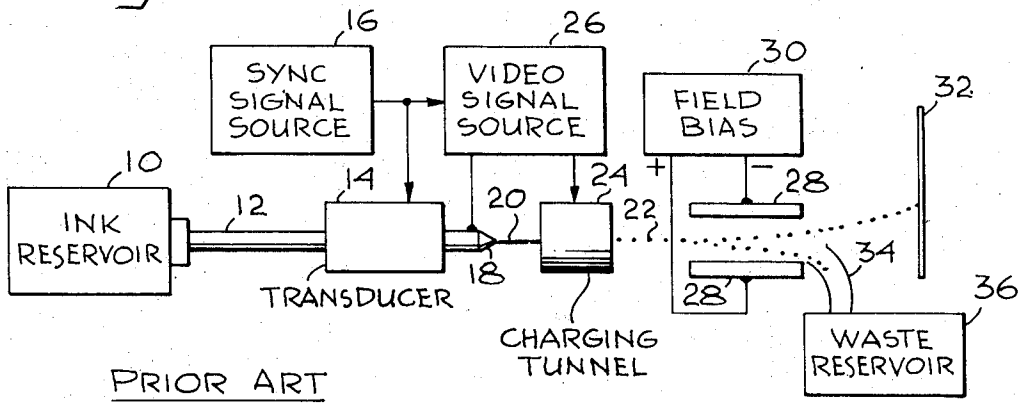
Jan. 12, 1971 D. M. SHERMAN 3,555,558

INK DROP WRITING APPARATUS WITH DATA SYNCHRONIZING MEANS

Filed Jan. 21, 1969 2 Sheets-Sheet 1

Fig. 1



PRIOR ART

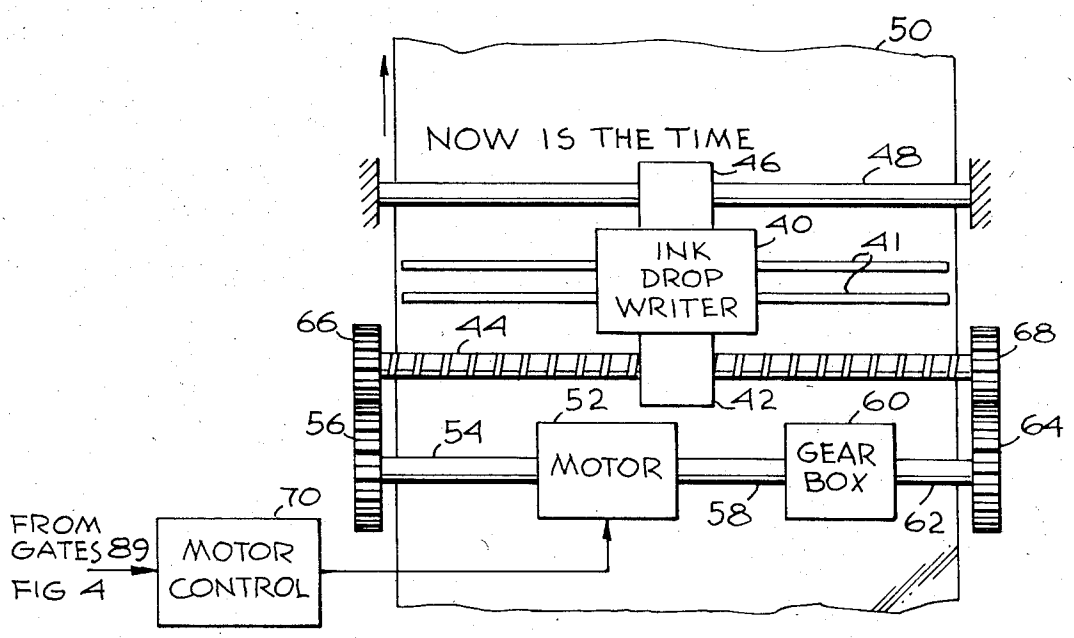


