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(54) **Improvements in or relating to continuous inkjet printers**

Verbesserungen an oder im Zusammenhang mit Tintenstrahldruckern

Améliorations de ou associées aux imprimantes à jet d'encre continu

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Description

Field of the Invention

[0001] This invention relates to continuous inkjet (CIJ) printers and more particularly, though not necessarily solely, to CIJ printers used in industrial and/or commercial marking and coding applications.

Background to the Invention

[0002] A typical CIJ printer has an ink supply system having a number of functions. The system provides for ink to be drawn from a reservoir and supplied to the print-head. It also provides for unprinted ink to be re-circulated and, if necessary, supplemented with make-up fluid to maintain the ink at the correct viscosity for printing. The system may also provide for make-up fluid to be circulated through the system for cleaning or flushing purposes.

[0003] It is both convenient and typical to control the flow of fluids through the ink supply system by means of solenoid valves, and a typical CIJ printer will have up to eight solenoid valves controlling various printer functions. The correct operation of these solenoid valves is critical to the performance of the printer and thus checks must be incorporated in the system to ensure the solenoid valves are operational as signalled by the controlling electronics. These checks also play their part in diagnosing faults in the printer.

[0004] In the past, checks on solenoid valve operation have typically been conducted by monitoring various downstream parameters. For example, by monitoring ink pressure it is possible to establish if an ink supply valve is open or not. Similarly monitoring the presence of wet ink in the gutter at particular times can indicate if a valve is open at the correct time, and monitoring ink viscosity can indicate whether a valve which operates to mix ink and make-up fluid, is functioning correctly.

[0005] Systems which monitor these downstream parameters require the provision of various sensors. In the examples outlined above the system would require a pressure sensor, a capacitive or conductive sensor, and a viscometer. Providing these sensors adds cost and complexity and the sensors, in themselves, comprise further components which can malfunction.

[0006] It is an object of this invention to provide a method and/or apparatus which will go at least some way in addressing the aforementioned problems; or which will at least offer a novel and useful alternative.

[0007] EP 0 065 103 A discloses a continuous inkjet printer having a solenoid. Current flowing through the coil is measured to set the value of a variable resistor.

Summary of the Invention

[0008] Accordingly, in one aspect, the invention provides a method of monitoring solenoid valve operation in

a continuous inkjet printer, said method being characterised in that it includes the step of detecting the presence of current draw by said solenoid valve.

[0009] Preferably said method comprises detecting the presence of current draw as said solenoid valve is opened.

[0010] Preferably said method is applied to a printer having a plurality of solenoid valves, said method including using a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened.

[0011] Preferably said method further comprises identifying the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve.

[0012] Said method may also further comprise monitoring current flow in said solenoid valve to thereby determine when said valve is closed.

[0013] In a second aspect the invention provides a continuous inkjet printer having at least one solenoid valve to control a function within said printer, said printer being characterised in that it includes sensing means operable to detect the presence of current draw by said solenoid valve.

[0014] Preferably said sensing means is operable to detect the presence of current draw as said solenoid valve is opened.

[0015] Preferably said printer includes a plurality of solenoid valves, said sensing means including a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened.

[0016] Preferably said printer further includes identification means operable to identify the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve.

[0017] Said printer may further include a facility to monitor current flow in said solenoid valve to thereby determine when said valve is closed.

[0018] Many variations in the way the present invention can be performed will present themselves to those skilled in the art. The description which follows is intended as an illustration only of one means of performing the invention and the lack of description of variants or equivalents should not be regarded as limiting. Wherever possible, a description of a specific element should be deemed to include any and all equivalents thereof whether in existence now or in the future.

Brief Description of the drawings

[0019] An embodiment of the invention will now be described with reference to the accompanying drawing in which:

Figure 1: shows, schematically, a circuit for determin-

ing solenoid valve operation in a continuous inkjet printer

Description of Working Embodiment

[0020] The present invention provides a low-cost effective means of determining solenoid valve operation in a CIJ printer. The essence of the invention is that solenoid valve operation is monitored directly by the solenoid driver electronics, in contrast to monitoring parameters downstream of the solenoid valve which could indicate if the valve is defective.

[0021] The invention relies on the assumption that a solenoid valve will be operating correctly providing the solenoid coil draws a current. In most instances this assumption will be true.

[0022] Typically a CIJ printer has a number of solenoid valves, each of which controls or influences different machine functions. Whilst the inventive concept described herein could be applied to each individual solenoid valve, in the preferred embodiment described, all solenoid valves are driven from a single source having a single detection circuit. In this way the invention can be implemented efficiently and at low cost.

