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(54) **LIQUID EJECTING APPARATUS AND CONTROL METHOD FOR LIQUID EJECTING APPARATUS**

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(57) **ABSTRACT**

A liquid ejecting apparatus includes a liquid ejecting head that includes a nozzle which ejects an ink, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection circuit which detects residual vibration of the diaphragm caused by driving the piezoelectric element, and an evaluation control portion which executes first evaluation for evaluating an ejection stability of the ink from the nozzle, in which in the first evaluation, the evaluation control portion causes the detection circuit to detect the residual vibration caused by continuously executing ejection driving of driving the piezoelectric element with a drive signal for ejecting the ink from the nozzle as first residual vibration, and evaluates the ejection stability of the ink from the nozzle based on the first residual vibration detected by the detection circuit.

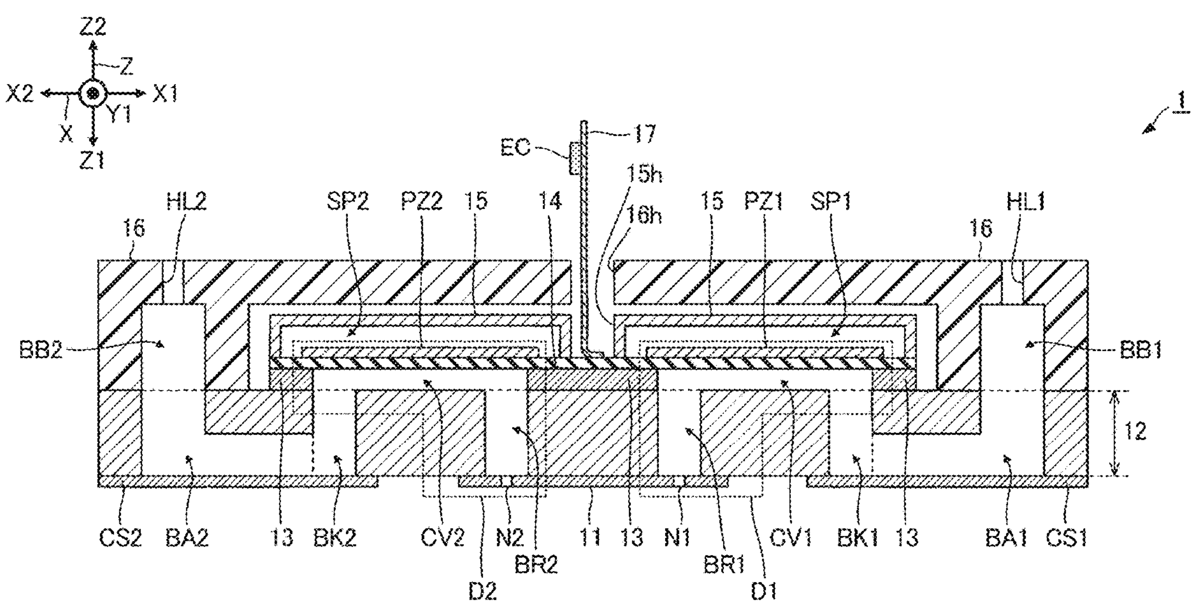


FIG. 1

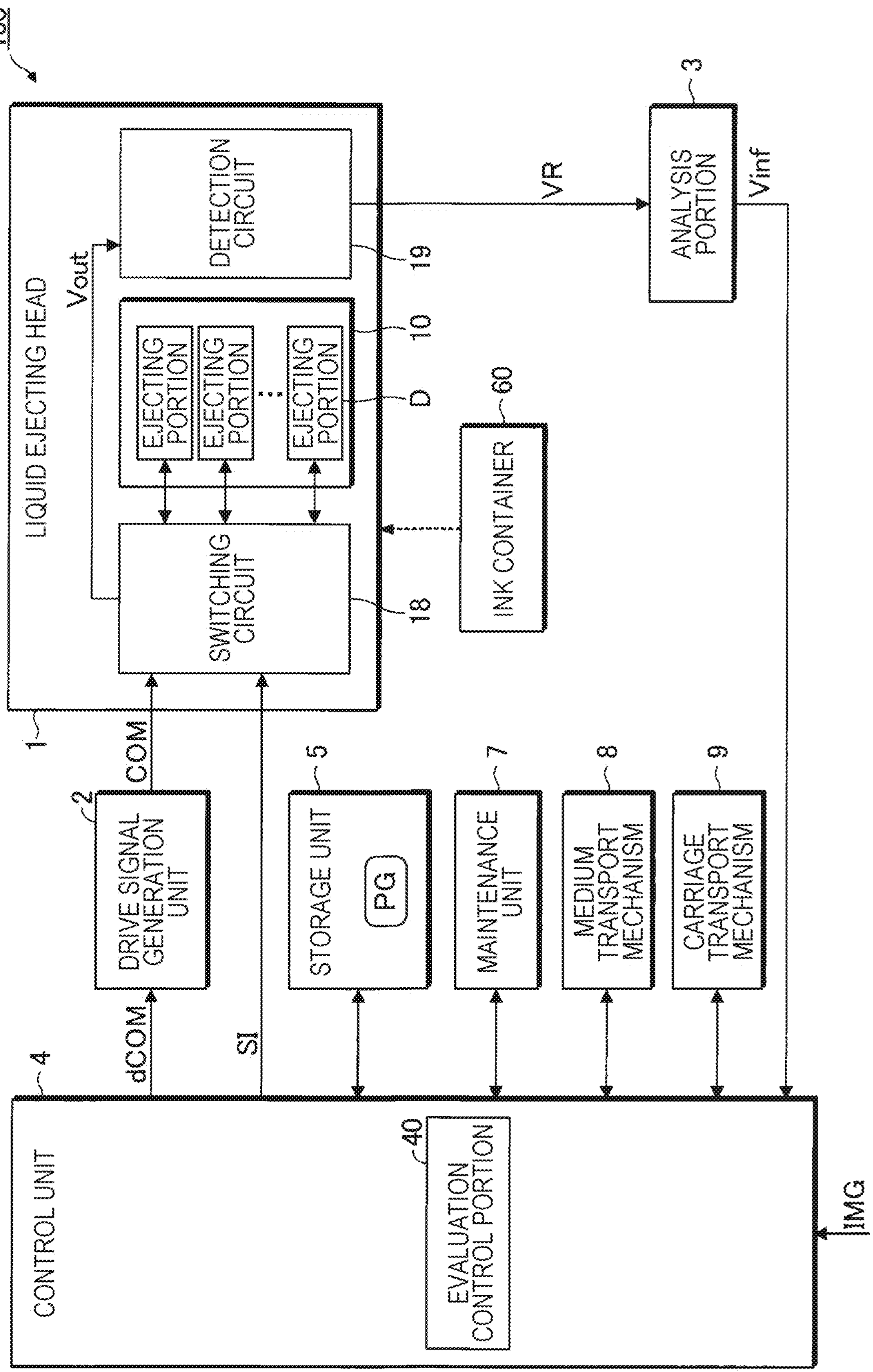
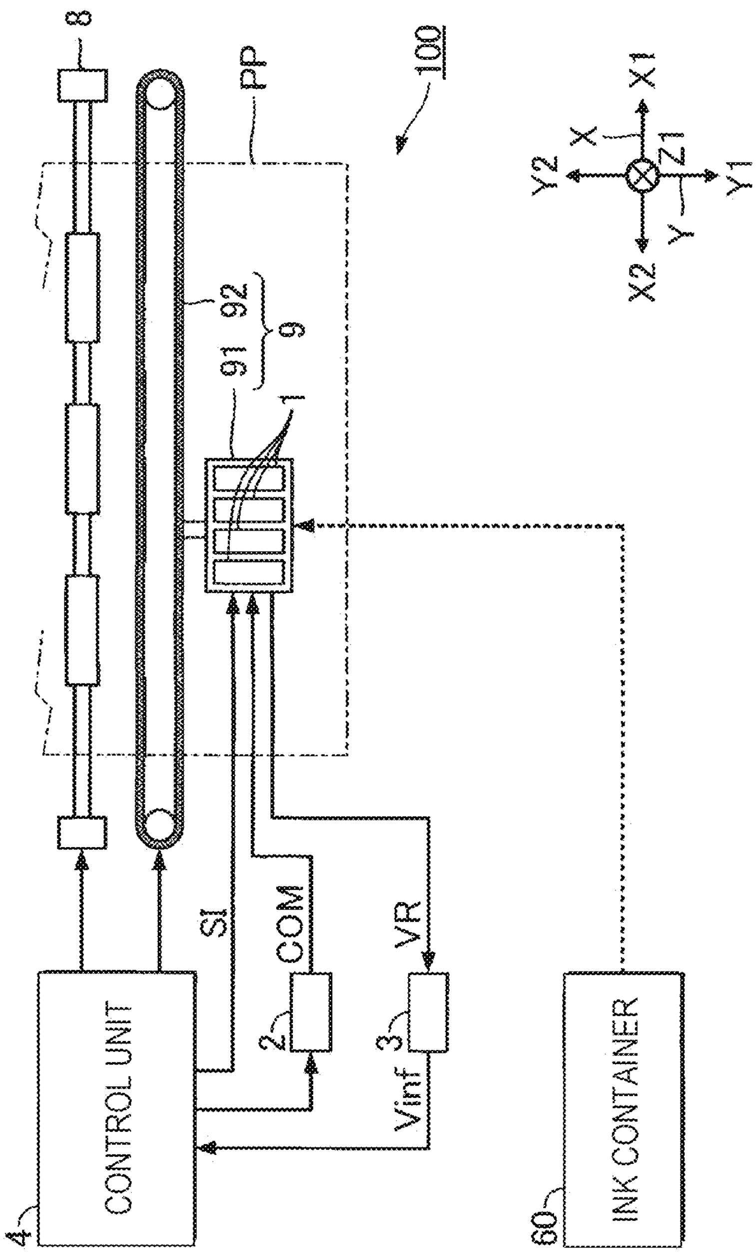

100
LIQUID EJECTING HEAD
DETECTION CIRCUIT
Vout
EJECTING PORTION
EJECTING PORTION
EJECTING PORTION
SWITCHING CIRCUIT
19
10
D
18
1
VR
ANALYSIS PORTION
3
Vinf
INK CONTAINER
60
COM
DRIVE SIGNAL GENERATION UNIT
2
STORAGE UNIT
PG
5
MAINTENANCE UNIT
7
MEDIUM TRANSPORT MECHANISM
8
CARRIAGE TRANSPORT MECHANISM
9
dCOM
SI
4
CONTROL UNIT
EVALUATION CONTROL PORTION
40
IMG

FIG. 2



8
PP
100
X1
X
Y2
Z1
Y1
Y
X2
91
92
9
1
SI
COM
VR
2
3
Vinf
CONTROL UNIT
4
INK CONTAINER
60

FIG. 3

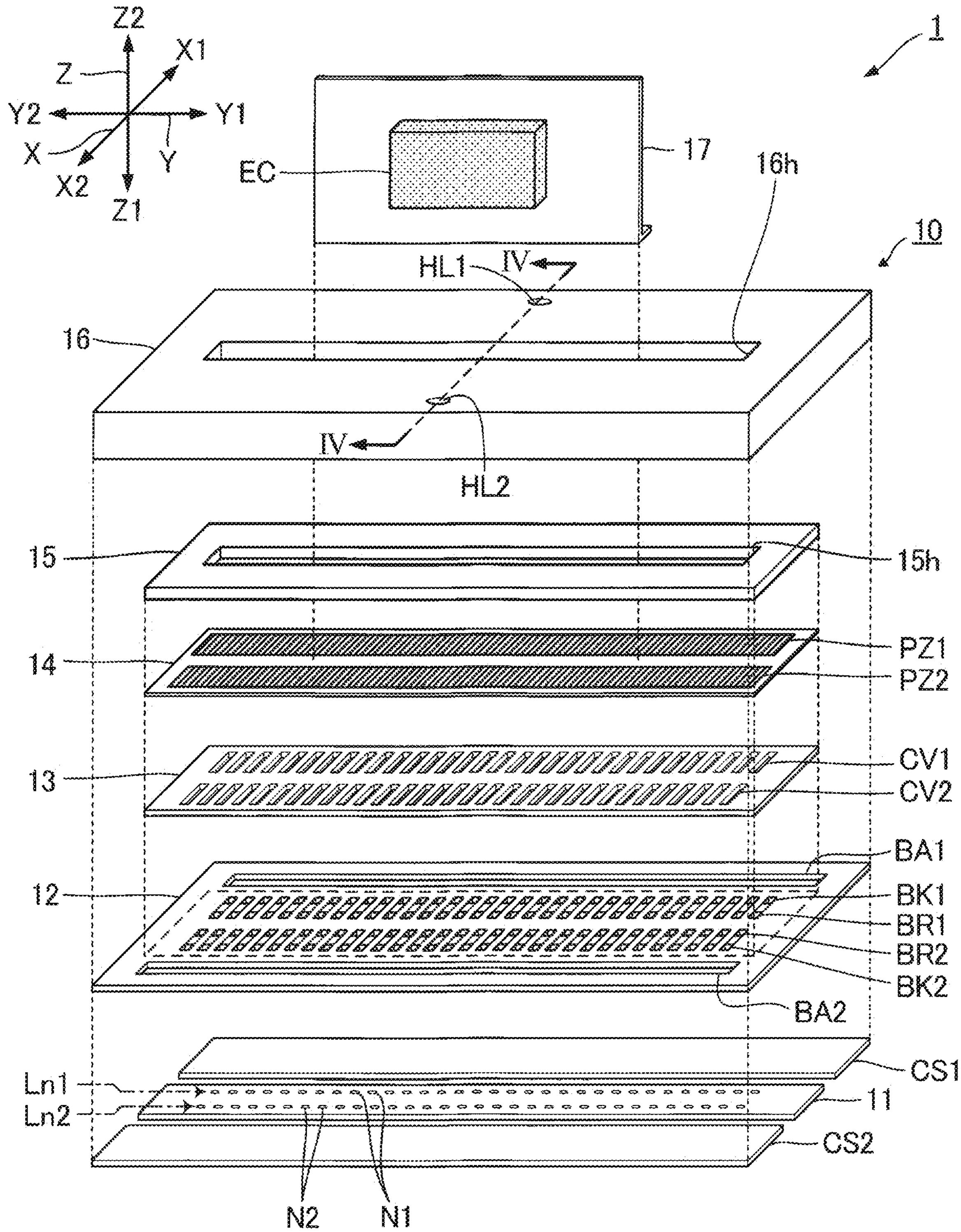

Z2
X1
Z
Y2
Y1
X
Y
X2
Z1
1
17
EC
16h
10
HL1
IV
16
IV
HL2
15
15h
14
PZ1
PZ2
13
CV1
CV2
BA1
12
BK1
BR1
BR2
BK2
BA2
CS1
Ln1
Ln2
11
CS2
N2
N1

FIG. 4

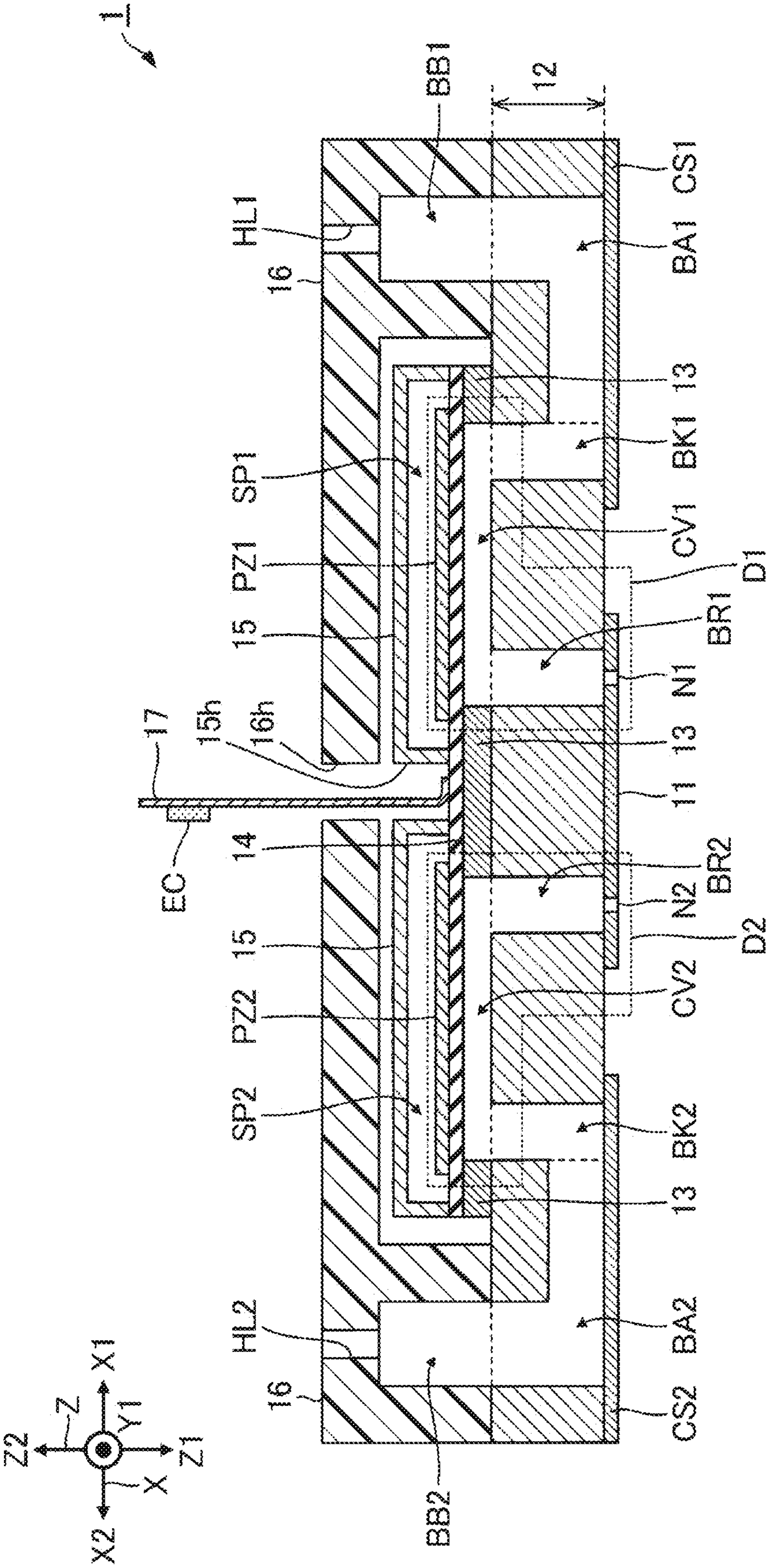

1
12
BB1
HL1
16
CS1
BA1
13
BK1
SP1
PZ1
CV1
D1
15
BR1
N1
17
15h
16h
13
11
EC
14
BR2
N2
15
D2
PZ2
CV2
SP2
BK2
13
HL2
BA2
16
CS2
BB2
X1
Z
Y1
Z2
Z1
X
X2

