

United States Patent

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[15] 3,681,778

[45] Aug. 1, 1972

[54] PHASING OF INK DROP CHARGING

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[22] Filed: May 3, 1971

[21] Appl. No.: 139,409

[52] U.S. Cl. 346/75, 178/6.6 R

[51] Int. Cl. G01d 18/00

[58] Field of Search 346/75; 178/6.6 R; 317/3

[56] References Cited

UNITED STATES PATENTS

3,562,761 2/1971 Stone et al. 346/75

3,596,275 7/1971 Sweet 346/75 X

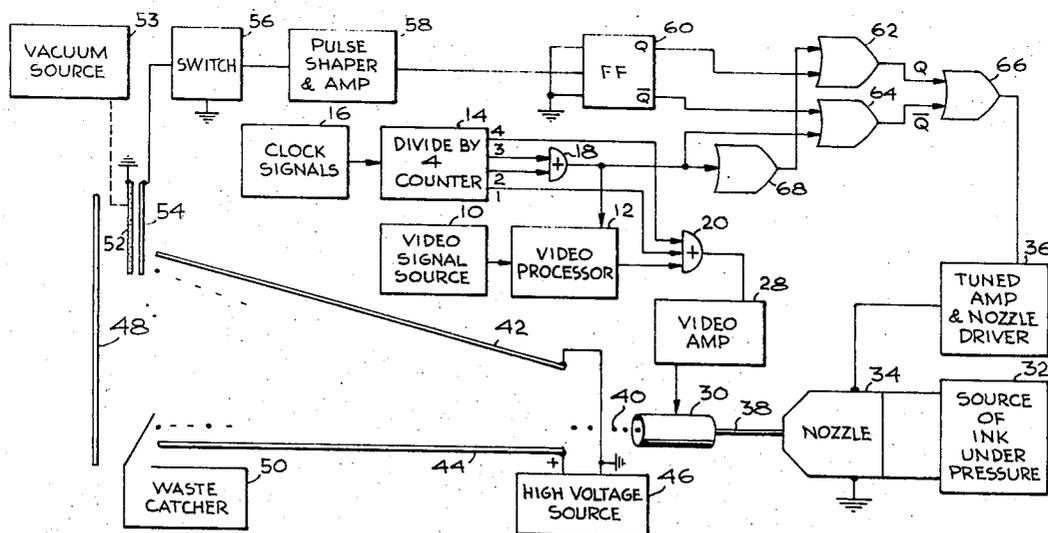
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[57] ABSTRACT

In a system wherein a stream of ink emitted from a vibrating nozzle passes through a charging tunnel wherein the ink stream breaks up into drops and the drops are charged by video signals, an arrangement is provided for insuring that the ink drops formed within the charging tunnel have the correct phase to receive a proper video signal.

5 Claims, 2 Drawing Figures



PHASING OF INK DROP CHARGING

BACKGROUND OF THE INVENTION

This invention relates to ink drop printing systems and more particularly to improvements therein.

In ink drop systems such as described in U.S. Pat. No. 3,465,350 a conductive fluid is forced from an orifice which is vibrating at a given rate and an appropriate amplitude to insure that the jet emitted from the orifice will break up downstream into uniform modular drops at the rate of vibration. Over the region at which the drops separate from the jet, there is usually an arrangement, such as a charging tunnel which applies a charging field to charge the drops as they separate from the jet. In order to apply the charge to the drops, the charging field must be maintained while the drop separates. In order to place specific charges on given drops one must know when drop separation is occurring. In U.S. Pat. Nos. 3,465,350 and 3,465,351, systems for correcting phasing are shown which requires the ink stream to strike a target prior to the commencement of the writing of a line of characters. While these systems are satisfactory, it would be better if drop phasing corrections could be made during the writing time, since it can happen that an out of phase condition may arise during such interval and remain uncorrected until the end of the line. Also, if phase correction can be made when necessary, during the writing interval, then the time required to make the phase test is avoided, and the writing process can therefore be speeded up.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide a system for testing in an ink drop writer the phase of drop formation during writing time.

It is another object of this invention to provide a phase testing system for an ink drop writer which continuously tests for phase correction and make corrections during writing time.

Yet another object of the present invention is the provision of a novel and unique phase tester for an ink drop writer.

The novel features of this 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 diagram of an embodiment of the invention.

FIG. 2 is a waveform diagram indicating test pulses as well as video signals.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block schematic diagram of an ink drop printing system which includes an embodiment of this invention for testing ink drops to determine whether or not they are in proper phase with the video signals. A source of video signals 10, desired to be printed, is connected to a video processor 12. The video processor converts the video signals into video pulses whose amplitude will determine where a drop will be deposited

on the paper on which writing occurs. In other words, the video processor converts the incoming video signals into signals of a type, which, when used to charge the stream of drops, will result in the drop pattern deposited on the paper having a form, be it letter or number or wave shape, which is represented by the video signal. The video processor has clock pulses for clocking the frequency of its pulse train output which are derived from the second and third output counts of a 4 counter 14. This counter is a cyclic counter which is driven by clock signals from a source 16. The second and third count outputs of 4 counter are applied through an OR gate 18 to the video processor to serve as its clock signals. The first and fourth count outputs of the 4 counter 14 are applied to an OR gate 20 which also has applied thereto a pulse train output of the video processor 12.