Fig. 2

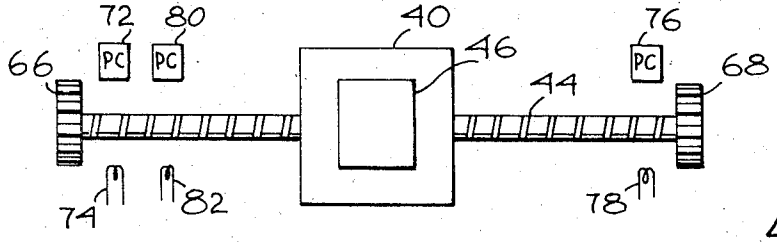


Fig. 3

INVENTOR
DAVID M. SHERMAN
BY Lindenberg & Freilich
ATTORNEYS

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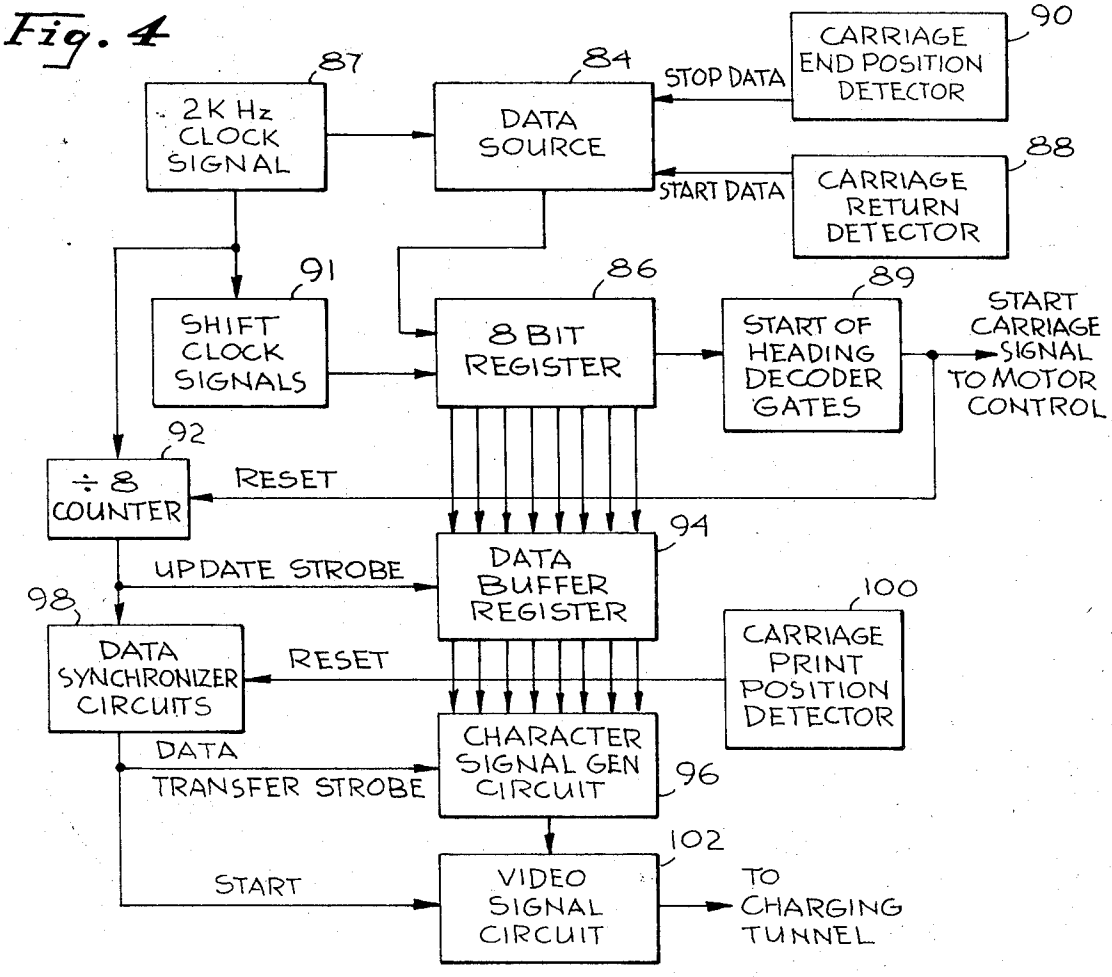
Fig. 4



