



(11) **EP 3 127 705 A1**

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

(43) Date of publication:
08.02.2017 Bulletin 2017/06

(51) Int Cl.:
B41J 2/015 ^(2006.01) **B41J 2/045** ^(2006.01)
B41J 2/14 ^(2006.01) **B41J 2/205** ^(2006.01)

(21) Application number: **15774447.5**

(86) International application number:
PCT/JP2015/060018

(22) Date of filing: **30.03.2015**

(87) International publication number:
WO 2015/152186 (08.10.2015 Gazette 2015/40)

(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
Designated Validation States:
MA

(72) Inventors:
• **KOBAYASHI Ryohei**
Tokyo 100-7015 (JP)
• **KIZAWA Akiko**
Tokyo 100-7015 (JP)

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

(30) Priority: **31.03.2014 JP 2014073970**

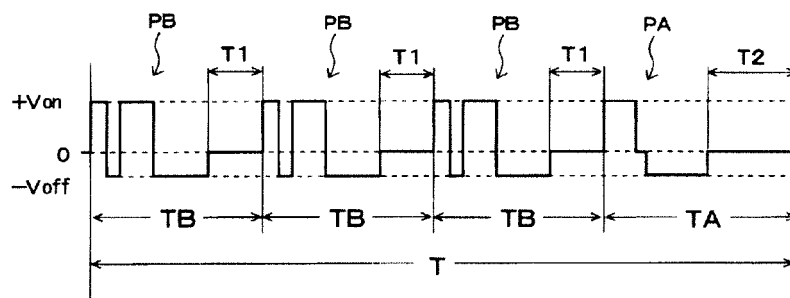
(71) Applicant: **Konica Minolta, Inc.**
Tokyo 100-7015 (JP)

(54) **INKJET HEAD DRIVING METHOD AND INKJET PRINTING APPARATUS**

(57) The purpose of the present invention is to provide an inkjet head driving method and an inkjet printing apparatus that can suppress reduction of productivity while limiting occurrence of satellites and are capable of high quality image printing even when multiple droplets are discharged in a one-pixel period to form a large dot on the medium. The drive signal, when applying a discharging pressure on a liquid in a pressure chamber by applying the drive signal on a pressure-generating means to discharge droplets from a nozzle, comprises

at least two kinds of drive signals, a first drive signal (PA) for discharging a droplet and a second drive signal (PB) for discharging a large droplet at a relatively slower speed than the first drive signal (PA). Pixels of dots obtained from droplets on a medium are formed by applying N of the second drive signals (PB) and applying the first drive signal (PA) at least at the end of a one-pixel period to discharge droplets from the same nozzle; N is an integer of at least 1.

FIG. 3



EP 3 127 705 A1

Description**TECHNICAL FIELD**

5 [0001] The present invention relates to a method for driving an inkjet head and an inkjet recording apparatus and particularly to a method for driving an inkjet head and an inkjet recording apparatus which can suppress occurrence of satellite even if a plurality of droplets is ejected in 1 pixel cycle so as to form a large dot on media.

BACKGROUND

10 [0002] When a large dot is to be formed on the media by ejecting a droplet from a nozzle of the inkjet head, a method of ejecting a plurality of the droplets from the same nozzle in the 1 pixel cycle and joining them during flying and causing them to be landed so as to be overlapped on the media is known. According to this method, since dark and bright can be expressed by selecting the number of droplets to be ejected in the 1 pixel cycle, it is used also in gradation expression.

15 [0003] Conventionally, a technology of ejecting plurality of the droplets from the same nozzle in the 1 pixel cycle is described in Patent Documents 1 to 3.

[0004] Patent Document 1 describes that, when one or more initial driving pulses are to be applied in accordance with gradation before a last driving pulse to be applied in the 1 pixel cycle, a droplet speed by the initial driving pulse is made slower than the droplet speed by the last driving pulse by making a voltage value of each pulse constant and by setting application time of the initial driving pulse longer or shorter than that of the last driving pulse while the droplet amounts ejected from the pulses are made equal.

20 [0005] Patent Document 2 describes that, when one or more driving pulses according to gradation are to be applied in the 1 pixel cycle, the voltage value of each driving pulse is made constant, output timing of the last driving pulse is matched between a maximum gradation waveform and the other gradation waveforms, and a pause period at a predetermined interval is provided in a pixel cycle.

25 [0006] Patent Document 3 describes that a plurality of ejection pulse signals and one auxiliary pulse signal for suppressing ink meniscus oscillation are generated in 1 pixel cycle, and the number of ejection pulse signals is selected in accordance with the gradation. Though the voltage value of each of the ejection pulse signals is constant, by prolonging the time interval of the pulses so as to be gradually closer to a natural period of an actuator for the ejection pulse signal which is later in the order so that the droplet ejected later has the faster droplet speed, and the plurality of droplets is joined during flying.

30 [0007] Patent Document 4 describes that, in a series of driving waveforms including different driving signals, that is, first to third driving signals, a part of the second driving signal is selected in the 1 pixel cycle and a small droplet is ejected, parts of the first and third driving signals are selected and a medium droplet is ejected, and parts of the first to third driving signals are selected and a large droplet is ejected so as to realize gradation expression.

PRIOR ART DOCUMENTS**PATENT DOCUMENTS****[0008]**

[Patent Document 1] Japanese Patent Laid-Open No. 2007-118278

[Patent Document 2] Japanese Patent Laid-Open No. 2008-93950

45 [Patent Document 3] Japanese Patent Laid-Open No. 2001-146011

[Patent Document 4] Japanese Patent Laid-Open No. 2007-105936

SUMMARY OF THE INVENTION**PROBLEM TO BE SOLVED BY THE INVENTION**

50 [0009] When as large a dot as possible is to be formed on media by ejecting a plurality of droplets within 1 pixel cycle, a large number of as large a droplet as possible need to be ejected from the same nozzle in the 1 pixel cycle.

[0010] However, the larger droplet amount becomes or if the droplet amount is large, the faster the droplet speed becomes, occurrence of satellite makes a problem. The satellite is a small droplet (airborne droplet) secondarily formed behind the droplet (main droplet) ejected from the nozzle and might incur drop of an image quality.

[0011] In Patent Documents 1 and 3, the droplet amount of the plurality of droplets ejected from the same nozzle in the 1 pixel cycle is the same. Thus, if small droplets are consecutively ejected, though the satellite can be suppressed,

many droplets need to be ejected in the 1 pixel cycle for forming a large dot, and productivity lowers, which is a problem. If large droplets are consecutively ejected, the lastly ejected droplet is also large and thus, there is a problem of occurrence of many satellites caused by the lastly ejected droplet.

[0012] Patent Document 2 has the purpose of reducing an influence of remaining oscillation by providing a pause period at a predetermined interval in the pixel cycle, but it is not sufficient in suppression of occurrence of the satellite.

[0013] Patent Document 4 does not refer to suppression of occurrence of the satellite at all.

[0014] The inventor has keenly examined a method of forming as large a dot as possible on the media by ejecting a plurality of the droplets in the 1 pixel cycle and as a result, the inventor has found that, by joining a relatively large droplet and a relatively small droplet and by devising a relation of their droplet speeds and timing at which a the relatively small droplet is ejected, a large dot can be formed on the media and occurrence of the satellite can be suppressed, and realized the present invention.

[0015] The inventor has also found that the occurrence of the satellite could be similarly suppressed in the case where the gradation expression is made by changing the number of droplets ejected in the 1 pixel cycle and realized the present invention.

[0016] That is, the present invention has an object to provide a method for driving an inkjet head and an inkjet recording apparatus which can suppress occurrence of the satellite and can perform high-quality image recording while drop of productivity is suppressed even though a plurality of droplets is ejected in the 1 pixel cycle so as to form a large dot on the media.

[0017] Moreover, the present invention has an object to provide a method for driving an inkjet head and an inkjet recording apparatus which can suppress occurrence of the satellite and can perform high-quality image recording while drop of productivity is suppressed when the gradation expression is to be made by changing the number of droplets to be ejected in the 1 pixel cycle.

[0018] The other objects of the present invention will be made apparent from the following description.

MEANS FOR SOLVING PROBLEM

[0019] In order to realize at least one of the aforementioned objects, a method for driving an inkjet head reflecting an aspect of the present invention has the following constitution.

[0020] A method for driving an inkjet head, in a method for driving an inkjet head which applies a driving signal to a pressure generator for giving a pressure for ejection to a liquid in a pressure chamber so as to cause a droplet to be ejected from a nozzle, in which

the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and by applying N pieces of the second driving signals, and by applying the first driving signal at least at last in 1 pixel cycle, the droplet is ejected from the same nozzle, and a pixel by a dot made of the droplet is formed on media and the aforementioned N is an integer not less than 1.

[0021] In order to realize at least one of the aforementioned objects, another method for driving an inkjet head reflecting an aspect of the present invention has the following constitution.

[0022] A method for driving an inkjet head, in a method for driving an inkjet head which applies a driving signal to the pressure generator for giving a pressure for ejection to a liquid in a pressure chamber so as to cause a droplet to be ejected from a nozzle, in which

the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and by applying N pieces of the second driving signals, and by applying the first driving signal at least at last in 1 pixel cycle, the droplet is ejected from the same nozzle, and a pixel by a dot made of the droplet is formed on media, and by changing the aforementioned N to an integer not less than 0 in accordance with image data so as to create dots with different sizes on the media for making gradation expression.

[0023] In order to realize at least one of the aforementioned objects, an inkjet recording apparatus reflecting an aspect of the present invention has the following constitution.

[0024] An inkjet recording apparatus including an inkjet head which applies a pressure for ejection to a liquid in a pressure chamber by driving of a pressure generator and causes a droplet to be ejected from a nozzle; and a driving controller which outputs a driving signal for driving the pressure generator, in which the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and the driving controller causes a droplet to be ejected from the same nozzle by applying N pieces of the second driving signals and by applying the first driving signal at least at last in 1 pixel cycle so as to form a pixel made of a dot by the droplet on media and the aforementioned N is an integer not less than 1.

[0025] In order to realize at least one of the aforementioned objects, another inkjet recording apparatus reflecting an

aspect of the present invention has the following constitution.

[0026] An inkjet recording apparatus including an inkjet head which applies a pressure for ejection to a liquid in a pressure chamber by driving of a pressure generator and causes a droplet to be ejected from a nozzle; and a driving controller which outputs a driving signal for driving the pressure generator, in which the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and the driving controller causes a droplet to be ejected from the same nozzle by applying N pieces of the second driving signals and by applying the first driving signal at least at last in 1 pixel cycle so as to form a pixel made of a dot by the droplet on media and creates dots with different sizes on the media by changing the aforementioned N to an integer not less than 0 in accordance with image data for making gradation expression.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

[Fig. 1] Fig. 1 is a schematic configuration diagram illustrating an example of an inkjet recording apparatus according to the present invention.

[Fig. 2] Figs. 2 are views illustrating an example of an inkjet head, in which Fig. 2A is a perspective view illustrating an appearance by a section, and Fig. 2B is a sectional view when seen from a side surface.

[Fig. 3] Fig. 3 is a view for explaining an example of a method for driving the inkjet head in the present invention.

[Fig. 4] Fig. 4A is a view for explaining an example of a first driving signal and Fig. 4B is a view for explaining an example of a second driving signal.

[Fig. 5] Figs. 5A to 5C are views for explaining an ejection operation of the inkjet head.

[Fig. 6] Fig. 6A is a conceptual diagram of a droplet ejected by the first driving signal and Fig. 6B is a conceptual diagram of the droplet ejected by the second driving signal.

[Fig. 7] Fig. 7A is a view for explaining another example of the first driving signal and Fig. 7B is a view for explaining another example of the second driving signal.

[Fig. 8] Fig. 8A is a view for explaining an example of a flying state of the droplet, and Fig. 8B is a view illustrating a dot formed on media by that.

[Fig. 9] Fig. 9A is a view for explaining another example of a flying state of the droplet, and Fig. 9B is a view illustrating a dot formed on media by that.

