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(54) METHOD OF OPERATING A DROPLET EJECTION DEVICE

VERFAHREN ZUR OPERATION EINER TRÖPFCHENAUSSTOSSVORRICHTUNG

PROCÉDÉ DE FONCTIONNEMENT D'UN DISPOSITIF D'ÉJECTION DE GOUTTELETTES

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Description

[0001] The invention relates to a method of operating a droplet ejection device comprising an ejection unit arranged to eject droplets of a liquid and comprising a nozzle formed in a nozzle face, a liquid duct connected to the nozzle, and an electro-mechanical transducer arranged to create an acoustic pressure wave in the liquid in the duct, wherein the liquid and the material constituting the nozzle face are paired such that the liquid is wetting for the nozzle face.

[0002] More particularly, the invention relates to ink jet printing.

[0003] The electro-mechanical transducer may for example be a piezoelectric. When a voltage pulse is applied to the transducer, this will cause a mechanical deformation of the transducer. As a consequence, an acoustic pressure wave is created in the liquid ink in the duct, and when the pressure wave propagates to the nozzle, an ink droplet is expelled from the nozzle.

[0004] EP 1 378 359 A1 and EP 1 378 360 A1 describe ink jet printers which comprise an electronic circuit for measuring the electric impedance of the piezoelectric transducer. Since the impedance of the transducer is changed when the body of the transducer is deformed or exposed to an external mechanical strain, the impedance can be used as a measure for the reaction forces which the liquid in the duct exerts upon the transducer. Consequently, the impedance measurement can be used for monitoring the pressure fluctuations in the ink that are caused by the acoustic pressure wave that is being generated or has been generated by the transducer.

[0005] The impedance measurement may be performed in the intervals between successive voltage pulses. In that case, the impedance fluctuations are indicative of the acoustic pressure wave that is gradually decaying in the duct after a droplet has been expelled. This information may then be used for adapting the amplitude and/or shape of the next voltage pulse.

[0006] In most ink jet printers, the nozzle face is coated with a non-wetting coating so as to prevent the nozzle face from becoming wetted with the ink. However, the non-wetting property of the nozzle face tends to decrease in the course of time, so that a pool of liquid ink may be formed on the nozzle face around the nozzle. Since it is considered that such a pool of ink is likely to cause instabilities in the droplet generation process, it is common practice to wipe the nozzle face with a wiper from time to time in order to remove such pools of ink. US 9 487 090 B2 discloses a jetting device in which the capability of the transducer to detect acoustic pressure waves in the ink duct is utilized for detecting the presence of an ink pool at the nozzle face, so that an error signal or a wiping command may be generated if such a pool is detected. US-A1-2013/0176354 discloses methods for driving ink-jet printers.

[0007] It is an object of invention to provide a method

of operating a droplet ejection device with improved jetting stability.

[0008] In order to achieve this object, the method according to the invention comprises a step of monitoring a parameter that represents a state of a liquid pool formed on the nozzle face around the nozzle, and a step of enabling the ejection unit to operate as long as the pool is present and the monitored parameter is within a predetermined range. According to the invention, the device is purposely operated under a condition in which a pool of liquid is present on the nozzle face. It has been found that it is nevertheless possible to obtain a stable jetting behavior of the device, provided that the condition of the liquid pool is stable. This is why, according to the invention, a parameter that represents the state of the liquid pool is constantly monitored, so that the operation of the device can be maintained as long as the state of the pool is stable. Thus, an error signal interrupting the operation of the device needs to be generated only in the case that the pool becomes unstable. An advantage of having a liquid pool on the nozzle face is that the pool reliably prevents the entry of ambient air into the nozzle, so that the droplet ejection process will not be disturbed by air bubbles in the nozzle or in the liquid duct.

[0009] Useful details and further developments of the invention are indicated in the dependent claims.

[0010] In a preferred embodiment the state of the pool is not only monitored but feedback-controlled actively so as to keep the state of the pool stable. As is known in the art, the condition of the pool influences the characteristic parameters such as frequency, energy and decay rate of the acoustic waves in the ink duct, so that the transducer can be used for monitoring the state of the pool. Then, if it is detected that the measured parameter or parameters are not within the desired range, it is possible to modify the state of the pool, for example by changing the shape and/or amplitude of the actuation pulses applied to the actuator for exciting the acoustic waves.

[0011] An important parameter to be monitored is the depth of the pool, i.e. the thickness of the layer of liquid formed on the nozzle face at the position of the nozzle. An increase of the depth of the pool leads to a decrease in the frequency of the acoustic wave.

[0012] The voltage pulses applied to the transducer in each jetting operation typically comprise two pulses, namely an actuation pulse for exciting the pressure wave, and, with a certain time delay, a quench pulse with smaller amplitude which has the purpose to accelerate the decay of the acoustic wave after the droplet has been ejected, so that the ejection of the next droplet will not be disturbed by a residual pressure wave in the duct. Each actuation pulse has a rising flank and a descending flank which do not necessarily have the same height, because the voltage level in the interval between the actuation pulse and the quench pulse may be different from the voltage level before the actuation pulse and after the quench pulse. It has been found that the ratio of the heights of the flanks of the actuation pulse influences the

size of the ink pool. If the rising flank is higher than the descending flank, then the amount of liquid that is "pumped" into the pool exceeds the amount that leaves the pool in the form of the droplet being ejected, so that the size and particularly the depth of the pool will increase. On the contrary, when the descending flank of the actuation pulse exceeds the rising flank, the pool will be deprived of liquid, and its depth will increase. In this way, it is possible to feedback-control the depth of the pool and thereby to keep the jetting behavior stable.