FIG. 5

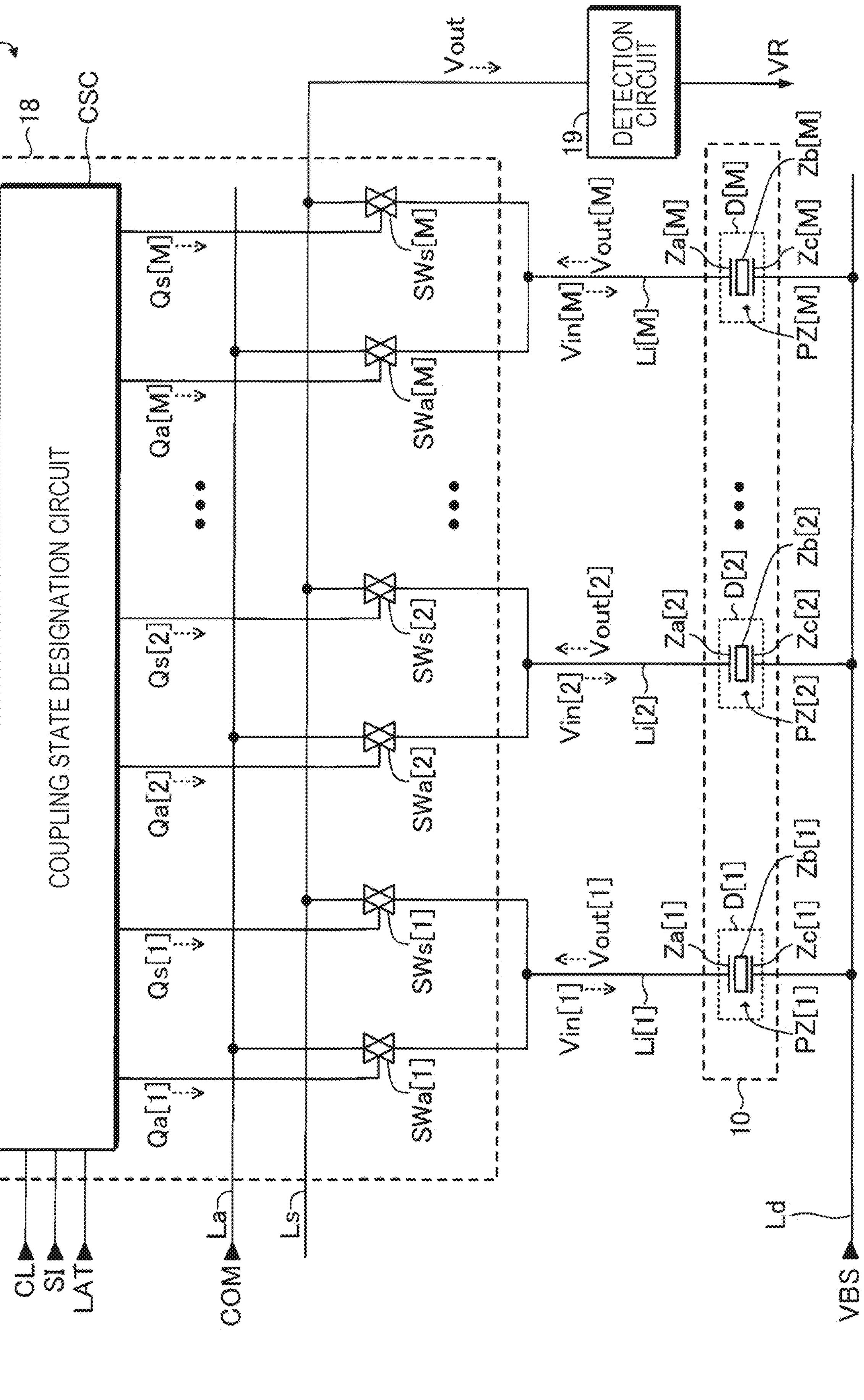

1
18
CSC
COUPLING STATE DESIGNATION CIRCUIT
CL
SI
LAT
COM
La
Ls
Qa[1]
Qs[1]
Qa[2]
Qs[2]
Qa[M]
Qs[M]
SWa[1]
SWs[1]
SWa[2]
SWs[2]
SWa[M]
SWs[M]
Vout
19
DETECTION CIRCUIT
VR
Vin[1]
Vout[1]
Vin[2]
Vout[2]
Vin[M]
Vout[M]
Li[1]
Li[2]
Li[M]
Za[1]
D[1]
Zb[1]
Zc[1]
PZ[1]
Za[2]
D[2]
Zb[2]
Zc[2]
PZ[2]
Za[M]
D[M]
Zb[M]
Zc[M]
PZ[M]
10
Ld
VBS

FIG. 6

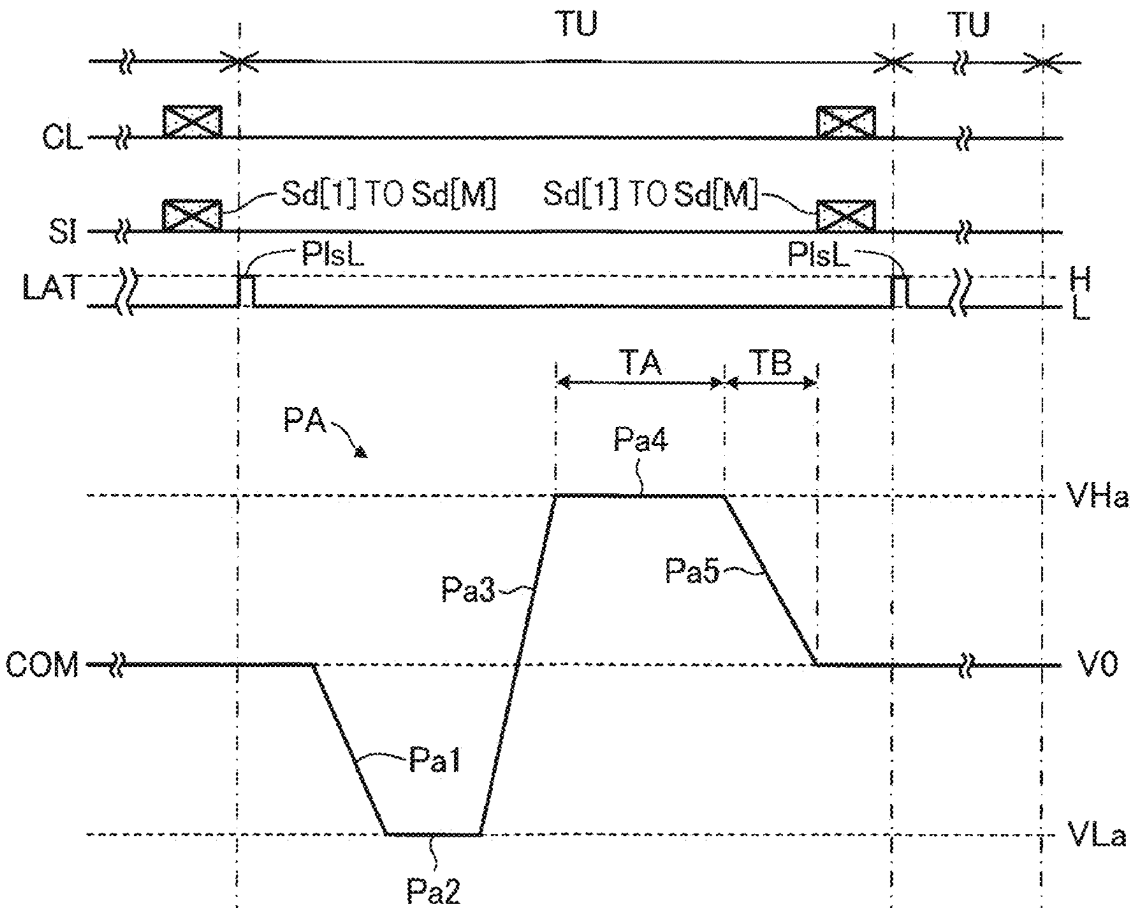

TU
TU
CL
SI
Sd[1] TO Sd[M]
Sd[1] TO Sd[M]
LAT
PlsL
PlsL
H
L
TA
TB
PA
Pa4
VHa
Pa3
Pa5
COM
V0
Pa1
VLa
Pa2

FIG. 7

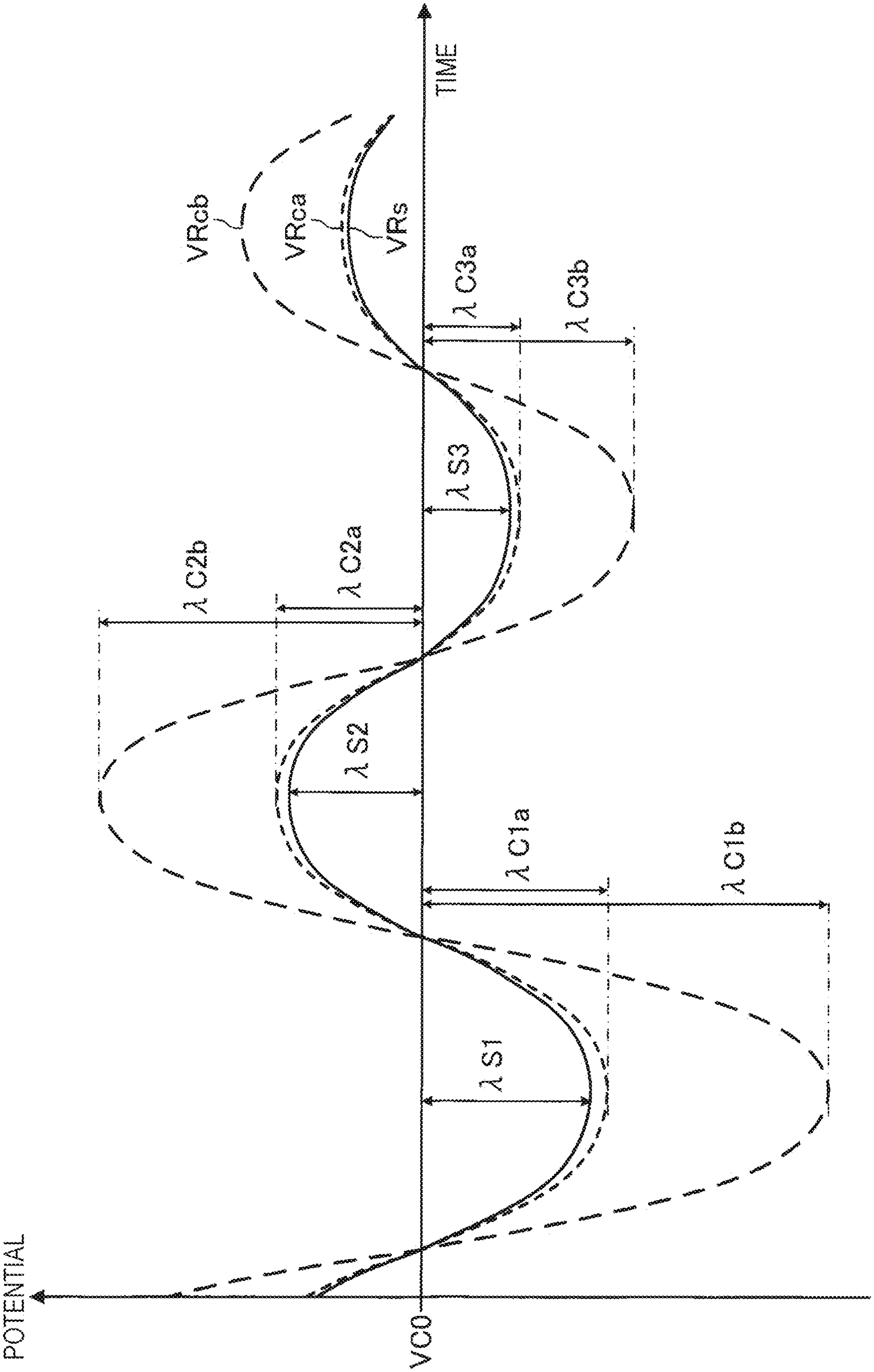

POTENTIAL
TIME
VC0
VRcb
VRca
VRs
λ S1
λ S2
λ S3
λ C1a
λ C1b
λ C2a
λ C2b
λ C3a
λ C3b

FIG. 8

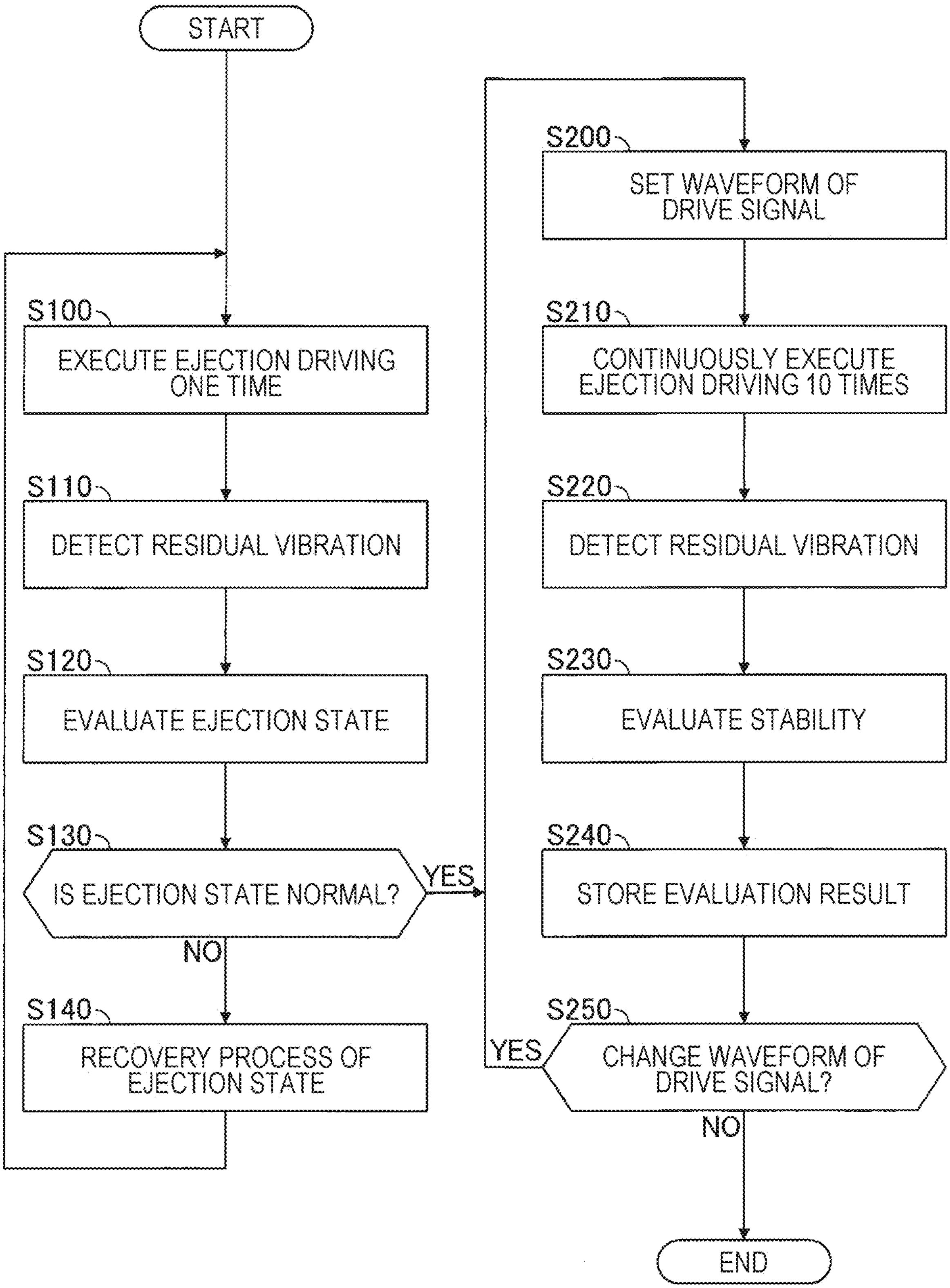

START
S100
EXECUTE EJECTION DRIVING ONE TIME
S110
DETECT RESIDUAL VIBRATION
S120
EVALUATE EJECTION STATE
S130
IS EJECTION STATE NORMAL?
YES
NO
S140
RECOVERY PROCESS OF EJECTION STATE
S200
SET WAVEFORM OF DRIVE SIGNAL
S210
CONTINUOUSLY EXECUTE EJECTION DRIVING 10 TIMES
S220
DETECT RESIDUAL VIBRATION
S230
EVALUATE STABILITY
S240
STORE EVALUATION RESULT
S250
CHANGE WAVEFORM OF DRIVE SIGNAL?
YES
NO
END

FIG. 9

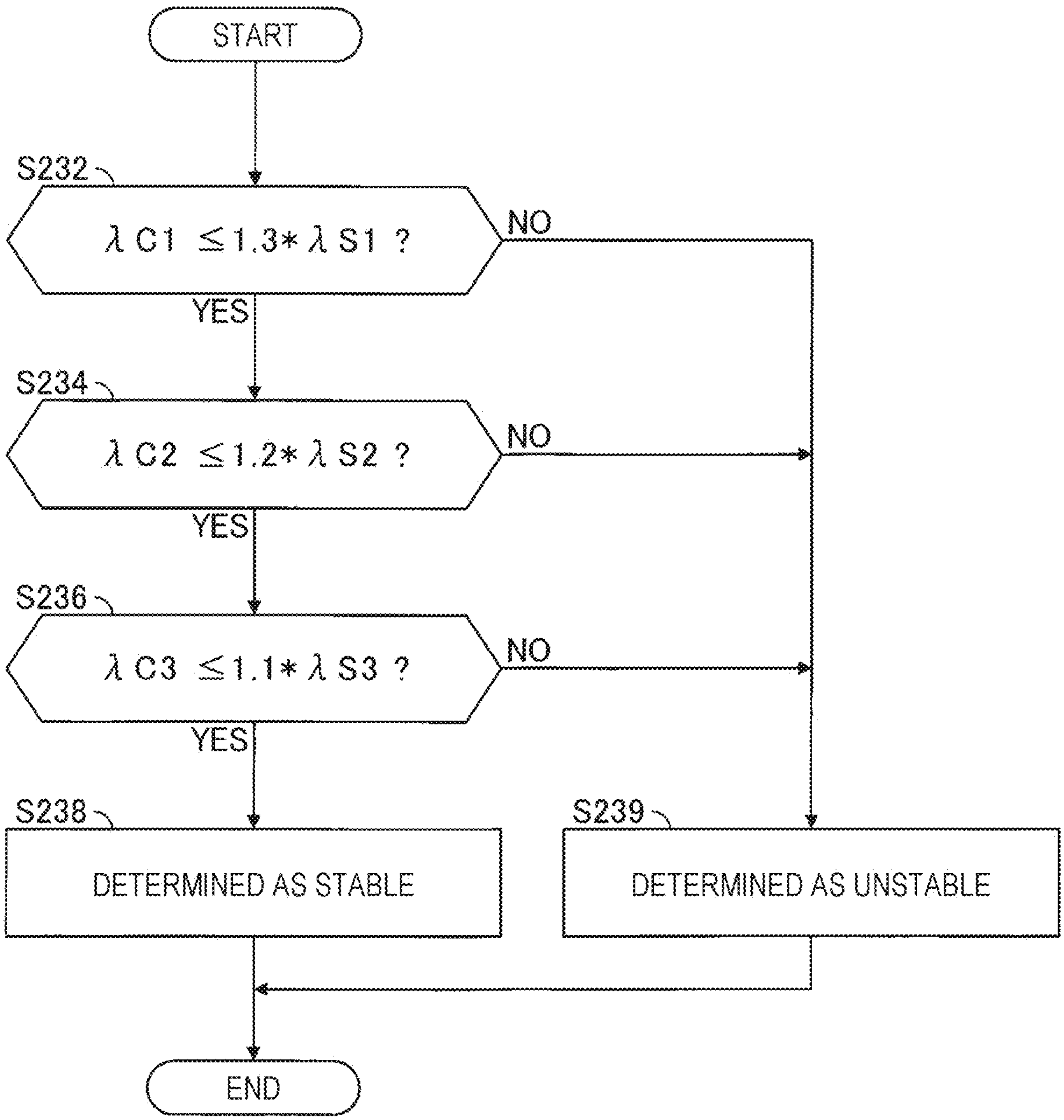

START
S232
λ C1 ≤1.3*λ S1 ?
NO
YES
S234
λ C2 ≤1.2*λ S2 ?
NO
YES
S236
λ C3 ≤1.1*λ S3 ?
NO
YES
S238
DETERMINED AS STABLE
S239
DETERMINED AS UNSTABLE
END

