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Hill et al.

[11] **3,769,630**

[45] **Oct. 30, 1973**

[54] **INK JET SYNCHRONIZATION AND FAILURE DETECTION SYSTEM**

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[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

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[21] Appl. No.: **266,790**

[52] **U.S. Cl.** **346/75**

[51] **Int. Cl.** **G01d 18/00**

[58] **Field of Search** 346/75; 317/3

[56] **References Cited**

UNITED STATES PATENTS

3,562,761	2/1971	Stone et al.	346/75
3,596,276	7/1971	Lovelady	346/75
3,681,778	8/1972	Keur	346/75

Primary Examiner—Joseph W. Hartary

Attorney—D. Kendall Cooper et al.

[57] **ABSTRACT**

Individual ink droplets are formed at a nozzle, propelled toward a record medium, variably charged by a charge electrode, and deflected by deflection plates for printing of characters. Droplets not required for printing are directed to a first gutter. The charges on the droplets develop a current in the first gutter that is sensed in an electronic feedback loop for synchronization of drop formation with drop charging. An auxiliary gutter is positioned to receive drops during a checking interval when a relatively high charge is applied to the unused drops. The relatively high charge on the drops develops a much larger current in the auxiliary gutter that is easier to detect. If desired, synchronization can also be effected by using the auxiliary gutter.

6 Claims, 4 Drawing Figures

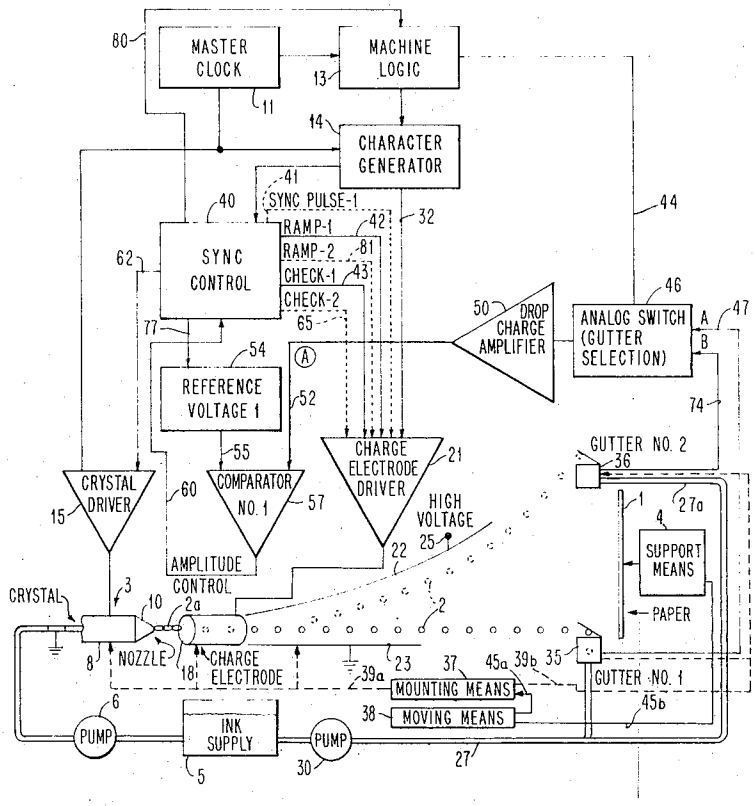
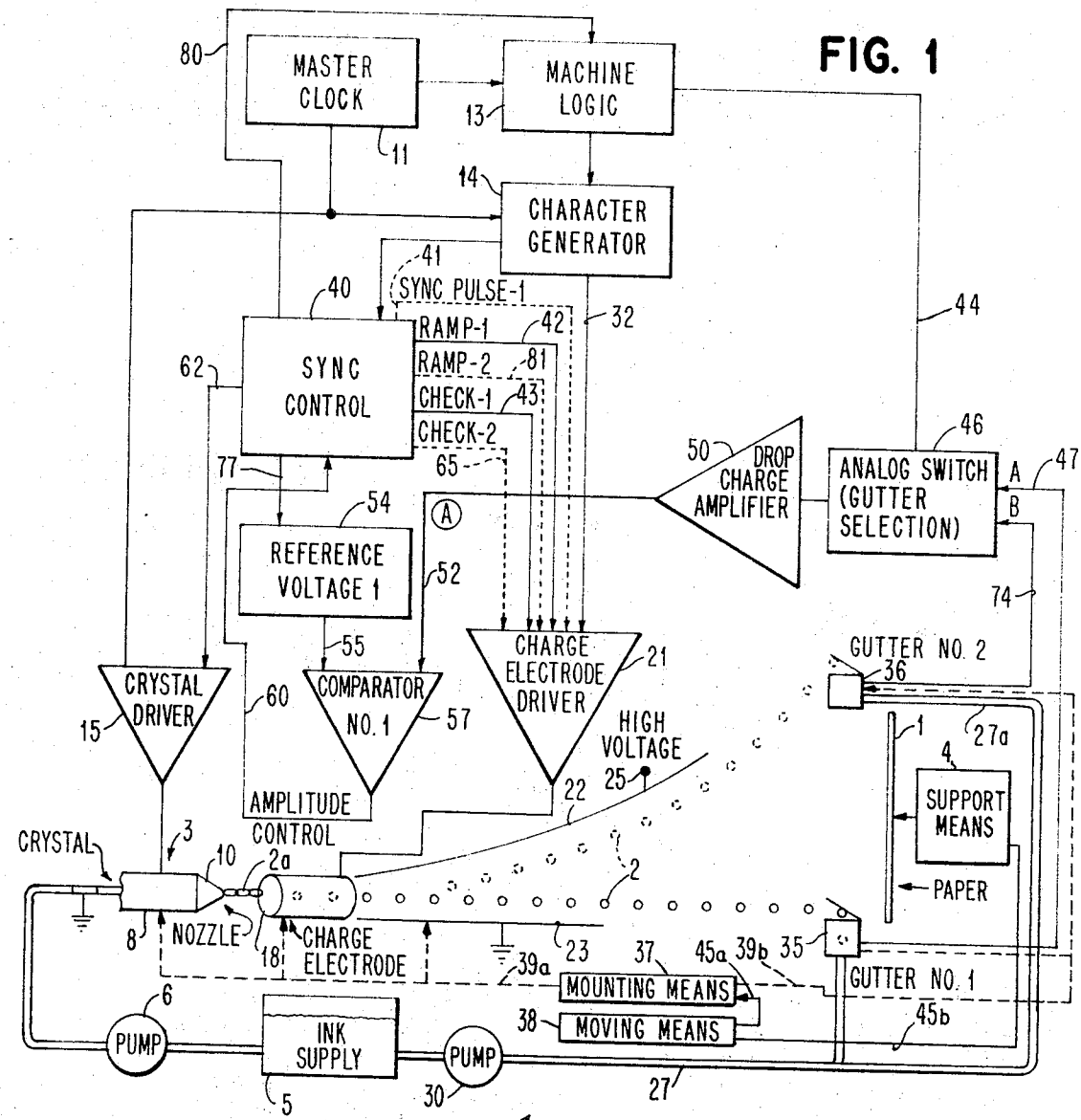