[0013] In particular in applications in which the liquid that forms the droplets contains water, e.g. in case of printing with water-based ink, condensation of water vapor on the nozzle face may cause the ink pool to become diluted with water, which influences the jetting behavior and the quality of the printed image. Since the viscosity of the liquid will depend upon its content of water and the viscosity of the liquid is an important factor influencing the decay pattern of the acoustic wave, it is also possible within the framework of the invention to monitor the content of water in the liquid and to stop the jetting process and/or take suitable counter-measures against condensation of water on the nozzle face, if the content of water becomes too high.

[0014] Embodiment examples of the invention will now be described in conjunction with the drawings, wherein:

Fig. 1 is a cross-sectional view of mechanical parts of a droplet ejection device according to the invention, together with an electronic circuit for controlling and monitoring the device;

Fig. 2 is a time diagram showing a patterns of voltage pulses to be applied to a transducer of the jetting device;

Fig. 3 is a time diagram illustrating acoustic pressure waves that may be excited by the pulses shown in Fig. 2;

Fig. 4 is a time diagram illustrating acoustic pressure waves that may be excited under operating conditions different from those in Fig. 3; and

Fig. 5 is a flow diagram showing essential steps of a method according to an embodiment of the invention.

[0015] A single ejection unit of an ink jet print head has been shown in Fig. 1. The print head constitutes an example of a droplet ejection device according to the invention. The device comprises a wafer 10 and a support member 12 that are bonded to opposite sides of a thin flexible membrane 14.

[0016] A recess that forms an ink duct 16 is formed in the face of the wafer 10 that engages the membrane 14, e.g. the bottom face in Fig. 1. The ink duct 16 has an essentially rectangular shape. An end portion on the left

side in Fig. 1 is connected to an ink supply line 18 that passes through the wafer 10 in thickness direction of the wafer and serves for supplying liquid ink to the ink duct 16.

[0017] An opposite end of the ink duct 16, on the right side in Fig. 1, is connected, through an opening in the membrane 14, to a chamber 20 that is formed in the support member 12 and opens out into a nozzle 22 that is formed in a nozzle face 24 constituting the bottom face of the support member.

[0018] Adjacent to the membrane 14 and separated from the chamber 20, the support member 12 forms another cavity 26 accommodating a piezoelectric actuator 28 that is bonded to the membrane 14.

[0019] An ink supply system which has not been shown here keeps the pressure of the liquid ink in the ink duct 16 the slightly below the atmospheric pressure, so as to prevent the ink from leaking out through the nozzle 22.

[0020] The nozzle face 24 is made of or coated with a material which is wetted by the ink, so that adhesion forces cause a pool 30 of ink to be formed on the nozzle face 24 around the nozzle 22. The pool 30 is delimited on the outward (bottom) side by a meniscus 32a.

[0021] The piezoelectric transducer 28 has electrodes 34 that are connected to an electronic circuit that has been shown in the lower part of Fig. 1. In the example shown, one electrode of the transducer is grounded via a line 36 and a resistor 38. Another electrode of the transducer is connected to an output of an amplifier 40 that is feedback-controlled via a feedback network 42, so that a voltage V applied to the transducer will be proportional to a signal on an input line 44 of the amplifier. The signal on the input line 44 is generated by a D/A-converter 46 that receives a digital input from a local digital controller 48. The controller 48 is connected to a processor 50.

[0022] When an ink droplet is to be expelled from the nozzle 22, the processor 50 sends a command to the controller 48 which outputs a digital signal that causes the D/A-converter 46 and the amplifier 40 to apply a voltage pulse to the transducer 26. This voltage pulse causes the transducer to deform in a bending mode. More specifically, the transducer 28 is caused to flex downward, so that the membrane 14 which is bonded to the transducer 28 will also flex downward, thereby to increase the volume of the ink duct 16. As a consequence, additional ink will be sucked-in via the supply line 18. Then, when the voltage pulse falls off again, the membrane 14 will flex back into the original state, so that a positive acoustic pressure wave is generated in the liquid ink in the duct 16. This pressure wave propagates to the nozzle 22 and causes an ink droplet to be expelled.

[0023] The electrodes 34 of the transducer 28 are also connected to an A/D converter 52 which measures a voltage drop across the transducer and also a voltage drop across the resistor 38 and thereby implicitly the current flowing through the transducer. Corresponding digital signals are forwarded to the controller 48 which can derive the impedance of the transducer 28 from these signals. The measured electric response (current, voltage,

impedance, etc.) is signaled to the processor 50 where the electric response is processed further.

[0024] Fig. 2 shows the voltage V (in arbitrary units) applied to the transducer 28 as a function of the time t .