[0023] Referring now to Figure 1, a control circuit is shown having two solenoid valves incorporated therein. It will be appreciated, however, that more than two solenoid valves can be incorporated and, indeed, a CIJ printer manufactured by the applicant typically has eight solenoid valves driven and controlled in the manner described.

[0024] Two voltages are used in the solenoid control circuit shown. Solenoid valves 1, 2 etc are turned on via the 24V supply and thereafter maintained on via the 12V supply. The extra power provided by the 24V supply is required to bring the solenoids into operation but the 12V supply is sufficient to hold the solenoid on once pulled in.

[0025] A sense resistor R_{sense} is placed in circuit from the 24V supply such that when turned on via the 24V supply all solenoid valves derive their power via this resistor. Each solenoid valve only needs to be powered for a short duration via the 24V supply for it to operate. Opening of each solenoid valve is effected by biasing on the appropriate HIT ENABLE transistor, and also the appropriate LOW SIDE ENABLE to sink current to ground. Typically a period of 30mS is sufficient to operate each solenoid.

[0026] Once pulled in, the solenoid valve is maintained on by maintaining the LOW side enable transistor on. In this configuration current is drawn only from the 12V supply through the diode D.

[0027] It will be appreciated that current is only drawn via R_{sense} during the turn-on period of the solenoid and hence sensing of the solenoid current may only be made during the turn-on period. This feature allows the same sensing circuit to be used to sense current for all solenoids as they are each turned on during different time slots.

[0028] An identical control (HOLD) circuit is provided for each solenoid. The diodes (D1 etc) are provided to prevent connection between the 12V and 24V supplies (the 24V would otherwise connect directly to the 12V supply via the hit enable transistors and result in possible damage to the power supplies).

[0029] Details of the R_{sense} circuit are not shown in the circuit diagram but will be readily apparent to those skilled in the art. Various well known methods may be used for this function and these include the use of a comparator or the use of a transistor biased on by the voltage drop across the current sense resistor.

[0030] The R_{sense} circuit monitors current in the 24V supply and preferably outputs a pulse every time the total draw increases, as occurs when a solenoid valve is opened. The timing of these output pulses can be compared with expected events within the printer operation to identify a particular solenoid valve either operating correctly, or malfunctioning. This is advantageously effected digitally with each pulse being latched into a register within the operating device, e.g. an FPGA, which can be read by the operating software. So when the software commands a solenoid valve to open, it can then look to the register to see if a pulse of current was drawn by the R_{sense} circuit.

[0031] Further routines may be included in the printer operating system which would check the state of the solenoid valves at various times and compare them to their expected states.

[0032] If a malfunction in any of the solenoid valves is detected this is signalled to the operator and possibly used to initiate a shut-down of the printing system, depending on the significance of the malfunction.

[0033] A further enhancement of this system could include current sensing which would detect too much current as well as no (or not sufficient) current. This would use two current sensing circuits each of which are configured to sense either more than or less than a predicted voltage drop across R_{sense} .

[0034] It will thus be appreciated that the present invention, at least in the case of the working embodiment herein described, provides a method and/or apparatus which provides an effective low-cost means of monitoring solenoid valve operation in a continuous inkjet printer.

Claims

1. A method of monitoring solenoid valve operation in a continuous inkjet printer, said method being **characterised in that** it includes the step of detecting the presence of current draw by said solenoid valve.
2. A method as claimed in claim 1 comprising detecting the presence of current draw as said solenoid valve is opened.
3. A method as claimed in claim 2 when applied to a

printer having a plurality of solenoid valves, said method including using a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened.

4. A method as claimed in claim 3 further comprising identifying the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve.
5. A method as claimed in any one of claims 1 to 4 further comprising monitoring current flow in said solenoid valve to thereby determine when said valve is closed.
6. A continuous inkjet printer having at least one solenoid valve to control a function within said printer, said printer being **characterised in that** it includes sensing means operable to detect the presence of current draw by said solenoid valve, in order to monitor operation of said solenoid valve.
7. A continuous inkjet printer as claimed in claim 6 wherein said sensing means is operable to detect the presence of current draw as said solenoid valve is opened.
8. A continuous inkjet printer as claimed in claim 6 or claim 7 including a plurality of solenoid valves, said sensing means including a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened.
9. A continuous inkjet printer as claimed in claim 8 further including identification means operable to identify the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve.
10. A continuous inkjet printer as claimed in any one of claims 6 to 9 further including a facility to monitor current flow in said solenoid valve to thereby determine when said valve is closed.

