print medium vary with a change in the operating temperature of the ink within the printhead, thus affecting the print quality.

It is known to provide at least one substrate heater which is mounted on the substrate within the printhead for the purpose of maintaining the ink within the printhead at an approximate desired operating temperature, thereby providing a more uniform and improved print quality. The substrate heaters are typically actuated upon initial power-up of the printhead or during periods of inactivity of the printhead such that the ink within the printhead is maintained at an approximate desired temperature.

Conventional printheads employing one or more substrate heaters typically include driver circuitry for driving the substrate heaters which is located on a printed circuit board of the printer. Using a separate substrate heater driver located on the printed circuit board of the printer (i.e., off the printhead) requires additional interconnects between the substrate heater driver and the printhead, thereby increasing the cost and complexity associated with the printer and printhead.

What is needed in the art is an ink jet printer having a printhead which does not require additional electrical interconnects for actuation of the substrate heaters.

SUMMARY OF THE INVENTION

The present invention provides a substrate heater driver and decoder which are mounted on and integral with a printhead in an ink jet printer. The decoder receives encoded address signals for the jetting heaters. The encoded address signals also include encoded information for the substrate heater(s) which is decoded by the decoder and used to actuate the substrate heater(s).

The invention comprises, in one form thereof, an ink jet printer including an electrical processor providing an output signal. A printhead includes a substrate, a nozzle plate having a plurality of ink emitting orifices, a plurality of jetting heaters respectively associated with the plurality of ink emitting orifices, and at least one substrate heater associated with the substrate. A substrate heater driver is located on and integral with the printhead. The substrate heater driver includes at least one input and at least one energizable output. At least one input is connected with the electrical circuit and receives a signal corresponding to the output signal from the electrical circuit. One of the energizable outputs is coupled with at least one of the substrate heaters. The substrate heater driver is configured to selectively actuate at least one substrate heater, dependent upon the received signal.

An advantage of the present invention is that the substrate heater driver is mounted on and integral with the printhead, and is actuated by the already existent encoded address lines, thereby reducing the interconnect requirements of the printhead with a printed circuit board in the printer.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a schematic view of an embodiment of a printhead of the present invention, illustrating a typical configuration of ink emitting orifices, jetting heaters and substrate heaters; and

Fig. 2 is an electrical schematic illustration of the printhead shown in Fig. 1.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one preferred embodiment of the invention, in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and more particularly to Fig. 1, there is shown a schematic view of one embodiment of a printhead 10 of the present invention. Printhead 10 includes a nozzle plate 12 having a plurality of ink emitting orifices 14 formed therein. In the embodiment shown, ink emitting orifices 14 are formed in two vertical columns with fifty two ink emitting orifices 14 in each column, (i.e., a 2 x 52 array). For discussion purposes, the majority of ink emitting orifices 14 are labeled with an individual index number between 1 and 104 in Fig. 1. Ink emitting orifices 14 are shown staggered or off-set relative to ink emitting orifices 14 in an adjacent row by a distance of approximately one-half the distance between vertically adjacent orifices 14. However, ink emitting orifices 14 may be substantially aligned relative to each other between adjacent columns.

Printhead 10 also includes a substrate 16 which is connected to nozzle plate 12. A plurality of jetting heaters 18 are mounted on substrate 16 and positioned relative to respective ink emitting orifices 14. More particularly, each of the plurality of jetting heaters 18 is positioned substantially in axial alignment with a respective ink emitting orifice 14. Actuation of a jetting heater 18 rapidly heats the ink disposed adjacent thereto, and creates a gas bubble which jets ink from the associated ink emitting orifice 14.

A pair of substrate heaters 20, one of which is shown in Fig. 1, are also mounted on substrate 16 at opposite ends of printhead 10 outside the area where jetting heaters 18 are located. Substrate heaters 20 may be actuated to provide additional heat to printhead 10 and thereby control the operating temperature of printhead 10. As the operating temperature of printhead 10 varies, the temperature of the ink within printhead 10 likewise varies which results in varying physical properties of the ink such as viscosity, etc. Maintaining the operating temperature of printhead 10 at an approximate desired level provides an improved print quality by maintaining physical properties of the ink at a relatively constant level. Although printhead 10 shown in Fig. 1 includes two substrate heaters 20, more or fewer substrate heaters may be utilized depending upon the particular application and the heat transfer characteristics of printhead 10.

Referring now to Fig. 2, there is shown an electrical schematic illustration of printhead 10 shown in Fig. 1. Printhead 10 is connected with an Application Specific Integrated Circuit (ASIC) or microprocessor 52, P-line driver 34 and encoded A-line driver 36.