[0025] When an ink droplet is to be expelled from the nozzle, the actuator 28 is at first energized with an actuation pulse 54a with positive polarity and then, after a certain delay time, with a quench pulse 56a which has negative polarity and a somewhat smaller amplitude. The actuation pulse 54a has a rising flank 58 with a height $A1$, and a descending flank 60 with a height $A2$. In case of the actuation pulse 54a shown in continuous lines in Fig. 2, the pulse has a symmetric shape, so that $A1 = A2$. During the rising flank 58 of the actuation pulse, the membrane 14 is flexed downwardly in Fig. 1, so that fresh ink is drawn in from the ink supply line 18. Then, during the descending flank 60, the membrane 14 moves upwards again, so that the volume of the ink duct 16 is reduced and a pressure wave is excited in the liquid ink. This pressure wave will propagate to the nozzle 22 and will cause an ink droplet to be expelled. While the droplet is being jetting out, the pressure wave is reflected (with phase reversal) at the meniscus 32a and will propagate back into the ink duct 16 at the end of which it will be reflected again, so that the ink in the ink duct 16 under-

goes periodic pressure fluctuations which gradually decay in the course of time, before a next droplet is to be ejected.

[0026] The quench pulse 56A is timed and dimensioned so as to attenuate the pressure fluctuations by destructive interference, so that the fluctuations may be reduced to practically zero before the next ink droplet is to be ejected.

[0027] Fig. 3 shows a typical waveform 62A of a pressure fluctuation decaying in the ink duct 16, the pressure fluctuations being represented by a function $P(t)$ of the time t . The electronic circuit shown in Fig. 1 is capable of measuring the response of the transducer 28 to these pressure fluctuations, so that the processor 50 may record and analyze the function $P(t)$.

[0028] The frequency f of the pressure fluctuations depends upon the density and viscosity of the liquid ink and also on the dimensions of the resonance cavity which extends from the left end of the ink duct 16 in Fig. 1 to the meniscus 32a of the ink in the pool 30. If the pool 30 becomes larger, so that it is delimited by a meniscus 32b shown in dashed line in Fig. 1, then the frequency of the pressure fluctuations will be slightly lower, as shown by the waveform 62b in Fig. 3. Further, due to the increased mass of the oscillating ink volume, the amplitude of the pressure fluctuations and, consequently, their total energy content becomes smaller. Thus, it is possible to infer the depth of the ink pool 30 from the characteristic parameters, in particular frequency f and amplitude or energy, of the waveform 62a or 62b currently detected by the transducer.

[0029] In order to visualize the difference in the frequencies of the waveforms 62a and 62b in Fig. 3, the

time intervals $6Ta$ and $6Tb$, which correspond to six times the period T of the respective waveform have been shown in this figure.

[0030] In order to obtain a stable droplet ejection behavior of the device, it is essential that the depth of the pool 30 is kept constant. It shall be assumed here that the waveform 62a shown in Fig. 3 corresponds to a target depth of the pool 30. If a deviation in the frequency shows that the depth of the pool has become too large, as represented by the waveform 62b, the controller changes the shape of the actuation pulses as illustrated by an actuation pulse 54b in Fig. 2. This pulse is asymmetric in the sense that the height $B1$ of the rising flank is smaller than the height $B2$ of the descending flank or, in other words, the flank ratio $B1/B2$ is smaller than 1. This asymmetry is compensated by a corresponding asymmetry in a related quench pulse 56b. The effect of the asymmetry of the actuation pulse 54b is that less ink is drawn in during the rising flank 58 and more ink is squeezed out through the nozzle 22 during the descending flank 60. The major part of this increased amount of ink will be consumed by the generation of the ink droplet. When the membrane 14 returns to the non-deflected state at the end of the quench pulse, there will be a deficit of ink in the ink duct, and ink will be withdrawn from the pool 30 into the ink duct, so that the pool 30 will shrink and its depth will decrease.

[0031] In this way, the depth of the pool is returned to the target value.

[0032] Conversely, if an increase in the frequency of the pressure fluctuations shows that the depth of the pool 30 has become too small, the shape of the actuation pulse will be modified such that the flank ratio becomes larger than 1, so that excessive ink will be pumped in the pool 30 and the pool will grow again.

[0033] The asymmetries in the actuation pulses 54b may be controlled such that their influence on the size of the ejected ink droplets is negligible but the depth of the pool 30 can nevertheless be returned to the target value in a few ejection cycles.

[0034] In certain applications, such as a printing application with water-based ink, an increased production of water vapor in the vicinity of the droplet ejection device 10 may result in condensation of water on the nozzle face 24. This may have the consequence that the pool 30 formed at the nozzle 22 does not consist only of ink with a high viscosity but instead consists mainly of water which has a significantly lower viscosity. This results in a modified waveform 62c of the pressure fluctuations, as has been shown in Fig. 4. For comparison, the "regular" waveform 62a has also been shown in Fig. 4.

[0035] It can be seen in Fig. 4 that the pool of water causes essentially the same decrease in the frequency f as the pool of ink, but, due to the lower viscosity (and density) of the water, the amplitude and energy of the pressure fluctuations are higher than in case of the waveform 62b (Fig. 3), so that the initial amplitude is almost as high as for the waveform 62a. Moreover, the lower

viscosity of the water has the effect that the pressure fluctuations are dampened more slowly. A dashed line 64 in Fig. 4 is an envelope of the waveform 62c and corresponds approximately to the graph of an exponential decay function $C \cdot \exp(-t/\tau)$, wherein C is a constant (indicating the initial amplitude of the fluctuation), and τ is the decay time constant. As is shown in Fig. 4, the decay of the waveform 62c is much slower than that of the waveform 62a, which means that the waveform 62c has a significantly larger decay time constant τ .