[Fig. 10] Fig. 10A is a view for explaining still another example of a flying state of the droplet, and Fig. 10B is a view illustrating a dot formed on media by that.

[Fig. 11] Fig. 11 is a view for explaining an example of a method for driving the inkjet head when gradation expression is to be made in the present invention.

[Fig. 12] Fig. 12A is a view for explaining an example of the method for driving in which only the second driving signal is applied in 1 pixel cycle and Fig. 12B is a view for explaining an example of the method for driving in which timing of the first driving signal in Fig. 3 is made different.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] Fig. 1 is a schematic configuration diagram illustrating an example of an inkjet recording apparatus according to the present invention.

[0029] In the inkjet recording apparatus 1, a conveying mechanism 2 sandwiches media 7 made of paper, plastic sheets, cloth and or the like by a pair of conveying rollers 22 and conveys it by rotation of a conveying roller 21 by a conveying motor 23 in a Y-direction (sub scan direction) in the figure. An inkjet head (hereinafter referred to simply as a head) 3 is provided between the conveying roller 21 and the pair of conveying rollers 22. The head 3 is mounted on a carriage 5 so that a nozzle surface side is faced with a recording surface 71 of the media 7 and is electrically connected to a driving control unit 8 constituting driving control means in the present invention through a flexible cable 6.

[0030] The carriage 5 is provided capable of reciprocating movement in an X-X' direction (main scan direction) in the figure substantially orthogonal to the sub scan direction which is a conveying direction of the media 7 by driving means, not shown, along guide rails 4 extended over a width direction of the media 7. The head 3 moves the recording surface 71 of the media 7 in the main scan direction with the reciprocating movement of the carriage 5, causes a droplet to be ejected from a nozzle in the course of this movement in accordance with image data and records an inkjet image.

[0031] Fig. 2 is a view illustrating an example of the head 3, in which Fig. 2A is a perspective view illustrating an appearance by a section and Fig. 2B is a sectional view when seen from a side surface.

[0032] In the head 3, reference numeral 30 denotes a channel substrate. On the channel substrate 30, a large number of narrow-groove shaped channels 31 and partition walls 32 are juxtaposed alternately. On an upper surface of the

channel substrate 30, a cover substrate 33 is provided so as to close an upper part of all the channels 31. A nozzle plate 34 is joined to end surfaces of the channel substrate 30 and the cover substrate 33. One end of each of the channels 31 communicates with an outside through a nozzle 341 formed in this nozzle plate 34.

[0033] The other end of each of the channels 31 is formed so as to be a gradually shallow groove with respect to the channel substrate 30. In the cover substrate 33, a common channel 331 common to each of the channels 31 is formed, and this common channel 331 communicates with each of the channels 31. The common channel 331 is closed by a plate 35. In the plate 35, an ink supply port 351 is formed. Through this ink supply port 351, ink is supplied from an ink supply pipe 352 into the common channel 331 and each of the channels 31.

[0034] The partition wall 32 is made of a piezoelectric element such as PZT or the like which is electro-mechanical converting means. As this partition wall 32, those formed of the piezoelectric element in which an upper wall portion 321 and a lower wall portion 322 are subjected to polarization treatment in directions opposite to each other are exemplified. However, a portion formed by the piezoelectric element in the partition wall 32 may be only the upper wall portion 321, for example. Since the partition walls 32 and the channels 31 are alternately juxtaposed, one partition wall 32 is shared by the adjacent channels 31 and 31 on both sides.

[0035] On an inner surface of the channel 31, a driving electrode (not shown in Figs. 2) is formed from wall surfaces to bottom surfaces of both partition walls 32 and 32, respectively. When a driving signal at a predetermined voltage is applied from the driving control unit 8 to the two driving electrodes arranged by sandwiching the partition wall 32, the partition wall 32 is sheared and deformed at a joint surface between the upper wall portion 321 and the lower wall portion 322 as a boundary. If the adjacent two partition walls 32 and 32 are sheared/deformed in directions opposite to each other, a capacity of the channel 31 sandwiched by the partition walls 32 and 32 is expanded or contracted, and a pressure wave is generated inside. As a result, a pressure for ejection is applied to the ink in the channel 31.

[0036] This head 3 is a shear-mode head for ejecting the ink in the channel 31 from the nozzle 341 by shear deformation of the partition wall 32 and is a preferable mode in the present invention. The channel 31 surrounded by the channel substrate 30, the partition wall 32, the cover substrate 33, and the nozzle plate 34 is an example of a pressure chamber in the present invention, and the partition wall 32 and the driving electrode on the surface thereof are an example of the pressure generator in the present invention.

[0037] The driving control unit 8 can generate a plurality of driving signals within 1 pixel cycle since it enables ejection of a plurality of droplets from the same nozzle 341 within the 1 pixel cycle. The generated driving signal is output to the head 3 and is applied to each of the driving electrodes formed on the partition wall 32. The 1 pixel cycle is a time interval for forming each pixel by a dot by causing the droplet ejected from the nozzle to be landed onto the media.

[0038] Fig. 3 is a view for explaining an example of a method for driving for forming a large dot on the media 7 by applying the plurality of driving signals in the 1 pixel cycle. Here, the plurality of driving signals applied within the 1 pixel cycle T to the driving electrode of the channel 31 corresponding to the nozzle 341 ejecting the droplet is exemplified.

[0039] The plurality of driving signals in the present invention includes at least two types of driving signals, that is, a first driving signal PA and a second driving signal PB. The first driving signal PA and the second driving signal PB are signals with different speeds and droplet amount of the droplets ejected by them. The droplet ejected by the second driving signal PB has a speed relatively lower than that of the droplet ejected by the first driving signal PA and the droplet amount is larger.

[0040] The droplet speed in the present invention is calculated by recognizing a droplet in an image by a droplet observing device and by obtaining elapsed time from ejection and a position coordinate where the droplet is present at that time. Specifically, it is calculated from a distance for which the droplet flies from a position away from a nozzle surface by 500 μm for 50 μs . The elapsed time from the ejection can be calculated by synchronizing an ejection signal of the inkjet head with strobe for observation. The position coordinate of the droplet can be calculated by applying image processing to a flying image.

[0041] According to the method for driving the inkjet head in the present invention for forming a large dot, N pieces of the second driving signals PB are applied within the 1 pixel cycle T and the first driving signal PA is applied at least at last of the 1 pixel cycle T so that a plurality of the droplets is ejected from the same nozzle 341. At this time, by setting N to an integer not less than 1, a pixel by dots made of the plurality of droplets is formed on the media 7. By joining the plurality of droplets ejected from the same nozzle 341 within the 1 pixel cycle T during flying, the pixel can be formed on the media 7 by the dot made of one joined droplets. Alternatively, by causing the plurality of droplets to be landed on the media 7 so as to overlap each other, the pixel can be also formed by the dot made of a collection of a plurality of dots.

[0042] The second driving signal PB is a driving signal for ejecting a droplet relatively larger than the droplet by the first driving signal PA and thus, application of one or more of them within the 1 pixel cycle T mainly contributes to formation of a large dot. The droplet by the second driving signal PB has a speed relatively lower than that of the droplet by the first driving signal PA, and since the occurring satellite is caught by the droplet ejected later in the same pixel cycle T, it does not make such a problem that lowers the image quality.

[0043] When a plurality of the droplets is ejected within the 1 pixel cycle T, since the satellite of the preceding droplet is caught by the droplet ejected later within the same pixel cycle T, from the viewpoint of the image quality, the satellite

accompanying the droplet ejected lastly within the 1 pixel cycle T particularly matters. According to the present invention, the first driving signal PA is applied at last without fail within the 1 pixel cycle T, whereby the droplet relatively smaller than the droplet by the second driving signal PB is ejected and thus, the satellite does not occur or is suppressed.

[0044] Therefore, even if the large dot is formed on the media 7 by applying the first driving signal PA and the second driving signal PB within the 1 pixel cycle T so as to cause a plurality of the droplets to be ejected, the method for driving the inkjet head 3 and the inkjet recording apparatus 1 which can suppress occurrence of the satellite while suppressing drop of productivity and can perform high-quality image recording can be provided.

[0045] In Fig. 3, reference character TA denotes a driving cycle of the first driving signal PA within the 1 pixel cycle T, and reference character PB denotes a driving cycle of the second driving signal PB within the 1 pixel cycle T. Here, an example in which three (N=3) second driving signals PB are applied within the 1 pixel cycle T with a predetermined pause period T1 provided between itself and the subsequent driving signal, and a predetermined pause period T2 provided between the end of application of the one first driving signal PA applied at last and the start of the subsequent 1 pixel cycle T is illustrated.

[0046] The Number N of the second driving signals PB is an integer not less than 1 and is not limited to the illustrated number of three, but whatever value of N not less than 1 is, the first driving signal PA is applied without fail at last of the 1 pixel cycle T. Thus, whatever value of N not less than 1 is, the satellite is suppressed as described above. Though not shown, whatever value of N not less than 1 is, the first driving signal PA applied at last is applied at the same timing within the 1 pixel cycle T.

[0047] Subsequently, specific configurations of the first driving signal PA and the second driving signal PB will be described by using Figs. 4. Fig. 4A illustrates the first driving signal PA, and Fig. 4B illustrates the second driving signal PB. However, the driving signals PA and PB illustrated in Figs. 4 are preferred examples in the present invention and the driving signals are not limited to those illustrated.

[0048] First, the configuration of the first driving signal PA will be described.

[0049] The first driving signal PA has an expansion pulse Pa1 for expanding a capacity of the channel 31 and contracting it after certain time and a contraction pulse Pa2 for contracting the capacity of the channel 31 and expanding it after certain time.

[0050] In an example illustrated in Fig. 4A, the expansion pulse Pa1 is a pulse which rises from a reference potential and falls to the reference potential after certain time. The contraction pulse Pa2 is a pulse which falls from the reference potential and rises to the reference potential after certain time. Here, the reference potential is assumed to be 0 potential, but that is not particularly limiting.

[0051] A driving voltage value (+Von) of the expansion pulse Pa1 and the driving voltage value (-Voff) of the contraction pulse Pa2 are set to $|Von| : |Voff| = 2:1$.

[0052] In the example of this first driving signal PA, a pause period PWA3 for maintaining the reference potential for the certain time is provided between a terminal end of falling of the expansion pulse Pa1 and a start end of falling of the contraction pulse Pa2. This is provided in order to avoid that the droplet speed becomes too fast since the capacity of the channel 31 is rapidly changed from the expanded state by the expansion pulse Pa1 to the contracted state by the contraction pulse Pa2 due to a relation with the second driving signal PB which will be described later and to avoid that the droplet amount of the ejected droplet becomes too large. By adjusting a length of this pause period PWA3, the speed and the droplet amount of the droplet ejected by application of the first driving signal PA can be easily adjusted in relation with the droplet ejected by the second driving signal PB which will be described later. Thus, this pause period PWA3 is preferably provided in the first driving signal PA.

[0053] In the present invention, it is only necessary to apply one first driving signal PA without fail at least at last within the 1 pixel cycle T. Therefore, it does not prevent application of the one or more first driving signals PA in addition to the second driving signal PB before the first driving signal PA applied at last within the 1 pixel cycle T. At this time, the first driving signal PA can be applied at first within the 1 pixel cycle T, but in this case, impact performances are preferably improved by setting the pause period PWA3 of the first driving signal PA applied at first longer than the pause period PWA3 of the first driving signal PA applied at last so that the speed of the droplet ejected at first becomes slower, for example.

[0054] Moreover, this first driving signal PA is preferably a driving signal for forming the smallest droplet in the plurality of the driving signals aligned in a time series within the 1 pixel cycle T. As a result, the effect of suppressing the satellite can be further improved, and an impact position shift can be also suppressed.

[0055] Furthermore, the first driving signal PA is preferably the driving signal for forming the smallest droplet and with the fastest droplet speed in the plurality of the driving signals aligned in a time series within the 1 pixel cycle T from the viewpoint of further improvement of the satellite suppression effect and the suppression effect of the impact position shift.