Printhead 10 includes a decoder 24 which is connected with a plurality of input pins EA1 through EA5. Decoder 24 receives encoded signals through the connection with pins EA1 through EA5 and decodes the encoded signals for selectively actuating transistors 22 which are associated with respective ink jetting heaters

18. Decoder 24 also includes an input connected to pin BSELECT on printhead 10. Decoder 24 receives a signal for selection and deselection of printhead 10 through the connection with pin BSELECT, as will be described in more detail below. Decoder 24 may include a number of configurations capable of decoding the encoded signals received from pins EA1 through EA5. For example, decoder 24 may include a combination of transistors, which are configured to decode the encoded signals received from pins EA1 through EA5.

Decoder 24 includes a plurality of decoded outputs A1-A13 which are connected with and used to selectively actuate transistors 22 associated with each group of thirteen ink jetting heaters 18, shown as resistor elements and individually referenced 18A-18F in Fig. 2. Each group of thirteen jetting heaters 18 shown in Fig. 2 corresponds to each consecutive group of thirteen jetting heaters 18 shown in Fig. 1. That is, jetting heaters 18 labeled 1-13 in Fig. 1 correspond to the first group of jetting heaters 18, jetting heaters 18 labeled 92-104 in Fig. 1 correspond to the last group of jetting heaters, etc. There are eight separate groups of jetting heaters 18, with each of the thirteen jetting heaters 18 being respectively connected with outputs A1 through A13 on decoder 24. A plurality of MOS transistors 22 are respectively associated with each jetting heater 18 and provide selective actuation of the respective jetting heaters 18, as will be described in more detail hereinafter.

Each of the eight groups of thirteen jetting heaters 18 include first terminals (not numbered) which are respectively connected with high side, power pins P1 through P8. Any of the jetting heaters 18 of printhead 10 may be selectively actuated by applying power to one of the power pins P1 through P8 and selectively energizing MOS transistors 22 connected with decoder 24. For example, to selectively energize jetting heater 18A, power is applied to pin P1 (but not to pins P2-P8) which in turn applies power to a first terminal of jetting heater 18A. Assuming that printhead 10 has been selected for operation by applying an appropriate signal to pin BSELECT of printhead 10, an appropriate encoded signal may be applied to decoder 24 (such as EA5=0, EA4=0, EA3=0, EA2=0 and EA1=1), which in turn decodes the signal, energizes output A1, and actuates MOS transistor 22 associated with jetting heater 18A. Actuation of MOS transistor 22 associated with jetting heater 18A closes the circuit to ground and allows jetting heater 18A to be selectively energized. Although the other seven MOS transistors 22 associated with the other seven groups of thirteen jetting heaters are also actuated by applying the signal to pin A1, no power is applied to pins P2 through P8. Thus, jetting heater 18D associated with pin P8 is not selectively energized when power is applied to pin P1. To selectively energize jetting heater 18D, power is applied to pin P8 and a signal is applied to output A1. Thus, any of the jetting heaters 18 in the 104 jetting heaters of the 2 x 52 array of jetting

heaters may be selectively energized using pins P1 through P8 and decoder outputs A1 through A13.

Decoder 24 also includes at least one decoded output A14 which is connected to a transistor 26 for selectively actuating substrate heaters 20. Transistor 26 defines a substrate heater driver for selective actuation of substrate heaters 20. Transistor 26 is located on and integral with printhead 10 (i.e., transistor 26 is not located in a conventional manner on a printed circuit board off of printhead 10). Transistor 26 includes at least one input coupled with conductor 28 and at least one energizable output coupled with substrate heaters 20. Transistor 26 is connected with decoder 24 and receives a decoded signal over output A14 from decoder 24 corresponding to at least one encoded output signal from A-line driver 36. That is, transistor 26 receives an input signal derived from an encoded signal transmitted from A-line driver 36, such as EA5=1, EA4=1, EA3=1, EA2=0 and EA1=1.

In the embodiment shown in Fig. 2, the substrate heater driver which is located on and integral with printhead 10 is in the form of a single transistor 26. However, it is also possible to use any number of other transistors and/or electrical components on printhead 10 for selectively actuating substrate heaters 20. For example, conductor 28 may be connected in parallel to a pair of transistors 26 which are respectively connected with and used to actuate substrate heaters 20. Other embodiments are also possible and well within the scope of knowledge of a person of ordinary skill in the art.

Integrating substrate heater driver or transistor 26 on printhead 10 and actuating the substrate heater driver with a decoded output from decoder 24 allows the electrical interconnect requirements of printhead 10 with other electrical circuitry in the ink jet printer to be reduced, thereby reducing the complexity and cost of the ink jet printer and printhead. With conventional designs, one or more separate interconnect pins or pads are required on the printhead for electrically interconnecting the substrate heaters on the printhead with a substrate heater driver located on a printed circuit board off the printhead. Such additional pins or pads increase the physical size of the printhead, which may be a limitation for certain applications. Moreover, for a printhead with a high number of ink jetting heaters and associated orifices, the number of address lines which are required for sending signals to the printhead may be relatively large. It is correspondingly necessary to provide the printhead with a relatively large number of interconnect pins or pads for electrical connection with the address lines, thereby increasing the physical size of the printhead. Reducing the number of interconnect pins on the printhead by incorporating the substrate heater driver into the printhead and using encoded address lines typically used with the jetting heaters to actuate the substrate heater driver is thus also an advantage with such a configuration.

