



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
30.11.2016 Bulletin 2016/48

(51) Int Cl.:
B41J 2/015 ^(2006.01) **B41J 2/01** ^(2006.01)
B41J 2/045 ^(2006.01)

(21) Application number: **15739806.6**

(86) International application number:
PCT/JP2015/050489

(22) Date of filing: **09.01.2015**

(87) International publication number:
WO 2015/111451 (30.07.2015 Gazette 2015/30)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **Konica Minolta, Inc.**
Tokyo 100-7015 (JP)

(72) Inventor: **TAKEYA, Akira**
Tokyo 100-7015 (JP)

(74) Representative: **Henkel, Breuer & Partner**
Patentanwälte
Maximiliansplatz 21
80333 München (DE)

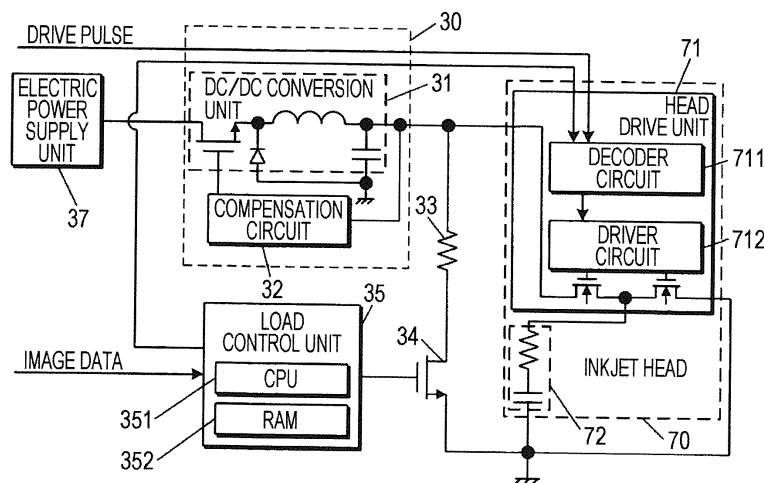
(30) Priority: **24.01.2014 JP 2014011356**

(54) **IMAGE FORMATION DEVICE**

(57) Provided is an image formation device that, using a simple configuration, is capable of more stable output of drive voltage in relation to load fluctuation following start of operation of a recording element. The image formation device comprises: a recording head having a plurality of recording elements arranged therein; a drive unit that supplies drive voltage to load elements in the recording elements on the basis of formed image data and causes each load element to operate; a voltage control unit that controls so as to suppress fluctuation in drive voltage supplied to the drive unit; a resistance element connected

to the voltage control unit, provided corresponding to the load elements in the recording elements; a switching element that switches whether or not to supply drive voltage to the resistance element; and a load control unit that controls the switching element so as to supply drive voltage to the resistance element for at least some of the time that drive voltage is not supplied to any of the load elements in the recording elements, said time being before the supply start timing at which drive voltage is supplied to the load elements in the recording elements.

FIG. 2



Description

Technical Field

[0001] This invention relates to an image forming apparatus.

Background Art

[0002] There is an inkjet image forming apparatus (inkjet recording apparatus) for forming an image on a recording medium by ejecting ink through openings of a plurality of nozzles arranged in a predetermined pattern while individually controlling timings thereof. This inkjet recording apparatus abruptly applies a pressure to ink in an ink channel communicating to the corresponding nozzle to push out the ink from the nozzle at high speed and therefore ejects and drops an ink droplet.

[0003] As a method of ejecting ink droplets, there are mainly used a piezoelectric method for pushing out ink by compressing and deforming an ink chamber communicating to a nozzle with the use of a piezoelectric element or the like and a thermal method for pushing out ink by electrifying a heater provided in a nozzle end to heat ink and generating bubbles in an ink channel. In those driving methods, a load element such as a piezoelectric element or a heater is individually provided in each nozzle. A predetermined voltage is applied to the load element corresponding to the nozzle for ejecting ink, and therefore a total load, i.e., power consumption is increased as the number of nozzles that simultaneously ejects ink is increased.

[0004] In an electrical apparatus whose power supply does not have a sufficient capacity with respect to a maximum load, a supply voltage is decreased or increased when a large load is abruptly applied or is removed. An amount of ejection of ink from each nozzle is closely related to a drive voltage applied to a load element corresponding to each nozzle, and therefore there is a problem in that, when the drive voltage is changed, density of ink becomes uneven and thus image quality of a formed image is reduced. In view of this, a technique for suppressing a change in output voltage by using a feedback circuit as a circuit for supplying a stable voltage has been conventionally used.

[0005] Patent Literature 1 discloses a technique for suppressing a change in consumption power by, before outputting drive pulse for ejecting ink, outputting prepulse at a degree at which ink is not ejected and then changing a length of this prepulse to compensate power consumption of a nozzle that does not eject ink.

[0006] However, in recent years, the number of nozzles provided in an inkjet recording apparatus has been increased in accordance with improvement in precision and increase in speed of an image formed by the inkjet recording apparatus. Therefore, in the technique disclosed in Patent Literature 1, even in the case where a change in drive voltage is corrected by increasing a con-

trol range of a prepulse width, ejection becomes unstable and therefore a change in drive voltage cannot be corrected in some cases. Meanwhile, Patent Literature 2 discloses a technique for suppressing a change in consumption power by providing a plurality of dummy resistors and switches in parallel to nozzles, counting the number of nozzles that simultaneously eject ink, and consuming electric power corresponding to an amount of reduction of consumption power in the nozzles with the use of a combination of the resistors, thereby preventing variation of voltage drop between lines during formation of an image.

Citation List

Patent Literature

[0007]

Patent Literature 1: JP 2003-237056 A
Patent Literature 2: JP 2002-254648 A

Summary of Invention

Technical Problem

[0008] However, in an output circuit of a drive voltage, a response time of a feedback circuit for suppressing a change in drive voltage with respect to a change in consumption power is determined depending on constants of a coil, a capacitor, and the like included in the feedback circuit. Therefore, when a speed of switching of a load is increased, the response time becomes longer than an output time of the drive voltage. Under such circumstances, a great change in drive voltage cannot be immediately suppressed.

[0009] In particular, in the case where a non-driving state in which no voltage is applied to a load element of each element related to image formation changes over to a driving state in which operation related to voltage application is performed and a drive voltage is first applied to start operation of a recording element, i.e., for example, at the time of starting image formation (including the time of restarting image formation after interruption caused by a margin or the like), consumption power is clearly and abruptly changed. Therefore, conventionally, there has been a problem in that a great change in drive voltage cannot be prevented from occurring also after image formation is started. There is also a problem in that improvement in a hardware configuration for reducing the response time causes complication of the circuit and increase in size thereof.

[0010] An object of this invention is to provide an image forming apparatus capable of outputting a drive voltage with a simple configuration more stably with respect to a change in load caused by start of operation of a recording element.

Solution to Problem

[0011] To achieve the above-mentioned object, an invention described in claim 1 is an image forming apparatus, including:

a recording head in which a plurality of recording elements is arranged;
 a drive unit for supplying a drive voltage to a load element of each of the recording elements on the basis of image data to be formed and operating the load element;
 a voltage control unit for performing control so as to suppress a change in the drive voltage to be supplied to the drive unit;
 a resistor element connected to the voltage control unit and provided to correspond to the load element of the recording element;
 a switching element for switching whether to supply the drive voltage to the resistor element; and
 a load control unit for controlling the switching element so as to supply the drive voltage to the resistor element before a supply start timing at which the drive voltage is supplied to the load element of the recording element and in at least a part of a period in which the drive voltage is not supplied to any load element of the recording element.

[0012] According to an invention described in claim 2, in the image forming apparatus according to claim 1, supply of the drive voltage to the load element of the recording element is started in a state in which the drive voltage is reduced by supplying the drive voltage to the resistor element.

[0013] According to an invention described in claim 3, in the image forming apparatus according to claim 1, an amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the load element of the recording element is equal to or less than an amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the resistor element.

[0014] According to an invention described in claim 4, in the image forming apparatus according to claim 1 or 2, an amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the load element of the recording element is smaller than an amount of reduction of the drive voltage at the time of virtual supply start time of supplying the drive voltage to the load element of the recording element without supplying the drive voltage to the resistor element.

[0015] According to an invention described in claim 5, in the image forming apparatus according to any one of claims 1 to 4, when a time after the drive voltage is changed in the case where the drive voltage is supplied to the resistor element until the drive voltage is converged at a predetermined drive voltage is defined to be a response time, the load control unit controls the switching element so as

to supply the drive voltage to the resistor element from the response time or more before the supply start timing at which the drive voltage is supplied to the load element of the recording element until the supply start timing.

[0016] According to an invention described in claim 6, the image forming apparatus according to any one of claims 1 to 5,

the supply start timing includes a timing at which the drive voltage is supplied to the load element of the recording element at the time of start of image formation of one page.

[0017] According to an invention described in claim 7, in the image forming apparatus according to any one of claims 1 to 5,

the supply start timing includes a timing at which, in the case where image formation is performed by repeatedly moving the recording head along a recording medium and then forming an image of one band and conveying the recording medium and then forming an image of the next one band, the drive voltage is supplied to the load element of the recording element at the time of start of image formation of the one band.