[0056] The first driving signal PA is preferably a rectangular wave. That is, as illustrated, the expansion pulse Pa1 and the contraction pulse Pa2 are both constituted by rectangular waves. The shear-mode head 3 illustrated in this embodiment can generate pressure waves with aligned phases to application of the driving signal made of the rectangular wave and thus, the droplet can be efficiently ejected and the driving voltage can be kept low. Since the voltage is applied

to the head 3 at all times in general regardless of ejection or non-ejection, the low driving voltage is important in suppressing heat generation of the head 3 and stable ejection of the droplet.

[0057] Moreover, since the rectangular wave can be easily generated by using a simple digital circuit, circuit configuration can be simplified as compared with use of a trapezoidal wave having an inclined wave.

[0058] It is preferable that a pulse width PWA1 of the expansion pulse Pa1 is 0.8 AL or more and 1.2 AL or less, and a pulse width PWA2 of the contraction pulse Pa2 is 1.8 AL or more and 2.2 AL or less. As a result, the droplet can be ejected efficiently. Moreover, if the pause period PWA3 is too long, the ejection of the droplet with a droplet speed faster than the droplet by the second driving signal PB becomes difficult and the ejection efficiency is largely lowered and thus, it is preferably adjusted to 1/4 AL or less.

[0059] Here, the term AL is abbreviation of Acoustic Length and means 1/2 of an acoustic resonant period of a pressure wave in the channel 31. AL is acquired as a pulse width with which a flying speed of a droplet becomes the maximum when the pulse width of a rectangular wave is changed with a voltage value of the rectangular wave made constant by measuring the flying speed of the droplet ejected when the driving signal with the rectangular wave is applied to the driving electrode.

[0060] The pulse is a rectangular wave of a constant-voltage wave crest value and assuming that 0 V is 0%, a wave crest value voltage is 100%, the pulse width is defined as time from rising 10% from the voltage 0 V to falling 10% from the wave crest value voltage.

[0061] Moreover, the rectangular wave refers to a waveform in which both rising time and falling time between 10% and 90% of the voltage are within 1/2 or preferably within 1/4 of AL.

[0062] Subsequently, the configuration of the second driving signal PB will be described.

[0063] The example of the second driving signal PB has a first expansion pulse Pb1 for expanding the capacity of the channel 31 and contracting it after certain time, a first contraction pulse Pb2 for contracting the capacity of the channel 31 and expanding it after certain time, a second expansion pulse Pb3 for expanding the capacity of the channel 31 and contracting it after certain time, and a second contraction pulse Pb4 for contracting the capacity of the channel 31 and expanding it after certain time in this order.

[0064] In an example illustrated in Fig. 4B, the first expansion pulse Pb1 is a pulse which rises from a reference potential and falls to the reference potential after certain time. The first contraction pulse Pb2 is a pulse which falls from the reference potential and rises to the reference potential after certain time. The second expansion pulse Pb3 is a pulse which rises from a reference potential and falls to the reference potential after certain time. The second contraction pulse Pb4 is a pulse which falls from the reference potential and rises to the reference potential after certain time. Here, the reference potential is also assumed to be 0 potential, but that is not particularly limiting.

[0065] Driving voltage values (+Von) of the first expansion pulse Pb1 and the second expansion pulse Pb3 and driving voltage values (-Voff) of the first contraction pulse Pb2 and the second contraction pulse Pb4 are set to $|V_{on}| : |V_{off}| = 2:1$.

[0066] The first contraction pulse Pb2 consecutively falls without a pause period from a terminal end of falling of the first expansion pulse Pb1. Moreover, the second expansion pulse Pb3 consecutively rises without a pause period from a terminal end of rising of the first contraction pulse Pb2. Furthermore, the second contraction pulse Pb4 consecutively falls without a pause period from a terminal end of falling of the second expansion pulse Pb3.

[0067] This second driving signal PB is also preferably a rectangular wave from the reason similar to the first driving signal PA. As illustrated, the first expansion pulse Pb1, the first contraction pulse Pb2, the second expansion pulse Pb3, and the second contraction pulse Pb4 are constituted by rectangular waves.

[0068] It is preferable that a pulse width PWB1 of the first expansion pulse Pb1 in the second driving signal PB is 0.4 AL or more and 2.0 AL or less, a pulse width PWB2 of the first contraction pulse Pb2 is 0.4 AL or more and 0.7 AL or less, a pulse width PWB3 of the second expansion pulse Pb3 is 0.8 AL or more and 1.2 AL or less, a pulse width PWB4 of the second contraction pulse Pb4 is 1.8 AL or more and 2.2 AL or less. As a result, a large droplet can be ejected in a short driving cycle, and a droplet speed can be suppressed. Therefore, a droplet at a relatively lower speed and with a larger droplet amount as compared with the droplet by the first driving signal PA can be ejected.

[0069] Moreover, from the viewpoint of reducing an influence of the satellite present among the plurality of droplets, the pause period T1 is preferably 2AL or less, and from the viewpoint of suppression of an influence of a pressure-wave remaining oscillation within the channel 31 after ejection of the droplet and stabilization of the subsequent ejection of the droplet, the pause period T2 is preferably 1.5 AL or more.

[0070] Subsequently, an ejection operation of the head 3 when the first driving signal PA and the second driving signal PB illustrated in Figs. 4 are applied will be described by using Figs. 5. Figs. 5 illustrate a part of a section when the head 3 is cut in a direction orthogonal to a length direction of the channel 31. Here, it is assumed that the droplet is ejected from a channel 31B at a center in Figs. 5. Moreover, a conceptual diagram of the droplet ejected when the first driving signal PA and the second driving signal PB are applied is illustrated in Fig. 6.

[0071] First, the ejection operation by the first driving signal PA will be described.

[0072] As illustrated in Fig. 5A, when a driving signal is not applied to any of driving electrodes 36A, 36B or 36C in the mutually adjacent channels 31A, 31B, and 31C, partition walls 32A, 32B, 32C, and 32D are in a neutral state without

deformation. When the driving electrodes 36A and 36C are grounded and the expansion pulse Pa1 in the first driving signal PA is applied to the driving electrode 36B, an electric field in a direction orthogonal to a polarization direction of piezoelectric elements constituting the partition walls 32B and 32C is generated. As a result, the partition walls 32B and 32C are bent and deformed outward from each other as illustrated in Fig. 5B, and the capacity of the channel 31B is expanded (Draw). As a result, a negative pressure is generated in the channel 31B, and the ink flows therein.

[0073] Since the pressure in the channel 31B is inverted at every AL, after this expansion pulse Pa1 is maintained for a period of 0.8 AL or more and 1.2 AL or less, the inside of the channel 31B is changed to a positive pressure. If the application of the expansion pulse Pa1 is finished and the potential is returned to the reference potential at this timing, the partition walls 32B and 32C return to the neutral state illustrated in Fig. 5A (Release). At this time, a large pressure is applied to the ink in the channel 31B, and the ink is moved to a direction in which the ink is pushed out of the nozzle 341.

[0074] By applying the contraction pulse Pa2 to the driving electrode 36B after the neutral state is maintained only for the pause period PWA3, the partition walls 32B and 32C are bent and deformed inward to each other as illustrated in Fig. 5C, and the capacity of the channel 31B is contracted (Reinforce). As a result, the pressure is further applied to the ink in the channel 31B, and the ink having been moved in the direction of being pushed out of the nozzle 341 is further pushed out. After that, the pushed-out ink is torn off, and a single droplet 100 is ejected as illustrated in Fig. 6A.

[0075] This droplet 100 is a small droplet with a droplet amount smaller than that of the droplet by the second driving signal PB which will be described later. When the droplet 100 is ejected, satellites do not occur or are suppressed to an extremely small amount if any.

[0076] The contracted state by the contraction pulse Pa2 is returned to the original when the pressure in the channel 31B changes to positive after 1.8 AL or more and 2.2 AL or less have elapsed. As a result, the partition walls 32B and 32C return to the neutral state in Fig. 5A.

[0077] Subsequently, the ejection operation by the second driving signal PB will be described.

[0078] When the driving electrodes 36A and 36C are grounded from the neutral state illustrated in Fig. 5A and the first expansion pulse Pb1 in the second driving signal PB is applied to the driving electrode 36B, the partition walls 32B and 32C are bent and deformed outward from each other as illustrated in Fig. 5B, and the capacity of the channel 31B is expanded. As a result, a negative pressure is generated in the channel 31B, and the ink flows therein.

[0079] After the first expansion pulse Pb1 is maintained at 0.4 AL or more and 2.0 AL or less, the application of the first expansion pulse Pb1 is finished. As a result, the partition walls 32B and 32C are contracted from the expanded state and return to the neutral state. Then, by consecutively applying the first contraction pulse Pb2 without a pause period, the partition walls 32B and 32C enter the contracted state illustrated in Fig. 5C immediately via the neutral state. At this time, the pressure is applied to the ink in the channel 31B, and the ink is pushed out of the nozzle 341 and ejected as a first droplet.

[0080] The first contraction pulse Pb2 is maintained for 0.4 AL or more and 0.7 AL or less. Then, by consecutively applying the second expansion pulse Pb3 without a pause period, the partition walls 32B and 32C are expanded from the contracted state and enter the expanded state illustrated in Fig. 5B immediately via the neutral state, and a negative pressure is generated in the channel 31. Thus, the speed of the first droplet previously ejected is suppressed. Moreover, the negative pressure is generated in the channel 31B by that, and the ink flows in again.

[0081] After the second expansion pulse Pb3 is maintained for 0.8 AL or more and 1.2 AL or less, the application is finished about time when the pressure in the channel 31B changes to positive. Then, by consecutively applying the second contraction pulse Pb4 without a pause period, the partition walls 32B and 32C are contracted from the expanded state and enter the contracted state illustrated in Fig. 5C immediately via the neutral state. At this time, a large pressure is applied to the ink in the channel 31B, and ink is further largely pushed out subsequent to the first droplet ejected by the first expansion pulse Pb1 and the first contraction pulse Pb2 and the pushed-out ink is eventually torn off and a second droplet with a large droplet speed is ejected.

[0082] Regarding the droplet ejected by the second driving signal PB, as illustrated in Fig. 6B, subsequent to a first droplet 201 with a small droplet speed ejected by the first expansion pulse Pb1 and the first contraction pulse Pb2, a second droplet 202 with a large droplet speed ejected by the second expansion pulse Pb3 and the second contraction pulse Pb4 is formed. Thus, at the beginning of the ejection, the droplet is a droplet 200 in which the first droplet 201 and the second droplet 202 are connected. The first droplet 201 and the second droplet 202 are joined during flying immediately after the ejection and form a single large droplet 200.

[0083] This droplet 200 is a large droplet with a droplet amount larger than the droplet 100 ejected by the first driving signal PA. However, since the first droplet 201 with the small droplet speed and the second droplet 202 with the large droplet speed are joined, the droplet speed becomes slower than the case of ejection of one large droplet with the same droplet amount from the nozzle 341, and according to this embodiment, the speed is lower than that of the droplet 100 ejected by the first driving signal PA. At this time, the droplet speed of the droplet 100 ejected by the first driving signal PA is preferably adjusted smaller than the droplet speed of the second droplet 202. The satellite amount of the droplet 200 depends of the droplet speed of the second droplet 202, and by adjusting the droplet speed of the droplet 100 to be smaller than the droplet speed of the second droplet 202 by the second driving signal PB, the satellite amount of the

droplet 100 can be suppressed.

[0084] The droplet speed of the droplet 200 ejected by the second driving signal PB is a droplet speed in a state where the first droplet 201 and the second droplet 202 are joined.

[0085] The contracted state by the second contraction pulse Pb4 is returned to the original when the pressure in the channel 31B changes to positive after 1.8 AL or more and 2.2 AL or less have elapsed. As a result, the partition walls 32B and 32C are expanded from the contracted state and returned to the neutral state.

[0086] According to the driving method illustrated in Fig. 3, consecutive application of the three second driving signals PB at first within the 1 pixel cycle T causes three large droplets 200 to be ejected from the same nozzle 341, and subsequently, application of the one first driving signal PA at last causes the one droplet 100 to be ejected and thus, a pixel is formed on the media 7 by a dot made of four droplets.