FIG. 10

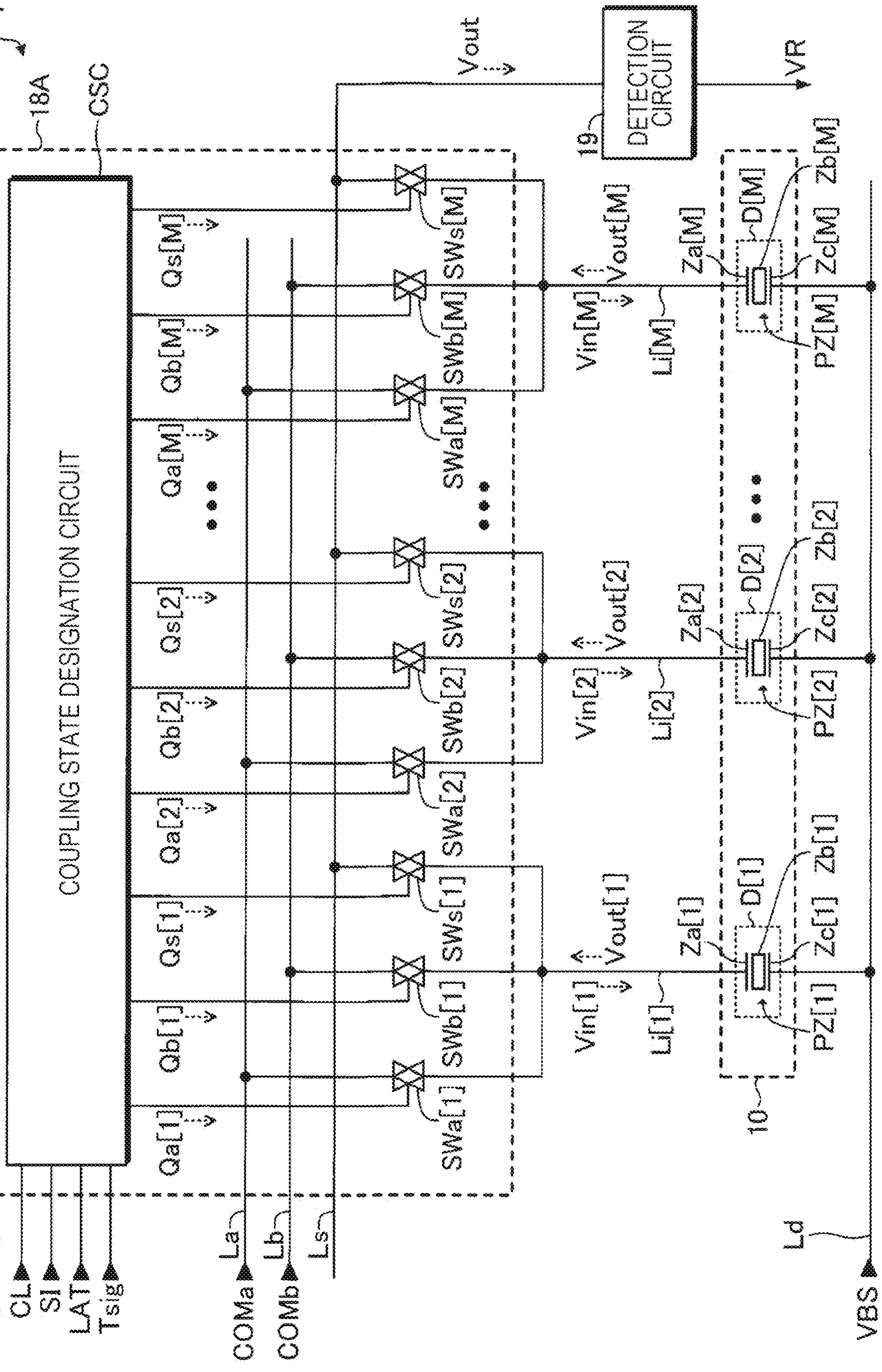

1
18A
CSC
COUPLING STATE DESIGNATION CIRCUIT
CL
SI
LAT
Tsig
COMa
COMb
La
Lb
Ls
Ld
VBS
Qa[1]
Qb[1]
Qs[1]
Qa[2]
Qb[2]
Qs[2]
Qa[M]
Qb[M]
Qs[M]
SWa[1]
SWb[1]
SWs[1]
SWa[2]
SWb[2]
SWs[2]
SWa[M]
SWb[M]
SWs[M]
Vin[1]
Vout[1]
Li[1]
Vin[2]
Vout[2]
Li[2]
Vin[M]
Vout[M]
Li[M]
Vout
19
DETECTION CIRCUIT
VR
10
Za[1]
D[1]
Zb[1]
Zc[1]
PZ[1]
Za[2]
D[2]
Zb[2]
Zc[2]
PZ[2]
Za[M]
D[M]
Zb[M]
Zc[M]
PZ[M]

FIG. 11

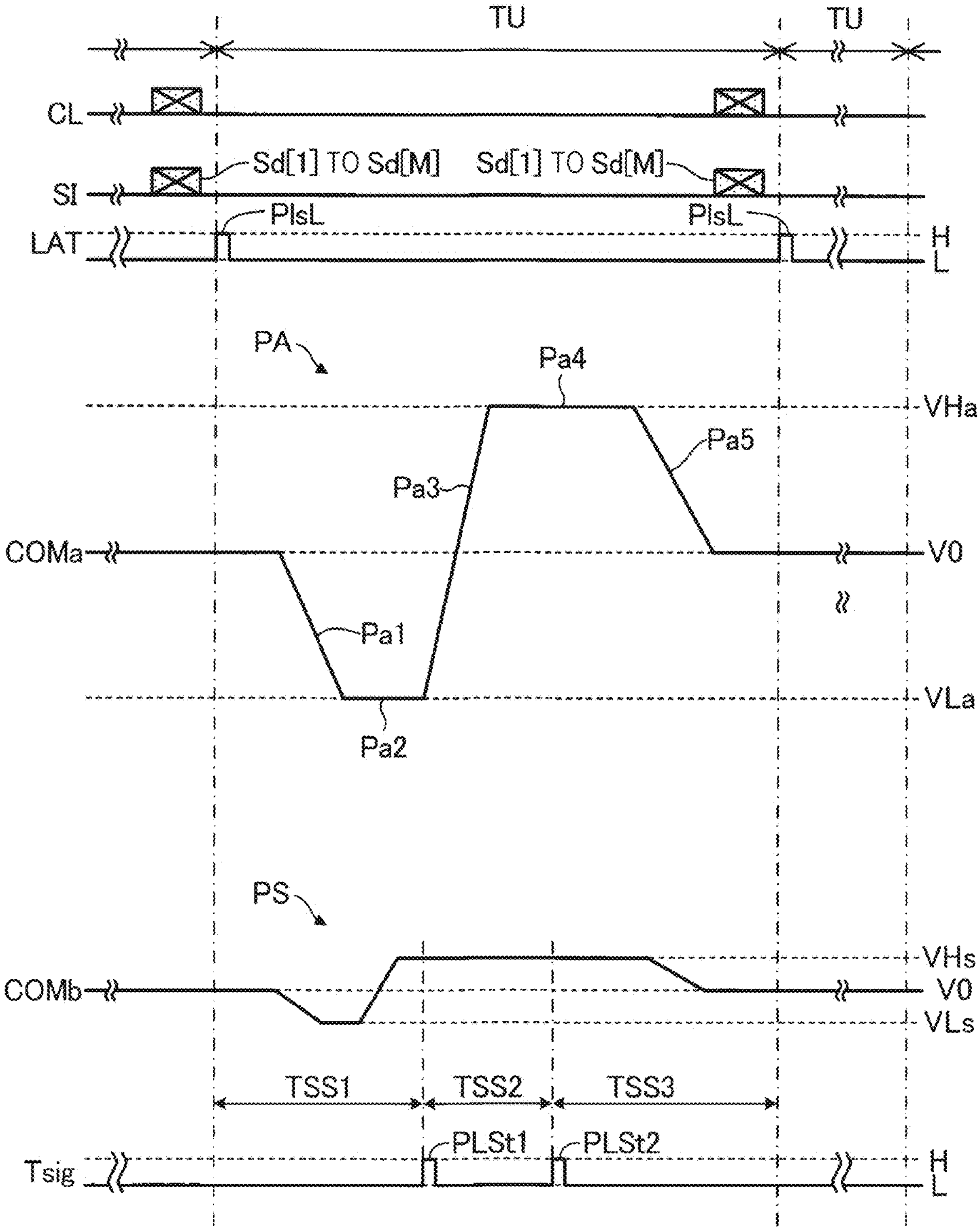
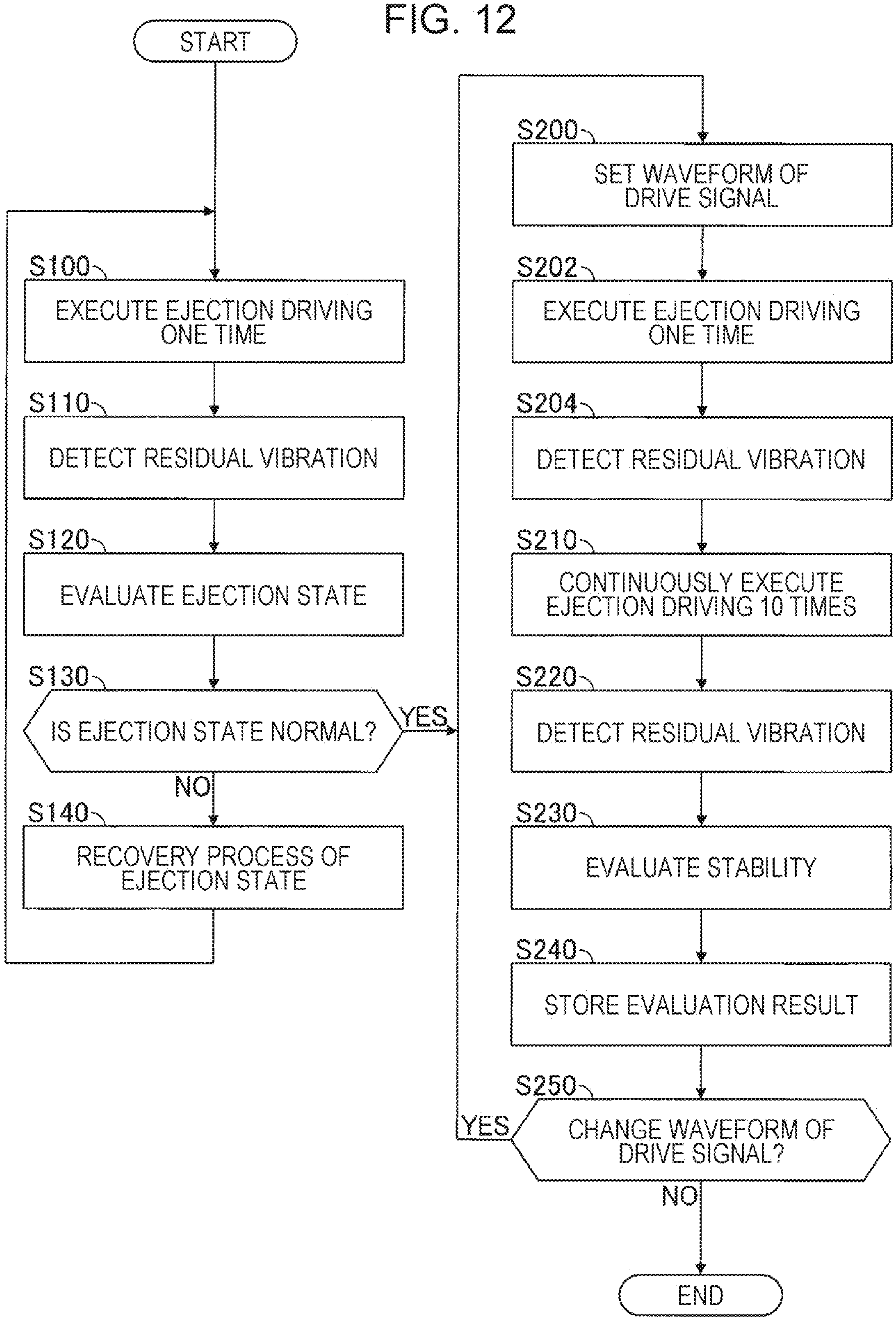

TU
TU
CL
SI
Sd[1] TO Sd[M]
Sd[1] TO Sd[M]
LAT
PlsL
PlsL
H
L
PA
Pa4
VHa
Pa5
Pa3
COMa
V0
Pa1
VLa
Pa2
PS
VHs
COMb
V0
VLs
TSS1
TSS2
TSS3
Tsig
PLSt1
PLSt2
H
L

FIG. 12


START
S100
EXECUTE EJECTION DRIVING ONE TIME
S110
DETECT RESIDUAL VIBRATION
S120
EVALUATE EJECTION STATE
S130
IS EJECTION STATE NORMAL?
YES
NO
S140
RECOVERY PROCESS OF EJECTION STATE
S200
SET WAVEFORM OF DRIVE SIGNAL
S202
EXECUTE EJECTION DRIVING ONE TIME
S204
DETECT RESIDUAL VIBRATION
S210
CONTINUOUSLY EXECUTE EJECTION DRIVING 10 TIMES
S220
DETECT RESIDUAL VIBRATION
S230
EVALUATE STABILITY
S240
STORE EVALUATION RESULT
S250
CHANGE WAVEFORM OF DRIVE SIGNAL?
YES
NO
END

LIQUID EJECTING APPARATUS AND CONTROL METHOD FOR LIQUID EJECTING APPARATUS

[0001] The present application is based on, and claims priority from JP Application Serial Number 2024-020153, filed Feb. 14, 2024, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a liquid ejecting apparatus and a control method for the liquid ejecting apparatus.

2. Related Art

[0003] A liquid ejecting apparatus that prints an image by causing a nozzle to eject a liquid such as an ink by using a piezoelectric element is known. For example, the liquid ejecting apparatus includes a liquid ejecting head that causes the nozzle to eject the liquid with which a pressure chamber is filled, by vibrating a diaphragm that constitutes a part of the pressure chamber by the piezoelectric element. In this type of liquid ejecting apparatus, as a method of evaluating the liquid ejecting head, a method of detecting an ejection defect of the nozzle is proposed. For example, JP-A-2021-172053 discloses an ejection image analysis apparatus that analyzes a plurality of ejection images obtained by capturing a flight state of a liquid droplet ejected from a nozzle of a liquid droplet ejecting apparatus at a certain timing.

[0004] Meanwhile, in the method of analyzing the plurality of ejection images obtained by capturing the flight state of the liquid droplet ejected from the nozzle at the certain timing, it is necessary to prepare an imaging environment or the like to set an evaluation environment for detecting an ejection defect of the nozzle. Therefore, in the method of analyzing the plurality of ejection images, a load for setting the evaluation environment is large.

[0005] In addition, as a method for detecting an ejection defect of a nozzle without requiring an external element such as the imaging environment, for example, a method is known in which residual vibration generated in a diaphragm is detected after driving a piezoelectric element, and the ejection defect such as thickening of a liquid and non-ejection is detected based on the detected residual vibration. In the method using the residual vibration, it is not necessary to prepare a special evaluation environment, and thus an increase in load for detecting the ejection defect of the nozzle is prevented.

[0006] Here, in a liquid ejecting apparatus, it is desired that a waveform of a drive signal for driving the piezoelectric element is determined such that the ejection of the liquid from the nozzle is stable. Therefore, in evaluation of the liquid ejecting head, it is considered that evaluation for an ejection stability is performed, instead of the ejection defect detection described above or in addition to the ejection defect detection. Therefore, it is desired that the evaluation for the ejection stability of the liquid from the nozzle and the determination of the waveform of the drive signal for driving the piezoelectric element can be appropriately and easily performed without requiring the external element such as the imaging environment. In particular, it is desired to appropriately and easily evaluate the ejection stability of the liquid from the nozzle without requiring the external element such as the imaging environment.

SUMMARY

[0007] According to an aspect of the present disclosure, there is provided a liquid ejecting apparatus including: a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element; and a control portion that executes first evaluation for evaluating an ejection stability of the liquid from the nozzle, in which in the first evaluation, the control portion causes the detection portion to detect the residual vibration caused by continuously executing ejection driving of driving the piezoelectric element with a drive signal for ejecting the liquid from the nozzle as first residual vibration, and evaluates the ejection stability of the liquid from the nozzle based on the first residual vibration detected by the detection portion.

[0008] In addition, according to another aspect of the present disclosure, there is provided a liquid ejecting apparatus including: a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element; and a control portion, in which the control portion causes the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration, and determines a waveform of the drive signal based on the first residual vibration detected by the detection portion.

[0009] In addition, according to still another aspect of the present disclosure, there is provided a control method for a liquid ejecting apparatus including a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element, the method including: causing the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration; and evaluating an ejection stability of the liquid from the nozzle based on the first residual vibration detected by the detection portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a block diagram illustrating an example of a configuration of a liquid ejecting apparatus according to an embodiment of the present disclosure.

[0011] FIG. **2** is a configuration diagram schematically illustrating the liquid ejecting apparatus.

[0012] FIG. **3** is an exploded perspective view of a liquid ejecting head.

[0013] FIG. **4** is a cross-sectional diagram taken along a line IV-IV in FIG. **3**.

[0014] FIG. **5** is a block diagram illustrating an example of a configuration of the liquid ejecting head.

[0015] FIG. **6** is a timing chart illustrating an example of an operation of the liquid ejecting apparatus in a unit period.

[0016] FIG. **7** is a diagram illustrating an example of a waveform of a residual vibration signal.

[0017] FIG. **8** is a flowchart illustrating an example of an operation of the liquid ejecting apparatus when evaluating an ejection stability of an ink from a nozzle.

[0018] FIG. **9** is a flowchart illustrating an example of evaluating the stability illustrated in FIG. **8**.

[0019] FIG. **10** is a block diagram illustrating an example of a configuration of a liquid ejecting head according to a first modification example.

[0020] FIG. **11** is a timing chart illustrating an example of an operation of the liquid ejecting apparatus according to the first modification example.

[0021] FIG. **12** is a flowchart illustrating an example of an operation of a liquid ejecting apparatus according to a second modification example.

DESCRIPTION OF EMBODIMENTS

[0022] Hereinafter, embodiments for carrying out the present disclosure will be described with reference to the drawings. Meanwhile, in each drawing, the size and scale of each portion are appropriately different from the actual ones. The embodiments described below are preferred specific examples of the present disclosure and are thus added with technically preferred various limitations, but the scope of the present disclosure is not limited to such embodiments unless description for limiting the present disclosure is made in the following description.

1. Embodiment

[0023] First, an outline of a liquid ejecting apparatus **100** according to the present embodiment will be described with reference to FIG. **1**. In the present embodiment, it is assumed that the liquid ejecting apparatus **100** is an ink jet printer that ejects an ink to a medium PP to form an image, as an example. In the present embodiment, a recording paper illustrated in FIG. **2** to be described below is assumed as the medium PP. The ink is an example of a "liquid".

[0024] FIG. **1** is a block diagram illustrating an example of a configuration of the liquid ejecting apparatus **100** according to an embodiment of the present disclosure.

[0025] For example, print data IMG indicating an image to be formed by the liquid ejecting apparatus **100** is supplied to the liquid ejecting apparatus **100** from a host computer such as a personal computer or a digital camera. The liquid ejecting apparatus **100** executes a printing process of forming the image indicated by the print data IMG supplied from the host computer on the medium PP.

[0026] The liquid ejecting apparatus **100** includes a liquid ejecting head **1** provided with an ejecting portion D including a nozzle N that ejects inks, a drive signal generation unit **2** that generates a drive signal COM for driving the ejecting portion D, and an analysis portion **3** that analyzes residual vibration, which will be described below. The nozzle N will be described below with reference to FIGS. **3** and **4**. Further, the liquid ejecting apparatus **100** includes a control unit **4** that controls each portion of the liquid ejecting apparatus **100**, and a storage unit **5** that stores various types of information such as the print data IMG and a control program PG of the liquid ejecting apparatus **100**. Further, the liquid ejecting apparatus **100** includes a maintenance unit **7** that executes a maintenance process of the liquid ejecting head **1**, a medium transport mechanism **8** that transports the medium PP, a carriage transport mechanism **9** that reciprocates a carriage **91**, and an ink container **60** that stores the inks. The carriage **91** will be described below with reference to FIG. **2**.

[0027] In the present embodiment, a case is assumed in which the liquid ejecting head **1** and the drive signal generation unit **2** correspond to each other, and the liquid ejecting head **1** and the analysis portion **3** correspond to each other. For example, the liquid ejecting apparatus **100** may include a plurality of liquid ejecting heads **1**, a plurality of drive signal generation units **2**, and a plurality of analysis portions **3**. In this case, for example, the plurality of drive signal generation units **2** correspond to the plurality of liquid ejecting heads **1** on a one-to-one basis, and the plurality of analysis portions **3** correspond to the plurality of liquid ejecting heads **1** on a one-to-one basis. Alternatively, the liquid ejecting apparatus **100** may include one liquid ejecting head **1**, one drive signal generation unit **2** corresponding to the liquid ejecting head **1**, and one analysis portion **3** corresponding to the liquid ejecting head **1**.