[0018] According to an invention described in claim 8, in the image forming apparatus according to any one of claims 1 to 5, the image forming apparatus includes a conveyance unit for conveying a recording medium on which an image is to be formed by the recording head, the conveyance unit includes a first measurement unit for measuring a position of the recording medium relative to the plurality of recording elements in a conveyance direction of the recording medium, and the supply start timing is a timing at which the recording medium is conveyed by the conveyance unit to a position at which the position of the recording medium relative to the plurality of recording elements in the conveyance direction of the recording medium set with respect to the recording medium is overlapped on a position at which the recording elements are caused to start the operation related to start of printing on the recording medium.

[0019] According to an invention described in claim 9, in the image forming apparatus according to any one of claims 1 to 5, the image forming apparatus includes:

a conveyance unit for conveying a recording medium on which an image is to be formed by the recording head; and

a power source for reciprocally moving the recording head in a direction orthogonal to a conveyance direction of the recording medium, the conveyance unit includes a first measurement unit for measuring a position of the recording medium relative to the plurality of recording elements in the conveyance direction of the recording medium, the power source includes a second measurement unit for measuring a position of the recording medium relative to the plurality of recording elements in the direction in which the recording head reciprocally moves, and

the supply start timing is a timing at which the recording medium is conveyed by the conveyance unit to a position at which a position of the recording medium relative to the plurality of recording elements in the conveyance direction of the recording medium set with respect to the recording medium is overlapped on a position in the conveyance direction of the recording medium at which the recording elements are caused to start the operation related to start of printing on the recording medium and the recording head is moved by the power source to a position at which a position of the recording medium relative to the plurality of recording elements in a direction in which the recording head set with respect to the recording medium reciprocally moves is overlapped on a position at which the recording elements are caused to start the operation related to the start of printing.

[0020] According to an invention described in claim 10, in the image forming apparatus according to any one of claims 1 to 9,

the load control unit sets, as a magnitude of a load amount caused by the resistor element, a load amount that is 50% of a load amount applied to the voltage control unit in the case where the drive voltage is supplied to all load elements of the plurality of recording elements.

[0021] According to an invention described in claim 11, in the image forming apparatus according to claim 10, the load control unit adjusts, with PWM control, a period in which the drive voltage is supplied to the resistor element so that the load amount caused by the resistor element has the set magnitude.

[0022] According to an invention described in claim 12, in the image forming apparatus according to claim 1, the load control unit includes a buffer storage unit for sequentially storing image data to be formed, and output determination means for determining whether to operate at least one load element of the recording element in each block in which image formation of the stored image data to be formed is simultaneously performed, and

in the case where the output determination means acquires data of a block in which the load element of the recording element is operated, the drive voltage is supplied to the resistor element until the load element is operated by the drive unit on the basis of the data of the block.

[0023] According to an invention described in claim 13, in the image forming apparatus according to claim 12, the output determination means counts the number of operations of the load elements of the recording elements operated in the each block, and the load control unit determines a magnitude of a load amount caused by the resistor element on the basis of the number of operations in a first predetermined number of blocks after the drive unit changes over from the non-

driving state to the driving state.

[0024] According to an invention described in claim 14, in the image forming apparatus according to claim 13, the load control unit adjusts, with PWM control, a period in which the drive voltage is supplied to the resistor element so that a load amount caused by the resistor element has the set magnitude.

[0025] According to an invention described in claim 15, in the image forming apparatus according to any one of claims 12 to 14,

when a time after the drive voltage is changed in the case where the drive voltage is supplied to the resistor element until the drive voltage is converged at a predetermined drive voltage is defined to be a response time, the load control unit controls the switching element so as to supply the drive voltage to the resistor element from the response time or more before the supply start timing at which the drive voltage is supplied to the load element of the recording element until the supply start timing.

[0026] According to an invention described in claim 16, in the image forming apparatus according to claim 15, the response time is equal to or more than a time required for forming an image of two blocks.

[0027] According to an invention described in claim 17, in the image forming apparatus according to any one of claims 1 to 16,

the recording head is an inkjet head, and the recording element is a nozzle and an ink ejection mechanism for ejecting ink from the nozzle.

[0028] According to an invention described in claim 18, in the image forming apparatus according to any one of claims 1 to 17, the load element of the recording element is a piezoelectric element.

Advantageous Effects of Invention

[0029] According to the present invention, in an image forming apparatus, it is possible to output a drive voltage with a simple configuration more stably with respect to a change in load caused by start of operation of a recording element.

Brief Description of Drawings

[0030]

Fig. 1 is a block diagram showing an internal configuration of an inkjet recording apparatus.

Fig. 2 is an explanatory view of a circuit configuration related to supply of electric power to an inkjet head. Fig. 3A is a schematic diagram showing a relationship between an output voltage of a DC/DC conversion unit and a head load.

Fig. 3B is a schematic diagram showing a relationship among an output voltage of a DC/DC conversion unit, a resistance load, and a head load in an inkjet recording apparatus of this embodiment.

Fig. 3C is a schematic diagram showing a load pattern obtained in the case where a resistance load is subjected to PWM control.

Fig. 4 is a flowchart showing a control procedure of load control processing.

Description of Embodiments

[0031] Hereinafter, an embodiment of the present invention will be described with reference to the drawings.

[0032] Fig. 1 is a block diagram showing an internal configuration of an inkjet recording apparatus 1 which is an embodiment of an image forming apparatus of the present invention.

[0033] The inkjet recording apparatus 1 includes a line head in which a plurality of nozzles is arranged over a width of a recording medium, the width being a width in which an image can be formed, in a width direction vertical to a conveyance direction of the recording medium on which an image is to be formed, and employs a one-pass method in which an image is formed in each row (line) extending in the width direction by controlling a timing at which ink is ejected from each nozzle of the fixed line head and conveying the recording medium. This line head is formed by arranging a plurality of inkjet heads 70 (recording heads) in parallel. In each of the inkjet heads 70, ink channels for supplying ink to a predetermined number of nozzles, for example, 1024 nozzles, respectively, which are aligned and are alternately arranged in two rows extending in parallel in the width direction and pressurization mechanisms 72 (see Fig. 2) for pressurizing ink in the ink channels and ejecting the ink from the nozzles are provided. As the pressurization mechanisms 72, piezoelectric elements for deforming the ink channels (pressure chambers) are used herein.

[0034] A combination (ink ejection mechanism) of the nozzle, the ink channel corresponding thereto, and the pressurization mechanism 72 forms a recording element. Among them, the pressurization mechanism 72 serves as a load element.

[0035] The inkjet recording apparatus 1 includes a control unit 10, a storage unit 20, a voltage control unit 30 of a power supply unit 90, a load control unit 35, a communication unit 40, an operation display unit 50, a conveyance unit 60, a head drive unit 71 (drive unit) of the inkjet head 70, and the like.

[0036] The control unit 10 controls various kinds of operation of the inkjet recording apparatus 1. The control unit 10 includes a CPU (Central Processing Unit) 101, a RAM (Random Access Memory) 102, and the like. The CPU 101 performs arithmetic processing and outputs control signals related to operation control to each unit. The RAM 102 is a volatile memory and provides a working memory space to the CPU 101 and stores temporary data.

[0037] The storage unit 20 stores acquired image data that is an image forming target, intermediate data and raster image data processed for forming an image, and

the like and further stores various kinds of setting data and the like. The storage unit 20 includes a volatile memory such as a DRAM, a nonvolatile memory such as a flash memory, and an HDD (Hard Disk Drive), each of which has an appropriate capacity.

[0038] In the power supply unit 90, the voltage control unit 30 outputs a drive voltage to be supplied to the pressurization mechanism 72 of the nozzle of the inkjet head 70 from an electric power supply unit 37 (see Fig. 2) and adjusts a load of electric power to be supplied as the drive voltage of the nozzle (see Fig. 2). The voltage control unit 30 is provided for each of the plurality of the inkjet heads 70 and can be independently controlled. In the case where the number of nozzles is large as compared to a capacity of electric power of the voltage control unit 30, a plurality of voltage control units 30 may be provided with respect to a single inkjet head 70 and may be used in parallel.

[0039] The load control unit 35 calculates a change in load amount in the inkjet head 70 in advance and performs control for applying a load amount corresponding to the load amount to a dummy resistor element 33 described below.

[0040] The voltage control unit 30 and the load control unit 35 will be described below.

[0041] The communication unit 40 is an interface for performing communication to a print server or an external computer terminal and includes, for example, a network card and a control module of wireless LAN. The control unit 10 receives image data that is an image forming target, a print job related to image formation, and the like and transmits status data via the communication unit 40.

[0042] The operation display unit 50 includes a display screen for displaying an operation menu and a status and an operation unit for accepting operation from a user. The display screen is not particularly limited and is, for example, a liquid crystal display (LCD). Various kinds of display are performed in response to drive signals generated in a liquid crystal driver on the basis of control signals output from the control unit 10.