[0087] In this embodiment, it is assumed that the droplet 100 of 6 pl (picoliters) is ejected by the first driving signal PA, and the droplet 200 of 10 pl is ejected by the second driving signal PB. Therefore, a large dot made of the droplet of 36 pl in total can be formed on the media 7 within the 1 pixel cycle T in Fig. 3.

[0088] Assuming that only the four first driving signals PA are consecutively applied, even though the satellite can be suppressed, only a dot made of a droplet of 24 pl in total can be formed. In order to form a dot made of a droplet of 36 pl, the six first driving signals PA need to be consecutively applied within the 1 pixel cycle T, which lowers productivity. If only the second driving signals PB are consecutively applied, the droplet ejected at last is also a large droplet, whereby occurrence of satellite is concerned about. However, as in the present invention, by applying one or more of the second driving signals PB within the 1 pixel cycle T and by applying the first driving signal PA at last without fail in the plurality of the driving signals aligned in a time series within the 1 pixel cycle T, a large dot can be formed on the media 7, while the droplet 100 made of the smallest droplet is ejected at last without fail, whereby occurrence of satellite is suppressed while drop of productivity is suppressed.

[0089] Moreover, a large droplet can be also ejected by using a driving signal made of a DRR (Draw-Release-Reinforce) waveform similar to the first driving signal PA and by prolonging its pulse width in general. However, it becomes a long-cycle driving signal in this case, and many droplets cannot be ejected within limited period of the 1 pixel cycle T. However, since the second driving signal PB can cause the large droplet 200 with a short cycle and a relatively low speed to be ejected, more droplets can be ejected within the limited period of the 1 pixel cycle T, and a pixel made of a large dot can be formed on the media 7 for that portion.

[0090] Deformation of the partition wall 32 is caused by a voltage difference between the two driving electrodes provided so as to sandwich the partition wall 32. Thus, when ejection is to be performed by the first driving signal PA from the channel 31B illustrated in Fig. 5, as illustrated in Fig. 7A, similar driving can be performed also by applying the expansion pulse Pa1 at +Von to the driving electrode 36B in the channel 31B which is the ejection channel and by applying the contraction pulse Pa2 at +Voff to the driving electrodes 36A and 36C of the adjacent channels 31A and 31C.

[0091] Similarly, when the ejection is to be performed by the second driving signal PB from the channel 31B illustrated in Fig. 5, as illustrated in Fig. 7B, driving can be performed similarly also by applying the first expansion pulse Pb1 and the second expansion pulse Pb3 at +Von to the driving electrode 36B in the channel 31B which is the ejection channel and by applying the first contraction pulse Pb2 and the second contraction pulse Pb4 at +Voff to the driving electrodes 36A and 36C of the adjacent channels 31A and 31C.

[0092] When the first driving signal PA and the second driving signal PB illustrated in Figs. 7A and 7B are to be used, since each of the driving signals can be constituted only by a positive voltage, constitution of the driving control unit 8 can be simplified.

[0093] In the present invention, a diameter of the droplet 100 ejected by the first driving signal PA is preferably smaller than a diameter of the nozzle 341. By setting the diameter of the droplet 100 smaller than the diameter of the nozzle 341, the satellite suppression effect can be further improved.

[0094] Here, the diameter of the nozzle is assumed to refer to a diameter of an opening at a tip end of the nozzle in an ejection direction when its shape is circular and if it is not circular, a diameter of a circle obtained by replacing the opening with a circle with the same area.

[0095] Moreover, the diameter of the droplet is assumed to refer to a diameter when the droplet is spherical and if it is not spherical, a diameter of a ball obtained by replacing the droplet with a ball with the same volume.

[0096] On the other hand, the diameter of the droplet 200 ejected by the second driving signal PB is preferably larger than the diameter of the nozzle 341. By setting the diameter of the droplet 200 larger than the diameter of the nozzle 341, a dot as large as possible can be formed on the media 7.

[0097] The diameter of the droplet 200 ejected by the second driving signal PB is a diameter in a state where the first droplet 201 and the second droplet 202 are joined and form a single large droplet.

[0098] It is needless to say that the diameter of the droplet 100 ejected by the first driving signal PA is preferably smaller than the diameter of the nozzle 341 and the diameter of the droplet 200 ejected by the second driving signal PB is preferably larger than the diameter of the nozzle 341.

[0099] Assuming that the droplet amount of the droplet 100 ejected by the first driving signal PA is MA, and the droplet

amount of the droplet 200 ejected by the second driving signal PB is MB, it is preferably $MA \times 1.5 \geq MB$. As a result, a pixel made of dots as large as possible can be formed on the media 7 while the satellite is effectively suppressed.

[0100] In the shear-mode head 3 in which the adjacent channels 31 share the partition wall 32 in general, when the one channel 31 is driving for ejection, the both adjacent channels 31 and 31 cannot perform ejection. Thus, it is known that an independent driving type head in which the ejection channel for ejecting the droplet and a dummy channel not ejecting the droplet are arranged alternately is provided. If the head 3 is this independent driving type head, since it is likely that the ejection channel performs ejection in the whole pixel cycle T, the pixel cycles T for forming pixels continue in some cases.

[0101] At this time, the driving cycle TA of the first driving signal PA and the driving cycle TB of the second driving signal PB within the 1 pixel cycle T can be $TA = TB$ for expressing the gradation which will be described later on the media 7 while the satellite is suppressed, but $TA \geq TB$ is preferable. Since the large droplet 200 by the second driving signal PB is at a relatively low speed, by setting $TA \geq TB$, many large droplets 200 can be created in a short time and at a high speed within the 1 pixel cycle T by the second driving signal PB when as large a dot as possible is to be formed as in high density gradation, for example.

[0102] Moreover, it is preferable that the respective expansion pulses (the expansion pulse Pa1, the first expansion pulse Pb1, the second expansion pulse Pb3) of the first driving signal PA and the second driving signal PB applied to the driving electrode of the channel 31 corresponding to the same nozzle 341 have constant wave crests, and the respective contraction pulses (the contraction pulse Pa2, the first contraction pulse Pb2, the second contraction pulse Pb4) of the first driving signal PA and the second driving signal PB applied to the driving electrode of the channel 31 corresponding to the same nozzle 341 have constant wave crests as illustrated in Fig. 3. Since the voltage value of the expansion pulse and the voltage value of the contraction pulse of each of the driving signals PA and PB can be made constant, constitution of the driving control unit 8 can be further simplified.

[0103] If the number N of the second driving signal PB applied within the 1 pixel cycle T is $N \geq 2$, the droplet 200 ejected by each of the second driving signals PB may have the same speed or may have different speeds.

[0104] Figs. 8 illustrate flying states over time of the droplets 100 and 200 when each of the droplets 200 ejected from the same nozzle 341 by the plurality of the second driving signals PB is set to the same speed in the case of $N = 3$ illustrated in Fig. 3 and a plan view of a dot D formed on the media 7 by that as an example.

[0105] When each of the droplets 200 is set to the same speed, as illustrated in Fig. 8A, the three droplets 200 consecutively ejected within the 1 pixel cycle T fly at a constant speed, respectively. Then, when the last droplet 100 by the first driving signal PA is ejected, since the droplet 100 is faster than the droplet 200 ejected immediately before that, it catches up with and joins with it. Since the ejected droplet receives air resistance during flying and reduces its speed, the joined droplet further catches up with and joins with the droplet immediate before that, and all the droplets 100 and 200 are joined during flying. As a result, the pixel made of the dot D by the single droplet illustrated in Fig. 8B is formed on the media 7. Since all the droplets 100 and 200 are landed after being joined, the dot D with high accuracy without an impact position shift can be formed.

[0106] Moreover, the droplet speed of the droplet 200 by the second driving signal PB can be adjusted by the pulse width PWB1 of the first expansion pulse Pb1. Therefore, if the droplet speed of each of the droplets 200 ejected by each of the second driving signals PB is to be made different, it can be realized by adjusting the pulse width PWB1 of this first expansion pulse Pb1. In this embodiment, a preferable range of this pulse width PWB1 is exemplified as the range of 0.4 AL or more and 2.0 AL or less and thus, the length of the pulse width PWB1 is adjusted within this range.

[0107] At this time, the second driving signal PB is preferably applied in the order from the shorter pulse width PWB1 of the first expansion pulse Pb1 within the 1 pixel cycle T. As a result, in the ejected droplets 200, the later the droplet 200 is ejected, the faster its speed becomes, which is effective if each of the droplets 200 is to be reliably joined during flying.

[0108] Figs. 9 illustrate flying states over time of the droplets 100 and 200 when each of the droplets 200 ejected from the same nozzle 341 by the plurality of the second driving signals PB is set such that the later the droplet 100 is ejected, the faster its speed becomes in the case of $N = 3$ illustrated in Fig. 3 and a plan view of the dot D formed on the media 7 by that as an example.

[0109] In this case, as illustrated in Fig. 9A, the three droplets 200 consecutively ejected within the 1 pixel cycle T are joined during flying and form the joined droplet, and when the last droplet 100 by the first driving signal PA catches up with and joins with the joined droplet at last, all the droplets 100 and 200 are joined during flying. As a result, the dot D by the single droplet illustrated in Fig. 9B is formed on the media 7. In this case, too, since all the droplets 100 and 200 are landed after being joined, the dot D with high accuracy without an impact position shift can be formed.

[0110] On the other hand, within the 1 pixel cycle T, the second driving signal PB can be applied in the order from the longer of the pulse width PWB1 of the first expansion pulse Pb1 of the second driving signal PB, that is, in the order from the faster droplet speed.

[0111] Figs. 10 illustrate flying states over time of the droplets 100 and 200 when each of the droplets 200 ejected from the same nozzle 341 by the plurality of the second driving signals PB is set such that the earlier the droplet 200 is

ejected, the faster its speed becomes in the case of $N = 3$ illustrated in Fig. 3 and a plan view of the dot D formed on the media 7 by that as an example.

[0112] In this case, as illustrated in Fig. 10A, except the droplet 100 by the first driving signal PA joined with the droplet 200 ejected immediately before that so as to form the joined droplet, the pixel made of one dot D in which a plurality of the dots is overlapped on the media 7 as illustrated in Fig. 10B is formed. This is because energy of the droplet 100 ejected at last in an early stage after ejection is lost.

[0113] The dot D as illustrated in this Fig. 10B does not have a great influence on an image quality in an application of gradation expression by changing the droplet amount (number of droplets) ejected within the 1 pixel cycle T, as will be described later, though there is a concern that the impact position might be slightly shifted each time the droplet amount is different. Moreover, the image quality is not affected at all in an application of gaining a painted amount by using only the large dots as in the case of recording a solid image.

[0114] Subsequently, the case where the gradation expression is made in the present invention will be described.

[0115] In the present invention, the gradation expression is to form a pixel made of the droplet on the media 7 by applying N pieces of the second driving signals PB within the 1 pixel cycle T and by applying the first driving signal PA at least at last so as to eject the droplet from the same nozzle 341 and can be performed by forming the pixel made of the dots with various sizes the media 7 by creating dots with different sizes on the media 7 by changing the number N of the second driving signals PB to be applied to an integer not less than 0 in accordance with image data.

[0116] As a result, even when the gradation expression is to be made by changing the number of droplets to be ejected within the 1 pixel cycle T, the method for driving the inkjet head 3 and the inkjet recording apparatus 1 which can suppress occurrence of satellite while suppressing drop of productivity, and can also suppress the impact position shift, and perform high-quality image recording can be provided. Moreover, since it is only necessary to change the number N of the second driving signals PB to be applied within the 1 pixel cycle T, gradation can be expressed easily.

[0117] Fig. 11 illustrates an example of a method for driving in the present invention when the gradation expression is to be made by using the first driving signal PA and the second driving signal PB described above. Here, an example in which six-stage gradation expression is made from Level 0 (minimum gradation) to Level 5 (maximum gradation) by changing the number of the second driving signals PB to be applied within the 1 pixel cycle T from 0 ($N=0$) to 4 ($N=4$) at the maximum is illustrated. The Level 0 is a case where the driving signal is not applied at all.