Patentansprüche

1. Verfahren zum Überwachen einer Magnetventilbetätigung in einem kontinuierlichen Tintenstrahldrucker, wobei das Verfahren **dadurch gekennzeichnet ist, dass** es den Schritt eines Erfassens der Anwesenheit einer Stromaufnahme des Magnetventils umfasst.

2. Verfahren nach Anspruch 1, umfassend ein Erfassen der Anwesenheit einer Stromaufnahme, wenn das Magnetventil geöffnet ist/wird.

3. Verfahren nach Anspruch 2, wenn es an einem Drucker angewandt wird, welcher eine Mehrzahl von Magnetventilen aufweist, wobei das Verfahren ein Verwenden eines einzelnen Abtastkreis umfasst, um die Stromaufnahme zu erfassen, wenn ein Beliebiges der Mehrzahl von Magnetventilen geöffnet ist/wird.

4. Verfahren nach Anspruch 3, ferner umfassend ein Identifizieren der Betätigung eines Bestimmten der Mehrzahl von Magnetventilen durch ein Zuordnen des Zeitpunkts einer Erfassung einer Stromaufnahme durch den Abtastkreis zu dem Zeitpunkt eines bestimmten Betätigungsbefehls, welcher dem bestimmten Magnetventil zugeordnet ist.

5. Verfahren nach einem der Ansprüche 1 bis 4, ferner umfassend ein Überwachen von einem Stromfluss in dem Magnetventil, um dadurch zu bestimmen, wann das Ventil geschlossen ist/wird.

6. Kontinuierlicher Tintenstrahldrucker, welcher wenigstens ein Magnetventil aufweist, um eine Funktion innerhalb des Druckers zu regeln/steuern, wobei der Drucker **dadurch gekennzeichnet ist, dass** er ein Abtastmittel umfasst, welches betreibbar ist, die Anwesenheit einer Stromaufnahme durch das Magnetventil zu erfassen, um eine Betätigung des Magnetventils zu überwachen.

7. Kontinuierlicher Tintenstrahldrucker nach Anspruch 6, wobei das Abtastmittel betreibbar ist, um die Anwesenheit einer Stromaufnahme zu erfassen, wenn das Magnetventil geöffnet ist/wird.

8. Kontinuierlicher Tintenstrahldrucker nach Anspruch 6 oder Anspruch 7, umfassend eine Mehrzahl von Magnetventilen, wobei das Abtastmittel einen einzelnen Abtastkreis umfasst, um die Stromaufnahme zu erfassen, wenn ein Beliebiges der Mehrzahl von Magnetventilen geöffnet ist/wird.

9. Kontinuierlicher Tintenstrahldrucker nach Anspruch 8, ferner umfassend ein Identifikationsmittel, welches betreibbar ist, die Betätigung eines Bestimmten der Mehrzahl von Magnetventilen durch ein Zuordnen des Zeitpunkts einer Erfassung einer Stromaufnahme durch den Abtastkreis zu dem Zeitpunkt eines bestimmten Betätigungsbefehls, welcher dem bestimmten Magnetventil zugeordnet ist, zu identifizieren.

10. Kontinuierlicher Tintenstrahldrucker nach einem der Ansprüche 6 bis 9, ferner umfassend eine Einrichtung

tung, um einen Stromfluss in dem Magnetventil zu überwachen, um dadurch zu bestimmen, wann das Ventil geschlossen ist/wird.

Revendications

1. Procédé de surveillance de fonctionnement d'électrovanne dans une imprimante à jet d'encre continu, ledit procédé étant **caractérisé en ce qu'il** comporte l'étape qui consiste à détecter la présence de courant absorbé par ladite électrovanne. 10
2. Procédé tel que revendiqué dans la revendication 1, comprenant la détection de la présence de courant absorbé à mesure que ladite électrovanne est ouverte. 15
3. Procédé tel que revendiqué dans la revendication 2, lorsqu'il est appliqué à une imprimante ayant une pluralité d'électrovannes, ledit procédé comportant l'utilisation d'un circuit de détection unique pour détecter le courant absorbé à mesure que l'une quelconque de ladite pluralité d'électrovannes est ouverte. 20 25
4. Procédé tel que revendiqué dans la revendication 3, comprenant en outre l'identification du fonctionnement d'une électrovanne particulière de ladite pluralité d'électrovannes par l'association de la synchronisation d'une détection de courant absorbé par ledit circuit de détection à la synchronisation d'une instruction de fonctionnement particulière associée à ladite électrovanne particulière. 30 35
5. Procédé tel que revendiqué dans l'une quelconque des revendications 1 à 4, comprenant en outre la surveillance d'un flux de courant dans ladite électrovanne pour déterminer ainsi à quel moment ladite vanne est fermée. 40
6. Imprimante à jet d'encre continu ayant au moins une électrovanne pour commander une fonctionnalité dans ladite imprimante, ladite imprimante étant **caractérisée en ce qu'elle** comporte un moyen de détection pouvant fonctionner pour détecter la présence de courant absorbé par ladite électrovanne, afin de surveiller le fonctionnement de ladite électrovanne. 45 50
7. Imprimante à jet d'encre continu telle que revendiquée dans la revendication 6, dans laquelle ledit moyen de détection peut fonctionner pour détecter la présence de courant absorbé à mesure que ladite électrovanne est ouverte. 55
8. Imprimante à jet d'encre continu telle que revendiquée dans la revendication 6 ou 7, comportant une