[0043] The operation unit is a touchscreen including a touch sensor overlapped on this LCD. In addition, push button switches related to supply of power, reset, and the like may be provided on the operation unit. When the operation unit detects user's operation, the operation unit converts operation information to electrical signals and outputs the electrical signals to the control unit 10.

[0044] The conveyance unit 60 moves a recording medium on which an image is to be formed to an image forming position corresponding to the inkjet head 70 and discharges the recording medium from the image forming position after the image is formed. The conveyance unit 60 is a conveyance base for circularly moving a ring-shaped belt with the use of a motor, a conveyance drum for rotating a cylindrical drum with the use of a motor, or a linear stage on which a conveyance base is linearly operated. The conveyance unit 60 includes an encoder 61 (first measurement unit), and the encoder 61 can

measure, for example, a distance at which the recording medium is conveyed by the conveyance unit 60 by setting a value of a start position of conveyance performed by the conveyance unit 60 to "0".

[0045] In the inkjet head 70, the head drive unit 71 outputs a drive voltage signal for performing ink ejection operation at a timing appropriate for each nozzle in accordance with input raster image data to the pressurization mechanism 72 corresponding to the nozzle.

[0046] Fig. 2 is an explanatory view of a circuit configuration related to supply of electric power to the inkjet head 70.

[0047] In the inkjet head 70, the head drive unit 71 includes a decoder circuit 711 for decoding input image data and outputting a drive signal in accordance with drive pulse and a driver circuit 712 for outputting any one of a ground voltage and a drive voltage input from the voltage control unit 30 to the pressurization mechanism 72 of each nozzle on the basis of the output drive signal. Herein, although only a single pressurization mechanism 72 and a circuit configuration related to output of a drive voltage to the pressurization mechanism 72 are shown, the number of pressurization mechanisms and circuit configurations corresponding to the number of nozzles are provided electrically in parallel to one another. The decoder circuit 711 individually performs switching for switching whether to apply drive pulse to the pressurization mechanism 72 and is configured so that a driving state and a non-driving state are switched by the switching in a state in which ink ejection operation is not performed.

[0048] The voltage control unit 30 converts a signal having a predetermined input voltage output from the electric power supply unit 37 to a drive voltage suitable for driving each nozzle and outputs the drive voltage to the inkjet head 70 (head drive unit 71). The voltage control unit 30 includes a DC/DC conversion unit 31, a compensation circuit 32, and the like.

[0049] The DC/DC conversion unit 31 is a circuit for converting a predetermined DC voltage input by using PWM (Pulse Width Modulation) control to a drive voltage. A detailed circuit configuration of the DC/DC conversion unit 31 can be any known configuration and, herein, includes, for example, a switching element for switching whether to input a DC voltage, a coil connected in series to the switching element, a diode provided between an upstream side of the coil and a ground, and a smoothing capacitor provided between a downstream side of the coil and the ground. The switching element is subjected to opening/closing control so that a set voltage (herein, drive voltage) is output and is subjected to opening/closing drive by the compensation circuit 32 on the basis of a change in feedback voltage.

[0050] The compensation circuit 32 feeds back an output voltage of the DC/DC conversion unit 31 and performs switching operation of the switching element so that, in the case where the output voltage is changed, operation of the DC/DC conversion unit 31 is changed to suppress

the change.

[0051] A plurality of voltage control units 30 may be provided. For example, the DC/DC conversion unit 31 whose output voltage is 9 V and a DC/DC conversion unit whose output voltage is 18 V may be provided and a drive voltage to be output may be appropriately switched.

[0052] One end of the resistor element 33 is connected to output of the DC/DC conversion unit 31, whereas the other end thereof is connected to a switching element 34. A resistance value of the resistor element 33 is set so that, in the case where the switching element 34 is on, a current flowing through the resistor element 33 and the switching element 34 is not unnecessarily increased.

[0053] The switching element 34 is a switch for switching whether to electrify the resistor element 33, and one end of the switching element 34 is connected to the resistor element 33, whereas the other end thereof is grounded. On/off of the switching element 34 is controlled on the basis of a control signal from the load control unit 35. That is, when the switching element 34 is turned on, an output voltage of the DC/DC conversion unit 31 is applied to both ends of the resistor element 33 and a current flows to a ground plane. At this time, when a switching element of the head drive unit 71 is released and the inkjet head 70 enters the non-driving state, the output voltage of the DC/DC conversion unit 31 is not applied to the pressurization mechanism 72 of the inkjet head 70. Meanwhile, when the switching element 34 is turned off, the resistor element 33 enters a floating state, and, when the inkjet head 70 enters the driving state in this state, the output voltage of the DC/DC conversion unit 31 is applied to the inkjet head 70 (i.e., the pressurization mechanism 72 corresponding to a nozzle that ejects ink).

[0054] The switching element 34 is an FET (Field Effect Transistor) such as an n-channel MOSFET. Although this FET desirably has low resistance, an appropriate FET is selected in accordance with an expected load range. Alternatively, the switching element 34 may be a bipolar transistor, and a control signal from the load control unit 35 may be applied to a base terminal.

[0055] The load control unit 35 reads raster image data for forming an image, detects a start timing of ink ejection in advance, and causes the switching element 34 to operate on the basis of an amount of ejection of ink for a predetermined row (predetermined block) after the ink ejection is started, and therefore the resistor element 33 applies, to the DC/DC conversion unit 31, a load corresponding to a load of the pressurization mechanism 72 that is needed for ejection operation of the amount of ink ejected in the predetermined row before the ink ejection is actually started.

[0056] The load control unit 35 includes a CPU 351 (output determination means) and a RAM 352 (buffer storage unit). The RAM 352 can store a predetermined number of rows of data of an image to be formed before the data is output to the inkjet head 70. Herein, the RAM

352 can store raster image data for the number of "N+X" rows and functions as a buffer from which, in the case where raster image data for the next row is input, data for the earliest acquired row is output to the inkjet head 70.

[0057] The number of rows "N" corresponds to a response time of the DC/DC conversion unit 31 to a change in load. Further, the number of rows "X" (predetermined number of blocks) is the number of rows used for acquiring an amount of ejection of ink in order to determine a magnitude of a load applied to the DC/DC conversion unit 31 by using the load control unit 35. The CPU 351 performs switching control of the switching element 34 on the basis of the raster image data stored in the RAM 352.

[0058] As described above, in the case where the plurality of voltage control units 30 is provided, the plurality of voltage control units 30 can be controlled by the single load control unit 35 in such a manner that: the resistor elements 33 and the switching elements 34 corresponding to the respective voltage control units 30 are provided; the common load control unit 35 is used; the DC/DC conversion unit 31 to which a voltage is input from the electric power supply unit 37 is selected; and switching control of operation of the switching elements 34 related to on/off of supply of a voltage to the resistor elements 33 is collectively performed.

[0059] A method of controlling an output voltage of the DC/DC conversion unit 31 will be described.

[0060] Fig. 3A is a schematic diagram showing a relationship between an output voltage of the DC/DC conversion unit and a head load.

[0061] In the case where consumption power is large as compared with a capacity of electric power of the DC/DC conversion unit 31, the output voltage of the DC/DC conversion unit 31 is reduced from a voltage set in advance in accordance with a magnitude of the consumption power. In the case where, in a state in which the switching element 34 is released (off), the inkjet head 70 is in the non-driving state, i.e., no load is applied, consumption power has a substantially ignorable magnitude and voltage drop does not occur (period p1).

[0062] Then, in the case where driving of the inkjet head 70 is started at the time of 0.4 ms (supply start timing) and a drive voltage is applied to the pressurization mechanism 72 (piezoelectric element) for ejecting ink from the nozzle to thereby generate a load, a voltage output by the DC/DC conversion unit 31 drops and changes (period p2). An amount of this reduction is determined in accordance with the capacity of electric power of the DC/DC conversion unit 31 and the magnitude of the consumption power. A duration time (response period) of this change is determined in accordance with a time constant based on a magnitude of an effect of operation (pulse frequency of PWM, variable width of pulse, and the like) performed in order that the compensation circuit 32 stabilizes a voltage with respect to damped oscillation generated in accordance with inductance of the coil included in the DC/DC conversion unit 31, a capacity of

the capacitor included therein, and a magnitude of the load related to driving of the inkjet head 70. Herein, as described above, voltage drop occurs over a length corresponding to N times with drive pulse indicating an ink ejection timing. This voltage drop accompanies overshoot. Thereafter, the output voltage is stabilized within a voltage drop range having a level corresponding to the load (period p3).

[0063] This response time (time constant) can be determined by using a calculation value of a change in voltage obtained by numerical value simulation of the voltage control unit 30. For example, a moving average of voltage values within a predetermined time width (for example, an average value of a voltage value at a target time and a voltage value a predetermined time therebefore), an integrated value of an absolute value of an amount of voltage change, and the like are obtained, and a timing at which the former change amount or the latter value becomes equal to or less than a predetermined level (for example, $\pm 1.0\%$ or less of an initial variable amplitude (difference between drive voltages before and after change)) is set as a timing at which a change level is sufficiently attenuated and is converged at a changed drive voltage. This makes it possible to obtain a response time while eliminating an influence of maximum or minimum of a voltage caused by, for example, on/off of the resistor element 33.