[0118] Each driving signal group expressing gradation from Level 1 to Level 5 can be stored in association with each gradation in advance in the driving control unit 8. The driving control unit 8 selects desired gradation in accordance with the image data, calls the driving signal group corresponding to that and then, applies the driving signal group to the head 3.

[0119] When the gradation expression is to be made, though some of the Level 1 to Level 6 do not apply the second driving signal PB ($N=0$) except Level 0 at which no driving signal is applied, the first driving signal PA is applied without fail at last of the 1 pixel cycle T in any of the gradations from Level 1 to Level 5. Thus, in any of the gradations from Level 1 to Level 5, the satellite is suppressed as described above. In any of the gradations from Level 1 to Level 5, the first driving signal PA to be applied at last is applied so as to be at the same timing within the 1 pixel cycle T.

[0120] Here, too, it is assumed that the droplet 100 with 6 pl is ejected by the first driving signal PA, and the droplet 200 with 10 pl is ejected by the second driving signal PB. Thus, level 1=6 pl, Level 2=16 pl, Level 3=26 pl, Level 4=36 pl, and Level 5=46 pl, and wide gradation can be expressed while the minimum liquid amount (6 pl) by the first driving signal PA is ensured.

[0121] When the gradation expression is to be made by changing the number of droplets to be ejected within the 1 pixel cycle T as above, the impact position shift at every gradation makes a problem. That is because the droplet speed changes depending on the timing when each of the ejected droplets is joined with each other. Particularly if the droplet 100 ejected by the first driving signal PA is joined with the droplet 200 ejected by the second driving signal PB during flying, the energy of the droplet 100 is lost, which affects the droplet speed. That is because the droplet 200 is a droplet relatively larger than the droplet 100. Therefore, there is a concern that the impact positions are slightly different between the case of ejection of only the one droplet 100 and the case of ejection of a plurality of droplets 200, too, in addition to the droplet 100.

[0122] Assuming that the droplet speed of the droplet 100 by the first driving signal PA is VA, its droplet amount is MA, the droplet speed of the droplet 200 by the second driving signal PB is VB and its droplet amount is MB, an influence at joining depends on a ratio of motion amount between a large droplet and a small droplet ($(MA \times VA)/(MB \times VB)$), and an influence on the impact depends on a gap to the media 7 (distance between the nozzle surface of the head 3 and the surface of the media 7) L. Moreover, if the number N of the second driving signals PB increases to $N \geq 3$, the number of final joining times tends to increase, and the problem of the impact position shift becomes more remarkable than the other cases.

[0123] Thus, if the number N of the second driving signal PB applied within the 1 pixel cycle T is $N \geq 3$, it is preferable that the droplet 100 by the first driving signal PA applied at last of the 1 pixel cycle T and the droplet 200 by the second driving signal PB applied immediately before that do not form a joined droplet at least up to a position away from the nozzle by $(MA \times VA)/(MB \times VB) \times L$. That is, the droplet 100 and the droplet 200 are joined after crossing the position

away from the nozzle by $(MA \times VA)/(MB \times VB) \times L$ or land onto the media 7 so as to overlap each other.

[0124] As a result, the impact position shift at every gradation can be suppressed. Moreover, since the speed of the droplet 100 ejected at last within the 1 pixel cycle T does not have to be raised more than necessary, occurrence of the satellite can be further suppressed.

[0125] In the aforementioned explanation, a head capable of shear deformation of the partition wall 32 between the adjacent channels 31 and 31 is exemplified as the head 3, but the upper wall or the lower wall of the channel may be made the pressure generator constituted by the piezoelectric element such as PZT so as to shear/deform this upper wall or the lower wall.

[0126] Besides, the inkjet head in the present invention is not limited to the shear-mode at all. For example, the inkjet head may be of such a type that a wall surface of the pressure chamber is formed by a diaphragm, this diaphragm is oscillated by the pressure generator constituted by the piezoelectric element such as PZT so as to apply a pressure for ejecting the ink in the pressure chamber.

EXAMPLE

[0127] Examples of the present invention will be described below but the present invention is not limited by such examples.

(Example 1)

[0128] A shear-mode inkjet head (nozzle diameter = 24 μm , AL = 3.7 μs) illustrated in Fig. 2 was prepared. For the ink, UV curable ink was used at 40°C. Viscosity of the ink at this time was 0.01 Pa·s. An inkjet sheet was used as media, and a gap L between the media surface and the nozzle surface was set to 1.5 mm.

[0129] As a first driving waveform, a first driving waveform PA of a rectangular wave illustrated in Fig. 4A was used, and as a second driving waveform, a second waveform PB of a rectangular wave illustrated in Fig. 4B was used. Pulse widths and driving cycles are as follows.

<First driving waveform PA)

[0130]

Pulse width PWA1 of expansion pulse Pa1 = 3.7 μs (1 AL)
Pulse width PWA2 of contraction pulse Pa2 = 7.4 μs (2 AL)
Driving cycle TA = 26 μs (7 AL)

where the pause period PWA3 of 0.5 μs (1/4 AL or less) was provided between the expansion pulse Pa1 and the contraction pulse Pa2.

<Second driving waveform PB)

[0131]

Pulse width PWB1 of first expansion pulse Pb1 = 2.4 μs (0.65 AL)
Pulse width PWB2 of first contraction pulse Pb2 = 1.8 μs (0.5 AL)
Pulse width PWB3 of second expansion pulse Pb3 = 3.7 μs (1 AL)
Pulse width PWB4 of second contraction pulse Pb4 = 7.4 μs (2 AL)

Driving cycle TB = 18.5 μs (5 AL)

[0132] The reference potential of the first driving signal PA and the second driving signal PB was set to 0 potential, the voltage value (|Von|) of the expansion pulse (Pa1, Pb1, Pb3) was set to 11 V, and the voltage value (|Voff|) of the contraction pulse (Pa2, Pb2, Pb4) was set constant at 5.5 V.

[0133] Similarly to Fig. 3, the number N of the second driving signals PB within the 1 pixel cycle T was set to N=3, the one first driving signal PA was applied at last, and the three large droplets and the one small droplet were consecutively ejected.

[0134] The droplet speed of the droplet ejected by the first driving signal PA was 6 m/s, each of the droplet speeds of the three droplets ejected by the second driving signal PB was 5 m/s, and all of them were the same. The droplet amount of the single droplet ejected by the first driving signal PA was 6 pl (diameter: 22.5 μm), and the droplet amount of each

of the three droplets ejected by the second driving signal PB was 10 pl (diameter: 26.5 μm).

[0135] If the satellite has occurred in the ejected droplet, a splash caused by the satellite droplet is formed around the dot. Therefore, the dot on the media was microscopically observed and the satellite occurrence situation was evaluated on the basis of the following standard. The result is shown in Table 1.

[0136]

⊙: No satellite occurred.

○: Satellites slightly occurred but at a level not affecting the image quality at all.

△: Satellites occurred at a level slightly affecting the image quality.

×: Many satellites occurred at a level affecting the image quality.

[0137] Moreover, the dot formed on the media was microscopically observed, and the occurrence situation of the impact position shift was evaluated on the basis of the following standard. The result is shown in Table 1.

[0138]

⊙: No impact position shift at all, and a pixel with high precision was formed.

○: Slight impact position shift occurred but at a level not affecting the image quality at all.

△: Impact position shift occurred at a level slightly affecting the image quality.

×: Large impact position shift occurred at a level affecting the image quality.

(Comparative Example 1)

[0139] As illustrated in Fig. 12A, with the same constitution as in Example 1, except that the first driving signal PA was not applied within the 1 pixel cycle T and only the four second driving signals PB were consecutively applied, the occurrence situation of the satellite and the impact position shift were similarly evaluated. The result is shown in Table 1.

(Comparative Example 2)

[0140] As illustrated in Fig. 12B, with the same constitution as in Example 1, except that the timing when the first driving signal PA is applied was brought forward by one within the 1 pixel cycle T and the second driving signal PB was applied at last, the occurrence situation of the satellite and the occurrence situation of the impact position shift were similarly evaluated. The result is shown in Table 1.

(Comparative Example 3)

[0141] With the same constitution as in Example 1, except that the pause period PWA3 between the expansion pulse Pa1 and the contraction pulse Pa2 in the first driving signal PA was set to 1.2 μs (1/4 AL or more), the occurrence situation of the satellite and the occurrence situation of the impact position shift were similarly evaluated.

[0142] At this time, the droplet ejected at last was the droplet (6 pl) smaller than the droplet ejected by the second driving signal PB similarly to Example 1 but since the pause period PWA 3 was set longer, the droplet speed was 4.5 m/s, which was slower than that of the droplet ejected by the second driving signal PB. The result is shown in Table 1.

(Example 2)

[0143] With the same constitution as in Example 1, except that, by setting the pulse PWA1 of the expansion pulse Pa1 = 5.6 μs (1.5 AL) and the pulse width PWA of the contraction pulse Pa2 = 11.2 μs (3 AL) in the first driving signal PA so that the droplet amount of the single droplet by the first driving signal PA is 8 pl (diameter: 25 μm) and a droplet has a diameter larger than the nozzle diameter (24 μm), the occurrence situation of the satellite and the occurrence situation of the impact position shift were similarly evaluated. The result is shown in Table 1.

(Example 3)

[0144] With the same constitution as in Example 1, except that, the pulse widths PWB1 of the first expansion pulses Pb1 in the three second driving waveforms PB were set to 2.2 μs , 2.4 μs , and 2.6 μs , respectively, in the order of application within the 1 pixel cycle T so that the later the droplet is ejected, the faster the droplet speed becomes, the occurrence situation of the satellite and the occurrence situation of the impact position shift were similarly evaluated. The result is shown in Table 1.

[0145] The droplet speeds of the droplets ejected by the three second driving signals PB were 4.5 m/s, 5.0 m/s, and

EP 3 127 705 A1

5.5 m/s in the order. The droplet amounts of the three droplets ejected by the second driving signal PB were 9.5 pl (diameter: 26 μm), 10 pl (diameter: 26.5 μm), and 10.5 pl (diameter: 26 μm) in the order.

(Example 4)

[0146] With the same constitution as in Example 1, except that, the pulse widths PWB1 of the first expansion pulses Pb1 in the three second driving waveforms PB were set to 2.6 μs , 2.4 μs , and 2.2 μs in the order of application within the 1 pixel cycle T so that the later the droplet is ejected, the slower the droplet speed becomes, the occurrence situation of the satellite and the occurrence situation of the impact position shift were similarly evaluated. The result is shown in Table 1.

[0147] The droplet speeds of the droplets ejected by the three second driving signals PB were 5.5 m/s, 5.0 m/s, and 4.5 m/s in the order. The droplet amounts of the three droplets ejected by the second driving signal PB were 10.5 pl (diameter: 27 μm), 10 pl (diameter: 26.5 μm), and 9.5 pl (diameter: 26 μm) in the order.

(Example 5)

[0148] Assuming that the case where the number N of the second driving signals PB in Example 3 is the maximum gradation, gradation driving was performed using four levels, that is, the number N in the 1 pixel cycle T is reduced one by one to N=2, N=1, and N=0, and a confirmation test of the impact position shift between the gradations and of the satellite of the dot at each gradation was conducted. The result is shown in Table 1.

[0149] In this Example, the droplet amount MA of the droplet by the first driving signal PA = 6 pl, its droplet speed VA = 6 m/s, the droplet amount MB of the droplet by the second driving signal PB = 10.5 pl, its droplet speed VB = 5.5 m/s, and a gap L between the media surface and the nozzle surface = 1.5 mm and thus, $(L \times MA \times VA) / (MB \times VB)$ is 0.94 mm.

[0150] As the result of observation by the droplet observing device, it was confirmed that the droplet by the first driving signal PA applied at last within the 1 pixel cycle T and the droplet by the second driving signal PB applied immediately before that did not form the joined droplet at a position away from the nozzle by 0.94 mm.