FIG. 1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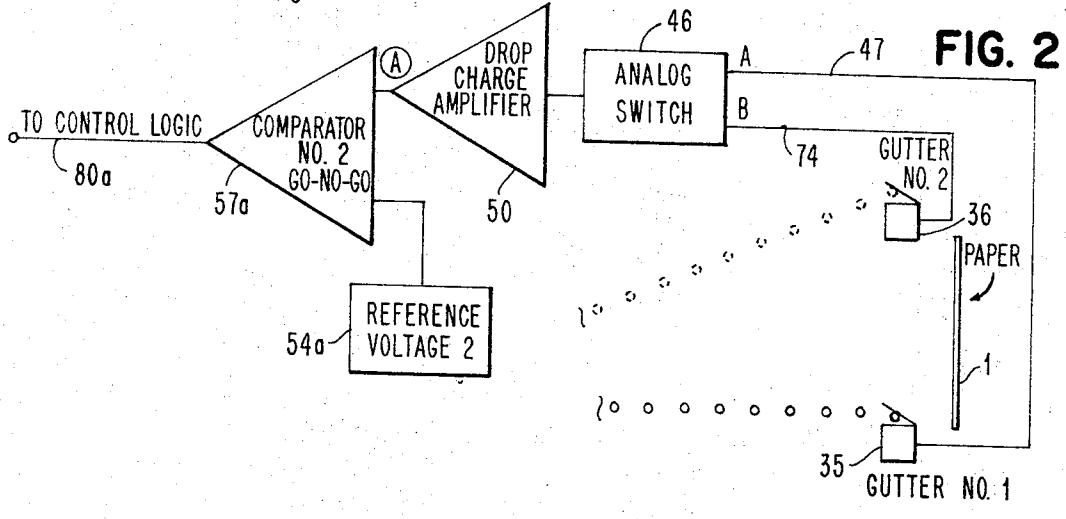
MASTER CLOCK
11
MACHINE LOGIC
13
14
CHARACTER GENERATOR
41
SYNC PULSE-1
40
RAMP-1
42
32
RAMP-2
81
62
SYNC CONTROL
CHECK-1
43
CHECK-2
65
77
44
50
DROP CHARGE AMPLIFIER
46
ANALOG SWITCH (GUTTER SELECTION)
A
47
B
74
54
REFERENCE VOLTAGE 1
52
A
55
CHARGE ELECTRODE DRIVER
21
GUTTER NO. 2
36
CRYSTAL DRIVER
15
60
COMPARATOR NO. 1
57
HIGH VOLTAGE
25
1
27a
4
SUPPORT MEANS
22
AMPLITUDE CONTROL
CRYSTAL
3
10
2a
2
PAPER
8
NOZZLE
18
CHARGE ELECTRODE
23
39a
37
45a
39b
35
GUTTER NO. 1
MOUNTING MEANS
6
38
MOVING MEANS
45b
PUMP
INK SUPPLY
PUMP
5
30
27