[0028] In the present embodiment, a case is assumed in which the liquid ejecting apparatus **100** has four liquid ejecting heads **1** respectively corresponding to four types of inks of cyan, magenta, yellow, and black. That is, in the present embodiment, a case is assumed in which the liquid ejecting apparatus **100** includes four liquid ejecting heads **1**, four drive signal generation units **2**, and four analysis portions **3**. Meanwhile, in the following, for convenience of description, as illustrated in FIG. **1**, there may be a case where one liquid ejecting head **1** of the four liquid ejecting heads **1** and one drive signal generation unit **2** corresponding to the one liquid ejecting head **1** are focused on and described.

[0029] First, the control unit **4**, the drive signal generation unit **2**, and the storage unit **5** will be described before the liquid ejecting head **1** is to be described.

[0030] The control unit **4** is configured with one or a plurality of central processing units (CPU). The control unit **4** may be configured with a programmable logic device such as a field-programmable gate array (FPGA), instead of the CPU or in addition to the CPU. Further, for example, the control unit **4** generates a signal for controlling an operation of each portion of the liquid ejecting apparatus **100**, such as a print signal SI and a waveform designation signal dCOM, by operating according to the control program PG stored in the storage unit **5**.

[0031] Here, the waveform designation signal dCOM is a digital signal that defines a waveform of the drive signal COM. In addition, the drive signal COM is an analog signal used to drive the ejecting portion D. In the present embodiment, a case is assumed in which there is one drive signal COM output from the drive signal generation unit **2** to the liquid ejecting head **1**, and a plurality of drive signals COM may be output from the drive signal generation unit **2** to the liquid ejecting head **1**. The print signal SI is a digital signal for designating a type of operation of the ejecting portion D. Specifically, the print signal SI is a signal for designating the type of operation of the ejecting portion D by designating whether or not the drive signal COM is supplied to the ejecting portion D.

[0032] In the present embodiment, the control unit **4** functions as the evaluation control portion **40** by operating according to the control program PG stored in the storage unit **5**. Details of the operation of the evaluation control portion **40** will be described with reference to FIGS. **8** and **9**. For example, the evaluation control portion **40** evaluates a stability of ejection of the ink from the nozzle N based on residual vibration analyzed by the analysis portion **3**. In the following, the stability of the ejection of the ink from the nozzle N is simply referred to as an ejection stability. The ejection stability means that, for example, ejection of the ink is stable in each ejection operation even when the ejection operation of ejecting the ink from the nozzle N is repeated a plurality of times. In the present embodiment, the evaluation control portion **40** also executes evaluation for an ejection state of the nozzle N, in addition to the evaluation of the ejection stability. In the evaluation of the ejection state, the evaluation control portion **40** determines, for example, whether or not the ejection state of the nozzle N is normal.

[0033] In this manner, in the present embodiment, the evaluation control portion **40** evaluates the ejection stability for the ink from the nozzle N. The evaluation control portion **40** is an example of a "control portion".

[0034] The drive signal generation unit **2** includes, for example, a digital analog converter (DAC), and generates the drive signal COM based on the waveform designation signal dCOM supplied from the control unit **4**. For example, the drive signal COM generated by the drive signal generation unit **2** includes a waveform defined by the waveform designation signal dCOM. The drive signal generation unit **2** outputs the drive signal COM generated based on the waveform designation signal dCOM to a switching circuit **18** included in the liquid ejecting head **1**.

[0035] The storage unit **5** is configured to include one or both of a volatile memory such as a random access memory (RAM), and a non-volatile memory such as a read only memory (ROM), an electrically erasable programmable read-only memory (EEPROM), or a programmable ROM (PROM). The storage unit **5** may be included in the control unit **4**.

[0036] The liquid ejecting head **1** includes the switching circuit **18**, a recording head **10**, and a detection circuit **19**. The detection circuit **19** is an example of a "detection portion".

[0037] The recording head **10** includes M ejecting portions D. In the present embodiment, a case

[0038] is assumed in which the value M is an even number equal to or more than 2. In the following, among the M ejecting portions D provided in the recording head **10**, an m-th ejecting portion D may be referred to as an ejecting portion D[m]. In this case, the variable m is a natural number that satisfies "1≤m≤M". Further, in the following, when a component, a signal, or the like of the liquid ejecting apparatus **100** corresponds to the ejecting portion D[m] among the M ejecting portions D, the subscript [m] may be added to the reference numerals for representing the component, the signals, or the like.

[0039] The switching circuit **18** switches whether or not to supply the drive signal COM to the ejecting portion D[m], based on the print signal SI. In the following, as illustrated in FIG. **5** and the like to be described below, the drive signal COM supplied to the ejecting portion D[m] among the drive signal COM may be referred to as an individual drive signal Vin[m]. Further, the switching circuit **18** switches whether or not to electrically couple the ejecting portion D[m] and the detection circuit **19** based on the print signal SI. When the ejecting portion D[m] and the detection circuit **19** are electrically coupled to each other, for example, a detection signal Vout[m] detected from the ejecting portion D[m] is supplied to the detection circuit **19** via the switching circuit **18**. The detection signal Vout[m] is, for example, an analog signal indicating a waveform of residual vibration, which is vibration remaining in the ejecting portion D[m] after the ejecting portion D[m] is driven by the individual drive signal Vin[m]. Specifically, for example, the detection signal Vout [m] indicates a waveform of residual vibration of a diaphragm **14** after a piezoelectric element PZ[m] is driven. The piezoelectric element PZ and the diaphragm **14** will be described below with reference to FIGS. **3** and **4**.

[0040] The detection circuit **19** generates a residual vibration signal VR[m] based on the detection signal Vout[m]. For example, the detection circuit **19** amplifies an amplitude of the detection signal Vout[m] or removes a noise component included in the detection signal Vout[m] to shape the detection signal Vout[m] into a waveform appropriate for a process in the analysis portion **3**. Therefore, the residual vibration signal VR[m] is generated. For example, the detection circuit **19** may have a configuration including a negative feedback type amplifier for amplifying the detection signal Vout[m], a low-pass filter for attenuating a high-frequency component of the detection signal Vout[m], and a voltage follower that converts an impedance and outputs the residual vibration signal VR[m] having a low impedance.

[0041] For example, the residual vibration signal VR[m] generated based on the detection signal Vout[m] is an analog signal indicating a waveform of residual vibration of the diaphragm **14** after the piezoelectric element PZ[m] is driven by the individual drive signal Vin[m]. The detection circuit **19** outputs the residual vibration signal VR[m] generated based on the detection signal Vout[m] to the analysis portion **3**. In this manner, the detection circuit **19** detects the residual vibration of the diaphragm **14** caused by driving the piezoelectric element PZ[m] based on the detection signal Vout[m].

[0042] The analysis portion **3** includes, for example, an analog to digital converter (ADC), and converts the analog residual vibration signal VR[m] into a digital signal. The analysis portion **3** analyzes, for example, the residual vibration detected by the detection circuit **19** by using the residual vibration signal VR[m] converted into a digital signal. The analysis portion **3** generates residual vibration information Vinf indicating an analysis result of the residual vibration, and outputs the generated residual vibration information Vinf to the control unit **4**. The residual vibration information Vinf indicates, for example, a cycle, an amplitude, and a phase of the residual vibration. Meanwhile, the residual vibration information Vinf may indicate a part of the cycle, the amplitude, and the phase of the residual vibration. Alternatively, the residual vibration information Vinf may include information other than the cycle, the amplitude, and the phase of the residual vibration. The evaluation control portion **40** described above evaluates, for example, an ejection state of the nozzle N and an ejection stability based on the residual vibration information Vinf. The analysis portion **3** may be included in the control unit **4**. For example, the control unit **4** may function as the analysis portion **3** by operating according to the control program PG stored in the storage unit **5**. In addition, a part of the analysis portion **3** may be included in the control unit **4**. Specifically, the control unit **4** may include a function of analyzing the residual vibration by using the residual vibration signal VR converted into a digital signal, the ADC being provided outside the control unit **4**.

[0043] Further, in the present embodiment, as described above, the maintenance process is executed by the maintenance unit **7**. For example, the maintenance unit **7** executes the maintenance process under the control of the control unit **4**. For example, the maintenance process includes flushing processing of discharging inks from the ejecting portion D, wiping processing of wiping off a foreign matter such as an ink adhering to the vicinity of a nozzle N of the ejecting portion D with a wiper, and pumping processing of suctioning the ink in the ejecting portion D with a tube pump or the like.

[0044] The maintenance unit **7** includes a discharge ink receiving portion for receiving the discharged ink when the ink in the ejecting portion D is discharged, a wiper for wiping off a foreign matter such as an ink adhering to the vicinity of the nozzle N of the ejecting portion D, and a tube pump for suctioning the ink, air bubbles, and the like in the ejecting portion D, in the flushing processing. The discharge ink receiving portion, the wiper, and the tube pump are not illustrated.

[0045] Next, a schematic overall configuration of the liquid ejecting apparatus **100** will be described with reference to FIG. **2**.

[0046] FIG. **2** is a configuration diagram schematically illustrating the liquid ejecting apparatus **100**. In FIG. **2**, the ink container **60**, the medium transport mechanism **8**, and the carriage transport mechanism **9** will be mainly described.

[0047] The ink container **60** stores inks. As the ink container **60**, for example, a cartridge that can be attached to and detached from the liquid ejecting apparatus **100**, a bag-shaped ink pack formed of a flexible film, or an ink tank that can be replenished with inks can be adopted. A type of the ink stored in the ink container **60** is not particularly limited, and is optional. In the present embodiment, as described above, a case is assumed in which the liquid ejecting apparatus **100** includes four liquid ejecting heads **1** respectively corresponding to four types of inks of cyan, magenta, yellow, and black. Therefore, in the present embodiment, the ink container **60** stores four types of inks of cyan, magenta, yellow, and black. Further, the ink container **60** supplies the stored ink to the liquid ejecting head **1**.

[0048] The medium transport mechanism **8** transports the medium PP in a Y1 direction along a Y-axis under the control of the control unit **4**. In the following, the Y1 direction and a Y2 direction opposite to the Y1 direction are collectively referred to as a Y-axis direction. In addition, in the following, an X1 direction along an X-axis that intersects the Y-axis and an X2 direction opposite to the X1 direction are collectively referred to as an X-axis direction. In addition, in the following, a Z1 direction along a Z-axis that intersects the X-axis and the Y-axis and a Z2 direction opposite to the Z1 direction are collectively referred to as a Z-axis direction. In the present embodiment, as an example, description will be performed by assuming that the X-axis, the Y-axis, and the Z-axis are orthogonal to each other. Meanwhile, the present disclosure is not limited to such an aspect. The X-axis, the Y-axis, and the Z-axis may intersect each other.

[0049] The carriage transport mechanism **9** reciprocates the plurality of liquid ejecting heads **1** in the X1 direction and the X2 direction under the control of the control unit **4**. As illustrated in FIG. **2**, the carriage transport mechanism **9** includes the substantially box-shaped carriage **91** that accommodates the plurality of liquid ejecting heads **1**, and an endless belt **92** to which the carriage **91** is fixed. The ink container **60** may be stored in the carriage **91** together with the liquid ejecting head **1**.

[0050] The liquid ejecting head **1** is driven by the drive signal COM under the control of the print signal SI, and ejects the ink in the Z1 direction from some or all of a plurality of nozzles N provided in the liquid ejecting head **1**. That is, the liquid ejecting head **1** forms a desired image on a surface of the medium PP by ejecting the ink from the some or all of the plurality of nozzles N in conjunction with transport of the medium PP by the medium transport mechanism **8** and a reciprocating motion of the liquid ejecting head **1** by the carriage transport mechanism **9** and landing the ejected ink on the surface of the medium PP. In the present embodiment, as described above, the Z1 direction is a direction in which an ink is ejected from the nozzle N.

[0051] Next, a schematic structure of the liquid ejecting head **1** will be described with reference to FIGS. **3** and **4**.

[0052] FIG. **3** is an exploded perspective view of the liquid ejecting head **1**. FIG. **4** is a cross-sectional diagram taken along a line IV-IV illustrated in FIG. **3**. A cross section of the line IV-IV is parallel to the XZ plane and passes through inlets HL**1** and HL**2**, which will be described below. In FIGS. **3** and **4**, in order to distinguish two nozzle rows Ln from each other, which will be described below, an end of a reference sign of a nozzle row Ln is added with a number "1" or "2". In addition, in FIGS. **3** and **4**, in order to facilitate the description, the number "1" is added to the end of the reference sign of the nozzle N included in a nozzle row Ln**1**, and the number "2" is added to the end of the reference sign of the nozzle N included in a nozzle row Ln**2**.

[0053] As illustrated in FIGS. **3** and **4**, the liquid ejecting head **1** includes a nozzle substrate **11**, compliance sheets CS**1** and CS**2**, a communication plate **12**, a pressure chamber substrate **13**, a diaphragm **14**, a sealing substrate **15**, a flow path forming substrate **16**, and a wiring substrate **17** at which an electronic component EC is mounted. The electronic component EC includes, for example, an electric circuit such as the switching circuit **18** and the detection circuit **19**. For example, the recording head **10** is electrically coupled to the switching circuit **18**, the detection circuit **19**, and the like via the wiring substrate **17**.

[0054] As illustrated in FIG. **3**, the recording head **10** includes, for example, the nozzle substrate **11**, the compliance sheets CS**1** and CS**2**, the communication plate **12**, the pressure chamber substrate **13**, the diaphragm **14**, the sealing substrate **15**, and the flow path forming substrate **16**.

[0055] The nozzle substrate **11** is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to an XY plane. Here, "substantially parallel" is a concept that includes not only a case of being completely parallel but also a case of being considered to be parallel when an error is considered. In the present embodiment, "substantially parallel" is a concept that includes a case where it can be regarded as parallel when an error of approximately 10% is considered. The "substantially vertical" described below is also a concept that includes a case where it is considered to be vertical when an error is taken into consideration, in addition to a case where it is completely vertical, as in the case of the "substantially parallel". The nozzle substrate **11** is manufactured, for example, by processing a silicon single crystal substrate using a semiconductor manufacturing technology such as etching, and any known material and manufacturing method may be adopted to manufacture the nozzle substrate **11**.

[0056] M nozzles N are formed at the nozzle substrate **11**. Here, the nozzle Nis a through-hole

[0057] provided in the nozzle substrate **11**. In the present embodiment, a case is assumed in which the plurality of nozzles N formed in the nozzle substrate **11** include a plurality of nozzles N**1** arranged to extend in the Y-axis direction, and a plurality of nozzles N**2** arranged to extend in the Y-axis direction at a position in the X2 direction when viewed from the plurality of nozzles N**1**. In the following, the plurality of nozzles N**1** arranged to extend in the Y-axis direction are referred to as the nozzle row Ln**1**, and the plurality of nozzles N**2** arranged to extend in the Y-axis direction are referred to as the nozzle row Ln**2**. For example, the number of nozzles N included in each of the nozzle rows LN**1** and Ln**2** is half the value M. In the following, the nozzle row Ln**1** and the nozzle row Ln**2** may be collectively referred to as a nozzle row Ln. In addition, in FIGS. **3** and **4**, in order to facilitate the description, in the liquid ejecting head **1**, a number "1" is added to an end of a reference sign of a component corresponding to the nozzle row Ln**1**, and a number "2" is added to an end of a reference sign of a component corresponding to the nozzle row Ln**2**.

[0058] As illustrated in FIGS. **3** and **4**, a communication plate **12** is provided at a position in the Z2 direction when viewed from a nozzle substrate **11**. The communication plate **12** is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to the XY plane. The communication plate **12** is manufactured, for example, by processing a silicon single crystal substrate using semiconductor manufacturing technology, and any known material and manufacturing method may be adopted to manufacture the communication plate **12**.

[0059] A flow path for inks is formed in the communication plate **12**. Specifically, the communication plate **12** is formed with one supply flow path BA**1** provided to extend in the Y-axis direction, and one supply flow path BA**2** provided to extend in the Y-axis direction at a position in the X2 direction when viewed from the supply flow path BA**1**. In addition, the communication plate **12** is formed with a plurality of coupling flow paths BK**1** corresponding to the plurality of nozzles N**1**, a plurality of coupling flow paths BK**2** corresponding to the plurality of nozzles N**2**, a plurality of communication flow paths BR**1** corresponding to the plurality of nozzles N**1**, and a plurality of communication flow paths BR**2** corresponding to the plurality of nozzles N**2**.

[0060] As illustrated in FIG. **4**, the coupling flow path BK**1** is provided to communicate with the supply flow path BA**1** and extend in the Z-axis direction at a position in the X2 direction when viewed from the supply flow path BA**1**. The communication flow path BR**1** is provided to extend in the Z-axis direction at a position in the X2 direction when viewed from the coupling flow path BK**1**. The communication flow path BR**1** communicates with the nozzle N**1** corresponding to the communication flow path BR**1**. The coupling flow path BK**2** is provided to communicate with the supply flow path BA**2** and extend in the Z-axis direction at a position in the X1 direction when viewed from the supply flow path BA**2**. The communication flow path BR**2** is provided to extend in the Z-axis direction at a position, which is a position in the X1 direction when viewed from the coupling flow path BK**2** and in the X2 direction when viewed from the communication flow path BR**1**. The communication flow path BR**2** communicates with the nozzle N**2** corresponding to the communication flow path BR**2**.

[0061] The supply flow paths BA**1** and BA**2** are also referred to as a supply flow path BA without particular distinction, the coupling flow paths BK**1** and BK**2** are also referred to as a coupling flow path BK without particular distinction, and the communication flow paths BR**1** and BR**2** are also referred to as a communication flow path BR without particular distinction.

[0062] As illustrated in FIGS. **3** and **4**, the pressure chamber substrate **13** is provided at a position in the Z2 direction when viewed from the communication plate **12**. The pressure chamber substrate **13** is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to the XY plane. The pressure chamber substrate **13** is manufactured, for example, by processing a silicon single crystal substrate using semiconductor manufacturing technology, and any known material and manufacturing method may be adopted to manufacture the pressure chamber substrate **13**.

[0063] A flow path for inks is formed in the pressure chamber substrate **13**. Specifically, the pressure chamber substrate **13** is formed with a plurality of pressure chambers CV**1** corresponding to the plurality of nozzles N**1** and a plurality of pressure chambers CV**2** corresponding to the plurality of nozzles N**2**. Of these, the pressure chamber CV**1** is provided to couple an end portion of the coupling flow path BK**1** in the X2 direction and an end portion of the communication flow path BR**1** in the X1 direction when viewed in the Z-axis direction, and extend in the X-axis direction. When viewed in the Z-axis direction, the pressure chamber CV**2** is provided to couple an end portion of the coupling flow path BK**2** in the X1 direction and an end portion of the communication flow path BR**2** in the X2 direction, and extend in the X-axis direction. The pressure chambers CV**1** and CV**2** are also referred to as a pressure chamber CV without particular distinction.

[0064] As illustrated in FIGS. **3** and **4**, the diaphragm **14** is provided at a position in the Z2 direction when viewed from the pressure chamber substrate **13**. The diaphragm **14** is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to the XY plane, and is a member that can vibrate elastically. In the present embodiment, the diaphragm **14** has, for example, an elastic layer made of silicon oxide and an insulating layer made of zirconium oxide provided at a position in the Z2 direction when viewed from the elastic layer. That is, in the present embodiment, a surface of the diaphragm **14** in the Z2 direction is formed with a non-conductive member. Here, a surface of an element A in a first direction is a surface of the element A, which is substantially vertical to the first direction among surfaces of the element A, and is a surface which is visible when the element A is viewed in the first direction from a second direction. The second direction is a direction opposite to the first direction. The elastic layer of the diaphragm **14** is not limited to the elastic layer made of silicon oxide. In the same manner, the insulating layer of the diaphragm **14** is not limited to the insulating layer made of zirconium oxide.

[0065] As illustrated in FIGS. **3** and **4**, a plurality of piezoelectric elements PZ**1** corresponding to the plurality of pressure chambers CV**1** and a plurality of piezoelectric elements PZ**2** corresponding to the plurality of pressure chambers CV**2** are provided at a position in the Z2 direction when viewed from the diaphragm **14**. The piezoelectric elements PZ**1** and PZ**2** are also referred to as a piezoelectric element PZ without particular distinction. The piezoelectric element PZ is driven by the drive signal COM being supplied.