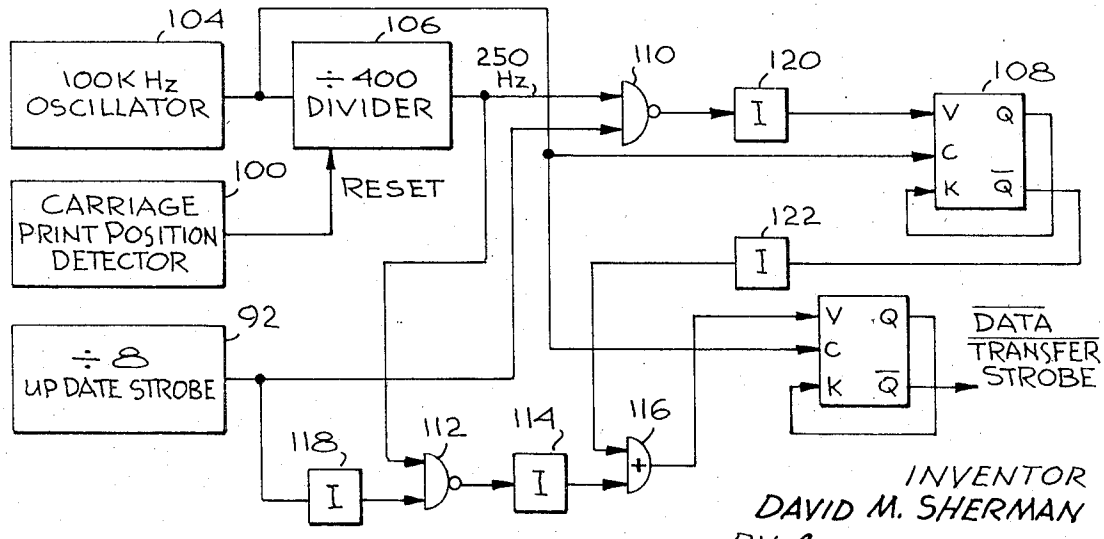


Fig. 5

INVENTOR
DAVID M. SHERMAN
BY Lindenberg & Freilich
ATTORNEYS

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INK DROP WRITING APPARATUS WITH DATA SYNCHRONIZING MEANS

David M. Sherman, La Grange, Ill., assignor to A. B. Dick Company, Chicago, Ill., a corporation of Illinois

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U.S. Cl. 346—75 6 Claims

ABSTRACT OF THE DISCLOSURE

In an ink drop writing apparatus in which a reciprocating carriage carries ink drop emitting apparatus, which ink drops are emitted through an electric field toward paper, and in flight are deflected in accordance with video signals for producing intelligible information on said paper, means are provided, in accordance with this invention, for insuring that despite variables, such as different carriage start-up time and acceleration, a uniform lefthand margin is produced on the paper, and also that printing free from timing errors occurs.

BACKGROUND OF THE INVENTION

This invention relates to apparatus for writing with ink drops which are charged by a video signal and directed through an electric field, to be deflected in accordance with the charge, and more particularly to improvements therein.

An ink drop writing apparatus has been developed, wherein ink is applied under pressure to a nozzle. The nozzle is vibrated in response to a synchronizing signal which is also used for synchronizing video signals. The vibrated nozzle causes an ink jet, which is emitted therefrom, to break up into uniform drops at a distance away from the tip of the nozzle. The rate of such drop formation is determined by the vibration rate. A means for charging each drop is provided at the location at which the ink stream begins to break into drops. This means usually is a conductive tube or cylinder. Video signals are applied between the nozzle and cylinder in response to which a drop assumes a charge determined by the amplitude of the video signal at the time that the drop breaks away from the jet stream.

The drop thereafter passes through a fixed electric field, as a result of which it is deflected by an amount determined by the amplitude of the charge on the drop. At the boundary of the electric field there is positioned a writing medium upon which the drop falls. Since the deflection of the drop is determined by the charge on the drop, the arrangement enables one to write information with the ink which is carried by the video signal.

The vibrating nozzle is carried by a carriage which is made to reciprocate along a predetermined path while the paper upon which writing is to occur is moved in a path which is orthogonal to the path of the carriage. One of the problems which arose with this apparatus is that because of variables such as variations in the carriage start-up time and carriage acceleration, and the presence of data, the paper upon which the writing occurred would have an irregular left-hand margin. Thus, the visual presentation of the results of writing with the ink jet writer was not commercially acceptable and tended to cause irritation to a reader.