[0064] Herein, in order to calculate the response time related to the voltage control unit 30, it is unnecessary to actually perform calculation of numerical values with the use of a circuit related to the head drive unit 71 and the inkjet head 70, and it is only necessary to perform the calculation of numerical values by determining a resistance value of the resistor element 33 so that, in the case where the switching element 34 is turned on, a load corresponding to the load generated in the inkjet head 70 is generated in the resistor element 33. As the load corresponding to the load generated in the inkjet head 70, for example, a resistance value can be set so that a total consumption current obtained in the case where a predetermined drive voltage is applied to the pressurization mechanisms 72 of all the nozzles of the inkjet head 70 flows through the resistor elements 33. For example, in the case where a total consumption current of 0.5 A is caused to flow by applying a drive voltage to all the nozzles of the inkjet head 70 including 512 nozzles, a resistance value for causing the consumption current to flow is $30.4\ \Omega$. In a simulation same as a pattern shown in Fig. 3A, a drive voltage is supplied to the resistor elements 33 at a cycle of $20\ \mu\text{s}$ from a timing of 0.4 ms in the form of pulse, and, as a result, the drive voltage of 15.2 V is reduced to the drive voltage of about 15.05 V and is converged at a variable amplitude of $\pm 1.5\ \mu\text{V}$ or less after $300\ \mu\text{s}$ (15 cycles) is passed.

[0065] Fig. 3B is a schematic diagram showing a relationship among an output voltage of the DC/DC conversion unit, a resistance load, and a head load in the inkjet recording apparatus according to this embodiment. Fig.

3C is a schematic diagram showing a load pattern obtained in the case where a resistance load is subjected to the PWM control.

[0066] In the inkjet recording apparatus 1 according to the invention of the present application, as shown in Fig. 3B, the inkjet head 70 enters the driving state at a timing of time = 0.4 ms, and, before supply of a drive voltage to the pressurization mechanism 72 is started and in a period in which the drive voltage is not supplied to any of the pressurization mechanisms 72 of the nozzles, i.e., in a period (period q1) in which the head load is zero, the switching element 34 is turned on and a load is applied in advance to the DC/DC conversion unit 31 by the resistor element 33. Herein, when drive pulse is input N times before (in the example related to the above-described simulation, 15 times before) the supply start timing (a predetermined time therebefore), i.e., between a response time or more before the supply start timing of the drive voltage and a time immediately before the inkjet head is switched to the driving state, the switching element 34 is turned on and the output voltage of the DC/DC conversion unit 31 is supplied to the resistor element 33. As a result, driving operation related to ink ejection is started in a stable state in which the output voltage from the DC/DC conversion unit 31 has already been reduced (period q2).

[0067] Even in the case where the switching element 34 is turned on after the drive pulse is input N times therebefore or the case where the switching element 34 is turned off before the supply start timing of the drive voltage, unless a time after the switching element is turned off is long and a voltage reduced once completely returns to the original output voltage, the output voltage from the DC/DC conversion unit 31 is not completely reduced to a value corresponding to the load of the resistor element 33, but an amount of reduction of the drive voltage after the supply start timing of the drive voltage becomes smaller than an amount of reduction thereof in the case shown in Fig. 3A, and the drive voltage quickly becomes a value corresponding to the load of the pressurization mechanism 72. That is, the switching element 34 is turned on for a predetermined period (at least a partial period) before the supply start timing of the drive voltage and causes the resistor element 33 to generate a load so that the drive voltage of the pressurization mechanism 72 is small as compared with an original state at the supply start timing.

[0068] In this case, it is preferable to set and control a period in which the switching element 34 is on so that a drop amount of the output voltage at a supply start time of the drive voltage (a drop amount temporarily occurring only in the vicinity of the top of the period q2) is smaller than a drop amount of the output voltage in the period q1 caused by turning on the switching element 34 (at the supply start time of the output voltage to the resistor element 33).

[0069] The load applied to the DC/DC conversion unit 31 by the resistor element 33 may be continuously set

as shown in Fig. 3B or may be intermittent as shown in Fig. 3C by determining a duty ratio with the PWM control in accordance with a magnitude of a load expected after the inkjet head enters the driving state. In this case, the switching element 34 is switched on/off at a time ratio corresponding to the duty ratio. Each timing at which the switching element 34 is turned on can be synchronized with the drive pulse, and, in this case, the drive pulse is also input to the load control unit 35.

[0070] As described above, a dropped voltage can be set by adjusting the magnitude of the load more precisely with the PWM control. Therefore, after driving of the inkjet head 70 is started, the voltage can be stabilized more quickly to have a voltage value obtained after voltage drop caused by nozzle operation.

[0071] Switching operation of the switching element 34 will be described.

[0072] Fig. 4 is a flowchart showing a control procedure of load control processing executed by the load control unit 35.

[0073] This load control processing is started as a part of image forming processing when an image forming command and image data that is an image forming target are received from an external print server or the like. The image data in this case may be image data of a single sheet (one page) of a recording medium that is a target to be output or may be image data of each page in image data of a plurality of pages. In, for example, a scanning inkjet recording apparatus described below, in the case where a recording image is formed in the unit of band on the same page or the like and a recording medium is successively conveyed by the conveyance unit 60 every time when the image is intermittently formed in the unit of band, the load control processing may be started in accordance with a data input start timing, a data processing start timing, or the like of each band.

[0074] When the load control processing is started, the CPU 351 first starts the DC/DC conversion unit 31 and the compensation circuit 32 and performs initial setting (Step S201). In this state, a drive voltage is output to the inkjet head 70 and then is not applied to the load element (piezoelectric element) of each nozzle, which is the non-driving state.

[0075] The control unit 10 permits the CPU 351 to read raster image data that is an image forming target, and the CPU 351 starts reading data of each row of the raster image data (Step S202).

[0076] The CPU 351 determines whether to eject ink from the nozzles in the read lines and counts the number (the number of operations) of nozzles that eject ink (Step S203).

[0077] The CPU 351 determines whether or not the counted number of ink ejection nozzles is "0" (Step S204). In the case where it is determined that the number of ink ejection nozzles is "0" ("YES" in Step S204), processing of the CPU 351 proceeds to Step S207. At this time, the CPU 351 counts the number of rows in which the number of ink ejection nozzles is continuously

determined to be "0".

[0078] In the case where it is determined that the number of ink ejection nozzles is not "0" ("NO" in Step S204), the CPU 351 determines whether or not the number of ink ejection nozzles has been "0" in consecutive "N+X" or more rows before a previous row (Step S205). In the case where it is determined that the number of ink ejection nozzles has not been "0" in the consecutive "N+X" or more rows ("NO" in Step S205), the processing of the CPU 351 proceeds to Step S207. In the case where it is determined that the number of ink ejection nozzles has been "0" in the consecutive "N+X" or more rows ("YES" in Step S205), the CPU 351 turns on (sets) a flag indicating that ink ejection is started or restarted in a state in which ink ejection has not been performed (Step S206). Then, the processing of the CPU 351 proceeds to Step S207.

[0079] When the processing proceeds to processing in Step S207, the CPU 351 determines whether or not the flag is on (Step S207). In the case where it is determined that the flag is not on ("NO" in Step S207), the processing of the CPU 351 proceeds to Step S211. In the case where it is determined that the flag is on ("YES" in Step S207), the CPU 351 determines whether or not a value of the number of ink ejection nozzles for "X" rows has been acquired since the flag had been turned on (Step S208). In the case where it is determined that the value has not been acquired ("NO" in Step S208), the processing of the CPU 351 proceeds to Step S211.

[0080] In the case where it is determined that the value of the number of ink ejection nozzles for "X" rows has been acquired ("YES" in Step S208), the CPU 351 determines an output voltage control level from the DC/DC conversion unit 31 on the basis of the acquired value of the number of ink ejection nozzles (Step S209). The CPU 351 starts control of the drive voltage in accordance with the determined output voltage control level (Step S210). Then, the processing of the CPU 351 proceeds to Step S211.

[0081] When the processing in Steps S207, S208, S210 proceed to processing in Step S211, the CPU 351 determines whether or not the flag is in an on state and the drive voltage has been controlled during input/output of the raster image data for N rows (Step S211). In the case where it is determined that the flag is in the on state and the drive voltage has been controlled during input/output of the raster image data for the N rows ("YES" in Step S211), the CPU 351 terminates the control of the drive voltage and turns off (resets) the flag (Step S212). Then, the processing of the CPU 351 proceeds to Step S213. In the case where it is determined that the flag is not in the on state or the drive voltage has not been controlled during input/output of the raster image data for the N rows ("NO" in Step S211), the processing of the CPU 351 directly proceeds to Step S213.

[0082] When the processing proceeds to processing in Step S213, the CPU 351 outputs the oldest data that is currently stored in the RAM 352 to the inkjet head 70

(Step S213). At this time, in the processing in Step S212, the CPU 351 transmits a command to the inkjet head 70 so that the inkjet head 70 changes over to the driving state at the same time that the CPU 351 cancels the control of the drive voltage, and therefore the non-driving state is maintained immediately before driving operation is started.