[0036] Consequently, the criteria: "high amplitude" and "slow decay" can be taken as an indication for the presence of a significant amount of water in the pool 30. So the processor 50 can also detect an unacceptably large amount of water in the pool 30 and can stop the droplet ejection process (print process) if the content of water becomes intolerable.

[0037] Fig. 5 is a flow diagram illustrating essential steps of an example of a method according to the invention.

[0038] The ink jet print head starts printing at step S1. It will be understood that the print head has a plurality of nozzle and actuator arrangements of the type shown in Fig. 1, and the subsequent steps to be described below will be performed separately for each pair of nozzle and actuator.

[0039] In step S2, the processor 50 measures the function $P(t)$ representing the pressure fluctuations and determines the frequency f of the recorded waveform as well as the parameters C and τ of the corresponding decay function.

[0040] In step S3, it is checked whether the frequency f is within an admissible frequency range defined by a lower limit $f_{\min}$ and an upper limit $f_{\max}$. If the result is positive (Y) in step S3, this means that the depth of the pool 30 is sufficiently close to the target value, so that the print process can be continued with the present shape of the actuation and quench pulses.

[0041] Regardless of the outcome of step S3, it is checked in steps S4 and S5 whether the parameter C, which is a measure of the amplitude or energy of the pressure fluctuations, is also within an admissible range defined by a lower limit $C_{\min}$ and an upper limit $C_{\max}$. As has been shown in Figs. 3 and 4, the parameter C should decrease significantly with decreasing frequency f if the pool 30 consists mainly of ink, whereas C will be larger if the pool contains water. Thus, the upper limit $C_{\max}$ is selected so as to discriminate between the case where the pool 30 consists mainly of ink, as desired, and the case where the pool contains an unacceptable amount of water, resulting in a higher value C. The comparison of the parameter C with the lower limit $C_{\min}$ is optional and may serve to detect any other types of malfunction.

[0042] If it is found in step S4 or S5 that the parameter C is not within the admissible range (N), an error signal is generated in step S6, and the print process aborted in step S7.

[0043] In a simple implementation, the limit $C_{\max}$

may be constant. It will be observed however, that the amplitude of the pressure fluctuations will decrease with increasing depth of the pool 30 and, consequently, will decrease frequency f . Therefore, in a more elaborated embodiment, the upper limit $C_{\max}$ of the amplitude range may be made dependent upon the detected frequency f .

[0044] If the result in step S4 or S5 has been "yes" (Y), it is checked in step S8 and S9, respectively, whether the decay time constant τ is below a certain upper limit $\tau_{\max}$. If this is not the case (N), this is an indication that the amount of water in the pool is too high, and, again, an error signal is sent in step S6 and the print process is aborted in step S7.

[0045] Otherwise, if the results have been "yes" (Y) in step S3 and also in steps S5 and S9, it can be concluded that the pool 30 is in the desired condition, and the process loops back to step S3, while the print process is continued without any modifications.

[0046] In a practical embodiment the loop constituted by the steps S3, S5 and S9 may be repeated every 100 ms, for example.

[0047] If a negative result (N) had been obtained in step S3 and positive results (Y) have been obtained in steps S4 and S8, this means that the water content of the pool 30 is acceptable but the depth of the pool differs significantly from the target value. Consequently, the flank ratio of the actuation pulses (Fig. 2) is modified in step S10 in order to restore the target depth of the pool 30, where after the process loops back to step S3 again.

Claims

1. A method of operating a droplet ejection device comprising an ejection unit arranged to eject droplets of a liquid and comprising a nozzle (22) formed in a nozzle face (24), a liquid duct (16) connected to the nozzle (22), and an electro-mechanical transducer (28) arranged to create an acoustic pressure wave in the liquid in the duct (16), wherein the liquid and the material constituting the nozzle face (24) are paired such that the liquid is wetting for the nozzle face (24), **characterized by** a step of monitoring a parameter (f ; C; τ) that represents a state of a liquid pool (30) formed on the nozzle face (24) around the nozzle (22), and a step of enabling the ejection unit to operate as long as the pool (30) is present and the monitored parameter is within a predetermined range.
2. The method according to claim 1, wherein the droplet ejection device comprises a plurality of nozzles (22), each with an associated actuator (28), and the steps indicated in claim 1 are performed separately for each pair of nozzle and actuator.
3. The method according to claim 1 or 2, wherein the

parameter (f ; C ; τ) representing the state of the pool (30) is monitored by using the transducer (28) as a sensor for sensing pressure fluctuations decaying in the liquid duct (16) when a droplet has been ejected.

4. The method according to any of the preceding claims, wherein the parameter representing the state of the pool (30) is a frequency (f) of the pressure fluctuations, said frequency being representative of a depth of the pool (30).
5. The method according to claim 4, wherein the depth of the pool (30) is feedback-controlled by controlling actuation pulses (54a, 54b) to be applied to the actuator (28).
6. The method according to claim 5, wherein controlling the actuation pulses (54a, 54b) comprises varying a ratio between a height (A_1 , B_1) of a rising flank (58) of the pulse and a height (A_2 , B_2) of a descending flank (60) of the pulse.
7. The method according to any of the claims 1 to 3, wherein the parameter representing the state of the pool (30) is a parameter (C) representative of an amplitude of the pressure fluctuations and/or a parameter (τ) representative of a decay time constant of the pressure fluctuations.
8. The method according to any of the claims 4 to 6 and claim 7, comprising monitoring at least two parameters, one of which is the parameter specified in claim 4 and another one of which is one of the parameters specified in claim 7.
9. The method according to any of the preceding claims, comprising a step of aborting the droplet ejection process if one of the monitored parameters is not within an admissible range.
10. A droplet ejection device comprising at least one ejection unit arranged to eject droplets of a liquid and comprising a nozzle (22) formed in a nozzle face (24), a liquid duct (16) connected to the nozzle (22), and an electro-mechanical transducer (28) arranged to create an acoustic pressure wave in the liquid in the duct (16), the device further comprising at least one processor (50) for controlling the operation of the device, **characterized in that** said at least one processor (50) is configured to perform the method according to any of the claims 1 to 9.
11. The droplet ejection device according to claim 10, configured as an ink jet printer.
12. A software product comprising program code on a machine-readable non-transitory medium, the program code, when loaded into a processor (50) of the