The output of the OR gate will comprise a pulse wavetrain having the waveform shown in FIG. 2. The first count from the 4 counter is represented by the pulse wave form 22. During the next two count intervals, a video pulse 24 will occur, whose amplitude is determined by the video signals. This amplitude will vary in order to secure different deflections for the drops which are charged in response thereto. The last high amplitude pulse 26 represents the last count of the counter. It should be noted that the first and last counts of the counter as represented by the pulses 22 and 26 have a much higher amplitude than any of the video signals 24.

Referring back to FIG. 1, the output of the OR gate 20 is applied to a video amplifier 28, whose output is applied to a charging tunnel or ring 30.

Ink, from a source of ink under pressure 32, is applied to a nozzle 34. The nozzle is vibrated at clock frequencies by a tuned amplifier and nozzle driver 36. As a result, the ink is emitted in a stream 38, from the nozzle 34, in which the stream breaks down into drops 40 within the charging tunnel, 30. The stream, because of the pressure applied from the source, will pass out of the tunnel and then between two charged plates, respectively 42, 44 onto writing paper 48. The plates have a voltage applied from a high voltage source 46. The charged drops are now passing through an electric field between the plates and are deflected in accordance with the amplitude of the charge which has been applied to them as they are formed in the ring 30. Drops then fall upon a document 48, at a location determined by the deflection of the drops during its transit through the field between the plates. Those drops which are not used in writing on the document are caught by a waste catcher 50.

Referring back to FIG. 2, it should be obvious that in order to properly charge a drop, it should be formed in the video tunnel 30 during the interval of the video pulse applied to the tunnel. This is illustrated in FIG. 2 as the video. However, the time at which the drop will form, or more specifically the interval of drop separation within the tunnel is not necessarily fixed in time but can occur over an interval such as illustrated in FIG. 2, indicated as the drop period. Thus, any drop which is formed within the interval of the test pulse waveform 26 will not receive a video pulse charge and would be lost as far as the writing process is concerned.

The interval of drop formation is a function of the frequency and phase with which the nozzle 34 is vibrated, which is determined by the frequency and phase of the signal which drives the nozzle driver 36. It should further be noted, that once the drops are formed out of phase, the drops formed thereafter will stay out of phase until the nozzle driver drifts back into phase with the video signals.

The arrangement whereby phase corrections are made, in accordance with this invention includes the pair of electrodes 52, 54, which are placed between the printing material 48 and the high voltage deflection plates 42, 44, and in line with the deflecting path of drops which may be charged by any one of the test pulses 22, 26. These are highly charged drops, higher than the highest video pulse will charge a drop. The electrodes 52, 54 are spaced closely enough so that they will be bridged by the test pulse charged drop. Plate 52 is grounded and plate 54 is connected to a transistorized switch 56. When a charged drop of conductive ink bridges the two electrodes 52, 54, the base of the transistorized switch 56 is grounded momentarily and thereby enables a pulse signal to pass to a pulse shaper and amplifier 58. The output from the pulse shaper and amplifier drives a toggle flip-flop 60.

The Q output of the toggle flip-flop is applied to a NAND gate 62. The \bar{Q} output of the toggle flip-flop is applied to a NAND gate 64. The NAND gate 64 is enabled to pass clock pulses comprising the output of NOR gate 18 in the presence of a \bar{Q} input. These clock pulses are also applied to a single input NAND gate 68, which acts as an inverter. In the presence of the Q output of flip-flop 60, NAND gate 62 is enabled to pass the output of NAND gate 66 which occurs upon the occurrence of the fourth count of the 4 counter.

The output of the NAND gates 62 and 64 are applied to a NAND gate 66. The output of this NAND gate will either be pulses from NAND gate 62 or pulses from NAND gate 64. That is, the output of NAND gate 66 will either be clock pulses in phase with clock pulses generated by counts 2 and 3 of counter 14 or clock pulses which are out of phase with counts 2 and 3 generated by the counter 14. The output of the NAND gate 66 drives the tuned amplifier nozzle driver 36, which in turn drives the nozzle.

From the foregoing description it should be apparent that when drops are formed during the video signal interval, the nozzle 34 is being vibrated with the proper phase and frequency and no change is made in the phase of the signal driving the nozzle driver. Should a drop be formed at an interval outside of the video pulse interval, then it will receive a high amplitude charge from a test pulse and will activate the switching system described to cause a $\frac{1}{2}$ drop period 180° phase shift in the signals driving the nozzle driver 36. This will bring the drops formed thereafter into phase with the video charging signals.