[0083] The CPU 351 determines whether or not data of all rows related to the image to be output has been output (Step S214). In the case where it is determined that the data of all the rows has not been output (there is data that has not been output yet) ("NO" in Step S214), the processing of the CPU 351 returns to Step S203. In the case where it is determined that the data of all the rows has been output ("YES" in Step S214), the CPU 351 performs setting related to termination of output of the drive voltage (Step S215). The CPU 351 can cause the inkjet head 70 to change over to the non-driving state after driving of the inkjet head 70 related to data of a row that has been last output is terminated. Then, the load control processing is terminated.

[0084] Herein, the case where a determination result is "YES" in the determination processing in Step S205 can include the case where a margin at the top of a page at the time of start of image formation is shifted to an image forming range and the case where, in the case where a blank part is included in the middle of image formation, the blank part is shifted to an image forming part. Considering the above-described cases, the inkjet head can temporarily change over to the non-driving state in the case where the determination results are "YES" in the consecutive (N+X) rows in the processing in Step S204. With this, operation of the nozzles in the head drive unit 71 is not performed in a blank part.

[0085] As described above, the inkjet recording apparatus 1 includes: the inkjet head 70 in which the plurality of nozzles is arranged; the head drive unit 71 for supplying a drive voltage to the pressurization mechanism 72 (piezoelectric element) of each of the nozzles on the basis of image data to be formed and operating the pressurization mechanism 72; the voltage control unit 30 for performing control operation so as to suppress a change in the drive voltage to be supplied to the head drive unit 71; the resistor element 33 connected to the voltage control unit 30 and provided to correspond to the pressurization mechanism 72 (piezoelectric element); the switching element 34 for switching whether to supply an output voltage from the DC/DC conversion unit 31 to the resistor element 33; and the load control unit 35 for controlling the switching element 34 so that the output voltage from the DC/DC conversion unit 31 is supplied to the resistor element 33 before a supply start timing at which supply of the output voltage to the pressurization mechanism 72 is started and in at least a part of a period in which the drive voltage is not supplied to any pressurization mechanism 72.

[0086] As described above, when, before supply of the drive voltage to each pressurization mechanism 72 of

the inkjet recording apparatus 1 is started to cause each nozzle to start ink ejection operation, the output voltage is supplied in advance to the resistor element 33 from the DC/DC conversion unit 31, it is possible to apply in advance a load corresponding to a load related to the ink ejection operation to the DC/DC conversion unit 31. This makes it possible to achieve a state in which the output voltage from the DC/DC conversion unit 31 (i.e., the drive voltage to the pressurization mechanism 72) has already been reduced at the time of start of the ink ejection operation. Thus, a change in the drive voltage generated at the supply start time of the drive voltage to the pressurization mechanism 72 can be reduced more easily than before. This makes it possible to form an image having a stable density by suppressing reduction of density of ink or generation of unevenness thereof in the vicinity of the top of the formed image.

[0087] It is possible to suppress reduction or unevenness of density of ink with simple software control, and therefore it is unnecessary to increase the capacity of the smoothing capacitor to increase the size thereof or complicate a hardware configuration in order to reduce a response time to a change in voltage in the voltage control unit 30.

[0088] Supply of the drive voltage from the DC/DC conversion unit 31 to the pressurization mechanism 72 is started in a state in which the output voltage from the DC/DC conversion unit 31 is reduced by supplying the output voltage (drive voltage) to the resistor element 33, and therefore it is possible to reduce a magnitude or length of an abrupt change in the drive voltage generated when the non-driving state changes over to the driving state.

[0089] An amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the pressurization mechanism 72 is controlled to be equal to or less than an amount of reduction of the output voltage at the supply start time of supplying the output voltage from the DC/DC conversion unit 31 to the resistor element 33, and therefore it is possible to suppress more effectively the change in the drive voltage at the time of start (restart) of image formation and therefore to reduce generation of unevenness and the like of density of ink.

[0090] The amount of reduction of the drive voltage at the supply start time of supplying the drive voltage to the pressurization mechanism 72 of the nozzle is controlled to be smaller than an amount of reduction of the drive voltage at a virtual supply start time of supplying the drive voltage to the pressurization mechanism 72 without supplying the output voltage to the resistor element 33 as shown in Fig. 3A, i.e., a supply period of the output voltage to the resistor element 33 is appropriately defined, and therefore it is possible to easily reduce generation of unevenness of density of ink caused by the change in the drive voltage at the supply start timing of the drive voltage to the pressurization mechanism 72 thereafter.

[0091] When a time after the output voltage is changed in the case where the output voltage is supplied to the

resistor element 33 from the DC/DC conversion unit 31 until the output voltage is converged at a predetermined output voltage (drive voltage) is defined to be a response time, the load control unit 35 controls the switching element 34 so as to supply the output voltage to the resistor element 33 from a response time or more before the supply start timing at which the drive voltage is supplied to the pressurization mechanism 72 of the nozzle until the supply start timing. That is, the output voltage is supplied to the resistor element 33 for a suitable time until the drive voltage is reduced in accordance with the load of the resistor element 33 and is stabilized, and therefore it is possible to suppress more effectively the change in the drive voltage at the supply start time of the drive voltage. Further, it is unnecessary to cause a current to unnecessarily flow through the resistor element 33, and therefore it is possible to suppress an unnecessary increase in consumption power.

[0092] The supply start timing of the drive voltage includes a timing at which the drive voltage is supplied to the pressurization mechanism 72 of the nozzle at the time of start of image formation of one page. That is, a change in the drive voltage, which is caused by interrupting driving of the pressurization mechanism 72 between pages in the case where image formation is performed in the unit of page, is effectively suppressed every time, and therefore it is possible to suppress unevenness of density of ink or the like from being generated in the vicinity of the top of each page.

[0093] The conveyance unit 60 for conveying a recording medium P on which an image is to be formed by the inkjet head 70 is provided, and the conveyance unit 60 includes the encoder 61. A position of the recording medium P relative to the nozzle is acquired by the encoder 61 measuring a moving distance of the recording medium P after conveyance is started. In addition, the supply start timing of the drive voltage is a timing at which the recording medium P conveyed by the conveyance unit 60 is conveyed by the conveyance unit 60 to a position at which, in a conveyance direction in which the recording medium P is conveyed by the conveyance unit 60, the position (printing start position) of the recording medium P relative to the plurality of nozzles set with respect to the recording medium P is overlapped on a position at which the nozzles start ejecting ink. Therefore, the moving distance of the recording medium P before the supply start timing of the drive voltage corresponding to the response time is calculated back on the basis of conveyance speed at which the recording medium P is conveyed by the encoder 61, and therefore it is possible to appropriately turn on the switching element 34 to thereby supply the drive voltage to the resistor element 33 a time corresponding to the response time before.

[0094] Note that, in the case where a scanning image forming apparatus is used instead of the one-pass image forming apparatus including the line head, an inkjet head has a predetermined length in a conveyance direction while reciprocally moving in the width direction of the

recording medium P which is a direction orthogonal to the conveyance direction along a guide rail by using a power source (for example, motor) and forms, on the recording medium P, an image in the unit of band (image of one band) extending over the width of the recording medium P in the width direction. The conveyance unit 60 forms the whole image by repeating operation of moving the recording medium P at the above-described each predetermined length every time when the image in the unit of band is formed. In the case where the scanning image forming apparatus is used, for example, it is preferable that a moving distance of the recording head in the width direction be measured by further providing, in addition to the encoder 61 described above, a second encoder (second measurement unit) in a rotating shaft of the motor for reciprocally moving the recording head and setting one end of the width direction in which the recording head is reciprocally moved to "0". In the above-described case, the supply start timing of the drive voltage is a time at which the recording medium P conveyed by the conveyance unit 60 reaches the printing start position set with respect to the recording medium P and the recording head moves to a position of the recording medium relative to the plurality of recording elements in the direction in which the recording head set with respect to the recording medium P reciprocally moves. Therefore, in the case where the scanning image forming apparatus is used, the moving distance at which the recording medium P is moved by the conveyance unit 60 and the moving distance of the recording head that is reciprocally moved by the power source are set as the printing start position.

[0095] In the above description, there has been described an example where the moving distance of the recording head is measured by providing the second encoder in the rotating shaft of the motor for reciprocally moving the recording head and setting one end of the width direction in which the recording head is reciprocally moved to "0". However, for example, the moving distance of the recording head may be measured by separately providing a linear scale in the guide rail and reading the linear scale with the use of an optical sensor such as a CCD camera or a magnetic sensor.

[0096] This configuration, as well as the one-pass inkjet recording apparatus, can also appropriately acquire in advance the supply start timing of the drive voltage to thereby apply the output voltage to the resistor element 33 in an appropriate period and can reduce the change in the drive voltage at the supply start time of the drive voltage.

[0097] In the scanning inkjet recording apparatus, driving of the pressurization mechanism 72 is interrupted every time when an image of one band is formed, and therefore, by applying the output voltage to the resistor element 33 in advance in accordance with the supply start timing of the drive voltage related to start of image formation of each band, it is possible to reduce the change in the drive voltage at the time of the start of

image formation of each band and unevenness of density of ink caused by this change.