[0066] Although not illustrated in FIGS. **3** and **4**, the piezoelectric element PZ has a common electrode Zc to which a predetermined bias potential VBS is supplied, an individual electrode Za to which the individual drive signal Vin is supplied, and a piezoelectric body Zb provided between the individual electrode Za and the common electrode Zc, as illustrated in FIG. **5**. For example, the individual electrode Za, the piezoelectric body Zb, and the common electrode Zc are provided in this order along the Z2 direction on the surface of the diaphragm **14** in the Z2 direction. Here, an expression "an element B is formed at the surface of the element A" in the present specification is not intended to limit the configuration to a configuration in which the element A and the element B are in direct contact with each other. That is, a configuration in which an element C is formed at the surface of the element A and the element B is formed at a surface of the element C is also included in the concept of "the element B is formed at the surface of the element A" insofar as the element A and the element B overlap at least in part in plan view.

[0067] In the present embodiment, the common electrode Zc is a so-called upper electrode, and the individual electrode Za is a so-called lower electrode, and the common electrode Zc may be a lower electrode and the individual electrode Za may be an upper electrode.

[0068] The piezoelectric element PZ is a passive element that is deformed in response to a potential change of the drive signal COM supplied to the individual electrode Za as the individual drive signal Vin. In other words, the piezoelectric element PZ is an example of an energy conversion element that converts the electric energy of the drive signal COM into kinetic energy. Specifically, the piezoelectric element PZ is driven and deformed in response to a potential change of the drive signal COM.

[0069] As illustrated in FIGS. **3** and **4**, since the piezoelectric element PZ is provided on the surface of the diaphragm **14** in the Z2 direction, the diaphragm **14** vibrates in conjunction with the deformation of the piezoelectric element PZ. That is, the diaphragm **14** vibrates by driving the piezoelectric element PZ. When the diaphragm **14** vibrates, a pressure in the pressure chamber CV fluctuates. Then, the pressure inside the pressure chamber CV fluctuates, and an ink with which an inside of the pressure chamber CV is filled is ejected from the nozzle N via the communication flow path BR. In this manner, the pressure chamber CV is filled with the ink, and a pressure for ejecting the ink from the nozzle Nis applied by the vibration of the diaphragm **14**. In addition, the vibration remaining in the ejecting portion D[m] described in FIG. **1** can be regarded as, for example, vibration remaining in the ink in the pressure chamber CV of the ejecting portion D. Therefore, residual vibration of the diaphragm **14**, that is, the residual vibration of the ejecting portion D[m] indicates a behavior of the ink in the pressure chamber CV of the ejecting portion D.

[0070] As illustrated in FIGS. **3** and **4**, the sealing substrate **15** for protecting the plurality of piezoelectric elements PZ**1** and the plurality of piezoelectric elements PZ**2** is provided at a position in the Z2 direction when viewed from the pressure chamber substrate **13**. The sealing substrate **15** is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to the XY plane. The sealing substrate **15** is manufactured, for example, by processing a silicon single crystal substrate using semiconductor manufacturing technology, and any known material and manufacturing method may be adopted to manufacture the sealing substrate **15**.

[0071] As illustrated in FIG. **4**, a surface of the sealing substrate **15** in the Z1 direction is provided with a recess portion for covering the plurality of piezoelectric elements PZ**1** and a recess portion for covering the plurality of piezoelectric elements PZ**2**. In the following, a sealing space covering the plurality of piezoelectric elements PZ**1** and formed between the diaphragm **14** and the sealing substrate **15** is referred to as a sealing space SP**1**, and a sealing space covering the plurality of piezoelectric elements PZ**2** and formed between the diaphragm **14** and the sealing substrate **15** is referred to as a sealing space SP**2**. Further, the sealing spaces SP**1** and SP**2** are also referred to as a sealing space SP without particular distinction. The sealing space SP is a space for sealing the piezoelectric element PZ and preventing the piezoelectric element PZ from deteriorating due to an influence of moisture or the like.

[0072] The sealing substrate **15** is provided with a through-hole **15***h*. The through-hole **15***h* is a hole that is located between the sealing space SP**1** and the sealing space SP**2** when the sealing substrate **15** is viewed in the Z1 direction, and penetrates from the surface of the sealing substrate **15** in the Z1 direction to the surface of the sealing substrate **15** in the Z2 direction. The wiring substrate **17** is inserted into the through-hole **15***h*.

[0073] As illustrated in FIGS. **3** and **4**, the flow path forming substrate **16** is provided at a position in the Z2 direction when viewed from the communication plate **12**. The flow path forming substrate **16** is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to the XY plane. The flow path forming substrate **16** is formed by, for example, injection molding of a resin material, and any known material and manufacturing method may be adopted to manufacture the flow path forming substrate **16**.

[0074] As illustrated in FIG. **4**, a flow path for inks is formed in the flow path forming substrate **16**. Specifically, the flow path forming substrate **16** is formed with one supply flow path BB**1** and one supply flow path BB**2**. Among these, the supply flow path BB**1** is provided to communicate with the supply flow path BA**1** and extend in the Y-axis direction at a position in the Z2 direction when viewed from the supply flow path BA**1**. The supply flow path BB**2** is provided to communicate with the supply flow path BA**2** and extend in the Y-axis direction at a position, which is a position in the Z2 direction when viewed from the supply flow path BA**2** and in the X2 direction when viewed from the supply flow path BB**1**. The supply flow paths BB**1** and BB**2** are also referred to as a supply flow path BB without particular distinction.

[0075] The flow path forming substrate **16** is provided with the inlet HL**1** communicating with the supply flow path BB**1** and the inlet HL**2** communicating with the supply flow path BB**2**. The ink is supplied from the ink container **60** to the supply flow path BB**1** via the inlet HL**1**. The ink supplied from the ink container **60** to the supply flow path BB**1** via the inlet HL**1** flows into the supply flow path BA**1**. The pressure chamber CV**1** is filled with a part of the ink flowing into the supply flow path BA**1**, via the coupling flow path BK**1**. When the piezoelectric element PZ**1** is driven by the drive signal COM, the part of the ink filled in the pressure chamber CV**1** is ejected from the nozzle N**1** via the communication flow path BR**1**.

[0076] In addition, the ink is supplied from the ink container **60** to the supply flow path BB**2** via the inlet HL**2**. The ink supplied from the ink container **60** to the supply flow path BB**2** via the inlet HL**2** flows into the supply flow path BA**2**. The pressure chamber CV**2** is filled with a part of the ink flowing into the supply flow path BA**2**, via the coupling flow path BK**2**. When the piezoelectric element PZ**2** is driven by the drive signal COM, the part of the ink filled in the pressure chamber CV**2** is ejected from the nozzle N**2** via the communication flow path BR**2**.

[0077] The flow path forming substrate **16** is provided with a through-hole **16***h*. The through-hole **16***h* is a hole that is located between the supply flow path BB**1** and the supply flow path BB**2** when the flow path forming substrate **16** is viewed in the Z1 direction, and penetrates from a surface of the flow path forming substrate **16** in the Z1 direction to the surface of the flow path forming substrate **16** in the Z2 direction. The wiring substrate **17** is inserted into the through-hole **16***h*.

[0078] As illustrated in FIGS. **3** and **4**, the wiring substrate **17** is mounted on a surface of the diaphragm **14** in the Z2 direction. The wiring substrate **17** is a component for electrically coupling the liquid ejecting head **1** to the control unit **4**. As the wiring substrate **17**, for example, a flexible wiring substrate such as a flexible printed circuit (FPC) or a flexible flat cable (FFC) is preferably adopted. As described above, the electronic component EC including the switching circuit **18**, the detection circuit **19**, and the like is mounted at the wiring substrate **17**.

[0079] As illustrated in FIGS. **3** and **4**, the compliance sheet CS**1** is provided to close the supply flow path BA**1** and the coupling flow path BK**1**, and the compliance sheet CS**2** is provided to close the supply flow path BA**2** and the coupling flow path BK**2**, at a position in the Z1 direction when viewed from the communication plate **12**. The compliance sheets CS**1** and CS**2** are also referred to as a compliance sheet CS without particular distinction. The compliance sheet CS is a plate-shaped member elongated in the Y-axis direction and extending substantially parallel to the XY plane. The compliance sheet CS is formed with an elastic material, and absorbs the pressure fluctuation of the ink inside the supply flow path BA and the coupling flow path BK.

[0080] Here, as illustrated in FIG. **4**, the ejecting portion D**1** includes the piezoelectric element PZ**1**, the pressure chamber CV**1**, the nozzle N**1** communicating with the pressure chamber CV**1**, and a portion of the diaphragm **14** that is in contact with the piezoelectric element PZ**1**. In the same manner, the ejecting portion D**2** includes the piezoelectric element PZ**2**, the pressure chamber CV**2**, the nozzle N**2** communicating with the pressure chamber CV**2**, and a portion of the diaphragm **14** that is in contact with the piezoelectric element PZ**2**. The ejecting portions D**1** and D**2** are also referred to as an ejecting portion D without particular distinction. In addition, in the following, between a first element and a second element included in one ejecting portion D, the second element is also referred to as the second element corresponding to the first element. Specifically, for example, the piezoelectric element PZ included in the ejecting portion D having one nozzle N is also referred to as the piezoelectric element PZ corresponding to one nozzle N.

[0081] In addition, although not illustrated, the liquid ejecting head **1** has a cap for sealing a nozzle surface, which is a surface of the nozzle substrate **11** in the Z1 direction. The cap seals the nozzle surface of the nozzle substrate **11** at which the nozzle N is formed in a period in which the ink is not ejected from the nozzle N.

[0082] Next, an outline of the liquid ejecting head **1** will be described with reference to FIG. **5**.

[0083] FIG. **5** is a block diagram illustrating an example of a configuration of the liquid ejecting head **1**.

[0084] As described in FIG. **1**, the liquid ejecting head **1** includes the recording head **10**, the switching circuit **18**, and the detection circuit **19**. Further, the liquid ejecting head **1** has a wiring La through which the drive signal COM is supplied from the drive signal generation unit **2**, and a wiring Ls through which the detection signal Vout is supplied to the detection circuit **19**. Further, the liquid ejecting head **1** has a wiring Li[m] through which the individual drive signal Vin[m] is supplied to the ejecting portion D[m] and a wiring Ld through which the bias potential VBS is supplied. In the present embodiment, a case is assumed in which the drive signal COM supplied to the wiring La is the drive signal COM for ejecting inks from the nozzle N.

[0085] The switching circuit **18** includes M switches SWa [**1**] to SWa[M] corresponding to the M ejecting portions D[**1**] to D[M] on a one-to-one basis and M switches SWs[**1**] to SWs[M] corresponding to the M ejecting portions D[**1**] to D[M] on a one-to-one basis.

[0086] Further, the switching circuit **18** includes a coupling state designation circuit CSC. The coupling state designation circuit CSC designates a coupling state of each of the M switches SWa and the M switches SWs. For example, the coupling state designation circuit CSC generates coupling state designation signals Qa[m] and Qs[m], based on at least some signals of the print signal SI and a latch signal LAT supplied from the control unit **4**.

[0087] For example, the coupling state designation signal Qa[m] is a signal for designating ON or OFF of the switch SWa[m], and the coupling state designation signal Qs[m] is a signal for designating ON or OFF of the switch SWs[m].

[0088] The switch SWa[m] switches conduction and non-conduction between the wiring La and the individual electrode Za[m] of the piezoelectric element PZ[m] provided in the ejecting portion D[m], based on the coupling state designation signal Qa[m]. That is, the switch SWa[m] switches conduction and non-conduction between the wiring La and the wiring Li[m] coupled to the individual electrode Za[m], based on the coupling state designation signal Qa[m]. In the present embodiment, the switch SWa[m] is turned on when the coupling state designation signal Qa[m] is at a high level, and is turned off when the coupling state designation signal Qa[m] is at a low level. When the switch SWa[m] is turned on, the drive signal COM supplied to the wiring La is supplied to the individual electrode Za[m] of the ejecting portion D[m] as the individual drive signal Vin[m] via the wiring Li[m]. That is, the individual drive signal Vin[m] is the drive signal COM supplied to the piezoelectric element PZ[m] included in the ejecting portion D[m] via the switch SWa[m].

[0089] The switch SWs[m] switches conduction and non-conduction between the wiring Ls and the individual electrode Za[m] of the piezoelectric element PZ[m] provided in the ejecting portion D[m], based on the coupling state designation signal Qs[m]. That is, the switch SWs[m] switches conduction and non-conduction between the wiring Ls and the wiring Li[m] coupled to the individual electrode Za[m], based on the coupling state designation signal Qs[m]. In the present embodiment, the switch SWs[m] is turned on when the coupling state designation signal Qs[m] is at a high level, and is turned off when the coupling state designation signal Qs[m] is at a low level.

[0090] For example, the coupling state designation signal Qs[m] becomes a high level when the residual vibration of the ejecting portion D[m] is detected. In the following, the ejecting portion D in which the residual vibration is detected may be referred to as the ejecting portion D as a detection target. In addition, in the following, the nozzle N included in the ejecting portion D, which is a detection target, may be referred to as the nozzle N as a detection target. When the switch SWs[m] is turned on, the detection signal Vout[m] indicating a potential of the individual electrode Za[m] of the piezoelectric element PZ[m] included in the ejecting portion D[m] as a detection target is supplied to the detection circuit **19** via the wiring Li[m] and the wiring Ls. The detection circuit **19** generates the residual vibration signal VR[m] based on the detection signal Vout[m].

[0091] As described above, the residual vibration signal VR[m] is used for evaluating an ejection state of the nozzle N and evaluating an ejection stability. Specifically, in the evaluation of the ejection state of the nozzle N, for example, the residual vibration signal VR[m] indicating residual vibration of the diaphragm **14** caused by executing ejection driving of driving the piezoelectric element PZ by the drive signal COM for ejecting the ink from the nozzle N only one time is used. For example, when it can be considered that the residual vibration of the diaphragm **14** caused by one ejection driving coincides with residual vibration in a normal situation assumed in advance, it is determined that the ejection state of the nozzle N is normal.

[0092] Meanwhile, when the ejection operation is continuously executed a plurality of times even when it is determined that the ejection state of the nozzle N is normal, vibration of a meniscus becomes large, and there is a concern that the ejection of the ink becomes unstable due to winding of air bubbles due to the vibration of the meniscus. Therefore, in the method of evaluating the ejection stability based on the residual vibration signal VR[m] indicating the residual vibration of the diaphragm **14** caused by one ejection driving, there is a concern that the ejection stability cannot be evaluated with high accuracy. Therefore, in the present embodiment, the residual vibration signal VR[m] indicating the residual vibration of the diaphragm **14** caused by executing the ejection driving a plurality of times is used for evaluating the ejection stability. Therefore, in the present embodiment, the ejection stability can be evaluated with high accuracy.

[0093] Next, an operation of the liquid ejecting apparatus **100** in a unit period TU will be described with reference to FIG. **6**.

[0094] FIG. **6** is a timing chart illustrating an example of the operation of the liquid ejecting apparatus **100** in the unit period TU. In the present embodiment, when the liquid ejecting apparatus **100** executes a printing process, a printing process period including one or a plurality of unit periods TU is set as an operation period of the liquid ejecting apparatus **100**. The unit period TU is, for example, a drive cycle of the M ejecting portions D. For example, the liquid ejecting apparatus **100** according to the present embodiment can drive each ejecting portion D for a printing process in each unit period TU. Further, the liquid ejecting apparatus **100** according to the present embodiment can drive the ejecting portion D as a detection target and detect the detection signal Vout[m] from the ejecting portion D as a detection target in each unit period TU.

[0095] The control unit **4** outputs the latch signal LAT having a pulse PlsL. Therefore, the control unit **4** defines the unit period TU as a period from rising of the pulse PlsL to rising of the next pulse PlsL.

[0096] The print signal SI includes, for example, M individual designation signals Sd[**1**] to Sd[M] corresponding to the M ejecting portions D[**1**] to D[M] on a one-to-one basis. The individual designation signal Sd[m] designates a mode of the driving of the ejecting portion D[m] in each unit period TU when the liquid ejecting apparatus **100** executes the printing process.

[0097] The control unit **4** supplies the print signal SI including the individual designation signals Sd[**1**] to Sd[M] to the coupling state designation circuit CSC in synchronization with a clock signal CL before each unit period TU in which the printing process is executed. The coupling state designation circuit CSC generates the coupling state designation signals Qa[m] and Qs[m] based on the individual designation signal Sd[m] in the unit period TU.

[0098] For example, the ejecting portion D[m] is designated as any of the ejecting portion D that forms a dot, the ejecting portion D that does not form a dot, and the ejecting portion D as a detection target, by the individual designation signal Sd[m], in a unit period TP during which the printing process is executed. The ejecting portion D that forms a dot is the ejecting portion D in which the piezoelectric element PZ of the ejecting portion D is driven such that an ink is ejected from the nozzle N of the ejecting portion D. That is, the ejecting portion D that is an ejection driving target for driving the piezoelectric element PZ by the drive signal COM for ejecting the ink from the nozzle N. In addition, the ejecting portion D that does not form the dot is the ejecting portion D in which the piezoelectric element PZ of the ejecting portion D is driven such that the ink is not ejected from the nozzle N of the ejecting portion D.

[0099] First, an operation of the coupling state designation circuit CSC or the like when a driving mode as the ejecting portion D for forming a dot is designated by the individual designation signal Sd[m] will be described. When a driving mode as the ejecting portion D for forming a dot is designated by the individual designation signal Sd[m], for example, the coupling state designation circuit CSC respectively sets the coupling state designation signal Qa[m] to a high level and the coupling state designation signal Qs[m] to a low level, in the unit period TU. Therefore, the drive signal COM is supplied to the ejecting portion D that forms the dot from the drive signal generation unit **2**.

[0100] For example, the drive signal generation unit **2** outputs the drive signal COM having a pulse PA. The pulse PA is, for example, a pulse for ejecting the ink from the nozzle N. The pulse PA is a waveform in which a potential of the drive signal COM is changed from a potential V**0** (intermediate potential and reference potential) to a potential VLa (minimum potential and expansion potential) lower than the potential V**0** and a potential VHa (maximum potential and contraction potential) higher than the potential V**0**, and returns to the potential V**0**. The potential V**0** is a potential at a start and an end of the pulse PA, and is a reference potential of the drive signal COM.

[0101] For example, the pulse PA has a waveform element Pa**1** in which a potential is changed from the potential V**0** to the potential VLa, a waveform element Pa**2** in which the potential is maintained at the potential VLa at an end of the waveform element Pa**1**, and a waveform element Pa**3** in which the potential is changed from the potential VLa to the potential VHa. Further, the pulse PA includes a waveform element Pa**4** in which the potential is maintained at the potential VHa at an end of the waveform element Pa**3**, and a waveform element Pa**5** in which the potential is changed from the potential VHa to the potential V**0**.

[0102] The waveform elements Pa**1** and Pa**5** are expansion elements for displacing the piezoelectric body Zb in the Z2 direction. In the expansion element, the potential of the drive signal COM is changed for driving the piezoelectric element PZ to expand a volume of the pressure chamber CV. Therefore, in the waveform elements Pa**1** and Pa**5**, the potential of the drive signal COM is changed to expand the volume of the pressure chamber CV. When the volume of the pressure chamber CV expands, a surface of the ink in the nozzle Nis pulled in the Z2 direction, which is a direction opposite to an ejection direction. In the following, the pulling of the surface of the ink in the nozzle N in the direction opposite to the ejection direction may be referred to as a pull.

[0103] In addition, the waveform element Pa**3** is a contraction element for displacing the piezoelectric body Zb in the Z1 direction. In the contraction element, the potential of the drive signal COM is changed for driving the piezoelectric element PZ to contract the volume of the pressure chamber CV. Therefore, in the waveform element Pa**3**, the potential of the drive signal COM is changed to contract the volume of the pressure chamber CV. When the volume of the pressure chamber CV is contracted, the surface of the ink in the nozzle N is pushed out in the Z1 direction, which is the ejection direction. In the following, the act of pushing the surface of the ink in the nozzle N in the ejection direction may be referred to as a push.