droplet ejection device according to any one of claims 10-11, causes the processor (50) to perform the method according to any of the claims 1 to 9.

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Patentansprüche

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1. Verfahren zum Betrieb einer Tröpfchenausstoßvorrichtung, die eine Ausstoßeinheit aufweist, die dazu eingerichtet ist, Tröpfchen einer Flüssigkeit auszu stoßen, und eine in einer Düsenfläche (24) gebildete Düse (22), eine mit der Düse (22) verbundene Flüssigkeitsleitung (16) und einen elektromechanischen Aktuator (28) aufweist, der dazu ausgebildet ist, in der Flüssigkeit in der Leitung (16) eine akustische Druckwelle zu erzeugen, wobei die Flüssigkeit und das Material, das die Düsenfläche (24) bildet, so gepaart sind, dass die Flüssigkeit für die Düsenfläche (24) benetzend ist, **gekennzeichnet durch** einen Schritt der Überwachung eines Parameters (f ; C ; τ), der einen Zustand eines auf der Düsenfläche (24) um die Düse (22) herum gebildeten Flüssigkeitspools repräsentiert, und einen Schritt der Freigabe des Betriebs der Ausstoßeinheit, solange der Pool (30) vorhanden ist und der überwachte Parameter innerhalb eines vorbestimmten Bereiches liegt.
2. Verfahren nach Anspruch 1, bei dem die Tröpfchenausstoßvorrichtung mehrere Düsen (22) aufweist, denen jeweils ein Aktuator (28) zugeordnet ist, und bei dem die in Anspruch 1 angegebenen Schritte getrennt für jedes Paar aus Düse und Aktuator ausgeführt werden.
3. Verfahren nach Anspruch 1 oder 2, bei dem der Parameter (f ; C ; τ), der den Zustand des Pools (30) repräsentiert, überwacht wird, indem der Aktuator (28) als ein Sensor zur Erfassung von Druckfluktuationen benutzt wird, die in der Flüssigkeitsleitung (16) abklingen, wenn ein Tröpfchen ausgestoßen worden ist.
4. Verfahren nach einem der vorstehenden Ansprüche, bei dem der Parameter, der den Zustand des Pools (30) repräsentiert, eine Frequenz (f) der Druckfluktuationen ist, wobei diese Frequenz für eine Tiefe des Pools (30) repräsentativ ist.
5. Verfahren nach Anspruch 4, bei dem die Tiefe des Pools (30) geregelt wird durch Steuerung von Aktivierungspulsen (54a, 54b), die an den Aktuator (28) anzulegen sind.
6. Verfahren nach Anspruch 5, bei dem die Steuerung der Aktivierungspulse (54a, 54b) das Variieren eines Verhältnisses zwischen einer Höhe (A_1 , B_1) einer ansteigenden Flanke (58) des Pulses und einer Hö-

he (A2, B2) einer abfallenden Flanke (60) des Pulses umfasst.

7. Verfahren nach einem der Ansprüche 1 bis 3, bei dem der Parameter, der den Zustand des Pools (30) repräsentiert, ein Parameter (C), der für eine Amplitude der Druckfluktuationen repräsentativ ist, und/oder ein Parameter (τ) ist, der für eine Abklingzeitkonstante der Druckfluktuationen repräsentativ ist. 5 10
8. Verfahren nach einem der Ansprüche 4 bis 6 und Anspruch 7, mit Überwachung wenigstens zweier Parameter, von denen einer der in Anspruch 4 spezifizierte Parameter ist und der andere einer der in Anspruch 7 spezifizierten Parameter ist. 15
9. Verfahren nach einem der vorstehenden Ansprüche, mit dem Schritt des Abbrechens des Tröpfchenausstoßprozesses, wenn einer der überwachten Parameter nicht innerhalb eines zulässigen Bereiches liegt. 20
10. Tröpfchenausstoßvorrichtung mit wenigstens einer Ausstoßeinheit, die dazu ausgebildet ist, Tröpfchen einer Flüssigkeit auszustoßen, und die eine in einer Düsenfläche (24) gebildete Düse (22), eine mit der Düse (22) verbundene Flüssigkeitsleitung (16), und einen elektromechanischen Aktuator (28) aufweist, der dazu eingerichtet ist, eine akustische Druckwelle in der Flüssigkeit in der Leitung (16) zu erzeugen, wobei die Vorrichtung weiterhin wenigstens einen Prozessor (50) zur Steuerung des Betriebs der Vorrichtung aufweist, **dadurch gekennzeichnet, dass** der wenigstens eine Prozessor (50) dazu konfiguriert ist, das Verfahren nach einem der Ansprüche 1 bis 9 auszuführen. 25 30 35
11. Tröpfchenausstoßvorrichtung nach Anspruch 10, konfiguriert als Tintenstrahldrucker. 40
12. Softwareprodukt mit Programmcode auf einem maschinenlesbaren nichtflüchtigen Medium, welcher Programmcode, wenn er in einen Prozessor (50) einer Tröpfchenausstoßvorrichtung nach einem der Ansprüche 10 bis 11 geladen ist, den Prozessor (50) veranlasst, das Verfahren nach einem der Ansprüche 1 bis 9 auszuführen. 45 50