OBJECTS AND SUMMARY OF THE INVENTION

An object of this invention is to provide apparatus whereby an ink jet writing system, of the type described can provide a uniform left-hand margin despite variations in carriage start-up and acceleration. This is achieved by sensing that data is available, starting carriage motion, sensing when the carriage reaches a predetermined location spaced from the lefthand edge of the carriage path of travel which is a sufficient distance to insure that the carriage is up to its proper speed, and then permitting writing to commence. Also logic circuits are provided to sense whether or not the circuit provide the video signals to the charging tunnel are in condition for providing correct character video signals. If not, a delay is provided to enable this to occur.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block schematic drawing of a prior art ink drop writing system.

FIG. 2 is a schematic drawing illustrating the mechanical arrangement for writing with the ink drop writer.

FIG. 3 is a schematic drawing showing photocell placement along the carriage travel path.

FIG. 4 is a block schematic diagram illustrative of an embodiment of this invention.

FIG. 5 is a block schematic diagram illustrative of a data synchronizer circuit which is shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a schematic drawing of a presently known arrangement which is shown to afford a better understanding of the invention.

An ink reservoir **10** provides ink under pressure to tubing **12** which is flexible. An electromechanical transducer **14** is usually placed adjacent to or around the tubing. The transducer is driven in response to signals from a source **16**. The transducer serves to vibrate and/or compress the tubing **12** in the region of the nozzle **18**. This results in an ink jet **20** being emitted which, at a short distance downstream, breaks up into drops **22**, which are formed at a rate determined by the frequency of the vibration. In the region where the stream **20** breaks down into drops, a charging tunnel **24** is provided. This comprises a conductive cylinder to which video signals from a video signal source **26** are applied. The video signals establish a field within the charging tunnel so that the ink drops which are formed therein assume a charge determined by the amplitude of the video signal present at the time the drop separates from the ink jet.

Downstream of the charging tunnel there are usually placed a pair of electrodes **28** which are connected to a field bias source **30**. As a result there is established between the electrodes a constant electric field. The ink drops, which bear charges in accordance with the video signal, enter this field and are deflected by an amount which is proportional to the amplitude of the charge. This enables intelligent writing to occur on a writing medium **32**, which is moved at some synchronous rate past the electrodes. Drops which do not bear a video charge are captured by a tube or trough **34** which is judiciously placed at one side so as to capture these drops. It leads to a waste reservoir **36**. The paper moves into the plane of the drawing whereby its motion, together with the deflection of the drops, may be used for forming intelligible characters.

In order to write lines of information across a wide sheet of paper, an arrangement such as is schematically represented in FIG. 2 may be employed. By way of illustration, the ink drop writer **40** is attached to a traveling nut **42**, which is free to move on journally supported lead screw **44**. At the top of the ink drop writer is a nut **46**

which is free to slide along a rod **48**. Accordingly, as the lead screw **44** is rotated in one direction or the other, the ink drop writer will move in a direction dictated by this rotation along a path parallel to the lead screw.

By "ink drop writer" is here meant a housing which supports the ink reservoir **10**, tubing **12**, transducer **14**, nozzle **20** and charging tunnel **24**. The video and sync signal sources are placed elsewhere and are connected to the ink drop writer by wires. The function of the deflection electrodes **28** is performed by a pair of spaced plates **41** which extend along the path of travel of the ink drop writer and are placed so that the stream of drops pass between them on their way to the paper. A trough (not shown) identical to the tube **34** is provided which extends adjacent to the bottom plate.

The paper **50** upon which writing is to occur moves in a direction vertical to the direction of the path of motion of the ink drop writer. A motor **52** has a first shaft **54** extending therefrom to a half sector gear **56**. The motor has a second shaft **58** extending therefrom to a gear box **60**, which functions to reverse the direction of rotation of the shaft **62**. This reverse motion is communicated through a shaft **62** to another half sector gear **64** in which it terminates. The sector gears are cut so that as the motor rotates, the sector gear **56** engages a gear **66** atached to one end of the lead screw, to rotate the lead screw **44** so that the ink drop writer is moved from left to right. When the ink drop writer reaches the right-hand end of the lead screw, the sector gear **56** is disengaged from the gear **66** and a sector gear **64** engages a gear **68** on the other end of the lead screw. This results in the lead screw being rotated in the opposite direction thereby returning the ink drop writer **40** to its home position on the left-hand side of the lead screw. Motor control apparatus **70** serves the function of energizing the motor to rotate over the interval required for the ink drop writer to make one round trip path along the lead screw. The motor control then waits until it receives a signal which enables the motor to again function to cause the ink drop writer to make a round trip path.