Microprocessor 32 provides a select signal BSELECT to pin BSELECT of printhead 10. Select signal BSELECT is received and used by decoder 24 for selecting and deselecting printhead 10. An additional pin shown at the bottom of printhead 10 in Fig. 2 is used for identification of the particular printhead, etc.

P-line driver 34 includes a plurality of energizable power line outputs P1 through P8 which are respectively connected to pins P1 through P8 of printhead 10. Power line output P1 is connected with the first group of thirteen jetting heaters 18, and also is connected with substrate heaters 20, as described above. Power line outputs P2 through P8 are respectively connected with the seven other groups of thirteen jetting heaters 18 in printhead 10. More particularly, a transistor 38 in P-line driver 34 selectively couples one of the power line outputs P1 through P8 to a voltage source reference V+. Any one of the eight groups of thirteen jetting heaters 18 may be selectively connected with voltage source V+ by selectively enabling a power line output P1 through P8.

A-line driver 36 defines an electrical circuit which includes a plurality of outputs EA1 through EA5 which are respectively connected with pins EA1 through EA5 of printhead 10. Outputs EA1 through EA5 are coupled via decoder 24 with second terminals of respective jetting heaters 18 in printhead 10. Encoded outputs EA1 through EA5 may be selectively energized to transmit encoded enable signals to decoder 24, which in turn decodes the encoded signals and uses the decoded signals to actuate MOS transistors 22 and/or transistor 26 connected therewith.

During use, any of the jetting heaters 18 in the eight groups of jetting heaters 18 may be selectively energized by coupling one of the power line outputs P1 through P8 to a first terminal of each of the jetting heaters 18 in a selected group of jetting heaters. Encoded outputs EA1 through EA5 of A-line driver 36 are then selectively energized to transmit encoded signals to decoder 24. The encoded signals are decoded by decoder 24 and used to actuate a selected MOS transistor 22 and close the circuit to ground of the corresponding jetting heater 18. The encoded signals received by decoder 24 are also used to selectively actuate substrate heaters 20 by selectively outputting a signal from decoder 24 over conductor 28 to a transistor 26 to thereby close transistor 26 and complete the circuit to ground when power is applied to pin P1.

Printhead 10 may be incorporated into an ink jet cartridge which is carried by a carriage assembly which traverses the width of a print medium during printing, in known manner. A print image is defined with respect to the print medium, with a print margin positioned at each side of the print image. In one embodiment of the invention, decoder 24 selectively actuates MOS transistors 22 as printhead 10 traverses across the print image, thereby causing ink to be jetted onto the print medium using the associated jetting heaters 18. When printhead 10 is positioned in the margins outside the area of the

print image, power is applied to substrate heaters 20 by applying power to pin P1. Decoder 24 does not actuate transistors 22 but rather outputs a signal over conductor 28 to actuate transistor 26 and thereby energize substrate heaters 20. Substrate heaters 20 are therefore selectively energized when printhead 10 is in the margins, resulting in decreased cooling of printhead 10 associated with inactivity of jetting heaters 18.

In addition to having a single printhead 10, the ink jet printer may also include one or more additional printheads for jetting different colored inks onto the jet medium. For example, a second printhead 40 is shown in Fig. 2 for jetting a colored ink such as cyan, magenta or yellow ink onto the print medium. The electrical schematic for printhead 40 is the same as that shown and described with reference to black printhead 10, and thus will not be described in detail. However, it is to be understood that the same or a different P-line driver and/or A-line driver may be connected with each separate printhead. Moreover, the actual combination of power line outputs and enable line outputs may vary from one printhead to another.

In the embodiment of the present invention shown in Fig. 2 and described above, printhead 10 includes a decoder 24 having thirteen outputs A1 through A13 which are each coupled to a plurality of corresponding jetting heaters 18. For example, output A1 is connected to each of jetting heaters 18A and 18D shown in Figs. 2 and 3. However, printheads 10 and 40 may include a decoder with separate outputs A1...AN associated with each jetting heater 18 in the eight groups of jetting heaters. That is, printhead 10 may include a decoder having 104 outputs A1-A104 which are respectively coupled to jetting heaters 18 in the 2 x 52 array of jetting heaters 14. If printheads 10 and 40 are configured in this manner, A-line driver 36 might include seven encoded outputs EA1-EA7 providing encoded signals from which the 104 outputs A1-A104 would be derived.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

Claims

1. An ink jet printer, comprising:

an electrical circuit providing an output signal;
a printhead including a substrate, a nozzle plate having a plurality of ink emitting orifices, a plurality of jetting heaters on said substrate and respectively associated with said plurality of ink

emitting orifices, at least one substrate heater associated with said substrate, and a substrate heater driver located on and integral with said printhead, said substrate heater driver including at least one input and at least one energizable output, said at least one input being connected with said electrical circuit and receiving a signal corresponding to said output signal from said electrical circuit, one of said energizable outputs being coupled with at least one of said substrate heaters, said substrate heater driver configured to selectively actuate said at least one substrate heater, dependent upon said received signal.