Revendications

1. Procédé pour faire fonctionner un dispositif d'éjection de gouttelettes comprenant une unité d'éjection agencée pour éjecter des gouttelettes d'un liquide et comprenant une buse (22) formée dans une face de buse (24), un conduit de liquide (16) relié à la buse (22), et un transducteur électromécanique (28) 55

agencé pour créer une onde de pression acoustique dans le liquide dans le conduit (16), dans lequel le liquide et le matériau constituant la face de buse (24) sont appariés de telle sorte que le liquide est mouillant pour la face de buse (24), **caractérisé par** une étape de surveillance d'un paramètre (f ; C ; τ) qui représente un état d'une nappe de liquide (30) formée sur la face de buse (24) autour de la buse (22), et une étape d'autorisation pour l'unité d'éjection de fonctionner tant que la nappe (30) est présente et que le paramètre surveillé se situe dans une plage prédéterminée.

2. Procédé selon la revendication 1, dans lequel le dispositif d'éjection de gouttelettes comprend une pluralité de buses (22), chacune avec un actionneur associé (28), et les étapes indiquées dans la revendication 1 sont effectuées séparément pour chaque paire de buse et d'actionneur.
3. Procédé selon la revendication 1 ou 2, dans lequel le paramètre (f ; C ; τ) représentant l'état de la nappe (30) est surveillé en utilisant le transducteur (28) en tant que capteur pour détecter des fluctuations de pression en déclin dans le conduit de liquide (16) lorsqu'une gouttelette a été éjectée.
4. Procédé selon l'une quelconque des revendications précédentes, dans lequel le paramètre représentant l'état de la nappe (30) est une fréquence (f) des fluctuations de pression, ladite fréquence étant représentative d'une profondeur de la nappe (30).
5. Procédé selon la revendication 4, dans lequel la profondeur de la nappe (30) est commandée par rétroaction en commandant des impulsions d'actionnement (54a, 54b) à appliquer à l'actionneur (28).
6. Procédé selon la revendication 5, dans lequel une commande des impulsions d'actionnement (54a, 54b) comprend une variation d'un rapport entre une hauteur (A1, B1) d'un flanc ascendant (58) de l'impulsion et une hauteur (A2, B2) d'un flanc descendant (60) de l'impulsion.
7. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel le paramètre représentant l'état de la nappe (30) est un paramètre (C) représentatif d'une amplitude des fluctuations de pression et/ou un paramètre (τ) représentatif d'une constante de temps de déclin des fluctuations de pression.
8. Procédé selon l'une quelconque des revendications 4 à 6 et la revendication 7, comprenant une surveillance d'au moins deux paramètres, dont un premier est le paramètre spécifié dans la revendication 4 et dont un autre est l'un des paramètres spécifiés dans la revendication 7.

9. Procédé selon l'une quelconque des revendications précédentes, comprenant une étape d'interruption du processus d'éjection de gouttelettes si l'un des paramètres surveillés n'est pas dans une plage admissible. 5
10. Dispositif d'éjection de gouttelettes comprenant au moins une unité d'éjection agencée pour éjecter des gouttelettes d'un liquide et comprenant une buse (22) formée dans une face de buse (24), un conduit de liquide (16) connecté à la buse (22), et un transducteur électromécanique (28) agencé pour créer une onde de pression acoustique dans le liquide dans le conduit (16), le dispositif comprenant en outre au moins un processeur (50) pour commander le fonctionnement du dispositif, **caractérisé en ce que** ledit au moins un processeur (50) est configuré pour exécuter le procédé selon l'une quelconque des revendications 1 à 9. 10 15 20
11. Dispositif d'éjection de gouttelettes selon la revendication 10, configuré sous la forme d'une imprimante à jet d'encre. 25
12. Produit logiciel comprenant un code de programme sur un support non transitoire lisible par machine, le code de programme, lorsqu'il est chargé dans un processeur (50) du dispositif d'éjection de gouttelettes selon l'une quelconque des revendications 10-11, amène le processeur (50) à exécuter le procédé selon l'une quelconque des revendications 1 à 9. 30 35 40 45 50 55