[0098] When a load amount, which is 50% of the load amount applied to the voltage control unit 30 (DC/DC conversion unit 31) in the case where the drive voltage is supplied to all the nozzles of the inkjet head 70, is set as the magnitude of the load amount generated in the inkjet head 70, control can be performed more easily, and a magnitude of shift from an actual load amount can be reduced by half, as compared with a conventional load amount.

[0099] The load control unit 35 adjusts, with the PWM control, a period in which the output voltage (drive voltage) is applied to the resistor element 33 so that the load caused by the resistor element 33 has a magnitude determined in advance, and therefore it is possible to apply an appropriate load to the DC/DC conversion unit 31 with easy control by using a single resistor element 33 without unnecessarily increasing constituent elements.

[0100] The load control unit 35 includes the RAM 352 for sequentially storing image data to be formed and the CPU 351. The CPU 351 serving as the output determination means determines whether to operate the pressurization mechanism 72 of at least one nozzle in each row in which image formation of the stored image data to be formed is simultaneously performed, and, in the case where data of a row in which the pressurization mechanism 72 of at least one nozzle is operated is acquired, the CPU 351 applies the drive voltage to the resistor element 33 after the head drive unit 71 applies the drive voltage to the pressurization mechanism 72 on the basis of the data of the row until the pressurization mechanism 72 is operated.

[0101] Therefore, it is possible to easily detect a start timing of the nozzle operation in advance and electrify the resistor element 33 at an appropriate timing.

[0102] Herein, the term "simultaneously" indicates a range in which output periods of drive voltage pulse are partially or fully overlapped.

[0103] The CPU 351 serving as the output determination means counts the number (the number of operations) of pressurization mechanisms 72 operated in each row on the basis of data of the each row stored in the RAM 352, and the load control unit 35 determines the magnitude of the load caused by the resistor element 33 on the basis of the number of operations of the nozzles in first X rows after the head drive unit 71 changes over from the non-driving state to the driving state. That is, the output voltage of the DC/DC conversion unit 31 is changed in advance to a corresponding drop voltage in accordance with a magnitude of voltage drop from the non-driving state to the driving state, and therefore it is possible to suppress more effectively a change in the voltage after operation of the pressurization mechanisms 72 is actually started.

[0104] The voltage is supplied to the resistor element 33 the response time before, the response time being equal to or longer than a time required for outputting data

of two or more rows, and therefore it is possible to stabilize in advance a supply voltage at a level corresponding to the number of operations of the nozzles by effectively using raster data of an image to be formed which has been stored in the RAM 352.

[0105] When the present invention is particularly applied to an inkjet recording apparatus including the inkjet head 70 for ejecting ink to form an image, the inkjet head 70 being an inkjet head in which the plurality of nozzles is arranged, it is possible to form an image while further stabilizing density of ink which sensitively reacts to the drive voltage.

[0106] The voltage supplied to the piezoelectric element that is a load element is stably controlled, and therefore it is possible to accurately control a deformation amount of the piezoelectric element to suppress generation of unevenness of a formed image.

[0107] Note that the present invention is not limited to the above-described embodiment and can be variously changed.

[0108] For example, in the above-described embodiment, image data is actually acquired and whether to drive the head drive unit 71 is determined in advance. However, more simply, in the case where an image is output without providing a margin on a recording medium or the case of an image in which the head is necessarily driven in a margin, image data may be output to the inkjet head 70 after the load is simply applied by the resistor element 33 for about a response time. Alternatively, information about lines in which the nozzle is not continuously operated may be generated in advance in the case where raster image data for forming an image is generated, and the load control unit 35 may operate the switching element 34 on the basis of the information, instead of performing control in real time.

[0109] The DC/DC converter and the compensation circuit are used to output the drive voltage. However, the drive voltage may be output by using another configuration related to DC voltage control, such as a 3-terminal regulator.

[0110] The resistor element 33 is not limited to one resistor. A plurality of resistors may be arranged in series or in parallel and may be collectively or individually subjected to switching control. As the resistor element 33, an element for limiting a current such as a constant current diode may be used.

[0111] In the above-described embodiment, the CPU 351 counts the number of ink ejection nozzles. However, the flag may be a flag for simply determining whether to eject ink. In this case, the load caused by the resistor element 33 is set to a fixed value without depending on the number of ink ejection nozzles. The fixed value may be an average value or may correspond to a load generated in the case where 1/2 of all the center nozzles is driven (eject ink). With this, it is possible to reduce an amount of voltage change by at least half while further simplifying processing without changing the simple circuit configuration shown in Fig. 2.

[0112] In the above-described embodiment, although the case where ink is ejected from nozzles for one row at once has been described, the invention is not limited thereto. For example, in the case where the nozzles that are arranged in a pattern over a plurality of rows are considered as one block and all the nozzles simultaneously eject ink or the case where nozzle arrangement of a single row or a plurality of rows is divided into a plurality of blocks each of which has a predetermined row(s) and/or column (s) and ink is ejected in the each block, it is possible to perform control related to drive voltage drop in the unit of block to which the drive voltage is simultaneously applied.

[0113] In the above-described embodiment, although the configuration in which the head drive unit 71 is provided inside the inkjet head 70 has been described as an example, the head drive unit 71 may be provided outside the inkjet head 70. In this case, for example, a head drive unit for generating only a drive waveform on the basis of a drive voltage and drive pulse can be provided outside the inkjet head 70 and switching control of whether to output the drive waveform to the pressurization mechanism 72 can be performed in the inkjet head 70 on the basis of signals obtained by decoding image data.

[0114] In the above-described embodiment, the inkjet recording apparatus has been described an example. However, the present invention can also be applied to another apparatus for forming an image by using a combination of pixel points from a plurality of output elements, such as an LED printer.

[0115] Further, as those image forming apparatuses, the present invention can be applied to a piezoelectric inkjet recording apparatus, and, in addition, the present invention can be applied for suppressing a change in a voltage applied to a heater resistor that is a load element in a thermal inkjet recording apparatus.

[0116] In addition, the configuration described in the above-described embodiment and specific details such as a control procedure and numerical values can be appropriately changed within the scope of the present invention.

Industrial Applicability

[0117] The present invention can be used for image forming apparatuses.

Reference Signs List

[0118]

1	inkjet recording apparatus
10	control unit
101	CPU
102	RAM
20	storage unit
30	voltage control unit
31	DC/DC conversion unit

32 compensation circuit
 33 resistor element
 34 switching element
 35 load control unit
 351 CPU
 352 RAM
 37 electric power supply unit
 40 communication unit
 50 operation display unit
 60 conveyance unit
 61 encoder
 70 inkjet head
 71 head drive unit
 711 decoder circuit
 712 driver circuit
 72 pressurization mechanism
 90 power supply unit

Claims

1. An image forming apparatus, comprising:

a recording head in which a plurality of recording elements is arranged;
 a drive unit for supplying a drive voltage to a load element of each of the recording elements on the basis of image data to be formed and operating the load element;
 a voltage control unit for performing control so as to suppress a change in the drive voltage to be supplied to the drive unit;
 a resistor element connected to the voltage control unit and provided to correspond to the load element of the recording element;
 a switching element for switching whether to supply the drive voltage to the resistor element; and
 a load control unit for controlling the switching element so as to supply the drive voltage to the resistor element before a supply start timing at which the drive voltage is supplied to the load element of the recording element and in at least a part of a period in which the drive voltage is not supplied to any load element of the recording element.

2. The image forming apparatus according to claim 1, wherein

supply of the drive voltage to the load element of the recording element is started in a state in which the drive voltage is reduced by supplying the drive voltage to the resistor element.

3. The image forming apparatus according to claim 1, wherein

an amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the

load element of the recording element is equal to or less than an amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the resistor element.

4. The image forming apparatus according to claim 1 or 2, wherein

an amount of reduction of the drive voltage at a supply start time of supplying the drive voltage to the load element of the recording element is smaller than an amount of reduction of the drive voltage at the time of virtual supply start time of supplying the drive voltage to the load element of the recording element without supplying the drive voltage to the resistor element.

5. The image forming apparatus according to any one of claims 1 to 4, wherein

when a time after the drive voltage is changed in the case where the drive voltage is supplied to the resistor element until the drive voltage is converged at a predetermined drive voltage is defined to be a response time,

the load control unit controls the switching element so as to supply the drive voltage to the resistor element from the response time or more before the supply start timing at which the drive voltage is supplied to the load element of the recording element until the supply start timing.

6. The image forming apparatus according to any one of claims 1 to 5, wherein

the supply start timing includes a timing at which the drive voltage is supplied to the load element of the recording element at the time of start of image formation of one page.

7. The image forming apparatus according to any one of claims 1 to 5, wherein

the supply start timing includes a timing at which, in the case where image formation is performed by repeatedly moving the recording head along a recording medium and then forming an image of one band and conveying the recording medium and then forming an image of the next one band, the drive voltage is supplied to the load element of the recording element at the time of start of image formation of the one band.