pluralité d'électrovannes, ledit moyen de détection comportant un circuit de détection unique pour détecter le courant absorbé à mesure que l'une quelconque de ladite pluralité d'électrovannes est ouverte.

9. Imprimante à jet d'encre continu telle que revendiquée dans la revendication 8, comportant en outre un moyen d'identification pouvant fonctionner pour identifier le fonctionnement d'une électrovanne particulière de ladite pluralité d'électrovannes par l'association de la synchronisation d'une détection de courant absorbé par ledit circuit de détection à la synchronisation d'une instruction de fonctionnement particulière associée à ladite électrovanne particulière.
10. Imprimante à jet d'encre continu telle que revendiquée dans l'une quelconque des revendications 6 à 9, comportant en outre une installation pour surveiller le flux de courant dans ladite électrovanne afin de déterminer ainsi à quel moment ladite vanne est fermée.

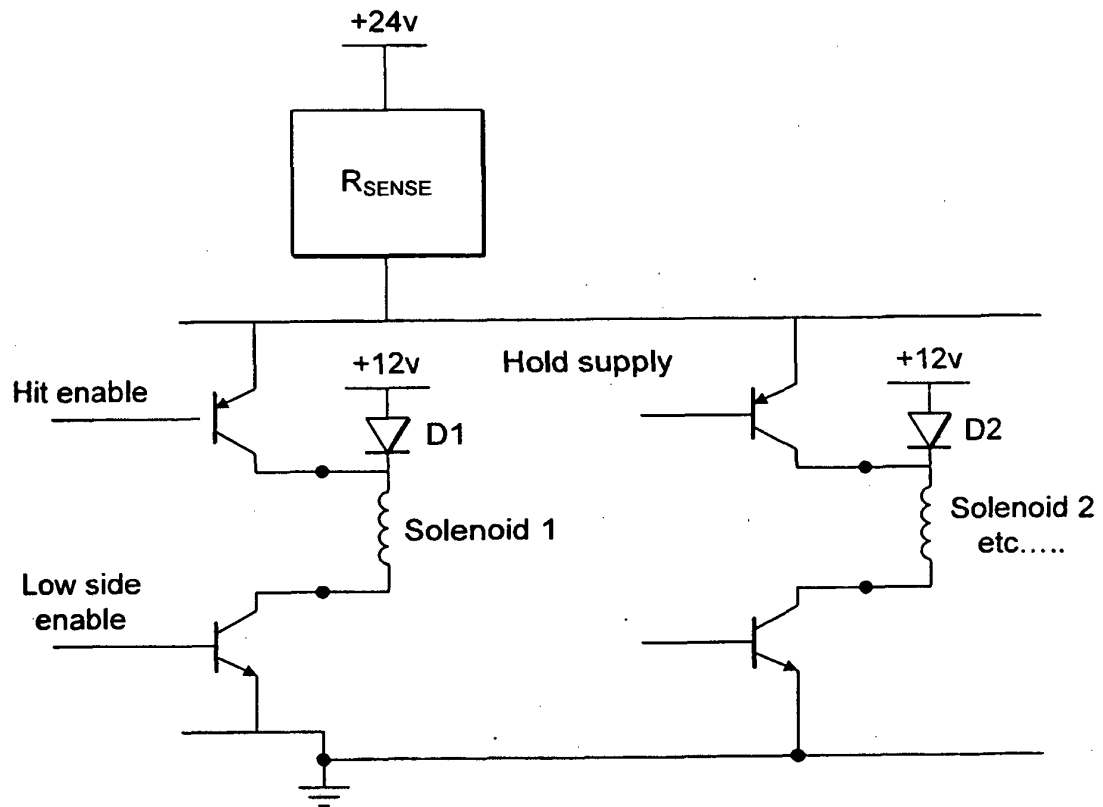


FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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