FIG. 2


46
A
47
DROP CHARGE AMPLIFIER
ANALOG SWITCH
B
74
GUTTER NO. 2
36
TO CONTROL LOGIC
80a
COMPARATOR NO. 2 GO-NO-GO
57a
50
PAPER
1
REFERENCE VOLTAGE 2
54a
35
GUTTER NO. 1

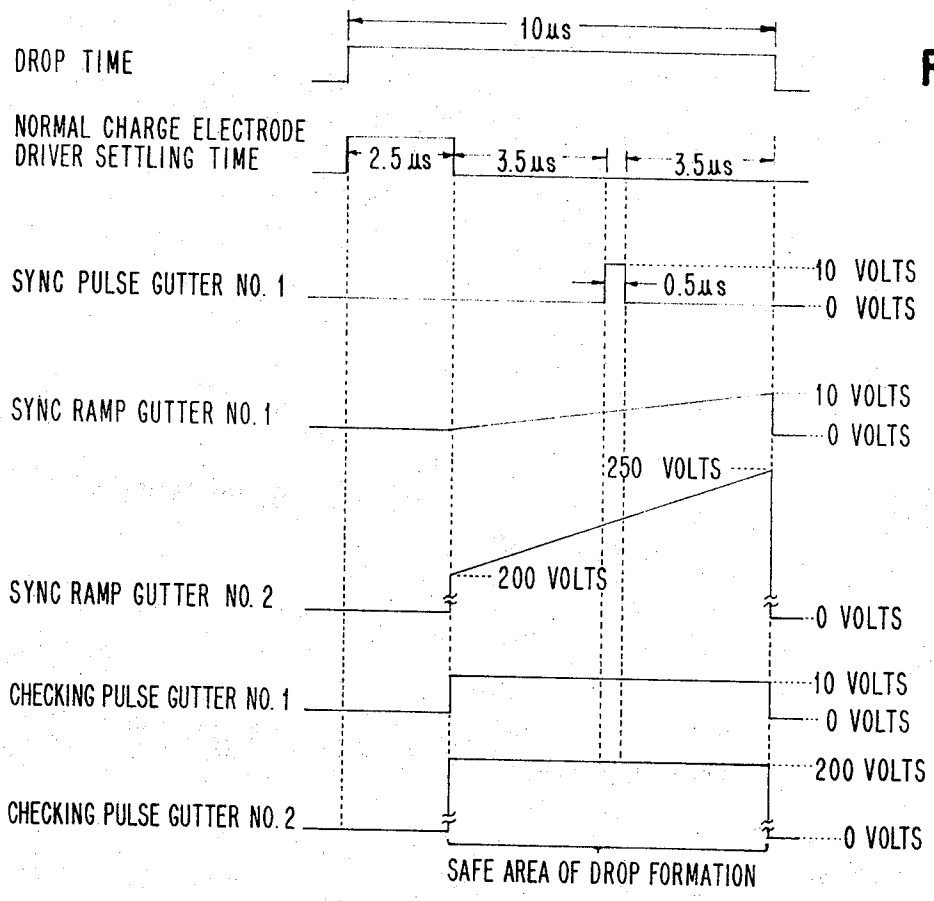
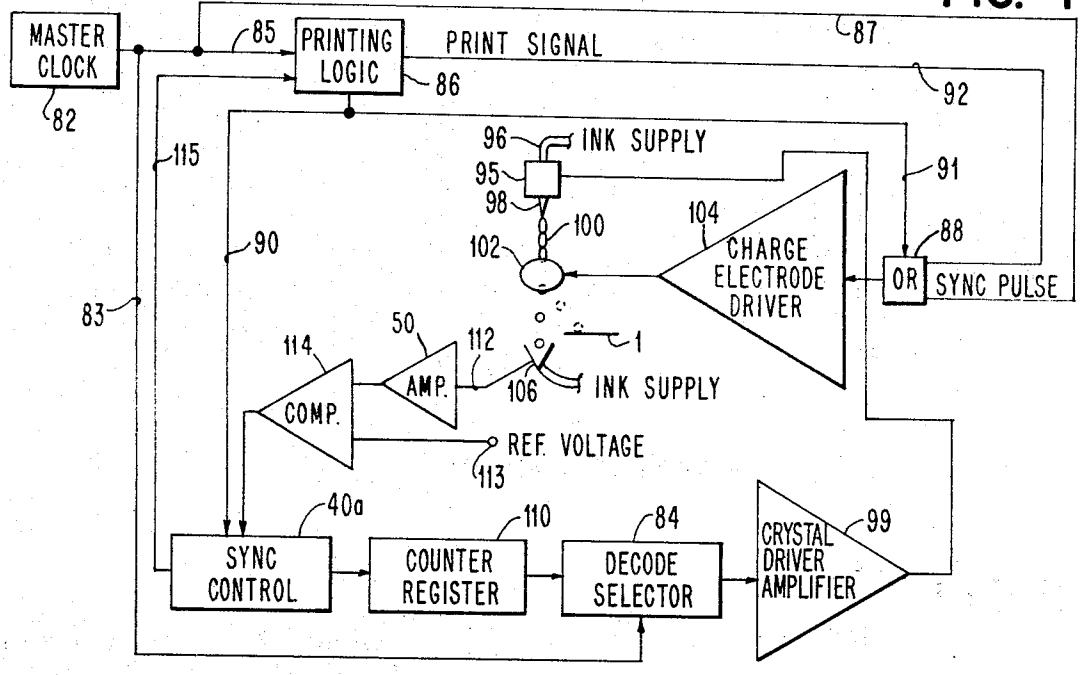