[0151] The result of the satellite and the impact position shift is shown in Table 1. In this Example, the impact position shift was not found between the gradations and a favorable image was obtained.

[Table 1]

	Satellite occurrence situation	Occurrence situation of impact position shift
Example 1	⊙	⊙
Example 2	○	⊙
Example 3	⊙	⊙
Example 4	⊙	○
Example 5	⊙	⊙
Comparative Example 1	×	Δ
Comparative Example 2	×	×
Comparative Example 3	Δ	×

EXPLANATIONS OF LETTERS OR NUMERALS

[0152]

1: inkjet recording apparatus

2: conveying mechanism

21: conveying roller

22: conveying roller pair

23: conveying motor

3: inkjet head

	30: channel substrate
	31: channel
	32 partition wall
5	321: upper wall portion 322: lower wall portion
	33: cover substrate
10	331: common channel
	34: nozzle plate
15	341: nozzle
	35: plate
20	351: ink supply port 352: ink supply pipe
	4: guide rail
	5: carriage
	6: flexible cable
25	7: media
	71: recording surface
	8: driving control unit
30	100: droplet 200: droplet
	201: small droplet 202: large droplet
35	D: dot PA: first driving signal
	Pa1: expansion pulse Pa2: contraction pulse
40	PWA1, PWA2: pulse width PWA3: pause period
	PB: second driving signal
45	Pb1: first expansion pulse Pb2: first contraction pulse Pb3: second expansion pulse Pb4: second contraction pulse
50	PWB1 to PWB4: pulse width
	T: pixel cycle
	TA: driving cycle of first driving signal TB: driving cycle of second driving signal
55	T1, T2: pause period

Claims

1. A method for driving an inkjet head which applies a driving signal to a pressure generator for giving a pressure for ejection to a liquid in a pressure chamber so as to cause a droplet to be ejected from a nozzle, wherein
the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and by applying N pieces of the second driving signals cycle, and by applying the first driving signal at least at last in 1 pixel, the droplet is ejected from the same nozzle, and a pixel by a dot made of the droplet is formed on media and the aforementioned N is an integer not less than 1.
2. A method for driving an inkjet head which applies a driving signal to a pressure generator for giving a pressure for ejection to a liquid in a pressure chamber so as to cause a droplet to be ejected from a nozzle, wherein the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and by applying N pieces of the second driving signals cycle, and by applying the first driving signal at least at last in 1 pixel, the droplet is ejected from the same nozzle, and a pixel by a dot made of the droplet is formed on media, and by changing the aforementioned N to an integer not less than 0 in accordance with image data so as to create dots with different sizes on the media for making gradation expression.
3. The method for driving an inkjet head according to claim 2, wherein assuming that a distance between a nozzle surface of the inkjet head and the media is L, a droplet speed by the first driving signal is VA, a droplet amount is MA, the droplet speed by the second driving signal is VB and a droplet amount is MB, in the case of $N \geq 3$, the droplet by the first driving signal and the droplet by the second driving signal immediately before that do not form a joined droplet up to a position at least away from the nozzle by $(L \times MA \times VA)/(MB \times VB)$.
4. The method for driving an inkjet head according to claim 1, 2 or 3, wherein a diameter of the droplet ejected by the first driving signal is smaller than a diameter of the nozzle.
5. The method for driving an inkjet head according to any one of claims 1 to 4, wherein a diameter of the droplet ejected by the second driving signal is larger than a diameter of the nozzle.
6. The method for driving an inkjet head according to any one of claims 1 to 5, wherein assuming that a driving cycle of the first driving signal is TA and a driving cycle of the second driving signal is TB, $TA \geq TB$.
7. The method for driving an inkjet head according to any one of claims 1 to 6, wherein assuming that a droplet amount of the droplet ejected by the first driving signal is MA and a droplet amount of the droplet ejected by the second driving signal is MB, $MA \times 1.5 \leq MB$.
8. The method for driving an inkjet head according to any one of claims 1 to 7, wherein the pressure generator is to expand or contract a capacity of the pressure chamber by driving; and the first driving signal and the second driving signal include an expansion pulse for expanding the capacity of the pressure chamber and contracting the same after certain time and a contraction pulse for contracting the capacity of the pressure chamber and expanding the same after certain time, respectively, a wave crest of the expansion pulse of each of the first driving signal and the second driving signal applied to the pressure generator corresponding to the same nozzle is constant, and a wave crest of the contraction pulse of each of the first driving signal and the second driving signal applied to the pressure generator corresponding to the same nozzle is constant.
9. The method for driving an inkjet head according to claim 8, wherein the first driving signal has the expansion pulse, the contraction pulse, and a pause period connecting the expansion pulse and the contraction pulse.
10. The method for driving an inkjet head according to claim 9, wherein a pulse width of the expansion pulse in the first driving signal is 0.8 AL or more and 1.2 AL or less (where AL is 1/2 of an acoustic resonant period of a pressure wave in the pressure chamber); a pulse width of the contraction pulse is 1.8 AL or more and 2.2 AL or less; and the pause period is 1/4 AL or less.

11. The method for driving an inkjet head according to claim 8, 9 or 10, wherein the second driving signal has a first expansion pulse made of the expansion pulse, a first contraction pulse made of the contraction pulse, a second expansion pulse made of the expansion pulse, and a second contraction pulse made of the contraction pulse in the order of a time series.
12. The method for driving an inkjet head according to claim 11, wherein a pulse width of the first expansion pulse in the second driving signal is 0.4 AL or more and 2.0 AL or less (where AL is 1/2 of an acoustic resonant period of a pressure wave in the pressure chamber); a pulse width of the first contraction pulse is 0.4 AL or more and 0.7 AL or less; a pulse width of the second expansion pulse is 0.8 AL or more and 1.2 AL or less; and a pulse width of the second contraction pulse is 1.8 AL or more and 2.2 AL or less.
13. The method for driving an inkjet head according to claim 12, wherein in the case of $N \geq 2$, the first expansion pulses of N pieces of the second driving signal to be applied within 1 pixel cycle have pulse widths different from each other.
14. The method for driving an inkjet head according to claim 13, wherein the first expansion pulses are applied in the order from the shorter pulse width in the 1 pixel cycle.
15. The method for driving an inkjet head according to any one of claims 1 to 14, wherein the first driving signal and the second driving signal are both rectangular waves.
16. The method for driving an inkjet head according to any one of claims 1 to 15, wherein the first driving signal is a driving signal for forming a smallest droplet in a plurality of the driving signals aligned in 1 pixel cycle in a time series.
17. An inkjet recording apparatus including an inkjet head which applies a pressure for ejection to a liquid in a pressure chamber by driving of a pressure generator and causes a droplet to be ejected from a nozzle; and a driving controller which outputs a driving signal for driving the pressure generator, wherein the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and the driving controller causes a droplet to be ejected from the same nozzle by applying N pieces of the second driving signal and by applying the first driving signal at least at last in 1 pixel cycle so as to form a pixel made of a dot by the droplet on media and the aforementioned N is an integer not less than 1.
18. An inkjet recording apparatus including an inkjet head which applies a pressure for ejection to a liquid in a pressure chamber by driving of a pressure generator and causes a droplet to be ejected from a nozzle; and a driving controller which outputs a driving signal for driving the pressure generator, wherein the driving signal includes at least two types of driving signals, that is, a first driving signal for ejecting a droplet and a second driving signal for ejecting a large droplet at a speed relatively lower than the first driving signal; and the driving controller causes a droplet to be ejected from the same nozzle by applying N pieces of the second driving signals cycle and by applying the first driving signal at least at last in 1 pixel so as to form a pixel made of by a dot by the droplet on media and creates dots with different sizes on the media by changing the aforementioned N to an integer not less than 0 in accordance with image data so as to make gradation expression.
19. The inkjet recording apparatus according to claim 18, wherein assuming that a distance between a nozzle surface of the inkjet head and the media is L, a droplet speed by the first driving signal is VA, a droplet amount is MA, the droplet speed by the second driving signal is VB and a droplet amount is MB, in the case of $N \geq 3$, the droplet by the first driving signal and the droplet by the second driving signal immediately before that do not form a joined droplet up to a position at least away from the nozzle by $(L \times MA \times VA) / (MB \times VB)$.
20. The inkjet recording apparatus according to claim 17, 18 or 19, wherein a diameter of the droplet ejected by the first driving signal is smaller than a diameter of the nozzle.
21. The inkjet recording apparatus according to any one of claims 17 to 20, wherein a diameter of the droplet ejected by the second driving signal is larger than a diameter of the nozzle.

22. The inkjet recording apparatus according to any one of claims 17 to 21, wherein assuming that a driving cycle of the first driving signal is TA and a driving cycle of the second driving signal is TB, $TA \geq TB$.

23. The inkjet recording apparatus according to any one of claims 17 to 22, wherein assuming that a droplet amount of the droplet ejected by the first driving signal is MA and a droplet amount of the droplet ejected by the second driving signal is MB, $MA \times 1.5 \leq MB$.

24. The inkjet recording apparatus according to any one of claims 17 to 23, wherein the pressure generator is to expand or contract a capacity of the pressure chamber by driving; and the first driving signal and the second driving signal include an expansion pulse for expanding the capacity of the pressure chamber and contracting the same after certain time and a contraction pulse for contracting the capacity of the pressure chamber and expanding the same after certain time, respectively, a wave crest of the expansion pulse of each of the first driving signal and the second driving signal applied to the pressure generator corresponding to the same nozzle is constant, and a wave crest of the contraction pulse of each of the first driving signal and the second driving signal applied to the pressure generator corresponding to the same nozzle is constant.

25. The inkjet recording apparatus according to claim 24, wherein the first driving signal has the expansion pulse, the contraction pulse, and a pause period connecting the expansion pulse and the contraction pulse.

26. The inkjet recording apparatus according to claim 25, wherein a pulse width of the expansion pulse in the first driving signal is 0.8 AL or more and 1.2 AL or less (where AL is 1/2 of an acoustic resonant period of a pressure wave in the pressure chamber); a pulse width of the contraction pulse is 1.8 AL or more and 2.2 AL or less; and the pause period is 1/4 AL or less.

27. The inkjet recording apparatus according to claim 24, 25 or 26, wherein the second driving signal has a first expansion pulse made of the expansion pulse, a first contraction pulse made of the contraction pulse, a second expansion pulse made of the expansion pulse, and a second contraction pulse made of the contraction pulse.

28. The inkjet recording apparatus according to claim 27, wherein a pulse width of the first expansion pulse in the second driving signal is 0.4 AL or more and 2.0 AL or less (where AL is 1/2 of an acoustic resonant period of a pressure wave in the pressure chamber); a pulse width of the first contraction pulse is 0.4 AL or more and 0.7 AL or less; a pulse width of the second expansion pulse is 0.8 AL or more and 1.2 AL or less; and a pulse width of the second contraction pulse is 1.8 AL or more and 2.2 AL or less.

29. The inkjet recording apparatus according to claim 28, wherein in the case of $N \geq 2$, the first expansion pulses of N pieces of the second driving signal to be applied within 1 pixel cycle have pulse widths different from each other.

30. The inkjet recording apparatus according to claim 29, wherein the first expansion pulses are applied in the order from the shorter pulse width in the 1 pixel cycle.

31. The inkjet recording apparatus according any one of claims 17 to 30, wherein the first driving signal and the second driving signal are both rectangular waves.

32. The inkjet recording apparatus according any one of claims 17 to 31, wherein the first driving signal is a driving signal for forming a smallest droplet in a plurality of the driving signals aligned in 1 pixel cycle in a time series.