8. The image forming apparatus according to any one of claims 1 to 5, comprising

a conveyance unit for conveying a recording medium on which an image is to be formed by the recording head, wherein

the conveyance unit includes a first measurement unit for measuring a position of the recording medium relative to the plurality of recording elements in a conveyance direction of the recording medium, and

the supply start timing is a timing at which the recording medium is conveyed by the conveyance unit to a position at which the position of the recording medium relative to the plurality of recording elements in the conveyance direction of the recording medium set with respect to the recording medium is overlapped on a position at which the recording elements are caused to start the operation related to start of printing on the recording medium.

9. The image forming apparatus according to any one of claims 1 to 5, comprising:

a conveyance unit for conveying a recording medium on which an image is to be formed by the recording head; and

a power source for reciprocally moving the recording head in a direction orthogonal to a conveyance direction of the recording medium, wherein

the conveyance unit includes a first measurement unit for measuring a position of the recording medium relative to the plurality of recording elements in the conveyance direction of the recording medium,

the power source includes a second measurement unit for measuring a position of the recording medium relative to the plurality of recording elements in the direction in which the recording head reciprocally moves, and

the supply start timing is a timing at which the recording medium is conveyed by the conveyance unit to a position at which a position of the recording medium relative to the plurality of recording elements in the conveyance direction of the recording medium set with respect to the recording medium is overlapped on a position in the conveyance direction of the recording medium at which the recording elements are caused to start the operation related to start of printing on the recording medium and the recording head is moved by the power source to a position at which a position of the recording medium relative to the plurality of recording elements in a direction in which the recording head set with respect to the recording medium reciprocally moves is overlapped on a position at which the recording elements are caused to start the operation related to the start of printing.

10. The image forming apparatus according to any one of claims 1 to 9, wherein
the load control unit sets, as a magnitude of a load amount caused by the resistor element, a load amount that is 50% of a load amount applied to the voltage control unit in the case where the drive voltage is supplied to all load elements of the plurality of recording elements.

11. The image forming apparatus according to claim 10, wherein
the load control unit adjusts, with PWM control, a period in which the drive voltage is supplied to the resistor element so that the load amount caused by the resistor element has the set magnitude.

12. The image forming apparatus according to claim 1, wherein
the load control unit includes
a buffer storage unit for sequentially storing image data to be formed, and
output determination means for determining whether to operate at least one load element of the recording element in each block in which image formation of the stored image data to be formed is simultaneously performed, and
in the case where the output determination means acquires data of a block in which the load element of the recording element is operated, the drive voltage is supplied to the resistor element until the load element is operated by the drive unit on the basis of the data of the block.

13. The image forming apparatus according to claim 12, wherein
the output determination means counts the number of operations of the load elements of the recording elements operated in the each block, and
the load control unit determines a magnitude of a load amount caused by the resistor element on the basis of the number of operations in a first predetermined number of blocks after the drive unit changes over from the non-driving state to the driving state.

14. The image forming apparatus according to claim 7, wherein
the load control unit adjusts, with PWM control, a period in which the drive voltage is supplied to the resistor element so that a load amount caused by the resistor element has the set magnitude.

15. The image forming apparatus according to any one of claims 12 to 14, wherein
when a time after the drive voltage is changed in the case where the drive voltage is supplied to the resistor element until the drive voltage is converged at a predetermined drive voltage is defined to be a response time,
the load control unit controls the switching element so as to supply the drive voltage to the resistor element from the response time or more before the supply start timing at which the drive voltage is supplied to the load element of the recording element until the supply start timing.

16. The image forming apparatus according to claim 15, wherein

the response time is equal to or more than a time required for forming an image of two blocks.

17. The image forming apparatus according to any one of claims 1 to 16, wherein 5
the recording head is an inkjet head, and
the recording element is a nozzle and an ink ejection mechanism for ejecting ink from the nozzle.
18. The image forming apparatus according to any one of claims 1 to 17, wherein 10
the load element of the recording element is a piezoelectric element.