2. The ink jet printer of claim 1, wherein said printhead further comprises a decoder connected between said electrical circuit and said substrate heater driver, said decoder having at least one input and a plurality of outputs, said at least one decoder input being connected with said electrical circuit and receiving said output signal from said electrical circuit, at least one of said decoder outputs being coupled with said at least one substrate heater driver input and providing said received signal to said substrate heater driver, said received signal comprising a decoded signal.
3. The ink jet printer of claim 2, wherein at least another one of said plurality of said outputs of said decoder is coupled to at least one of said plurality of said jetting heaters.
4. The ink jet printer of claim 1, wherein said substrate heater driver comprises at least one transistor interconnecting said one energizable output of said decoder with said at least one substrate heater.
5. The ink jet printer of claim 1, wherein said output signal from said electrical circuit comprises an enable signal associated with said at least one substrate heater to be actuated.
6. The ink jet printer of claim 1, wherein said electrical circuit comprises an address line driver in said ink jet printer.
7. The ink jet printer of claim 6, wherein said output signal of said address line driver comprises an encoded address signal.
8. The ink jet printer of claim 1, wherein said at least one energizable output is coupled with two of said substrate heaters.

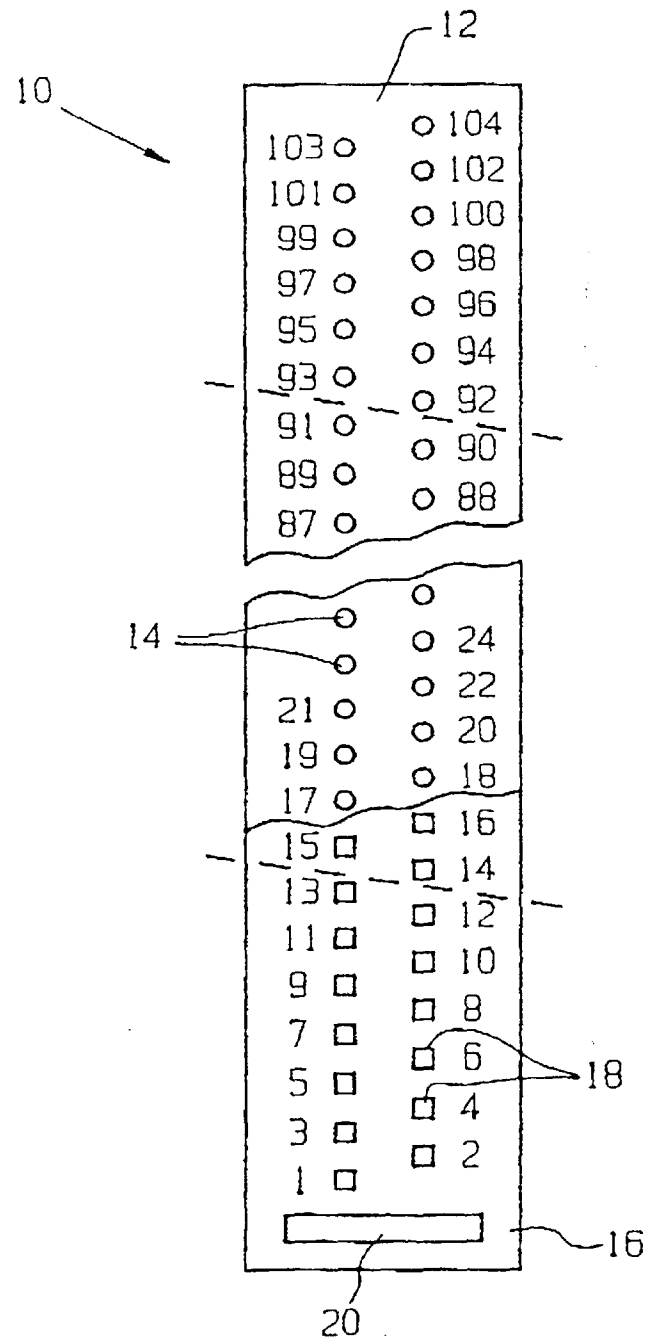


Fig. 1