10 μs
DROP TIME
NORMAL CHARGE ELECTRODE DRIVER SETTLING TIME
2.5 μs
3.5 μs
3.5 μs
SYNC PULSE GUTTER NO. 1
0.5 μs
10 VOLTS
0 VOLTS
SYNC RAMP GUTTER NO. 1
10 VOLTS
0 VOLTS
250 VOLTS
SYNC RAMP GUTTER NO. 2
200 VOLTS
0 VOLTS
CHECKING PULSE GUTTER NO. 1
10 VOLTS
0 VOLTS
CHECKING PULSE GUTTER NO. 2
200 VOLTS
0 VOLTS
SAFE AREA OF DROP FORMATION

FIG. 3

FIG. 4


MASTER CLOCK
82
85
PRINTING LOGIC
86
PRINT SIGNAL
87
92
115
96
INK SUPPLY
95
98
91
90
100
102
104
CHARGE ELECTRODE DRIVER
88
OR
SYNC PULSE
83
50
114
112
1
AMP.
COMP.
106
INK SUPPLY
REF. VOLTAGE
113
40a
110
84
99
SYNC CONTROL
COUNTER REGISTER
DECODE SELECTOR
CRYSTAL DRIVER AMPLIFIER

INK JET SYNCHRONIZATION AND FAILURE DETECTION SYSTEM

BACKGROUND OF THE INVENTION AND PRIOR ART

The following U.S. Pat. Nos. are representative of the prior art: Lewis, et al, 3,298,030; Keur, et al, 3,465,350; Keur, et al, 3,465,351; Lovelady, et al, 3,596,276; and Sweet 3,596,275.

The Lewis, et al, patent describes drop synchronization using a phase shifter to insure proper charging of drops at the correct time. The Keur, et al, U.S. Pat. No. 3,465,350 describes the use of a video pulse that is applied to the ink drops, and if the phase is correct, a drop detector is actuated to so indicate. The Keur, et al, U.S. Pat. No. 3,465,351 also makes use of a drop detector in various arrangements. The Sweet patent describes ink jet writing apparatus incorporating means for variably charging the drops and maintaining a constant potential on the deflection plates. The Lovelady patent illustrates a form of servo loop for controlling the phase of the charging voltage and making use of a drop catcher.

None of the foregoing art describes a system like the present system making use of a pair of drop catchers or gutters and the development of relatively high currents and signal levels not normally encountered in the system during printing of characters.

SUMMARY OF THE INVENTION

In accordance with the present invention, a system incorporates means for producing ink drops as a stream of drops, facilities for variably charging the droplets in accordance with information or for synchronization and checking purposes, deflection means for deflecting the variably charged drops toward paper or either one of a pair of gutters, in dependence upon the amount of charge on the drops, and circuitry for detecting proper phasing or synchronization of drops with respect to charging and formation of drops, as well as failure detection. In its various forms, the invention contemplates an electronic servo or feedback loop operable in a real time fashion to maintain proper synchronization.

In one version, a counter means is advanced until a change current above a predefined level is found. The synchronization procedures are combined in one embodiment with a failure detection capability making use of a second gutter that receives drops when properly phased and that develops higher currents that are easier to detect. The second gutter may also be used for synchronization purposes if higher charge potentials are applied.

OBJECTS

Accordingly, a primary object of the present invention is to provide a system for ink jet printing apparatus to determine proper synchronization of drops formed in the system.

Still another object of the invention is to provide a system having synchronization and failure detection capabilities.

Another object of the invention is to provide a synchronization system operable in one or the other of two modes, a first mode providing relatively low charging and current levels smaller than those normally encountered during printing of characters, and a second mode wherein relatively high currents and potentials are established to check proper drop formation and phasing.