[0104] In addition, the waveform elements Pa**2** and Pa**4** are maintenance elements for maintaining a position of the piezoelectric body Zb in the Z-axis direction. For example, in the waveform element Pa**2**, the potential of the drive signal COM is maintained for driving the piezoelectric element PZ to maintain the volume of the pressure chamber CV expanded by the waveform element Pa**1**. In addition, for example, in the waveform element Pa**4**, the potential of the drive signal COM is maintained for driving the piezoelectric element PZ to maintain the volume of the pressure chamber CV contracted by the waveform element Pa**3**.

[0105] In this manner, the pulse PA is a so-called pull-push-pull waveform. Meanwhile, a waveform of the drive signal COM for ejecting the ink from the nozzle N is not limited to the pull-push-pull waveform.

[0106] The pulse PA is determined such that a predetermined amount of ink is ejected from the ejecting portion D[m] when the individual drive signal Vin[m] having the pulse PA is supplied to the ejecting portion D[m]. In the present embodiment, a case is assumed in which the volume of the pressure chamber CV provided in the ejecting portion D[m] is reduced when a potential of the individual drive signal Vin[m] is a high potential as compared with a case where the potential is a low potential. Therefore, when the ejecting portion D[m] is driven by the individual drive signal Vin[m] having the pulse PA, the ink in the ejecting portion D[m] is ejected from the nozzle N by the waveform element Pa**3** in which the potential of the individual drive signal Vin[m] is changed from the low potential to the high potential.

[0107] For example, the waveform elements Pa**1**, Pa**2**, Pa**3**, Pa**4**, and Pa**5** included in the pulse PA are determined based on an ejection characteristic of the ink by the ejecting portion D, the ejection stability, and the like. The ejection characteristic of the ink is, for example, the amount of ink ejected as ink droplets, an ejection rate of the ejected ink droplets, or the like. In the present embodiment, a case is assumed in which, among the waveform elements Pa**1**, Pa**2**, Pa**3**, Pa**4**, and Pa**5** determined based on the ejection characteristic of the ink and the like, a length TA of the waveform element Pa**4** and a length TB of the waveform element Pa**5** are adjusted to improve the ejection stability. In the present embodiment, a case is assumed in which a start timing of the waveform element Pa**4** is not changed before and after the adjustment of the length TA, and an end timing of the waveform element Pa**5** is not changed before and after the adjustment of the length TB. That is, in the present embodiment, a total of the length TA of the waveform element Pa**4** and the length TB of the waveform element Pa**5** is not changed before and after the adjustment.

[0108] Therefore, for example, when the length TB is short, the potential change amount per unit time of the waveform element Pa**5**, that is, an inclination of the waveform element Pa**5** is more than when the length TB is long. When the inclination of the waveform element Pa**5** is large, a vibration damping capacity for attenuating the residual vibration of the ejecting portion D is more than the vibration damping capacity when the inclination of the waveform element Pa**5** is small. Therefore, when the inclination of the waveform element Pa**5** is large, a vibration damping capacity for attenuating the vibration of the meniscus is higher than that when the inclination of the waveform element Pa**5** is small, and thus the ejection stability tends to be improved. On the other hand, when the length TB is increased, it is necessary to increase a length of the entire pulse PA accordingly or to decrease any of the waveform elements Pal, Pa**2**, Pa**3**, and Pa**4**. The former may lead to a decrease in drive frequency, and the lengths of the waveform elements Pa**1**, Pa**2**, and Pa**3** among the latter may affect the ejection itself. Therefore, in the present embodiment, when the length TB of the waveform element Pa**5** is increased, the length TA of the waveform element Pa**4** is decreased instead. Meanwhile, a method of determining the waveform of the pulse PA for improving the ejection stability is not limited to adjusting the length TA of the waveform element Pa**4** and the length TB of the waveform element Pa**5**. The waveform elements Pa**1**, Pa**2**, Pa**3**, Pa**4**, and Pa**5** included in the pulse PA may be appropriately adjusted to improve the ejection stability in a range in which the ejection characteristic of the ink become a desired ejection characteristic.

[0109] Next, an operation of the coupling state designation circuit CSC or the like when a driving mode as the ejecting portion D that does not form a dot is designated by the individual designation signal Sd[m] will be described. When the driving mode as the ejecting portion D that does not form the dot is designated by the individual designation signal Sd[m], for example, the coupling state designation circuit CSC sets the coupling state designation signals Qa[m] and Qs[m] to a low level in the unit period TU. Therefore, when a leakage current does not occur, a potential of the individual electrode Za of the piezoelectric element PZ included in the ejecting portion D that does not form the dot is maintained at a potential before the coupling state designation signal Qa[m] is set to a low level, for example, a potential VO.

[0110] Next, an operation of the coupling state designation circuit CSC or the like when a driving mode of the ejecting portion D as a detection target is designated by the individual designation signal Sd[m] will be described. In the following, the operation of the coupling state designation circuit CSC or the like when the driving mode of the detection target ejecting portion D is designated by the individual designation signal Sd[m] will be described with reference to a case of evaluating an ejection stability. In the following, the unit period TU in which residual vibration for evaluating the ejection stability is detected may be referred to as the unit period TU for detection. When evaluating the ejection stability, for example, the ejecting portion D as a detection target operates as the ejecting portion D that forms a dot in each of K unit periods TU from the unit period TU before the K unit periods TU for detection to the unit period TU immediately before the unit period TU for detection. That is, the piezoelectric element PZ included in the ejecting portion D, which is a detection target, is driven by the drive signal COM for ejecting an ink from the nozzle N in each of the K consecutive unit periods TU before the unit period TU for detection. In the present embodiment, a case is assumed in which the value K is a natural number of 10 or more, and the value K is not particularly limited as long as the value K is a natural number of 2 or more.

[0111] For example, when the driving mode of the ejecting portion D, which is a detection target, is designated by the individual designation signal Sd[m], the coupling state designation circuit CSC sets the coupling state designation signal Qs[m] to a high level in the unit period TU for detection. Further, the coupling state designation circuit CSC sets the coupling state designation signal Qa[m] to a low level in the unit period TU for detection.

[0112] In this case, the piezoelectric element PZ[m] included in the ejecting portion D[m] as a detection target is driven by the drive signal COM in each of the K consecutive unit periods TU before the unit period TU for detection. Therefore, the piezoelectric element PZ[m] is displaced by the pulse PA of the drive signal COM in each of the K consecutive unit periods TU before the unit period TU for detection. As a result, vibration is generated in the ejecting portion D[m] of the detection target before the unit period TU for detection. The vibration generated before the unit period TU for detection also remains in the unit period TU for detection. Then, in the unit period TU for detection, a potential of the individual electrode Za[m] of the piezoelectric element PZ[m] included in the ejecting portion D[m] as a detection target is changed in accordance with the residual vibration generated in the ejecting portion D[m]. That is, in the unit period TU for detection, the potential of the individual electrode Za of the piezoelectric element PZ included in the ejecting portion D as a detection target becomes a potential corresponding to an electromotive force of the piezoelectric element PZ caused by the residual vibration generated in the ejecting portion D as a detection target. The potential of the individual electrode Za is detected as the detection signal Vout in the unit period TU for detection.

[0113] For example, the coupling state designation circuit CSC may set the coupling state designation signal Qs[m] to a high level in a former half period of the unit period TU for detection, and set the coupling state designation signal Qs[m] to a low level in a latter half period of the unit period TU for detection. Further, the coupling state designation signals Qa and Qs corresponding to the ejecting portions D other than the ejecting portion D[m] which is a detection target are set to a low level in the unit period TU for detection, for example.

[0114] In this manner, in the present embodiment, for example, the residual vibration signal VR[m] indicating the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving for driving the piezoelectric element PZ by the drive signal COM for ejecting the ink from the nozzle N is used for evaluating the ejection stability. The continuous execution of the ejection driving means, for example, that ejection driving is executed in each of the plurality of consecutive unit periods TU.

[0115] The operation of the liquid ejecting apparatus **100** is not limited to the example illustrated in FIG. **6**. For example, in FIG. **6**, the drive signal COM including one pulse PA for ejecting the ink from the nozzle N is illustrated as an example, and the present disclosure is not limited to such an aspect. For example, the drive signal COM may have a plurality of pulses for ejecting inks for forming dots having different sizes from the nozzle N. For example, in FIG. **6**, a case is illustrated as an example in which there is one drive signal COM for ejecting an ink from the nozzle N, and the present disclosure is not limited to such an aspect. For example, the plurality of drive signals COM corresponding to sizes of dots may be used as the drive signal COM for ejecting the ink from the nozzle N. The plurality of drive signals COM may include one or both of the drive signals COM having a minute vibration waveform for preventing thickening of the ink and the drive signal COM having a minute vibration waveform for generating residual vibration for evaluating the ejection state.

[0116] Next, an operation of the analysis portion **3** will be described with reference to FIG. **7**.

[0117] FIG. **7** is a diagram illustrating an example of a waveform of the residual vibration signal VR. FIG. **7** schematically illustrates the example of the waveform of the residual vibration signal VR indicating residual vibration detected in the unit period TU for detection. A vertical axis of a graph indicates a potential of the residual vibration signal VR, and a horizontal axis indicates a time.

[0118] In addition, a potential VC**0** indicates a reference potential of the residual vibration signal VR. For example, the potential VC**0** may be a potential of the residual vibration signal VR when residual vibration of the diaphragm **14** is attenuated and the residual vibration is settled, or may be an intermediate potential between a potential of a peak at which a waveform of the residual vibration signal VR becomes a mountain and a potential of a peak at which the waveform of the residual vibration signal VR becomes a valley. The peak at which the waveform of the residual vibration signal VR becomes a mountain is a peak at which the potential of the residual vibration signal VR becomes a maximum value, and the peak at which the waveform of the residual vibration signal VR becomes a valley is a peak at which the potential of the residual vibration signal VR becomes a minimum value.

[0119] Each of residual vibration signals VRca and VRcb is, for example, the residual vibration signal VR indicating residual vibration of the diaphragm **14** caused by continuously executing ejection driving **10** times. The residual vibration signal VRca is an example of the residual vibration signal VR when the ejection is stable, and the residual vibration signal VRcb is an example of the residual vibration signal VR when the ejection is unstable. In the following, the residual vibration signals VRca and VRcb are also referred to as a residual vibration signal VRc without particular distinction. For example, a residual vibration signal VRs is the residual vibration signal VR indicating residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. The residual vibration signal VRs is used for calculating a threshold value, for example, as compared with the residual vibration signal VRc. Each waveform illustrated in FIG. **7** is a waveform for describing the operation of the analysis portion **3**, and does not accurately represent a relationship between the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times and the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time.

[0120] As described above, the residual vibration signal VR indicates a waveform corresponding to the residual vibration of the ejecting portion D as a detection target, that is, the residual vibration of the diaphragm **14**. Specifically, the residual vibration signal VR indicates an amplitude corresponding to an amplitude of the residual vibration of the diaphragm **14**, a cycle corresponding to a cycle of the residual vibration of the diaphragm **14**, and a phase corresponding to a phase of the residual vibration of the diaphragm **14**.

[0121] In the example illustrated in FIG. **7**, for example, the analysis portion **3** specifies an amplitude λS**1** of a peak, which is first among a plurality of peaks at which a potential is the maximum value or the minimum value in the residual vibration signal VRs, as an amplitude of a peak which is first in the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. In addition, the analysis portion **3** respectively specifies an amplitude λS**2** of a peak which is second and an amplitude λS**3** of a peak which is third in the residual vibration signal VRs, as an amplitude of a peak which is second and an amplitude of a peak which is third in the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. In the following, the amplitudes λS**1**, λS**2**, and λS**3** of the residual vibration signal VRs may be collectively referred to as an amplitude λS.

[0122] In the same manner, the analysis portion **3** specifies the amplitude λC**1** at the peak which is first in the residual vibration signal VRc as the amplitude of the peak which is first in the residual vibration of the diaphragm **14** by continuously executing ejection driving **10** times. In addition, the analysis portion **3** respectively specifies the amplitude λC**2** of the peak which is second and the amplitude λC**3** of the peak which is third in the residual vibration signal VRc, as the amplitude of the peak which is second and the amplitude of the peak which is third in the residual vibration of the diaphragm **14** by continuously executing the ejection driving **10** times. In the following, the amplitudes λC**1**, λC**2**, and λC**3** of the residual vibration signal VRc may be collectively referred to as an amplitude λC.

[0123] In FIG. **7**, in order to distinguish the amplitude λC of the residual vibration signal VRca from the amplitude λC of the residual vibration signal VRcb, an alphabet “a” or “b” is added to the end of each of the reference numerals of the amplitudes λC**1**, λC**2**, and λC**3**. For example, the amplitudes λC**1**_a_, λC**2**_a_, and λC**3**_a_ respectively indicate the amplitude λC**1** of the peak which is first, the amplitude λC**2** of the peak which is second, and the amplitude λC**3** of the peak which is third in the residual vibration signal VRca. In addition, the amplitudes λC**1**_b_, λC**2**_b_, and λC**3**_b_ respectively indicate the amplitude λC**1** of the peak which is first, the amplitude λC**2** of the peak which is second, and the amplitude λC**3** of the peak which is third in the residual vibration signal VRcb.

[0124] When the ejection is stable, as illustrated in the residual vibration signals VRs and VRca, a waveform of the residual vibration signal VRc is a waveform similar to a waveform of the residual vibration signal VRs. That is, when the ejection is unstable, as illustrated in the residual vibration signals VRs and VRcb, the waveform of the residual vibration signal VRc is a waveform that is not similar to the waveform of the residual vibration signal VRs. When the ejection is unstable, a difference between the amplitude λC of the residual vibration signal VRc and the amplitude λS of the residual vibration signal VRs becomes large, which is obtained by the experiment of the inventor. Therefore, in the present embodiment, when at least one of a difference between the amplitude λS**1** and the amplitude λC**1**, a difference between the amplitude λS**2** and the amplitude λC**2**, and a difference between the amplitude λS**3** and the amplitude λC**3** is equal to or more than a predetermined value, it is assumed that the waveform of the residual vibration signal VRc is not similar to the waveform of the residual vibration signal VRs. The predetermined value is determined, for example, for each peak of the residual vibration signal VR.

[0125] The amplitude λC**1** is an example of an “amplitude of first peak”, and the amplitude λC**2** is an example of an “amplitude of second peak”. In addition, the amplitude λS**1** is an example of an “amplitude of third peak”, and the amplitude λS**2** is an example of an “amplitude of fourth peak”.

[0126] For example, the analysis portion **3** specifies a cycle of the residual vibration signal VR as a cycle of the residual vibration of the diaphragm **14**, and specifies a phase of the residual vibration signal VR as a phase of the residual vibration of the diaphragm **14**. Here, in the present embodiment, a case is assumed in which an amplitude of the residual vibration of the diaphragm **14** is used for evaluating the ejection stability among the amplitude, the cycle, and the phase. In this case, the analysis portion **3** may not specify the cycle and the phase of the residual vibration signal VRc. In the present embodiment, a case is assumed in which among the amplitude, the cycle, and the phase of the residual vibration of the diaphragm **14**, the cycle is used for evaluating the ejection state of the nozzle N. In this case, the analysis portion **3** may not specify the phase of the residual vibration signal VRs.

[0127] The analysis method of the residual vibration is not limited to the example described above, and a known method can be adopted.

[0128] The analysis portion **3** outputs, for example, an analysis result of the residual vibration, that is, the residual vibration information Vinf indicating the analysis result of the residual vibration signal VR to the control unit **4**. For example, the analysis portion **3** outputs the residual vibration information Vinf respectively indicating the amplitudes λC**1**, λC**2**, and λC**3** of the residual vibration signal VRc to the control unit **4**, as an analysis result of the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times. For example, the analysis portion **3** outputs the amplitudes λS**1**, λS**2**, and λS**3** of the residual vibration signal VRs and the residual vibration information Vinf respectively indicating the cycles, as the analysis result of the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time, to the control unit **4**.

[0129] Next, an operation of the liquid ejecting apparatus **100** when evaluating an ejection stability will be described with reference to FIG. **8**.

[0130] FIG. **8** is a flowchart illustrating an example of the operation of the liquid ejecting apparatus **100** when evaluating the ejection stability of the ink from the nozzle N. A timing at which the operation illustrated in FIG. **8** is executed is not particularly limited, and it is preferable to be executed when the liquid ejecting apparatus **100** is used for the first time or when a use condition of the liquid ejecting apparatus **100** is changed by a change in type of ink to be used. The use condition of the liquid ejecting apparatus **100** also includes a use condition of the liquid ejecting head **1**. The operation illustrated in FIG. **8** is executed on each of the plurality of liquid ejecting heads **1**, for example. In addition, in the operation illustrated in FIG. **8**, a case is assumed in which an ejection state of the nozzle Nis evaluated before the ejection stability is evaluated.

[0131] The control unit **4** functions as the evaluation control portion **40** in each step from step S**100** to step S**250** illustrated in FIG. **8**. A process in step S**100** is executed, for example, in a state in which the pressure chamber CV is filled with an ink to be used by a user of the liquid ejecting apparatus **100**. That is, after the pressure chamber CV is filled with the ink to be used by the user, the process in step S**100** is executed. The process of filling the pressure chamber CV with the ink may be executed by the evaluation control portion **40**, or may be executed by a processing portion other than the evaluation control portion **40**. The user is, for example, a user of the liquid ejecting apparatus **100**. Further, when a manufacturer and the user of the liquid ejecting apparatus **100** are the same, the manufacturer of the liquid ejecting apparatus **100** may be regarded as the user.

[0132] First, in step S**100**, the evaluation control portion **40** executes ejection driving one time. For example, the evaluation control portion **40** controls the liquid ejecting head **1** such that the piezoelectric element PZ of the ejecting portion D, which is a detection target, is driven by the drive signal COM for ejecting an ink from the nozzle N. Therefore, the piezoelectric element PZ of the ejecting portion D as a detection target is driven such that the ink is ejected from the nozzle N of the ejecting portion D as a detection target.

[0133] Next, in step S**110**, the evaluation control portion **40** detects residual vibration of the ejecting portion D, which is a detection target. For example, the evaluation control portion **40** causes the detection circuit **19** to detect the residual vibration from the piezoelectric element PZ of the ejecting portion D, which is a detection target, in the next unit period TU after the unit period TU in which the ejection driving is executed. Therefore, the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time is detected by the detection circuit **19**. The residual vibration detected by the detection circuit **19** is analyzed by the analysis portion **3**. Therefore, for example, the amplitudes λS**1**, λS**2**, and λS**3** of the residual vibration signal VRs and a cycle of the residual vibration signal VRs are respectively specified, as an analysis result of the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. The evaluation control portion **40** acquires the residual vibration information Vinf indicating the analysis result of the residual vibration detected by the detection circuit **19** from the analysis portion **3**. The residual vibration detected in step S**110** is an example of "second residual vibration".

[0134] Next, in step S**120**, the evaluation control portion **40** executes evaluation on an ejection state of the nozzle N. For example, when the amplitude λS**1** of the residual vibration signal VRs is equal to or more than a predetermined amplitude and the cycle of the residual vibration signal VRs is equal to or more than a first predetermined value and equal to or less than a second predetermined value, the evaluation control portion **40** evaluates that the ejection state of the nozzle N included in the detection target ejecting portion D is normal. That is, when the amplitude λS**1** of the residual vibration signal VRs is less than the predetermined amplitude or the cycle of the residual vibration signal VRs is out of a range of the first predetermined value or more and the second predetermined value or less, the evaluation control portion **40** evaluates that the ejection state of the nozzle Nis abnormal.

[0135] Here, the first predetermined value is a value for indicating a boundary between a time length of one cycle of residual vibration when the ejection state of the nozzle N is normal and a time length of one cycle of the residual vibration when air bubbles are mixed in the pressure chamber CV. The second predetermined value is a value for indicating a boundary between a time length of one cycle of residual vibration when the ejection state of the nozzle Nis normal and a time length of one cycle of the residual vibration when a foreign matter adheres to the vicinity of the nozzle N. In addition, a third predetermined value to be described below is a value for indicating a boundary between a time length of one cycle of residual vibration when a foreign matter adheres to the vicinity of the nozzle N and a time length of one cycle of the residual vibration when the ink in the pressure chamber CV is thickened. For example, the second predetermined value is more than the first predetermined value and less than the third predetermined value.