FIG. 3 is a schematic drawing which shows the placement of three photocells for detecting when the ink drop writer has attained three positions along its path of travel. Photocell **72**, in conjunction with the light source **74**, operates to detect when the ink drop writer carriage **40** has reached the home position at the left-hand end of its path of travel. Photocell **76**, in conjunction with light source **78**, indicates when the carriage has attained the right hand end of its path of travel. Photocell **80**, in conjunction with its light source **82**, indicates when the carriage, after leaving the home position, has arrived at a location at which it no longer is accelerating but is moving at a constant speed along its path of travel. It should be understood that the placement of the photocells as shown in FIG. 3 occurs on the structure shown in FIG. 2, but is not shown in the drawing of FIG. 2 in order to preserve clarity in the drawing.

FIG. 4 is a block schematic diagram illustrative of how this invention insures a uniform left-hand margin with the apparatus described. A data source **84** provides the information which is to be printed by the ink drop writer. The data source may be any of the known data supply systems such as magnetic cores, magnetic tape, or may be keyboard originated or information coming over a line. The data source can be rendered operative to transfer data into a register **86** by a signal from the carriage return detector **88**, which includes photocell **72** and light source **74**. The data source operation is stopped by a signal from the carriage end position detector **90**, which includes the photocell **76** and light source **78**.

In an embodiment of this invention that was actually built and operated, the data from the source was presented serially and each character consisted of eight binary bits. These were entered serially into an eight bit register **86**, being shifted by clock signals. A 2 kHz. clock signal source

87 provided clock signals for the data source **84**. The clock signal source output was also applied to a shift clock source **90**, which reshaped the signals so that they were suitable for shifting the eight bit register **86**. The output of the 2 kHz. clock signal source is also applied to a divide by eight circuit, **92**. The divide by eight circuit merely constitutes a counter having an eight count capacity.

The data from the source is arranged so that at the biginning of each line that is to be written a code is placed which signifies the beginning of a line of data. This code is identified by decoding gate circuits **89** labeled as "Start of Heading Decoder." These gate circuits merely constitute a set of AND gates which produce an output only when they sense the presence of the code representative of the beginning of a line of data. This output signal is applied to the motor control **70** to instruct it to start moving the ink drop writer carriage to the right. The output of the start of the heading decoder is also applied to the divide by eight counter, **92**, to cause it to reset.

The eight bit register contents are transferred in parallel to a data buffer register **94**, in response to an update strobe signal. The update strobe signal is the eighth count output of the divide by eight counter, **92**. The contents of the data buffer register are applied to a character signal generator circuit **96**. This circuit performs the function of converting an eight bit code into character representative signals which in this case is a train of signals suitable for application to the ink jet apparatus for printing. The character signal generator circuit is enabled to transfer out the character signals to a video signal circuit **102** only in the presence of a data transfer strobe signal which is received from a data synchronizer circuit **98**.

The data synchronizer circuits **98**, are reset and thus enabled to commence functioning in the presence of an output signal from the carriage print position detector **100**. This includes the photocell and light source **80, 82**, shown on FIG. 3. This photocell is enabled to produce a signal when the carriage reaches the position from which it will travel to the end of its path with no further change in velocity. Also, should the data synchronizer circuit **98** receive simultaneously a carriage print position signal and a signal from the divide by eight counter, it will delay the provision of a data transfer strobe signal for a period of 10 microseconds. The reason for this is that the data buffer register is being filled with new data at the time of the occurrence of the update strobe. Should the data transfer strobe occur during the interval when the data buffer register is being filled, the character signal generator circuit will function improperly since an improper code signal will be provided to it. The effect of the delay of 10 microseconds is negligible on the printed copy. When the speed of the carriage of the ink drop writer is compared with 10 microseconds, the eye cannot discern the difference between a character which is printed without delay, and one which is printed with delay.

The character signal generator circuit, as previously indicated may be any one of the well known character generator circuits which converts a coded input representative of characters to a train of output signals which can be used to control the position of an electron beam, in conjunction with a television scanning raster deflection of the electron beam to display characters. The analogy of the mechanical motions provided for the ink drop writer to a television type scanning raster may be seen from the fact that the writing paper moves vertically and the ink drop writer carriage moves transversely to the paper. Drops from the ink drop writer are either permitted to reach the paper or are deflected into the waste reservoir in response to the presence or absence of video signals. The circuits required for character generation are essentially the same, except of course allowance is made for the reduced speed of operation of the ink jet printer.