15

20

25

30

35

40

45

50

55

FIG. 1

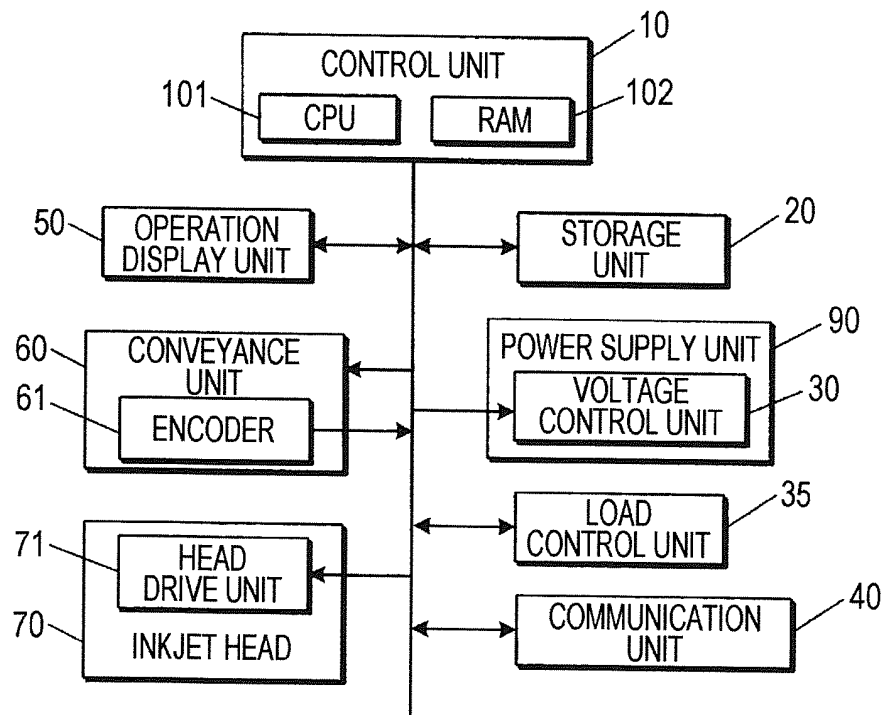


FIG. 2

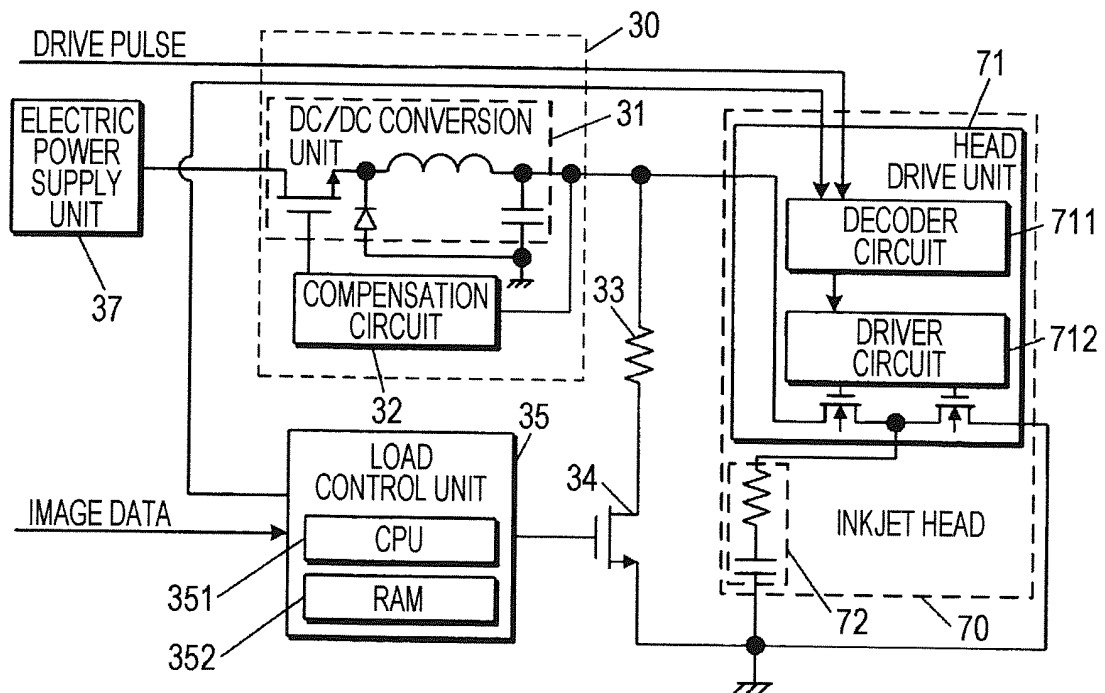


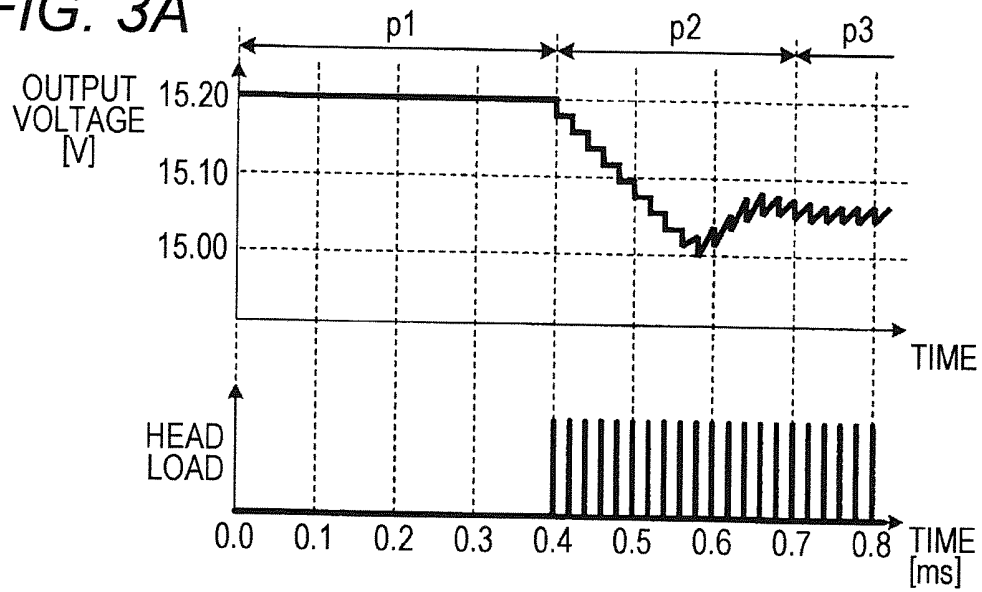
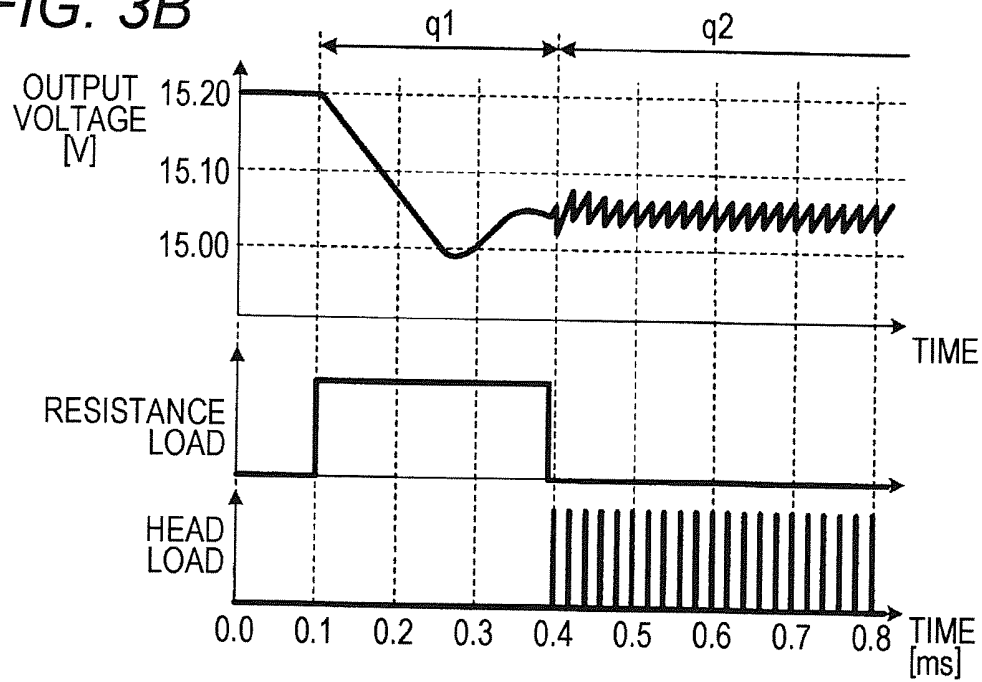
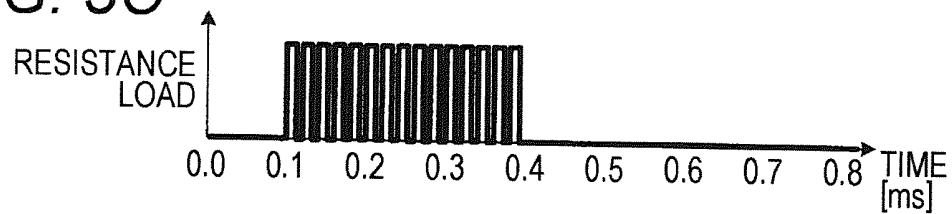
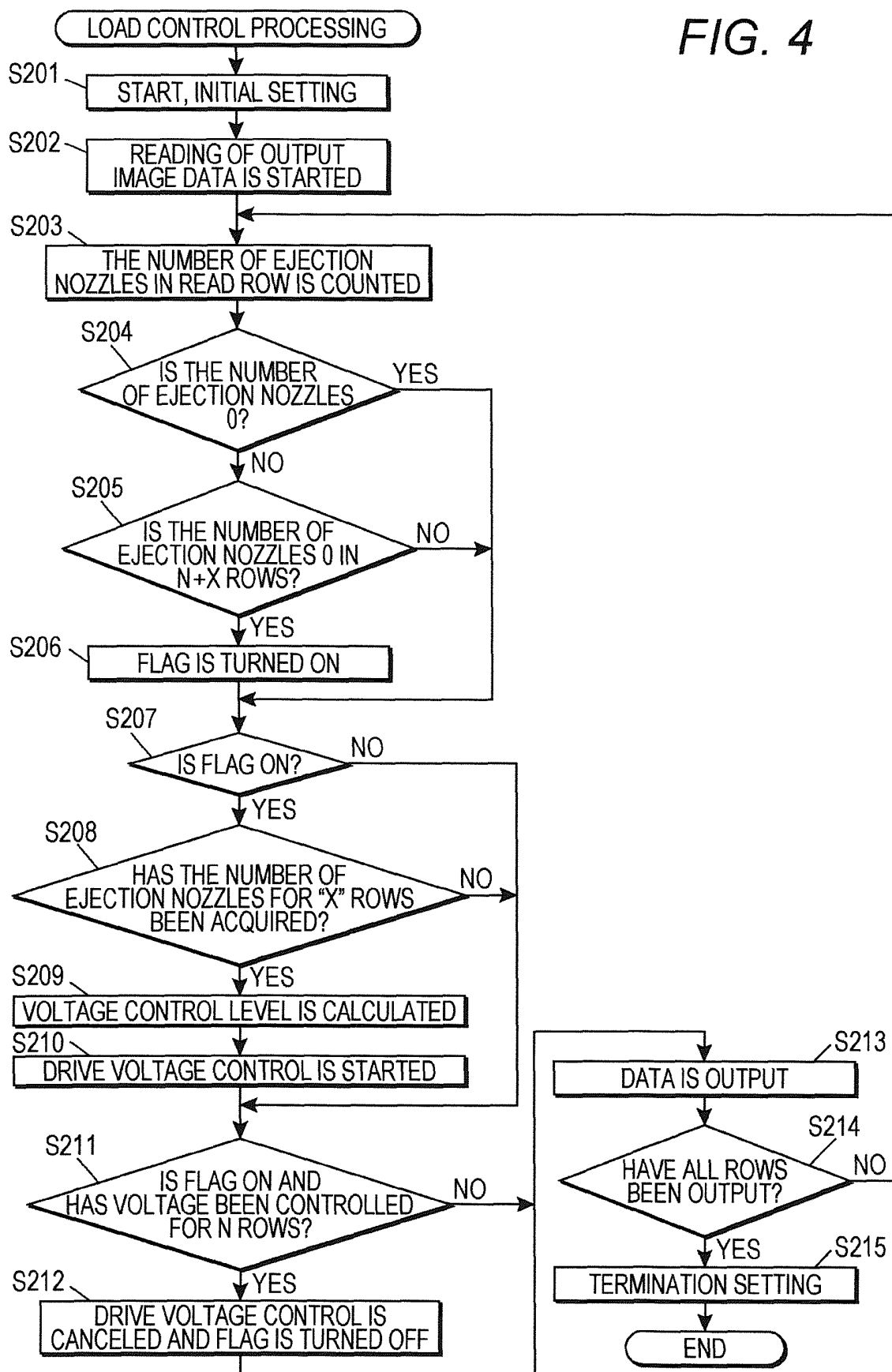
FIG. 3A**FIG. 3B****FIG. 3C**

FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/050489

A. CLASSIFICATION OF SUBJECT MATTER

B41J2/015(2006.01)i, B41J2/01(2006.01)i, B41J2/045(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B41J2/01-2/215

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-254648 A (Canon Inc.), 11 September 2002 (11.09.2002), entire text; all drawings (Family: none)	1-18
A	JP 2009-131990 A (Seiko Epson Corp.), 18 June 2009 (18.06.2009), entire text; all drawings & US 2009/0140780 A1	1-18
A	JP 2001-277516 A (Canon Inc.), 09 October 2001 (09.10.2001), entire text; all drawings & US 2001/0045968 A1 & EP 1142715 A1	1-18

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 March 2015 (25.03.15)

Date of mailing of the international search report

07 April 2015 (07.04.15)

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/050489

5	C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
10	A	JP 2006-256151 A (Fuji Xerox Co., Ltd.), 28 September 2006 (28.09.2006), entire text; all drawings (Family: none)	1-18
15			
20			
25			
30			
35			
40			
45			
50			
55			

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2003237056 A [0007]
- JP 2002254648 A [0007]