[0136] For example, when the amplitude λS**1** of the residual vibration signal VRs is equal to or more than the predetermined amplitude and the cycle of the residual vibration signal VRs is less than the first predetermined value, the evaluation control portion **40** specifies that the ejection state of the nozzle N is abnormal due to mixing of air bubbles into the nozzle N. In addition, when the amplitude λS**1** of the residual vibration signal VRs is equal to or more than the predetermined amplitude and the cycle of the residual vibration signal VRs is more than the second predetermined value and equal to or less than the third predetermined value, the evaluation control portion **40** specifies that the ejection state of the nozzle Nis abnormal due to a leakage of the ink from the nozzle N. Further, when the amplitude λS**1** of the residual vibration signal VRs is equal to or more than the predetermined amplitude and the cycle of the residual vibration signal VRs is more than the third predetermined value, the evaluation control portion **40** specifies that the ejection state of the nozzle N is abnormal due to thickening of the ink in the nozzle N. Further, when the amplitude λS**1** of the residual vibration signal VRs is less than the predetermined amplitude, the evaluation control portion **40** specifies that the ejection state of the nozzle N has an abnormality other than the abnormality described above.

[0137] The method of determining the ejection state is not limited to the example described above, and a known method can be adopted. The evaluation control portion **40** executes the process in step S**120**, and then shifts the process to step S**130**.

[0138] In step S**130**, the evaluation control portion **40** determines whether or not the ejection state of the nozzle Nis normal. For example, when it is evaluated that the ejection state of the nozzle N is normal in step S**120**, the evaluation control portion **40** determines that the ejection state of the nozzle N is normal. For example, when it is evaluated that the ejection state of the nozzle N is abnormal in step S**120**, the evaluation control portion **40** determines that the ejection state of the nozzle N is not normal.

[0139] When a result of the determination in step S**130** is negative, the evaluation control portion **40** executes a recovery process of the ejection state in step S**140**, then returns to step S**100** after a predetermined time elapses, and the same process is performed again. For example, the evaluation control portion **40** executes a recovery process of recovering the ejection state of the nozzle N to a normal state, based on a type of the abnormality specified in step S**120**. As the recovery process of the ejection state, a known process can be adopted. Here, a case is described as an example in which a series of processes in step S**100** to step S**140** are repeated until it is determined that the ejection state is normal in step S**130**. Meanwhile, when it is determined that the ejection state is abnormal in step S**130** even after the series of processes are repeated a predetermined number of times, the operation of the liquid ejecting apparatus **100** may be stopped and the user may be notified.

[0140] On the other hand, when the result of the determination in step S**130** is affirmative, the evaluation control portion **40** shifts the process to step S**200**.

[0141] In step S**200**, the evaluation control portion **40** sets a waveform of the drive signal COM to be used in step S**210**. For example, the evaluation control portion **40** sets the waveform of the drive signal COM used in step S**100** as the waveform of the drive signal COM to be used in step S**210**. For example, when a series of processes in step S**200** to step S**250** are repeated, the evaluation control portion **40** sets the waveform of the drive signal COM used in step S**100** as the waveform of the drive signal COM to be used in step S**210**, in step S**200** at a first time. In steps S**200** at a second time and subsequent times, the evaluation control portion **40** sets a waveform different from the waveform set in previous step S**200** as the waveform of the drive signal COM to be used in step S**210**. For example, the evaluation control portion **40** sets the length TA of the waveform element Pa**4** to a length different from the length set in previous step S**200**.

[0142] The drive signal COM of which the waveform is set in step S**200** is an example of a "drive signal candidate". The evaluation control portion **40** executes the process in step S**200**, and then shifts the process to step S**210**.

[0143] In step S**210**, the evaluation control portion **40** continuously executes the ejection driving **10** times. For example, the evaluation control portion **40** controls the liquid ejecting head **1** with the drive signal COM having the waveform set in step S**200** such that the piezoelectric element PZ of the ejecting portion D, which is a detection target, is driven in each of the **10** consecutive unit periods TU. Therefore, the ejection driving for ejecting the ink from the nozzle N of the ejecting portion D, which is a detection target, is continuously executed **10** times.

[0144] Next, in step S**220**, the evaluation control portion **40** detects residual vibration of the ejecting portion D, which is a detection target, immediately after the ejection driving is continuously performed **10** times in step S**210**. For example, the evaluation control portion **40** causes the detection circuit **19** to detect the residual vibration from the piezoelectric element PZ of the ejecting portion D, which is a detection target, in the next unit period TU after the **10** consecutive unit periods TU in which the ejection driving is executed. Therefore, the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times is detected by the detection circuit **19**. The residual vibration detected by the detection circuit **19** is analyzed by the analysis portion **3**. Therefore, for example, the amplitudes λC**1**, λC**2**, and λC**3** of the residual vibration signal VRc are respectively specified as an analysis result of the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times. The evaluation control portion **40** acquires the residual vibration information Vinf indicating the analysis result of the residual vibration detected by the detection circuit **19** from the analysis portion **3**. The residual vibration detected in step S**220** is an example of "first residual vibration".

[0145] Next, in step S**230**, the evaluation control portion **40** executes evaluation on an ejection stability. In the process in step S**230**, that is, by evaluating the stability, it is determined whether the ejection of the ink from the nozzle Nis stable or unstable when the piezoelectric element PZ is driven by the drive signal COM having the waveform set in step S**200**. Details of the evaluation on the stability will be described with reference to FIG. **9** which will be described below.

[0146] Next, in step S**240**, the evaluation control portion **40** stores an evaluation result of the ejection stability. For example, the evaluation control portion **40** stores the evaluation result of the ejection stability in the storage unit **5** in association with the waveform drive signal COM set in step S**200**.

[0147] Next, in step S**250**, the evaluation control portion **40** determines whether or not to change the waveform of the drive signal COM. That is, the evaluation control portion **40** determines whether or not to execute a series of processes in step S**210** to step S**230** again by changing the waveform of the drive signal COM.

[0148] For example, when the result of the stability evaluation executed in step S**230** indicates that the ejection of the ink is unstable, the evaluation control portion **40** may determine that the waveform of the drive signal COM is to be changed. Alternatively, when there is a drive signal candidate not used in step S**210**, among a plurality of drive signal candidates including the drive signal COM used in step S**100**, the evaluation control portion **40** may determine that the waveform of the drive signal COM is to be changed. For example, the waveforms of the plurality of drive signal candidates are determined based on an ejection characteristic of the ink of the ejecting portion D and the like, and are the same as each other, except for the length TA of the waveform element Pa**4** and the length TB of the waveform element Pa**5**.

[0149] When a result of the determination in step S**250** is affirmative, the evaluation control portion **40** returns the process to step S**200**. On the other hand, when the result of the determination in step S**250** is negative, the evaluation control portion **40** ends the operation illustrated in FIG. **8**.

[0150] In FIG. **8**, a case is illustrated as an example in which the length TA of the waveform element Pa**4** is changed by repeating the series of processes in step S**200** to step S**250**, and the present disclosure is not limited to such an aspect. For example, by repeating the series of processes in step S**200** to step S**250**, instead of the length TA of the waveform element Pa**4**, or in addition to the length TA of the waveform element Pa**4**, a parameter other than the length TA of the waveform element Pa**4** may be changed. The parameter other than the length TA of the waveform element Pa**4** is, for example, an inclination of the waveform element Pa**1**, a length of the waveform element Pa**2**, an inclination of the waveform element Pa**3**, an inclination of the waveform element Pa**5**, the potential VHa, the potential VLa, or the like.

[0151] A series of processes in step S**100** to step S**120** is an example of "second evaluation", and the series of processes in step S**210** to step S**230** is an example of "first evaluation".

[0152] Next, an example of stability evaluation executed in step S**230** will be described with reference to FIG. **9**.

[0153] FIG. **9** is a flowchart illustrating an example of the stability evaluation illustrated in FIG. **8**. A series of processes in step S**232** to step S**239** illustrated in FIG. **9** corresponds to the process in step S**230** illustrated in FIG. **8**. For example, the process in step S**232** is executed after the process in step S**220** illustrated in FIG. **8** is executed, and the process in step S**240** illustrated in FIG. **8** is executed after the process in step S**238** or the process in step S**239** is executed. The control unit **4** functions as the evaluation control portion **40** in each step from step S**232** to step S**239** illustrated in FIG. **9**.

[0154] In the operation illustrated in FIG. **9**, the amplitudes λS**1**, λS**2**, and λS**3** of the residual vibration signal VRs specified by the process in step S**110** illustrated in FIG. **8**, and the amplitudes λC**1**, λC**2**, and λC**3** of the residual vibration signal VRc specified by the process in step S**220** illustrated in FIG. **8** are used.

[0155] First, in step S**232**, the evaluation control portion **40** determines whether or not the amplitude λC**1** is equal to or less than 1.3 times the amplitude λS**1**. That is, the evaluation control portion **40** determines whether or not an amplitude of a peak which is first in residual vibration of the diaphragm **14** caused by the ejection driving continuously executed **10** times is equal to or less than 1.3 times an amplitude of a peak which is first in residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. A value obtained by multiplying the amplitude λS**1** by 1.3, that is, a value obtained by multiplying the amplitude λS**1** by a coefficient "1.3" is an example of a "first threshold value". In addition, the coefficient "1.3" multiplied by the amplitude λS**1** is an example of a "first coefficient". The "first coefficient" is not limited to "1.3".

[0156] When a result of the determination in step S**232** is negative, the evaluation control portion **40** determines that the ink ejection is unstable in step S**239**, and then shifts the process to step S**240** illustrated in FIG. **8**. That is, the evaluation control portion **40** ends the operation illustrated in FIG. **9** after executing the process in step S**239**. In this manner, when the amplitude λC**1** of the peak which is first in the residual vibration signal VRc is more than 1.3 times the amplitude λS**1** of the peak which is first in the residual vibration signal VRs, the evaluation control portion **40** determines that the ejection of the ink is unstable.

[0157] On the other hand, when the result of the determination in step S**232** is affirmative, the evaluation control portion **40** shifts the process to step S**234**.

[0158] In step S**234**, the evaluation control portion **40** determines whether or not the amplitude λC**2** is equal to or less than 1.2 times the amplitude λS**2**. That is, the evaluation control portion **40** determines whether or not an amplitude of a peak which is second in the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times is 1.2 times or less an amplitude of a peak which is second in the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. A value obtained by multiplying the amplitude λS**2** by 1.2, that is, a value obtained by multiplying the amplitude λS**2** by a coefficient "1.2" is an example of a "second threshold value". In addition, the coefficient "1.2" multiplied by the amplitude λS**2** is an example of a "second coefficient". The "second coefficient" is not limited to "1.2".

[0159] When a result of the determination in step S**234** is negative, the evaluation control portion **40** determines that the ink ejection is unstable in step S**239**, and then shifts the process to step S**240** illustrated in FIG. **8**. In this manner, the evaluation control portion **40** determines that the ejection of the ink is unstable when the amplitude λC**2** of the peak which is second in the residual vibration signal VRc is more than 1.2 times the amplitude λS**2** of the peak which is second in the residual vibration signal VRs.

[0160] On the other hand, when the result of the determination in step S**234** is affirmative, the evaluation control portion **40** shifts the process to step S**236**.

[0161] In step S**236**, the evaluation control portion **40** determines whether or not the amplitude λC**3** is equal to or less than 1.1 times the amplitude λS**3**. That is, the evaluation control portion **40** determines whether or not an amplitude of a peak which is third in the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times is 1.1 times or less an amplitude of a peak which is third in the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time. The coefficient multiplied by the amplitude λS**3** is not limited to "1.1".

[0162] When a result of the determination in step S**236** is negative, the evaluation control portion **40** determines that the ink ejection is unstable in step S**239**, and then shifts the process to step S**240** illustrated in FIG. **8**. In this manner, when the amplitude λC**3** of the peak which is third in the residual vibration signal VRc is more than 1.1 times the amplitude λS**2** of the peak which is third in the residual vibration signal VRs, the evaluation control portion **40** determines that the ejection of the ink is unstable.

[0163] On the other hand, when the result of the determination in step S**236** is affirmative, the evaluation control portion **40** shifts the process to step S**238**.

[0164] In step S**238**, the evaluation control portion **40** determines that the ink ejection is stable. That is, when the results of the determination in steps S**232**, S**234**, and S**236** are all affirmative, the evaluation control portion **40** determines that the ink ejection is stable. Then, the control unit **4** executes the process in step S**238**, and then shifts the process to step S**240** illustrated in FIG. **8**. That is, the evaluation control portion **40** ends the operation illustrated in FIG. **9** after executing the process in step S**238**.

[0165] In this manner, the drive signal COM with which the ink ejection is stable and the drive signal COM with which the ink ejection is unstable are specified by the stability evaluation illustrated in FIG. **9**.

[0166] In addition, in the evaluation on the stability illustrated in FIG. **9**, a value based on the amplitude λS of the residual vibration signal VRs is used as a threshold value to be compared to the amplitude λC of the residual vibration signal VRc. Specifically, the first threshold value to be compared with the amplitude λC**1** is a value based on the amplitude λS**1**, the second threshold value to be compared with the amplitude λC**2** is a value based on the amplitude λS**2**, and the third threshold value to be compared with the amplitude λC**3** is a value based on the amplitude λS**3**. In the present embodiment, the value based on the amplitude λS of the residual vibration signal VRs is used as a threshold value to be compared with the amplitude λC of the residual vibration signal VRc. Therefore, a threshold value according to a use condition of the liquid ejecting head **1**, such as a type of the used ink can be used. Therefore, in the present embodiment, the ejection stability can be evaluated with high accuracy.

[0167] In addition, in the stability evaluation illustrated in FIG. **9**, the first threshold value described above is a value obtained by multiplying the amplitude λS**1** and the first coefficient "1.3", the second threshold value is a value obtained by multiplying the amplitude λS**2** and the second coefficient "1.2", and the third threshold value is a value obtained by multiplying the amplitude λS**3** and the third coefficient "1.1". The second coefficient is less than the first coefficient, and the third coefficient is less than the second coefficient. Here, since the residual vibration is attenuated, among the amplitudes of the plurality of peaks of the residual vibration signal VR, the amplitude of the latter half peak tends to be less than the amplitude of the former half peak. As a value of actual data (peak amplitude) is increased, a deviation of the measurement value is also increased when a certain measurement error occurs. Therefore, by setting the first coefficient to be more than the second coefficient and setting the second coefficient to be more than the third coefficient, and allowing the deviation to be larger in the former half in which the amplitude of the peak is large, the ejection stability can be evaluated with high accuracy. Meanwhile, a relationship between the first coefficient, the second coefficient, and the third coefficient is not limited to the example described above. For example, the first coefficient, the second coefficient, and the third coefficient may have the same value as each other.

[0168] The operation of the liquid ejecting apparatus **100** when evaluating the ejection stability is not limited to the examples illustrated in FIGS. **8** and **9**. For example, in the operation illustrated in FIG. **9**, the evaluation control portion **40** may also determine a lower limit of the amplitude λC of the residual vibration signal VRc. Specifically, the evaluation control portion **40** may determine whether or not the amplitude λC**1** is equal to or more than 0.7 times the amplitude λS**1** before executing the process in step S**232**. When the amplitude λC**1** is less than 0.7 times the amplitude λS**1**, the evaluation control portion **40** may determine that the ejection of the ink is unstable in step S**239**, and then may shift the process to step S**240** illustrated in FIG. **8**. That is, in this aspect, the process in step S**232** is executed when the amplitude λC**1** is 0.7 times or more the amplitude λS**1**. A threshold value indicating the lower limit of the amplitude λC is not limited to 0.7 times the amplitude λS**1**. In addition, for example, in each of steps S**232**, S**234**, and S**236**, the lower limit of the amplitude λC may be set.

[0169] In addition, for example, in the operation illustrated in FIG. **9**, one process of the process in step S**232**, the process in step S**234**, and the process in step S**236** may be omitted. For example, in an aspect in which the process in step S**236** is omitted, the evaluation control portion **40** determines that the ejection is stable when the amplitude λC**1** is equal to or less than 1.3 times the amplitude λS**1** and the amplitude λC**2** is equal to or less than 1.2 times the amplitude λS**2**.

[0170] In addition, for example, in the operation illustrated in FIG. **9**, two processes of the process in step S**232**, the process in step S**234**, and the process in step S**236** may be omitted. That is, the evaluation control portion **40** may evaluate the ejection stability of the ink from the nozzle N based on the amplitude of at least one peak among a plurality of peaks of the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times.

[0171] In addition, for example, the threshold value to be compared with the amplitude λC of the residual vibration signal VRc may be a predetermined amplitude value. That is, each of the first threshold value to be compared with the amplitude λC**1**, the second threshold value to be compared with the amplitude λC**2**, and the third threshold value to be compared with the amplitude λC**3** may be a predetermined fixed value. In the present aspect, it is preferable that the second threshold value is less than the first threshold value, and the third threshold value is less than the second threshold value. In the present aspect, the series of processes in step S**100** to step S**140** illustrated in FIG. **8** may be omitted, or may be executed after the ejection stability is evaluated.

[0172] In addition, in the operation illustrated in FIG. **9**, instead of the amplitude λC of the residual vibration signal VRc, or in addition to the amplitude λC of the residual vibration signal VRc, one or both of the cycle and the phase of the residual vibration signal VRc may be used for evaluating the ejection stability. For example, the evaluation control portion **40** may determine that the ejection is unstable when the cycle of the residual vibration signal VRc is out of a range of 0.8 times or more and 1.2 times or less the cycle of the residual vibration signal VRs. In the same manner, when the phase of the residual vibration signal VRc is out of a range of 0.8 times or more and 1.2 times or less the phase of the residual vibration signal VRs, the evaluation control portion **40** may determine that the ejection is unstable. The lower limit and the upper limit of the cycle compared with the cycle of the residual vibration signal VRc, and the lower limit and the upper limit of the phase compared with the phase of the residual vibration signal VRc are not limited to the example described above.

[0173] For example, the evaluation control portion **40** may determine the waveform of the drive signal COM based on the result of evaluating the ejection stability. For example, the evaluation control portion **40** may adopt the drive signal COM with which it is determined that the ejection is stable in the stability evaluation illustrated in FIG. **9** as the drive signal COM to be used in the actual printing process. That is, the evaluation control portion **40** may determine the waveform of the drive signal COM based on the first residual vibration detected by the detection circuit **19** as the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving. In this manner, in the present embodiment, the waveform of the drive signal COM can be easily determined to be an appropriate waveform with which the ink ejection is stable, based on the first residual vibration. In addition, for example, when a plurality of candidates of the drive signal COM are determined to be stable in ejection, the evaluation control portion **40** may adopt, as the drive signal COM, a candidate of which the waveform of the residual vibration signal VRc coincides with or is most similar to the waveform of the residual vibration signal VRs among the plurality of candidates. In the present embodiment, the ejection of the ink from the nozzle N can be easily prevented from being unstable, by determining the waveform of the drive signal COM based on the evaluation result of the ejection stability.

[0174] As described above, in the present embodiment, the liquid ejecting apparatus **100** includes the liquid ejecting head **1** including the nozzle N that ejects inks, the piezoelectric element PZ corresponding to the nozzle N, the diaphragm **14** that vibrates by driving the piezoelectric element PZ, and the detection circuit **19** that detects residual vibration of the diaphragm **14** caused by driving the piezoelectric element PZ, and the evaluation control portion **40** that executes first evaluation for evaluating an ejection stability of the ink from the nozzle N. In the first evaluation, the evaluation control portion **40** causes the detection circuit **19** to detect the residual vibration caused by continuous execution of ejection driving for driving the piezoelectric element PZ by the drive signal COM for ejecting the ink from the nozzle N as first residual vibration, and evaluates the ejection stability of the ink from the nozzle N based on the first residual vibration detected by the detection circuit **19**. In addition, the evaluation control portion **40** may determine a waveform of the drive signal COM based on the first residual vibration detected by the detection circuit **19**.

[0175] In this manner, in the present embodiment, the evaluation control portion **40** evaluates the ejection stability of the ink based on the first residual vibration caused by continuously executing the ejection driving for driving the piezoelectric element PZ by the drive signal COM for ejecting the ink from the nozzle N. Therefore, in the present embodiment, the ejection stability of the ink from the nozzle N can be appropriately and easily evaluated, without requiring an external element such as an imaging environment. In the present embodiment, the evaluation control portion **40** determines the waveform of the drive signal COM based on the first residual vibration, and thus the waveform of the drive signal COM for driving the piezoelectric element PZ can be appropriately and easily determined.