Fig. 1

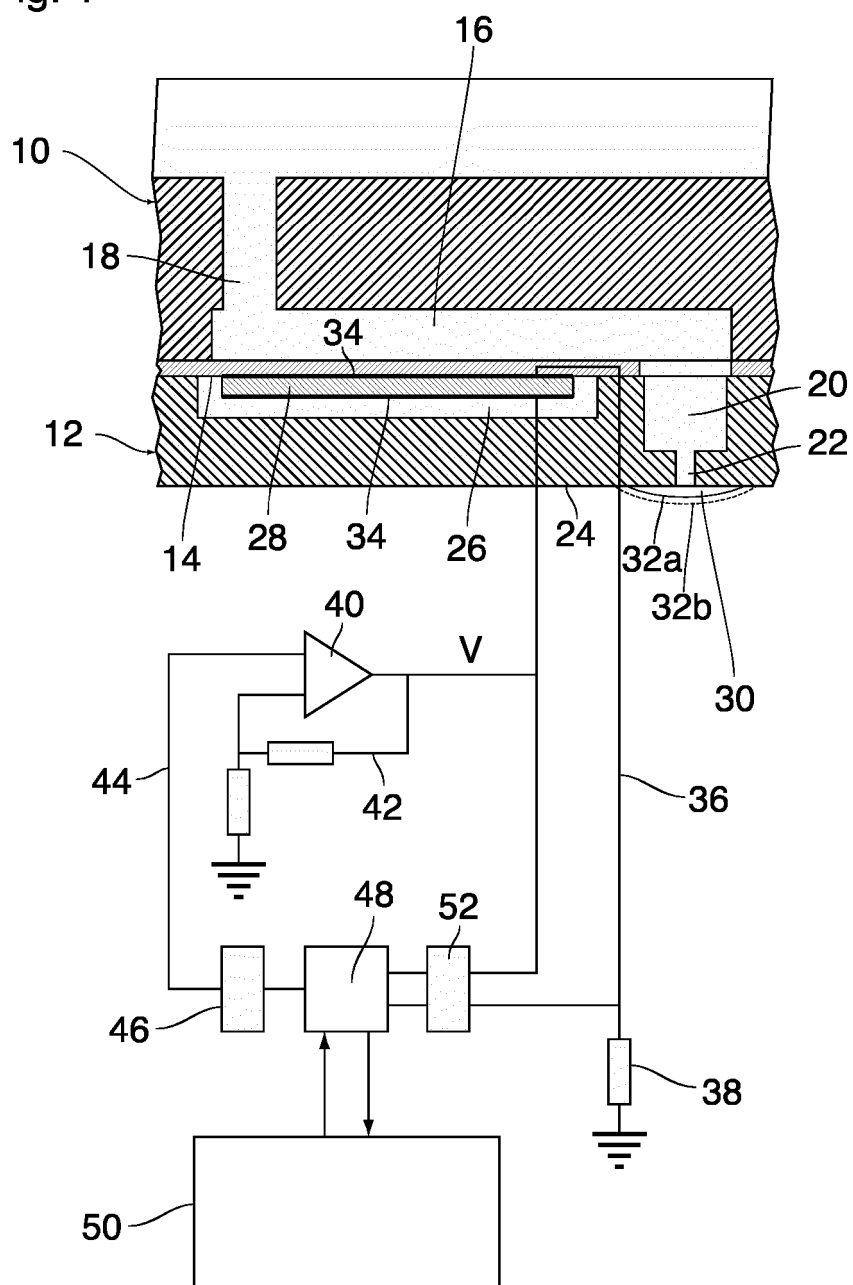


Fig. 2

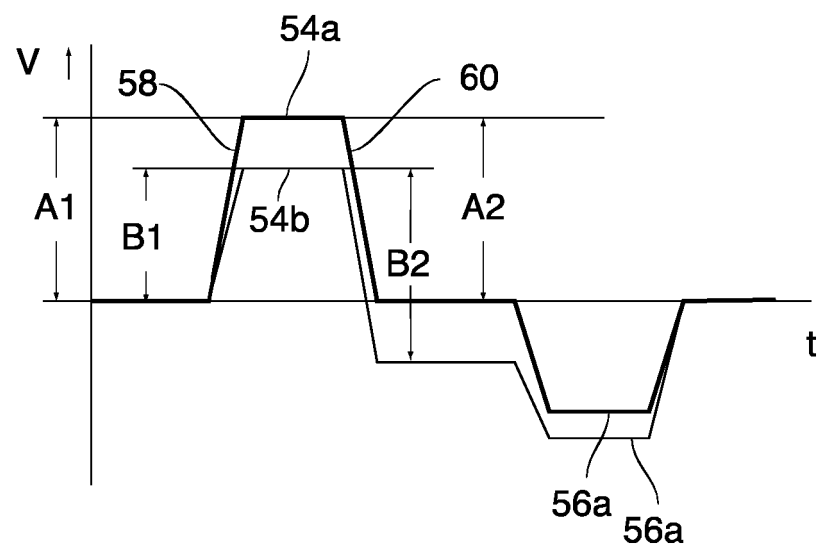


Fig. 3

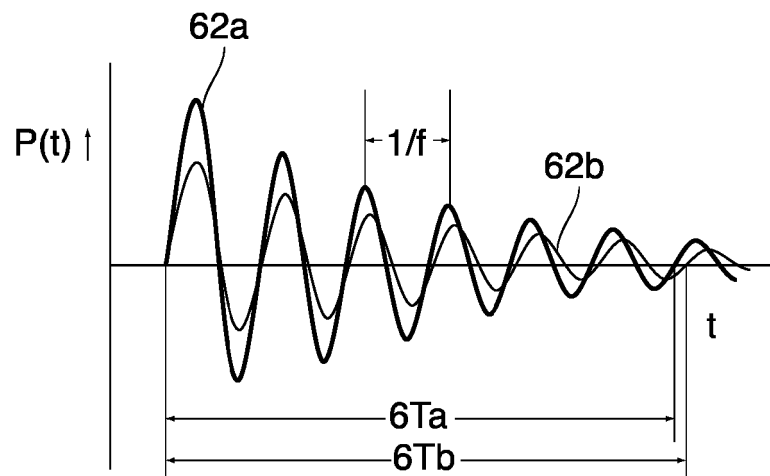


Fig. 4