Another object of the invention is to provide a system that is operable to detect loss of electric field, loss of charge voltage, and related failures in an ink jet apparatus.

Another object of the invention is to provide monitoring of an ink jet system while printing, between characters or while in the home position etc., by means so as to immediately detect a failure in synchronization.

A further object of the present invention is to enable synchronization on a line-by-line basis, as when the printing means is at a home position, or between characters during actual printing operations, or within the matrix boundaries of an individual character when unused drops are available for checking purposes.

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of the various embodiments of the invention as illustrated in the accompanying drawings.

IN THE DRAWINGS

FIG. 1 is a diagram of an ink jet printing system incorporating the synchronizing and checking techniques of the present invention and particularly including a pair of gutters, and various circuitry controlling printing, synchronizing, and checking.

FIG. 2 is a modified comparing arrangement for use in the circuit of FIG. 1.

FIG. 3 illustrates various pulse wave forms that are encountered in the system of FIG. 1.

FIG. 4 is a suggested alternative synchronizing arrangement for use in the system of FIG. 1, if desired.

DETAILED DESCRIPTION

Ink Jet Printing System

The system of FIG. 1 is primarily intended for printing of intelligence, such as characters or symbols on a record member, such as a sheet of paper 1, by formation, propulsion, charging, deflecting, and deposition of ink drops 2 on paper 1, supported by means 4. The drops move in a stream or streams at high speeds from a source 3. Ink from an ink supply 5 is directed by means of pump 6 to source 3 which incorporates a vibrating means, such as a piezoelectric crystal 8 and an associated nozzle 10. A master clock 11 provides basic timing pulses to the system including machine logic 13 and a character generator block 14. Crystal 8 is driven at the frequency provided by clock 11 under control of crystal driver 15. The frequency may be a very high range such as 100 kilohertz, or more. Pulsation by crystal 8 effects formation of individual droplets that are directed through the center of a charge electrode 18 as is known in the art. Characters on paper 1 may be formed as a matrix of droplets, for instance, 24 droplets wide by 40 droplets high. In order to control the placement of drops on paper 1, a varying amount of charging voltage is provided to charge electrode 18 from charge electrode driver 21. Individual drops are directed between deflection plates 22 and 23 having a high potential, such as 3,000 volts, supplied from terminal 25. As is taught in the art, the arrangement is such that a constant potential exists between plates 22 and 23 which when combined with the variable charging on drops 2 effects selective displacement of the drops in a vertical sense, for example, to any one of the 40 possible positions in the matrix. Unused drops are directed either to

gutter No. 1, designated 35, or to gutter No. 2, designated 36, as will be described in greater detail. These drops are returned by lines 27 and 27a under control of pump 30 to ink supply 5. The proper voltage applied to drops 2 by charge electrode 18 from driver 21 during printing of characters is supplied by line 32 from character generator 14. Ordinarily, a single vertical column of drops is propelled toward paper 1 with selective deflection onto the paper at appropriate positions or into one of the other of the gutters 35 or 36. Source 3 and elements 8, 10, 18, 22–23, 35 and 36 are customarily mounted on a mounted means 37 interconnected with said elements by dashed lines 39*a* and 39*b*. Formation of a plurality of columns in a horizontal direction, such as the exemplary number of 24 is effected by relatively moving paper 1 and source 3, as well as electrodes 18, 22, and 23 in a timed fashion to achieve a side-by-side arrangement of columns, as by moving means 38 interconnected to mounting means 37 by line 45*a* and to support means 4 by line 45*b*. Such movement may be effected on an incremental basis or on a continuous basis. In this manner, entire lines on a document are printed. Ordinarily, at the end of each line of printing, the ink drop generating and deflecting means is relatively displaced with respect to paper 1 to a home position in preparation for a succeeding line. At the home position, as well as between characters, during actual character formation and while returning to home position, the various synchronizing and checking procedures set forth herein may be employed to control drop formation, and the relative timing of charging by electrode 18 with respect to individual drops passing through electrode 18.

AUTOMATIC SYNCHRONIZATION OF DROP SEPARATION AND CHARGE VOLTAGE

In a synchronized pressure ink jet system of the type described herein, the drop breakoff and charge voltage timing must by synchronized. This requires that the charge voltage applied by electrode 18 shall have reached the proper desired value prior to the actual separation of drops 2*a* and that the charge voltage must not be changing at the time of drop separation. The system in FIG. 1 is arranged to provide automatic adjustment of drop formation time with respect to drop charging through an electronic feedback loop.

At any time when drops 2 are not being used to print characters on paper 1, such as at the home position, between characters, or during deflection of drops on a column by column basis, a sampling function is performed. Thus, synchronization can take place any time that printing is not taking place.