DRAWINGS

FIG. 1

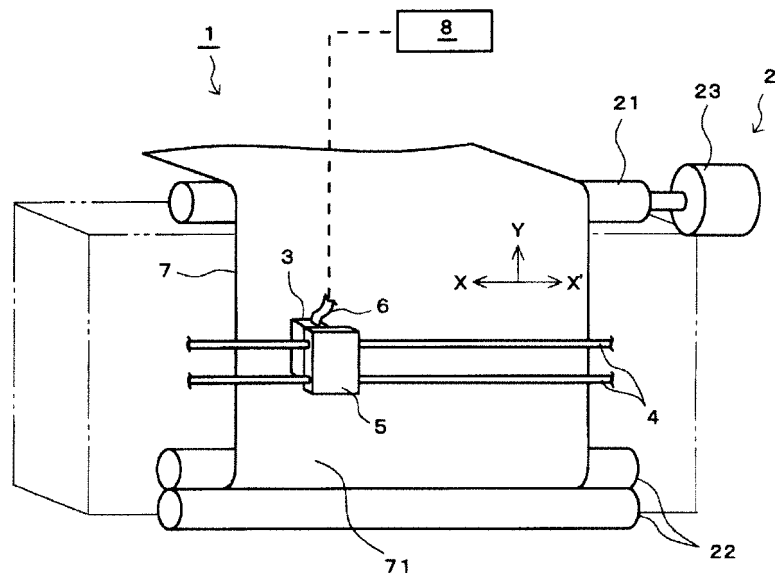


FIG. 2

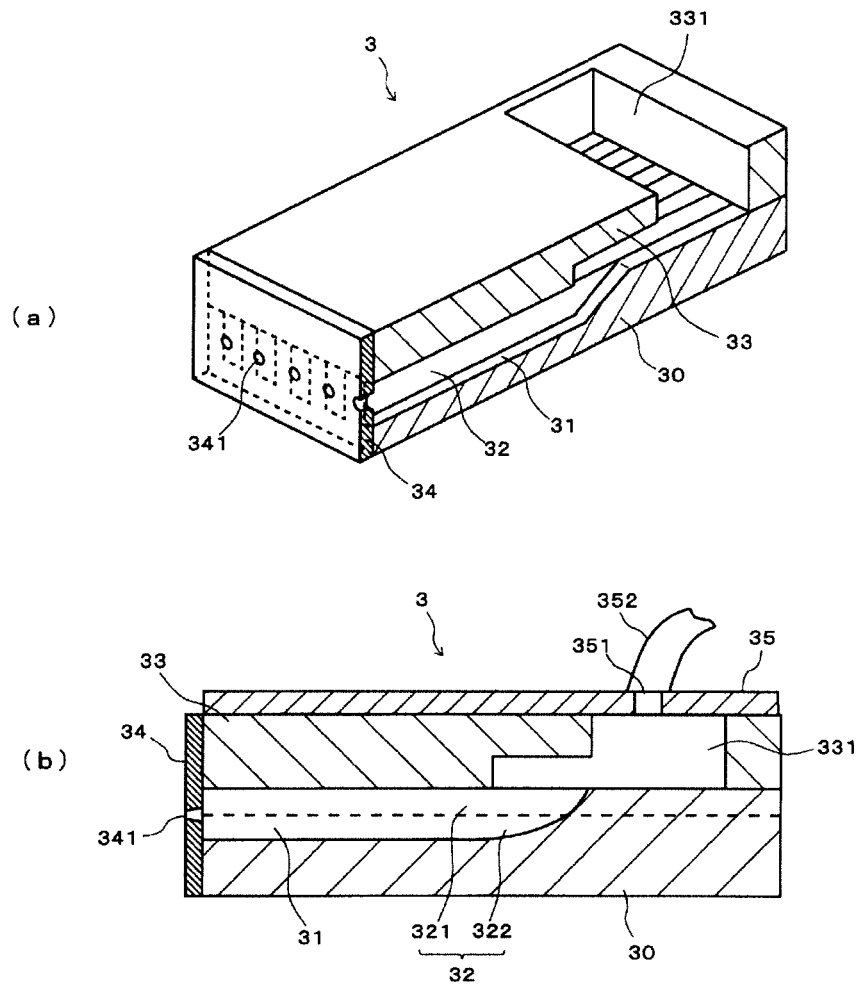


FIG. 3

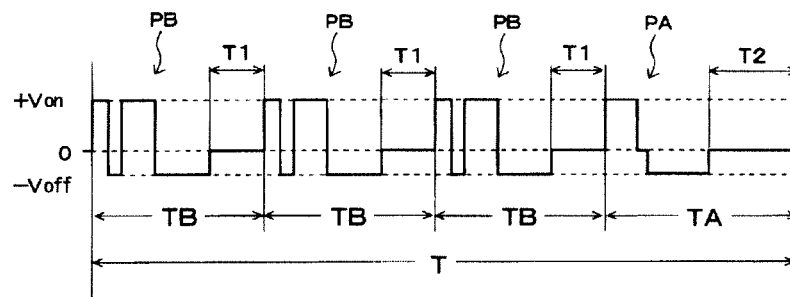


FIG. 4

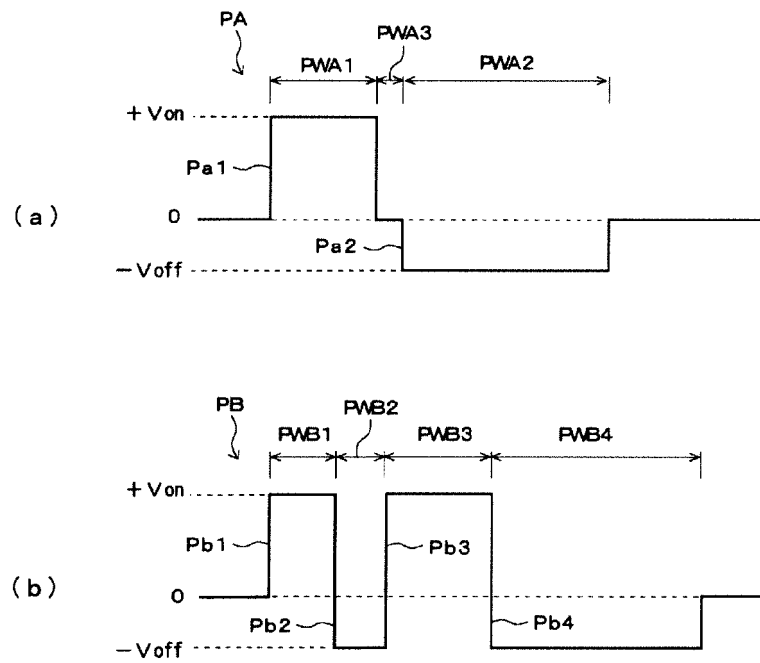


FIG. 5

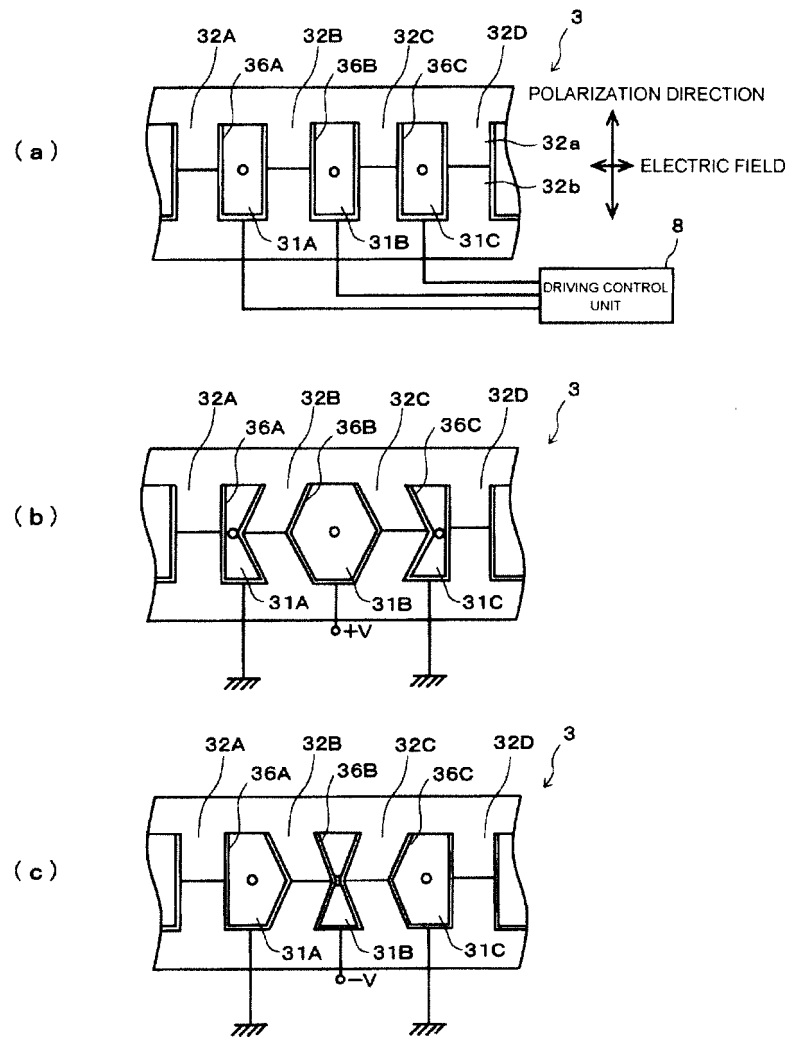


FIG. 6

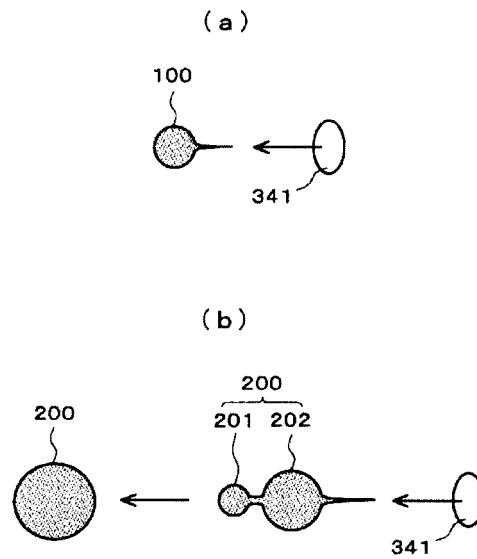


FIG. 7

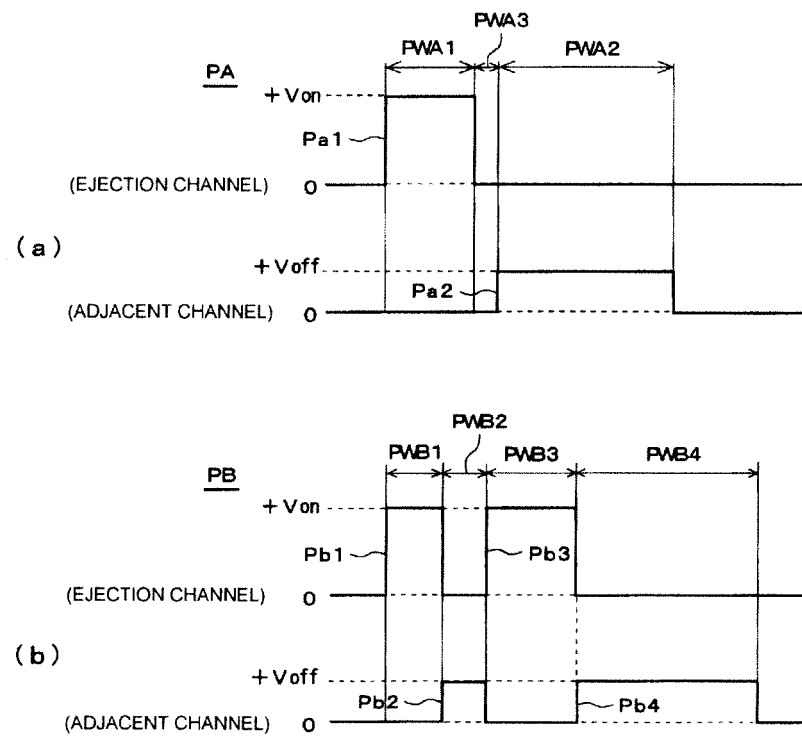


FIG. 8

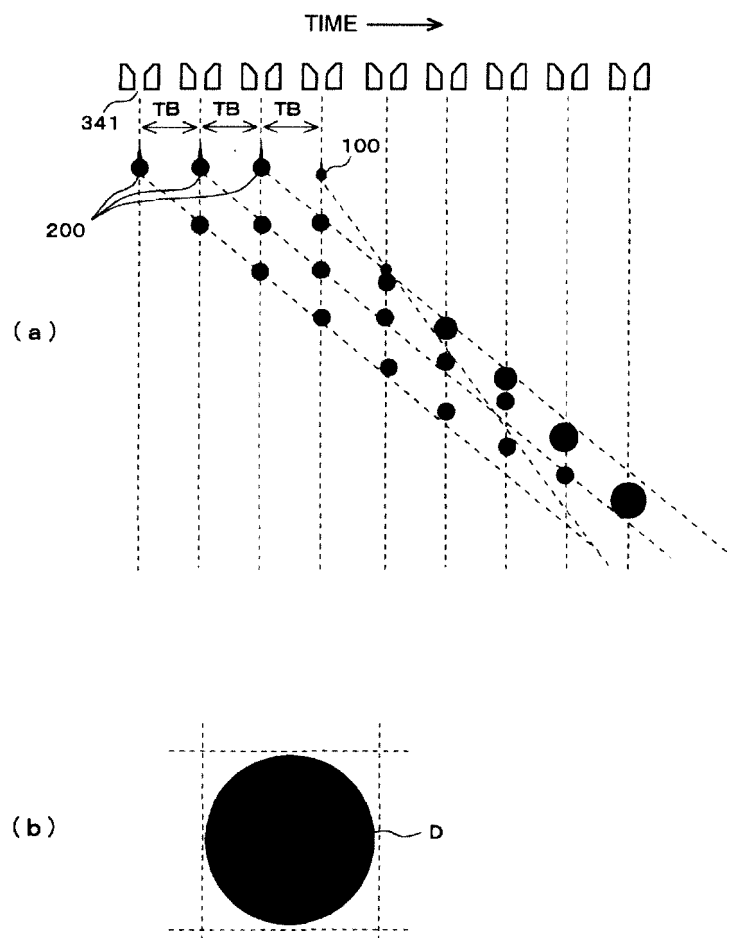


FIG. 9

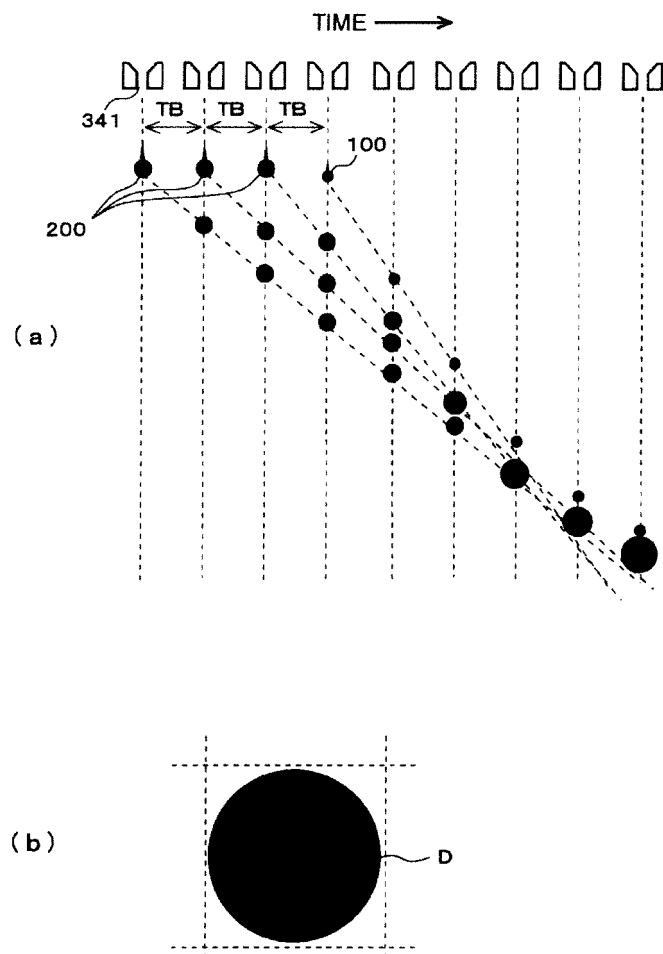


FIG. 10

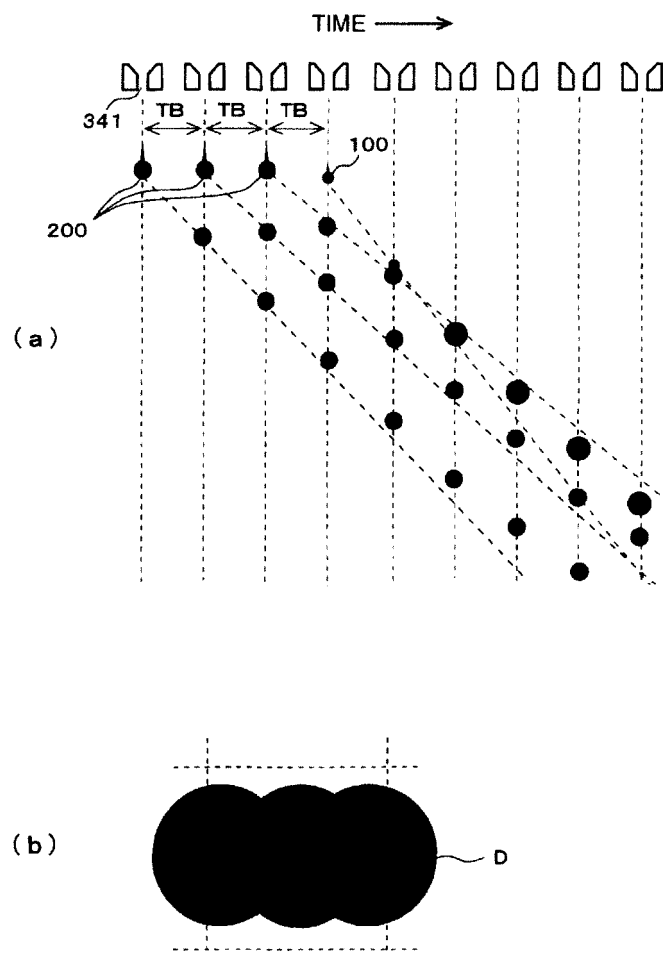


FIG. 11

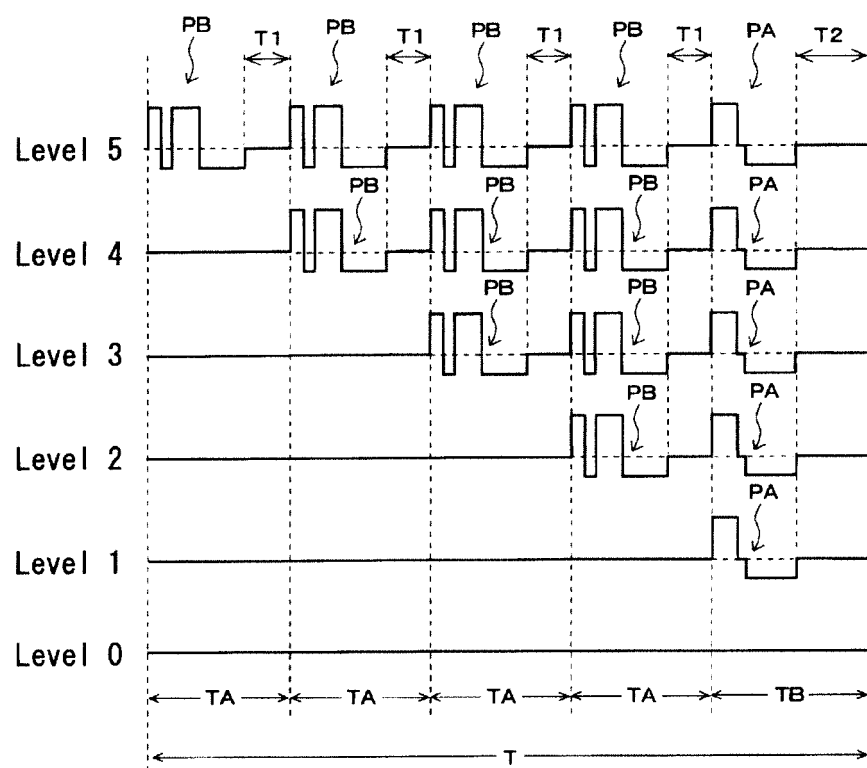
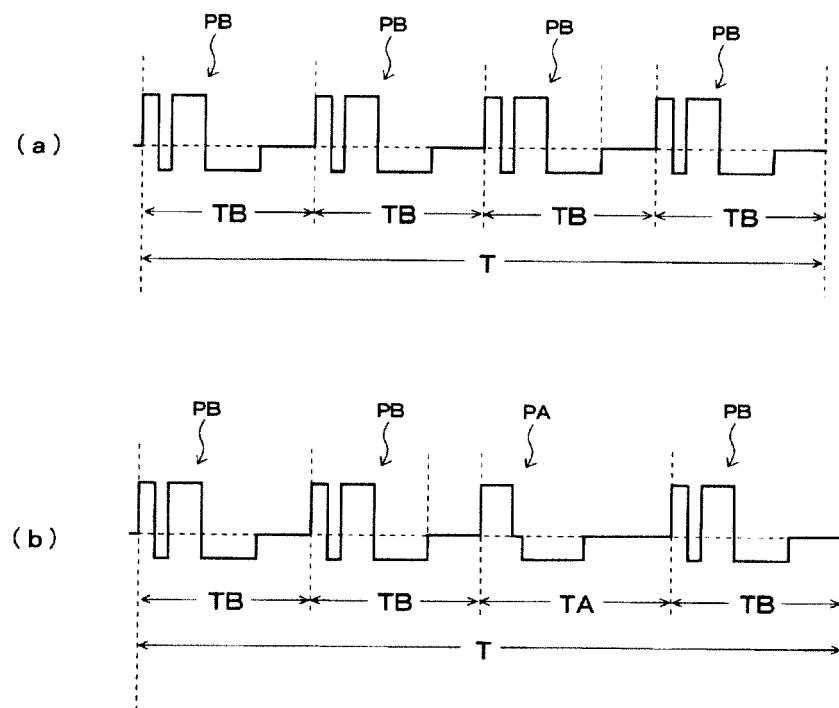


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/060018

A. CLASSIFICATION OF SUBJECT MATTER

B41J2/015(2006.01)i, B41J2/045(2006.01)i, B41J2/14(2006.01)i, B41J2/205(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)

B41J2/015, B41J2/045, B41J2/14, B41J2/205

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.
X	JP 2000-85158 A (Matsushita Electric Industrial Co., Ltd.), 28 March 2000 (28.03.2000), paragraphs [0027], [0036] to [0038], [0042], [0044]; fig. 9 (Family: none)	1-2, 6-7, 16-18, 22-23, 32 4-5, 8-11, 15, 20-21, 24-27, 31 3, 12-14, 19, 28-30
Y		
A		
Y	JP 2000-198226 A (Matsushita Electric Industrial Co., Ltd.), 18 July 2000 (18.07.2000), paragraphs [0056] to [0057]; fig. 3 to 4 & US 6513915 B1	4-5, 20-21

☒ 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
03 June 2015 (03.06.15)Date of mailing of the international search report
16 June 2015 (16.06.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/060018

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-31442 A (Riso Kagaku Corp.), 17 February 2011 (17.02.2011), paragraphs [0038] to [0043]; fig. 8 (Family: none)	8-11, 15, 24-27, 31
Y	JP 2001-301207 A (Konica Corp.), 30 October 2001 (30.10.2001), entire text; all drawings (Family: none)	11, 27
A	JP 2005-74651 A (Toshiba Tec Corp.), 24 March 2005 (24.03.2005), the whole; all drawings (Family: none)	1-32
A	JP 2004-188932 A (Sharp Corp.), 08 July 2004 (08.07.2004), entire text; all drawings (Family: none)	1-32

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 2007118278 A [0008]
- JP 2008093950 A [0008]
- JP 2001146011 A [0008]
- JP 2007105936 A [0008]