If desired, electrodes 52 and 54 may be cleared of a drop by making electrode 52 somewhat porous and applying vacuum from a source 53 to the back thereof to suck away a bridging ink drop.

It will be appreciated that the system described will correct the phase at which ink drops are formed at any time during the writing interval that the drops may be formed out of phase and no extra time for a phase test

has to be devoted to this. The system can be used with both stationary and moving writing heads because of the constant phase checking, the uniformity and fidelity of the printing is improved over that previously attainable. Finally, this system is more economical to implement than those used heretofore.

What is claimed is:

1. In a system for printing with ink drops on a sheet of paper of the type wherein ink is emitted from a vibrating nozzle in a stream which next passes through a drop charging device wherein said stream breaks up into drops whose formation is determined by the frequency and phase of the vibrating nozzle, said drop printing system including:

means for generating video pulses,

means for applying said video pulses to said drop charging device for charging each drop, and

means for establishing an electric field through which charged drops pass, after passing through said drop charging device, to be deflected an amount determined by the charge on each drop, the improvement comprising:

means for generating a test pulse immediately before and immediately after the interval of each video pulse having an amplitude greater than that of the largest video pulse,

means for applying the output of said means for generating a test pulse to said drop charging device whereby a drop is charged with either a video pulse or a test pulse,

drop interception means positioned beyond said electric field to intercept a drop which is charged by a test pulse,

means for generating nozzle vibrating signals having one or the other of two phases,

means responsive to interception of a drop by said drop interception means to transfer said nozzle vibrating signals from one to the other of said two phases, and

means for applying said nozzle vibrating signals to vibrate said nozzle.

2. In an ink drop printing system as recited in claim 1 wherein said drop interception means positioned beyond said electric field includes a pair of conductive electrodes spaced apart a distance to be bridged by an ink drop which is intercepted thereby.

3. In an ink drop system as recited in claim 1 wherein said means for generating nozzle vibrating signals having one or the other of two phases includes a toggle flip-flop having a first and a second output and being driven to successively provide first one output and then the other output in response to successive input signals,

a first NAND gate having two inputs and one output, a second NAND gate having two inputs and one output,

means respectively connecting said first and second toggle flip-flop outputs to one of said respective first and second NAND gate inputs,

a source of clock pulses, means for applying clock pulses from said source to the other of said first NAND gate inputs,

means for inverting clock pulses from said source to obtain inverted clock pulses,

means for applying inverted clock pulses to the other of said second NAND gate inputs,

means for applying said output signal to drive said toggle flipflop,
 a third NAND gate having two inputs and an output and
 means for applying the outputs of said first and second NAND gates to the inputs of said third NAND gate whereby its output constitutes nozzle vibrating signals of one or the other of two phases.

4. A system for printing with ink drops on a sheet of paper comprising a source of ink under pressure,
 nozzle means for emitting a stream of ink from said source of ink toward said sheet of paper,
 a source of clock pulses at a particular frequency,
 means to which clock pulses are applied for generating nozzle vibrating signals having one or the other of two phases,
 means for applying said nozzle vibrating signals to said nozzle to cause it to vibrate whereby said stream of ink breaks into a stream of drops at a location downstream of said nozzle,
 drop charging means positioned at the location where said stream of ink breaks into a stream of drops,
 electrode means extending along the path of said stream of drops after they leave said charging means for establishing an electric field transverse to said path,
 means to which clock pulses are applied for generating video pulses at a frequency responsive to the clock pulse frequency,
 test pulse means for generating a test pulse just before and just after each video pulse, said test pulses having an amplitude larger than the largest video pulse,
 means for applying said video pulses and test pulses to said drop charging means,

test electrode means positioned adjacent an end of said electrode means at a location for receiving only drops charged by a test pulse and producing an output signal indicative thereof, and
 means for applying output signals to said means for generating nozzle vibrating signals to shift the phase thereof from one to the other of said two phases.

5. A system as recited in claim 4 wherein said means to which clock pulses are applied for generating nozzle vibrating signals includes a toggle flip-flop having a first and a second output and being driven to successively provide first one and then the other in response to successive input signals,
 a first NAND gate having two inputs and one output, a second NAND gate having two inputs and one output,
 means respectively connecting said first and second toggle flip-flop outputs to one of said respective first and second NAND gate inputs,
 a source of clock pulses,
 means for applying clock pulses from said source to the other of said first NAND gate inputs,
 means for inverting clock pulses from said source to obtain inverted clock pulses,
 means for applying inverted clock pulses to the other of said second NAND gate inputs,
 means for applying said output signal to drive said toggle flip-flop,
 a third NAND gate having two inputs and an output, and
 means for applying the outputs of said first and second NAND gates to the inputs of said third NAND gate whereby its output constitutes nozzle vibrating signals of one or the other of two phases.

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