The output of the character signal generator circuit **96** is applied to a video signal generator circuit which con-

verts the signals received to signals suitable for application to the charging tunnel. The data transfer strobe which is the output of the data synchronizer circuit is applied to the video signal generator circuit **102** which converts to a form suitable for application to the charging tunnel **24**.

FIG. 5 is a block diagram illustrating the details of the data synchronizer circuit **98**. A 100 kHz. oscillator **104** applies its output to a divide by 400 counter circuit **106**, and as clock signals to a first flip-flop **108**, and a second flip-flop **111**. The divide by 400 circuit **106** is reset in the presence of a carriage print position detector signal. The output of the divide by 400 circuit **106**, consisting of 250 hertz signals, is applied as one input to a first NAND gate **110**, and to a second NAND gate **112**. In the presence of the output from the divide by 400 counter **106**, with the update strobe signal being absent, then the NAND gate **112** is enabled to apply its output through an inverter **114** to an OR gate **116**. The output of the OR gate, which is applied to the J input terminal of a JK flip-flop **111**, upon the occurrence of the next clock pulse from the 100 kHz. oscillator, causes the flip-flop **111** to be driven to the state with its Q output high whereupon a "NOT Data Transfer" strobe signal is obtained from its $\overline{Q}$ output. Flip-flop **111** is reset upon the occurrence of the following clock pulse by virtue of the fact that its Q output is connected to its K input. With its Q output now being high, this following clock pulse returns the JK flip-flop to its stable state with its $\overline{Q}$ output high.

Should an update strobe signal be provided by the divide by eight counter **92** at the time of the occurrence of an output from the divide by 400 counter **106**, then NAND gate **112** is inhibited from operation by virtue of the input received from the inverter circuit **118**. However, NAND gate **110** is enabled. Its output is applied through an inverter circuit **120** to the J input terminal of JK flip-flop **108**. Upon the occurrence of the next clock input from the 100 kHz. oscillator **104**, this flip-flop is driven to its set state whereupon the negative going output from the $\overline{Q}$ output terminal of the flip-flop **108** is applied, through an inverter **122** to the OR gate **116**. As in the previous case, the output of the OR gate drives the flip-flop **111** to its set state thus providing the "NOT Data Transfer" strobe signal. Flip-flop **108** and flip-flop **111** will both be reset upon the occurrence of the following clock pulse in view of their respective connections from the Q output terminals to their K input terminals.

The delay of the data transfer strobe signal which is caused by the introduction of flip-flop **108** into the circuit which drives flip-flop **111** is a one clock interval. The clock interval here is the time between two output pulses of the 100 kHz. oscillator **104**, or 10 microseconds. This is sufficient to enable the data buffer register to load up.

The data synchronizer circuit shown in FIG. 5 will function continuously to insure that the data buffer register has been loaded with a character before the data transfer strobe is provided.

There has been described above a novel, useful and simple system for insuring a margin alignment and a freedom from error in printing, in an ink drop writing system.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and consequently it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. In an ink drop writing system of a type wherein a source of data provides data signals to a means to convert said data signals to video signals and an ink drop forming mechanism projects ink drops toward a writing medium spaced therefrom means for applying video signals to said ink drops from said means to convert said data signals to video signals to determine the trajectory of said drops, and there is a carriage means for carrying said ink drop forming mechanism reciprocally along a path from a starting position to a finishing position, means for insuring vertical alignment of characters written by said ink drop writing system at the beginning of a line of characters comprising:

means for detecting when said ink drop forming mechanism reaches its starting position and providing a starting signal indicative thereof,

a buffer register having its input coupled to said data signal source and its output to said means to convert data signals to video signals,

means responsive to said starting signal to enable the flow of data from said source of data to said buffer register,

means for detecting the first of said data signals to flow from said data signal source and providing a heading signal indicative thereof,

means for initiating motion of said carriage means responsive to said heading signal,

a source of update strobe signals,

means for applying update strobe signals from said source to said buffer register to enable it to accept data signals from said data source,

means for generating data transfer signals,

means for applying said data transfer signals to said means to convert data signals to video signals and to enable transfer of video signals to said means for applying video signals, and

means responsive to the presence of an update strobe signal to delay the application of a data transfer signal until said buffering register has been loaded with data signals.