Reference is made to FIG. 3 that shows typical time intervals and pulse wave forms during a single drop time, assumed to be 10 microseconds in duration. The first portion of the total of 10 microseconds, that is, 2.5 microseconds, is set aside to allow the driver time to reach the proper charging voltage. The remainder of the drop time, that is, 7.5 microseconds, is characterized as the "safe area of drop formation." Accordingly, a drop formed any time during this interval should be properly charged and deflected as it is propelled toward paper 1.

SYNCHRONIZATION WITH NARROW PULSES — GUTTER NO. 1

Several wave forms are of interest in FIG. 3. As one example, a series of narrow pulses on line 41 may be directed to driver 21 under controlled conditions. Sync control 40 adjusts driver 15 voltage through a range of values until the narrow pulses effect charging of drops 2. During synchronization using gutter No. 1, pulse signals are applied from Sync Control block 40 by line 41 to charge electrode driver 21 and ultimately to charge electrode 18. As shown in FIG. 3, a typical pulse voltage range is from 0 volts to 10 volts. Machine logic 13 by line 44 switches analog analog switch 46 to receive an input only from gutter 35 on line 47 designated "A." Ordinarily, a sequence of drops moves into gutter No. 1 designated 35 developing a current of some level directly proportional to the amount of charge on a series of individual drops. Such a series may comprise a portion of a column of unused drops or several such columns, depending on system sensitivity. Means, known in the art, are mounted in association with gutter No. 1 to provide a current level on line 47 corresponding to and directly related to the charge levels on drops 2 going into gutter No. 1. As an example of one possible configuration, for every two volt difference potential applied onto a series of drops 2 by charge electrode 18, approximately one nanoampere of current is derived on line 47. If for example, drops in a series were charged by 10 volts on the charge electrode, on average, then 5 nanoamperes is available on line 47. The output of switch 46 is directed to a drop charge amplifier 50 that converts the current levels to a usable voltage level. The output of amplifier 50 is directed by line 52 along with reference voltage from source 54 on line 55 for comparison in a comparator circuit 57. The output of comparator 57 on line 60 is directed to Sync Control 40 which concurrently is supplying a series of stepped driving voltage levels by line 62 to crystal driver 15, thereby adjusting the timing of drop separation and maintaining the time of drop separation in a desired relationship with respect to the potential applied by driver 21. Synchronization is attained when charged drops are first detected. It is also possible to synchronize with narrow pulses using gutter No. 2 designated 36.

SYNCHRONIZATION WITH RAMP SIGNAL — GUTTER NO. 1

As a preferred alternative, a ramp signal ranging from 0 to 10 volts is provided by line 42 to driver 21. Synchronization is attained using gutter No. 1 designated 35.

During synchronization using gutter No. 1, the ramp signal is applied from Sync Control block 40 by line 42 to charge electrode driver 21 and ultimately to charge electrode 18. Machine logic 13 by line 44 switches analog switch 46 to receive an input only from gutter 35 on line 47 designated "A." As before, a sequence of drops moves into gutter No. 1 designated 35 developing a current of some level directly proportional to the amount of charge on a series of individual drops. Such a series may also comprise a portion of a column of unused drops or several such columns, depending on system sensitivity. A current level is developed on line 47 corresponding to and directly related to the charge levels on drops 2 going into gutter No. 1. The current level will depend upon the time of drop breakoff during the ramp signal interval. In this case, as before, the output of switch 46 is directed to a drop charge amplifier 50 that converts the current levels to a usable voltage level. The output of amplifier 50 is directed by line 52

along with a reference voltage from source **54** on line **55** for comparison in a comparator circuit **57.** The output of comparator **57** on line **60** is directed to Sync Control **40** that in turn directs a correction signal by line **62** to crystal driver **15,** thereby adjusting the timing of drop separation and maintaining the time of drop separation in a desired relationship with respect to the potential applied by driver **21.**

SYNCHRONIZATION WITH RAMP SIGNAL — GUTTER NO. 2

Gutter No. **2** designated **36** in FIG. **1** may also be used for normal drop synchronization of phasing, if desired. A synchronization pulse using gutter No. **2** is illustrated as a ramp wave form in FIG. **3,** and is supplied on line **81** from Sync Control **40** to driver **21.** Such pulse may, for example, be in the range of 200 to 250 volts. It is noted that a greater change that is, 50 volts, occurs in this case than in the case of synchronization using gutter No. **1,** where only a 10 volt change occurs. The greater rate of change when synchronization is effected with gutter No. **2** provides a much higher level of current that is easier to detect in the circuits.

In any of the foregoing instances, if a sufficient series of drops **2** passes through the selected gutter, a current in nanoamperes is developed that is detectable. Amplifier **50** converts its input current level to low impedance voltage level. If a ramp is used, and, as an example, reference voltage supply **54** indicates 5.0 volts as a desired voltage level, and amplifier **50** provides a 7.5 volt level to comparator **57,** a corrective signal is developed on line **60** to change the drive voltage applied by driver **15** under control of Sync Control **40** in order to more closely achieve the 5.0 volt level. It is somewhat impractical to attempt to sense the current levels developed by a single ink drop as would be done in a 100 percent servo system. Thus, a series of drops is integrated to develop the necessary current levels. Such a series of drops would be available, as an example, when an entire column of droplets or most of the droplets in a column are available during printing of characters of symbols.