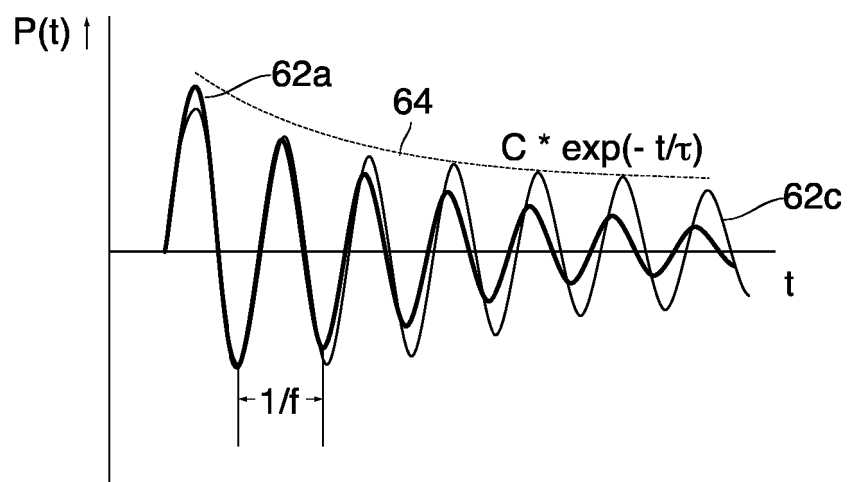
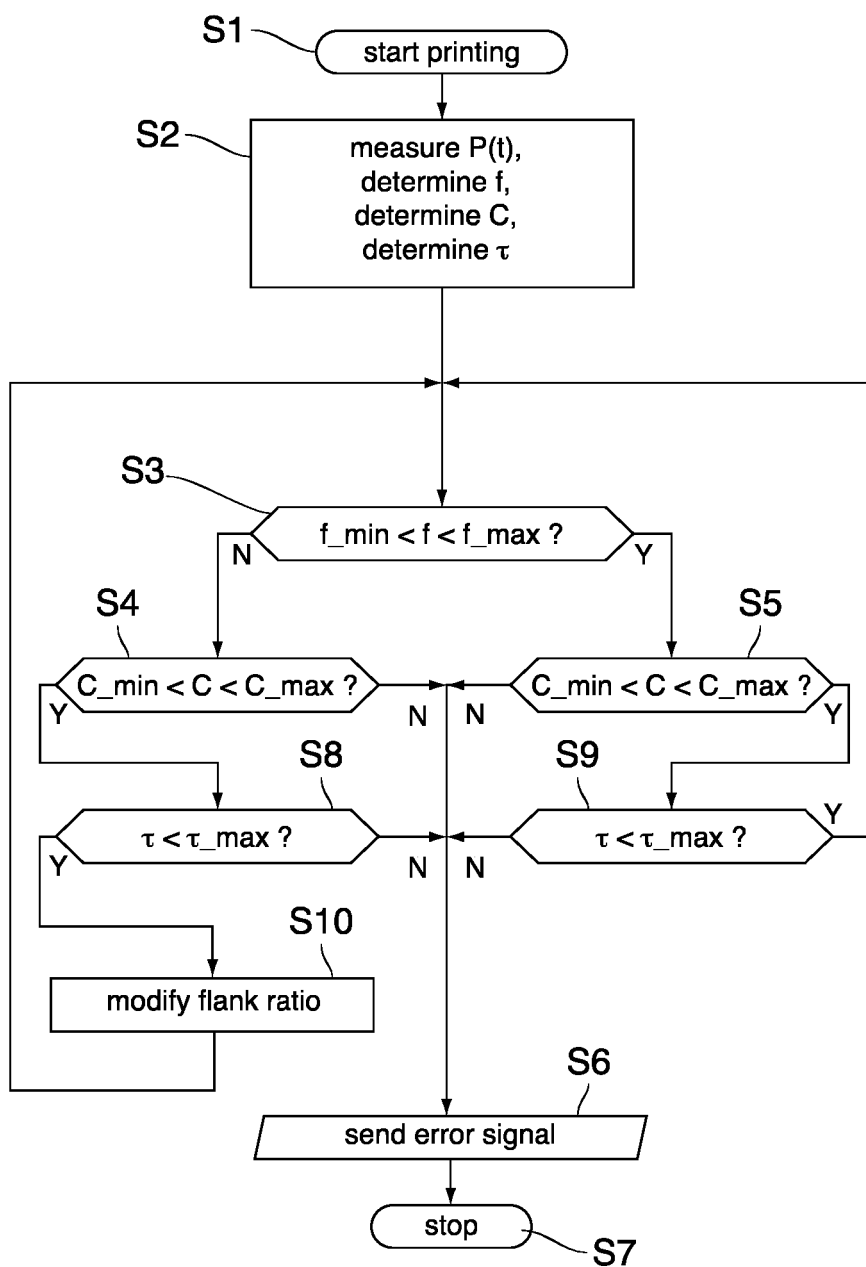


Fig. 5



REFERENCES CITED IN THE DESCRIPTION

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