2. In an ink drop writing system as recited in claim **1** wherein there is included a means for detecting when said ink drop forming mechanism reaches a predetermined position at which its velocity is constant and providing a write signal indicative thereof, and

means for resetting said update strobe signal source responsive thereto,

said system also including means for detecting when said ink drop forming mechanism reaches its finishing position and providing a stop signal indicative thereof, and

means for terminating the flow of data signals from said source of data signals to said buffer register.

3. In an ink drop writing system as recited in claim **1** wherein said means responsive to the presence of an update strobe signal to delay the application of a data transfer signal until said buffer register has been loaded with data signals includes a source of clock pulses,

means for generating a data transfer signal responsive to a clock pulse signal,

a delay means connected to said means for generating a data transfer signal,

first gate means for applying a clock pulse signal from said source to said means for generating a data transfer signal to activate it,

means for inhibiting operation of said first gate means in the presence of an update strobe signal, and

second gate means for applying a clock pulse signal from said source to said delay means, for generating a delayed data transfer signal in the presence of an update strobe signal.

4. In an ink drop writing system of a type wherein a source of data provides data signals to a means to convert said data signals to video signals and an ink drop forming mechanism projects ink drops toward a writing medium spaced therefrom, means for applying video signals to said ink drops from said means to convert said data signals to video signals to determine the trajectory of said drops, and there is a carriage means for carrying said ink drop forming mechanism reciprocally along a path from a starting position to a finishing position, means

for insuring vertical alignment of characters written by said ink drop writing system at the beginning of a line of characters comprising:

means for detecting when said ink drop forming mechanism reaches its starting position and providing a starting signal indicative thereof,

a buffer register,

means responsive to said starting signal for enabling the flow of data signals from said data signal source to said buffer register,

means for detecting the first of said data signals to flow from said data signal source and providing a heading signal indicative thereof,

means for initiating motion of said carriage means responsive to said head signal,

a source of update strobe signals,

means for resetting said update strobe signal source responsive to said start signal,

means for enabling said buffer register to receive data responsive to said update strobe signals,

means for detecting when said ink drop forming mechanism reaches a predetermined position at which its velocity is constant and providing a write signal indicative thereof,

means for generating data transfer signals,

means for resetting said means for generating data transfer signals responsive to a write signal,

means for enabling said means to convert data signals to video signals to transfer said video signals to said means for applying signals responsive to data transfer signals,

means to detect when said ink drop forming mechanism reaches its finishing position and providing a stop signal indicative thereof, and

means responsive to said stop signal to terminate said flow of data signals from said source of data signals to said buffer register.

5. In an ink drop writing system as recited in claim **4** wherein said means responsive to said data transfer signals for enabling said means to convert data signals to video signals to transfer said video signals to said means for applying video signals includes:

means for delaying the application of a data transfer signal to said means to convert data signals to video signals in the presence of an update strobe signal for an interval required to insure that said buffer register has been loaded with data signals.

6. In an ink drop writing system as in claim **5** wherein said means responsive to the presence of an update strobe signal to delay application of a data transfer signal to said means to convert data signals to video signals includes a source of clock pulses, having an interval between pulses at least equal to the time required to load said buffer register,

a first and a second flip-flop circuit each having a first and second input and a clock input, corresponding first and second outputs, and assuring a state with one of its outputs high in response to the one of its two inputs to which an input signal is applied when a clock signal is applied to its clock input,

means for applying clock pulses from said source to said first and second flip-flop circuit clock inputs,

a first and second NAND gate,

means connecting said first NAND gate output to said first flip-flop first input,

means connecting said second NAND gate output to said second flip-flop first input,

means connecting said first flip-flop second output to said second flip-flop first input,

means connecting clock pulses from said source to one input to said first and second NAND gates,

an inverter circuit having an input and an output connected to an input to said second NAND gate, and

means for applying an update strobe signal to said inverter circuit input and to said first NAND gate input whereby said second flip-flop produces a data transfer signal upon the occurrence of a first clock pulse and in the absence of an update strobe signal, and produces a data transfer signal upon the occurrence of a second clock pulse in the presence of an update strobe signal.

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JOSEPH W. HARTARY, Primary Examiner

U.S. Cl. X.R.

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