The foregoing synchronization procedures and feedback circuits are gated on by machine logic **13** during any non-printing time, as desired, and may occur when the machine is first turned on, when the first character is printed, in between characters, in between lines, etc.

USE OF CHECKING PULSE — GUTTER NO. 1

A checking pulse may be applied on line **43** in a low voltage range such as 0–10 volts which when sensed by current levels on line **47** can determine various system failure, such as drop charging failure, loss of synchronization, etc. However, for a most complete check, gutter No. **2** is preferably used.

USE OF CHECKING PULSE AND SYSTEM FAILURE DETECTION — USING GUTTER NO. 2

Detection of system failure may be performed by charging all unused drops with a checking pulse on line **65,** as shown in FIG. **3,** thus sending them to gutter No. **2** designated **36** in FIG. **1.** This can be done at any time when the system is not printing as between individual characters, or at home position. The advantage of checking with gutter No. **2** is that in addition to all the symptoms detected by use of gutter No. **1,** deflection voltage failure is also detected. In addition, successful checking with gutter No. **2** is evidence that proper character height is being maintained. This may also be done while printing is taking place whenever unused drops occur. When in checking mode "B," machine logic **13** forces switch **46** to pass current only from input "b" connected to gutter No. **2, 36,** by ling **74.** As an example, a sequence of **100** drops in a given series of **120** drop intervals could be sufficient to develop adequate current on line **74.**

The 10 volt level used for synchronization into gutter No. **1** develops a gutter current on line **47** in the range of 4 to 6 nanoamperes. A greater charge level required to deflect drops **2** up to gutter **36** achieves a higher current level that is easier to sense by circuits **46** and **50.** If, for example, 180 volts deflects drops **2** to the upper portion of paper **1** during printing of chaacters, 190 to 200 volts applied to unused drops can deflect those drops to gutter **36.** Such voltage levels develop current levels in gutter **36** and on line **74** in the range of 90 to 100 nanoamperes which is about 20 times the current levels developed on line **47.** It is apparent that the higher current levels are more readily sensed and worked with in the circuits as shown.

The advantage of the checking pulse applied over a number of drop intervals is that the system can determine whether proper synchronization is being maintained, whether the charge electrode and driver are operating properly, whether the high voltage from terminal **25** is present and of course, whether other components in the system are working properly. The checking pulses are applied by line **65** to driver **21** in order to produce the required currents in gutter **36.** These may be compared by comparator **57** against reference voltage from block **54** with suitable changing of reference level on line **77** from Sync Control **40.**

A possible approach using this technique is for machine logic **13** to determine the maxium number of drops used during printing of characters and thus also determine the minimum number of drops that should be available for gutter No. **2** during normal printing. Such minimum number of drops should result in a particular current level on line **74** which is measured by circuits **46** and **50** and compared at comparator **57** with a threshold level from block **54.** If such minimum potential is not available, a failure is indicated to machine logic **13** on line **80.** The machine logic can then take steps to turn off the crystal drive from driver **15,** to turn off driver **21,** deactivate pumps **30** and **6** and take any other steps necessary to minimize the amount of ink that is sprayed on paper **1** or other parts of the mechanism.

The foregoing techniques result in less costly measuring circuitry and less-noise sensitive signals. An important advantage of the checking procedure is that the logic **13** is able to continually monitor the performance of the ink jet mechanism, if desired.

ALTERNATIVE CHECKING CIRCUIT

FIG. **2** illustrates an alternative checking circuit having various members **35, 36, 46, 47, 50** and **74** corresponding to those similarly numbered members in FIG. **1,** but having a comparator **57a** and an independent second reference source **54*a*** that is based strictly on a "go-no-go" basis. The analog switch **46** monitors drops **2** impinging on gutter No. **2** (**36**) and essentially determines if the drops are present or absent. Reference voltage **2** from source **54*a*** establishes a threshold level

for comparator 57*a* and the output from amplifier 50 should always exceed such level. If it does not then a signal is provided by line 80*a* to indicate a machine failure.

ALTERNATIVE SYNCHRONIZING CIRCUIT

FIG. 4 illustrates another circuit that may be provided to achieve proper synchronization in the system. A master clock 82 supplies a driving signal on line 83 to decode selector 84, on line 85 to printing logic 86 and on line 87 to circuit 88. Sync time is indicated by printing logic 86 on lines 90 and 91 that are directed to Sync Control 40a and And circuit 88, respectively.

The circuit includes a crystal 95 receiving ink on line 96 from an ink supply, not shown, a nozzle 98 and a crystal driver amplifier 99. Amplifier 99 drives crystal 95 to form drops 100 that pass through charging electrode 102 driven by charge electrode driver 104. Driver 104 in turn is driven from Or circuit 88. Individual drops are deflected to paper 1, for printing or to gutter 106 when not used. The circuit includes a counter register 110 that serves during normal printing times to define the crystal driver signal.

During synchronization time, Sync Control 40*a* advances counter register 110 until a charge current above a predefined level is found. This is done by detection of current levels in gutter 106, supply of such levels on line 112 to amplifier (AMP) 50, conversion of such levels to voltage levels amplifier 50 and comparison of such levels with reference voltage from terminal 113 by comparator (COMP) 114. The output of comparator 114 is directed to Sync Control 40*a*. When a charge current above a predefined level is recognized, the value in counter 110, is held. This maintains the drive level from amplifier 99 until the next synchronization time. Counter register 110 outputs are decoded by block 84 which in turn is driven from master clock 82. The individual clock signals each have a different phase relationship with respect to the synchronization pulse on line 87. If Sync Control block 40*a* is unable to find a signal which provides synchronization it will so indicate by line 115 to printing logic 86 thereby evidencing a synchronization failure. The Sync Control logic contains a delay to compensate for the transit time of the drops.

The sync time signal produced by the printing logic 86 controls gate 88 so as to allow only printing signals to go to the charge electrode driver dring printing and allow only sync pulses to reach the charge electrode driver 104 during synchronization.

While the invention has been particularly shown and described with reference with several embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. An ink jet printing system for printing on a record medium by ink drop deposition, comprising:

means for supporting said record medium at a printing station;

means for forming and propelling ink drops toward said record medium;

cyclically operable means operable in timed relation with said forming and propelling means for charging and deflecting a plurality of said drops on a selective basis to form visible indicia upon said record medium, said charging and deflecting means being operable to charge and deflect said drops in a range from a relatively low to high potential with the extremes of said range representing drops not required for printing;

first gutter means positioned in the path of travel of a first type of unused drops charged at said relatively low potential to collect said first type of drops

said first gutter means providing a relatively low synchronization current from charged drops travelling in said first gutter means

second gutter means positioned in the path of travel of a second type of unused drops charged at said relatively high potential to collect said second type of drops

said second gutter means providing a relatively high checking current level; from charged drops travelling in said second gutter means;

amplifier means interconnected with said first gutter means for providing a low synchronization potential responsive to the relatively low synchronization current provided by said first gutter means, and further interconnected with said second gutter means for providing a high checking potential responsive to the high checking current level from said second gutter means;

character generating means for activating said charging and deflecting means in a printing range within but not including said relatively low and relatively high potential in order to deflect selected ones of said drops within a printin range on said record medium;

synchronization means operable to activate said charging and deflecting means at said relatively low potential in order that low synchronization potential is developed by said amplifier means;

checking means operable to activate said charging and deflecting means at said relatively high potential in order that the high checking potential is developed by said amplifier means;

comparing means for comparing said synchronization potential with predetermined reference levels representative of correct synchronization in said system;

means controlled by said comparing means for maintaining correct phase between drop formation and charging;

said comparing means comparing said checking potential with predetermined reference levels representative of correct operation of said system; and

output means from said comparing means for indicating a failure of said system.

2. The system of claim 1 further comprising:

means mounting said forming and propelling means, said charging and deflecting means and said first and second gutter means in a unitary structure adjacent said record medium;

means operable in timed relation to drop propulsion toward said record medium for relatively moving said mounting means and said record medium from a home position in order to form matrices arranged in lines printed intelligence on said record medium each of said matrices comprising a set of vertical columns and horizontal rows of drop locations and each of said matrices being separated from a preceding or succeeding matrix by an inter-matrix gap.

3. The system of claim 2 wherein:

said synchronization control means provides synchronization pulses when said mounting means and said record medium are relatively positioned at home position; and

checking pulses any time during relative movement when drops are not required for printing.

4. The system of claim **1** further comprising:

an analog switch responsive to current levels from said first sensing means when activated in a first mode and to current levels from said second sensing means when activated in a second mode;

selection means for selecting said first and second modes of said switch on a selective basis;

amplifier means responsive to current levels from said analog switch to develop potentials therefrom, and

means connecting potentials from said amplifier means to said comparing means.

5. The system of claim **1** further comprising:

a charge electrode and charge electrode driver associated with said drop charging and deflecting means;

a crystal and crystal driver associated with said drop forming and propelling means; and

means applying synchronization and checking signals from said synchronization control means to said charge electrode through said charge electrode driver;

means for applying output signals from said first comparing means to said synchronization control means;

and means in said synchronization control means for developing and applying correction signals to said crystal through said crystal driver in order to maintain in proper phase.

6. The system of claim **1** further comprising:

means responsive to a failure detection signal from said comparing means to de-activate said system.

* * * * *