[0176] In the present embodiment, the evaluation control portion **40** may evaluate the ejection stability of the ink from the nozzle N based on an amplitude of at least one peak of a plurality of peaks of the first residual vibration in the first evaluation. In this case, the ejection stability of the ink from the nozzle N can be appropriately and easily evaluated, without specifying a cycle and a phase of the first residual vibration.

[0177] In the present embodiment, in the first evaluation, the evaluation control portion **40** may determine that the ejection stability of the ink from the nozzle N is unstable when an amplitude of a first peak, which is first among the plurality of peaks of the first residual vibration, is more than a first threshold value. In this case as well, the ejection stability of the ink from the nozzle N can be appropriately and easily evaluated. In addition, when it is determined that the ejection of the ink is unstable based on the amplitude of the first peak among the plurality of peaks of the first residual vibration, it is not necessary to refer to the amplitudes of the other peaks, and thus an increase in load on the evaluation of the ejection stability can be prevented.

[0178] In the present embodiment, in the first evaluation, the evaluation control portion **40** may determine that the ejection of the ink from the nozzle Nis unstable when an amplitude of a second peak, which is second among the plurality of peaks of the first residual vibration, is more than a second threshold value. In this case, since the ejection stability is evaluated based on the plurality of peaks of the first residual vibration, the ejection stability can be evaluated with high accuracy.

[0179] In the present embodiment, in the first evaluation, the evaluation control portion **40** may determine that the ejection of the ink from the nozzle Nis stable when the amplitude of the first peak is equal to or less than the first threshold value and the amplitude of the second peak is equal to or less than the second threshold value. In this case as well, the ejection stability can be evaluated with high accuracy.

[0180] In the present embodiment, the evaluation control portion **40** may cause the detection circuit **19** to detect residual vibration caused by executing the ejection driving only one time as second residual vibration, and use a value based on an amplitude of a third peak, which is first among a plurality of peaks of the second residual vibration, as the first threshold value. In this manner, in the present aspect, a value based on an amplitude of a peak which is first in the second residual vibration caused by executing the ejection driving only one time is used as the first threshold value to be compared with the amplitude of the peak which is first of the first residual vibration. That is, in the present aspect, a threshold value according to a use condition of the liquid ejecting head **1** is used as the first threshold value. As a result, in the present aspect, the ejection stability can be accurately evaluated, in accordance with the use condition of the liquid ejecting head **1**.

[0181] In the present embodiment, in the first evaluation, the evaluation control portion **40** causes the detection circuit **19** to detect the residual vibration caused by executing the ejection driving only one time as the second residual vibration, and uses a value obtained by multiplying the amplitude of the third peak, which is first among the plurality of peaks of the second residual vibration, and the first coefficient as the first threshold value, and a value obtained by multiplying an amplitude of a fourth peak, which is second among the plurality of peaks of the second residual vibration, and the second coefficient less than the first coefficient as the second threshold value. In the present aspect as well, the ejection stability can be accurately evaluated, in accordance with the use condition of the liquid ejecting head **1**. In the present aspect, the ejection stability can be evaluated with higher accuracy, as compared with a case where the ejection stability is evaluated based on only the amplitude of the first peak which is first of the first residual vibration.

[0182] In the present embodiment, the evaluation control portion **40** may cause the detection circuit **19** to detect the residual vibration caused by executing the ejection driving only one time as the second residual vibration, and may further execute the second evaluation of evaluating the ejection state of the nozzle N based on the second residual vibration detected by the detection circuit **19**. In this manner, in the present aspect, the ejection state of the nozzle N can be appropriately and easily evaluated by using the second residual vibration.

[0183] In the present embodiment, the evaluation control portion **40** may execute the first evaluation for each of the plurality of drive signal candidates having different waveforms for ejecting the ink from the nozzle N, by using one drive signal candidate among the plurality of drive signal candidates as the drive signal COM, and may specify A drive signal candidate with which the ejection of the ink from the nozzle Nis stable and a drive signal candidate with which the ejection of the ink from the nozzle N is unstable, from the plurality of drive signal candidates. In the present aspect, the waveform of the drive signal candidate with which the ink is stably ejected from the nozzle N is determined as the waveform of the drive signal COM. Thus, the waveform of the drive signal COM for driving the piezoelectric element PZ can be appropriately and easily determined.

[0184] In the present embodiment, the evaluation control portion **40** may cause the detection circuit **19** to detect the residual vibration caused by continuously executing the ejection driving **10** times or more, as the first residual vibration in the first evaluation. In the present aspect as well, the ejection stability of the ink from the nozzle N can be appropriately and easily evaluated.

2. Modification Example

[0185] Each embodiment above can be variously modified. A specific aspect of the modification will be described below. Two or more aspects selected in any manner from the following examples can be appropriately combined with each other within a range not inconsistent with each other. In addition, in the modification examples described below, elements having the same effects and functions as those of the embodiment will be given the reference numerals used in the description above, and each detailed description thereof will be appropriately omitted.

First Modification Example

[0186] In the embodiment described above, the drive signal COM for detecting an ejection abnormality of the nozzle N may be supplied from the drive signal generation unit **2** to the liquid ejecting head **1**. In the present modification example, an ejection state of the nozzle N can be evaluated by driving the piezoelectric element PZ with the drive signal COM for detecting the ejection abnormality of the nozzle N.

[0187] FIG. **10** is a block diagram illustrating an example of a configuration of the liquid ejecting head **1** according to a first modification example. The liquid ejecting head **1** illustrated in FIG. **10** has the same manner as the liquid ejecting head **1** illustrated in FIG. **5**, except that a drive signal COMb for detecting an ejection abnormality of the nozzle N is supplied from the drive signal generation unit **2**. Specifically, the liquid ejecting head **1** illustrated in FIG. **10** has the same manner as the liquid ejecting head **1** illustrated in FIG. **5**, except that the liquid ejecting head **1** illustrated in FIG. **10** includes a switching circuit **18**A instead of the switching circuit **18** illustrated in FIG. **5**. The drive signal COMa illustrated in FIG. **10** has the same manner as the drive signal COM illustrated in FIG. **6**.

[0188] The switching circuit **18**A has the same manner as the switching circuit **18**, except that a wiring Lb through which the drive signal COMb is supplied from the drive signal generation unit **2** and M switches SWb[**1**] to SWb[M] corresponding to the M ejecting portions D[**1**] to D[M] on a one-to-one basis are added to the switching circuit **18** illustrated in FIG. **5**. Meanwhile, the coupling state designation circuit CSC generates coupling state designation signals Qa[m], Qb[m], and Qs[m], based on at least some of the print signal SI, a latch signal LAT, and a period designation signal Tsig, which are supplied from the control unit **4**.

[0189] The switch SWb[m] switches conduction and non-conduction between the wiring Lb and the individual electrode Za[m] of the piezoelectric element PZ[m] provided in the ejecting portion D[m], based on the coupling state designation signal Qb[m]. That is, the switch SWb[m] switches conduction and non-conduction between the wiring Lb and the wiring Li[m] coupled to the individual electrode Za[m], based on the coupling state designation signal Qb[m]. In the present modification example, the switch SWb[m] is turned on when the coupling state designation signal Qb[m] is at a high level, and is turned off when the coupling state designation signal Qb[m] is at a low level. When the switch SWb[m] is turned on, the drive signal COMb supplied to the wiring Lb is supplied to the individual electrode Za[m] of the ejecting portion D[m] as the individual drive signal Vin[m] via the wiring Li[m].

[0190] Next, an operation of the liquid ejecting apparatus **100** according to the first modification example will be described with reference to FIG. **11**.

[0191] FIG. **11** is a timing chart illustrating an example of the operation of the liquid ejecting apparatus **100** according to the first modification example. The operation of the coupling state designation circuit CSC or the like when a driving mode as the ejecting portion D that forms dots, the ejecting portion D that does not form the dots, and the ejecting portion D as a detection target when evaluating an ejection stability is designated by the individual designation signal Sd[m] has the same manner as the operation described in FIG. **6**. Therefore, in FIG. **11**, the operation of the coupling state designation circuit CSC or the like when the driving mode as the ejecting portion D, which is an ejection abnormality detection target of the nozzle N, is designated by the individual designation signal Sd[m] will be described.

[0192] For example, the drive signal generation unit **2** outputs the drive signal COMb having a pulse PS. The pulse

PS is a waveform in which a potential of the drive signal COMb is changed from the potential VO and returns to the potential V0, via a potential VLs less than the potential VO and a potential VHs more than the potential V0. In the present modification example, the pulse PS is determined such that a potential difference between the potential VHS, which is the highest potential of the pulse PS, and the potential VLS, which is the lowest potential of the pulse PS, is less than a potential difference between the potential VHa, which is the highest potential of the pulse PA, and the potential VLa, which is the lowest potential of the pulse PA. Specifically, when the drive signal COMb having the pulse PS is supplied to the ejecting portion D[m], a waveform of the pulse PS is determined to drive the ejecting portion D[m] to such an extent that an ink is not ejected from the ejecting portion D[m]. As described above, the potential of the pulse PS at the start and the end is set to the potential V0.

[0193] The control unit **4** outputs the period designation signal Tsig having a pulse PLSt**1** and a pulse PLSt**2**. Therefore, the control unit **4** divides the unit period TU into a control period TSS**1** from a start of the pulse PlsL to a start of the pulse PLSt**1**, a control period TSS**2** from a start of the pulse PLSt**1** to a start of the pulse PLSt**2**, and a control period TSS**3** from a start of the pulse PLSt**2** to a start of the next pulse PlsL.

[0194] For example, when the individual designation signal Sd[m] designates the ejecting portion D[m] as the ejecting portion D, which is an ejection abnormality detection target, the coupling state designation circuit CSC sets the coupling state designation signal Qa[m] to a low level in the unit period TU. Further, the coupling state designation circuit CSC sets the coupling state designation signal Qb[m] to a high level in the control periods TSS**1** and TSS**3** and to a low level in the control period TSS**2**, respectively. Further, the coupling state designation circuit CSC sets the coupling state designation signal Qs[m] to a low level in the control periods TSS**1** and TSS**3** and to a high level in the control period TSS**2**, respectively.

[0195] In this case, the piezoelectric element PZ[m] included in the ejecting portion D[m] as an ejection abnormality detection target is driven by the pulse PS of the drive signal COMb in the control period TSS**1**. Specifically, the piezoelectric element PZ[m] is displaced by the pulse PS of the drive signal COMb in the control period TSS**1**. As a result, vibration is generated in the ejecting portion D[m] as a detection target. The vibration generated in the control period TSS**1** remains in the control period TSS**2**. In the control period TSS**2**, the potential of the individual electrode Za[m] of the piezoelectric element PZ[m] included in the ejecting portion D[m] as a detection target is changed according to the residual vibration generated in the ejecting portion D[m]. That is, in the control period TSS**2**, the potential of the individual electrode Za of the piezoelectric element PZ included in the ejecting portion D as a detection target is a potential according to an electromotive force of the piezoelectric element PZ caused by the residual vibration generated in the ejecting portion D as a detection target. The potential of the individual electrode Za is detected as the detection signal Vout in the control period TSS**2**.

[0196] In FIG. **11**, a case is illustrated as an example in which the detection signal Vout indicating the residual vibration of the ejecting portion D as an ejection abnormality detection target is generated during a printing process period, and the detection signal Vout may be generated during a period different from the printing process period. That is, the process of detecting the residual vibration of the ejecting portion D, which is an ejection abnormality detection target, may be executed in a period different from the printing process period.

[0197] In this manner, in the present modification example, an ejection abnormality of the nozzle N can be detected based on the residual vibration detected by the drive signal COMb. The detection of the ejection abnormality by using the drive signal COMb may be executed before an ejection stability is evaluated, or may be executed after the ejection stability is evaluated. In the present modification example, when the ejection stability is evaluated, the series of processes in step **S100** to step **S140** illustrated in FIG. **8** may be omitted.

[0198] As described above, in the present modification example as well, the same effect as that of the embodiment described above can be obtained. In addition, in the present modification example, an ejection abnormality of the nozzle N can be detected based on the residual vibration detected by the drive signal COMb. That is, in the present modification example, the ejection state of the nozzle N can be evaluated based on the residual vibration detected by the drive signal COMb.

Second Modification Example

[0199] In the embodiment and modification example described above, when a waveform of the drive signal COM used for evaluating an ejection stability is changed, residual vibration of the diaphragm **14** may be detected by executing ejection driving only one time, with the drive signal COM of which the waveform is changed.

[0200] FIG. **12** is a flowchart illustrating an example of an operation of the liquid ejecting apparatus **100** according to a second modification example. The operation illustrated in FIG. **12** has the same manner as the operation illustrated in FIG. **8**, except that a series of processes in steps **S202** and **S204** are executed between steps **S200** and **S210**. The control unit **4** functions as the evaluation control portion **40** in each step of step **S202** and step **S204**.

[0201] For example, the evaluation control portion **40** executes the process in step **S200**, and then shifts the process to step **S202**.

[0202] In step **S202**, the evaluation control portion **40** executes ejection driving one time, by using the drive signal COM having the waveform set in step **S200**.

[0203] Next, in step **S204**, the evaluation control portion **40** detects residual vibration of the ejecting portion D, which is a detection target, in the same manner as in step **S110**. Therefore, for example, the amplitudes λS**1**, λS**2**, and λS**3** of the residual vibration signal VRs are respectively specified as an analysis result of the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time by using the drive signal COM of the waveform set in step **S200**. In step **S204**, a cycle and a phase of the residual vibration signal VRs may not be specified. The evaluation control portion **40** acquires the residual vibration information Vinf indicating the analysis result of the residual vibration detected by the detection circuit **19** from the analysis portion **3**. The residual vibration detected in step **S204** is an example of "second residual vibration".

[0204] The evaluation control portion **40** executes the process in step **S204**, and then shifts the process to step **S210**.

[0205] In this manner, in the present modification example, the same drive signal COM is used for detecting the residual vibration of the diaphragm **14** caused by executing the ejection driving only one time and detecting the residual vibration of the diaphragm **14** caused by continuously executing the ejection driving **10** times. Therefore, in the present modification example, a threshold value corresponding to the waveform of the drive signal COM used in step S**210** is used as a threshold value to be compared with the amplitude λC of the residual vibration signal VRc.

[0206] The operation of the liquid ejecting apparatus **100** according to the present modification example is not limited to the example illustrated in FIG. **12**. For example, the series of processes in step S**100** to step S**140** illustrated in FIG. **12** may be omitted. Further, for example, as the series of processes in step S**100** to step S**120**, ejection abnormality detection using the drive signal COMb described in FIG. **11** may be executed.

[0207] As described above, in the present modification example as well, the same effect as that of the embodiment described above can be obtained. Further, in the present modification example, since the threshold value corresponding to the waveform of the drive signal COM is used as the threshold value to be compared with the amplitude λC of the residual vibration signal VRc, an ejection stability can be evaluated with high accuracy.

Third Modification Example

[0208] In the embodiment and modification example described above, waveform information indicating a candidate of the drive signal COM used for evaluating an ejection stability may be stored in advance in a storage unit (not illustrated) of the liquid ejecting head **1** at a time point when the liquid ejecting head **1** is manufactured by a head manufacturer. Alternatively, the waveform information indicating the candidate of the drive signal COM may be stored in the storage unit **5** or the like from the head manufacturer via a network (not illustrated) after the shipment of the liquid ejecting head **1**. For example, the waveform information indicating the candidate of the drive signal COM prepared by the head manufacturer is read from the storage unit **5** or the like in which the waveform information indicating the candidate of the drive signal COM is stored when the operation illustrated in FIG. **8** is executed.

[0209] As described above, in the present modification example as well, the same effect as that of the embodiment described above can be obtained.

Fourth Modification Example

[0210] In the embodiment and modification example described above, a case is described as an example in which the piezoelectric body Zb is displaced in the Z1 direction by changing a potential of the individual drive signal Vin[m] from a low potential to a high potential, and the present disclosure is not limited to such an aspect. For example, the piezoelectric body Zb that is displaced in the Z1 direction by the potential of the individual drive signal Vin[m] changing from the high potential to the low potential may be used. In this case, for example, the potential of the drive signal COM is changed from the low potential to the high potential in a portion corresponding to an expansion element, and is changed from the high potential to the low potential in a portion corresponding to a contraction element. In the present modification example as well, the same effect as the effect of the embodiment and modification examples described above can be obtained.

Fifth Modification Example

[0211] In the embodiment and the modification example described above, a case is described as an example in which one piezoelectric element PZ, one pressure chamber CV, and one nozzle N are provided for one ejecting portion D, and the present disclosure is not limited to such an aspect. For example, one ejecting portion D may have two piezoelectric elements PZ, two pressure chambers CV, and one nozzle N. As described above, also in the present modification example, the same effect as the effect of the embodiment and modification example described above can be obtained.

Sixth Modification Example

[0212] In the embodiment and the modification example described above, the liquid ejecting apparatus **100** having a serial method in which the carriage **91** at which the liquid ejecting head **1** is mounted is reciprocated in the X-axis direction is described as an example, and the present disclosure is not limited to such an aspect. For example, the liquid ejecting apparatus **100** may have a line method liquid ejecting apparatus in which the plurality of nozzles N are distributed over an entire width of the medium PP. As described above, also in the present modification example, the same effect as the effect of the embodiment and modification example described above can be obtained.

Seventh Modification Example

[0213] The liquid ejecting apparatus **100** described in the embodiment and the modification example described above can be adopted in various devices such as a facsimile machine and a copying machine, in addition to a device dedicated to printing. Moreover, the application of the liquid ejecting apparatus of the present disclosure is not limited to printing. For example, a liquid ejecting apparatus that ejects a solution of a coloring material is used as a manufacturing apparatus that forms a color filter of a liquid crystal display device. In addition, a liquid ejecting apparatus that ejects a solution of a conductive material is used as a manufacturing apparatus that forms a wire or an electrode of a wiring substrate. As described above, also in the present modification example, the same effect as the effect of the embodiment and modification example described above can be obtained.

3. Appendixes

[0214] From the embodiments described above, for example, the following configuration can be ascertained.

[0215] According to Aspect 1 that is a preferred aspect, there is provided a liquid ejecting apparatus including: a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element; and a control portion that executes first evaluation for evaluating an ejection stability of the liquid from the nozzle, in which in the first evaluation, the control portion causes the detection portion to detect the residual vibration caused by continuously executing ejection driving of driving the piezoelectric element with a drive signal for ejecting the liquid from the nozzle as first residual vibration, and evaluates the ejection stability of the liquid from the nozzle based on the first residual vibration detected by the detection portion.

[0216] With Aspect 1, the ejection stability of the liquid from the nozzle can be appropriately and easily evaluated, without requiring an external element such as an imaging environment.

[0217] In the liquid ejecting apparatus according to Aspect 2 that is a specific example of Aspect 1, in the first evaluation, the control portion evaluates the ejection stability of the liquid from the nozzle based on an amplitude of at least one peak among a plurality of peaks of the first residual vibration.

[0218] With Aspect 2, the ejection stability of the liquid from the nozzle can be appropriately and easily evaluated, without specifying a cycle and a phase of the first residual vibration.

[0219] In the liquid ejecting apparatus according to Aspect 3 that is a specific example of Aspect 2, in the first evaluation, when an amplitude of a first peak, which is first among the plurality of peaks of the first residual vibration, is more than a first threshold value, the control portion determines that the ejection of the liquid from the nozzle is unstable.

[0220] With Aspect 3 as well, the ejection stability of the liquid from the nozzle can be appropriately and easily evaluated.

[0221] In the liquid ejecting apparatus according to Aspect 4 that is a specific example of Aspect 3, in the first evaluation, when an amplitude of a second peak, which is second among the plurality of peaks of the first residual vibration, is more than a second threshold value, the control portion determines that the ejection of the liquid from the nozzle is unstable.

[0222] With Aspect 4, since the ejection stability is evaluated based on the plurality of peaks of the first residual vibration, the ejection stability can be evaluated with high accuracy.

[0223] In the liquid ejecting apparatus according to Aspect 5 that is a specific example of Aspect 4, in the first evaluation, when the amplitude of the first peak is equal to or less than the first threshold value and the amplitude of the second peak is equal to or less than the second threshold value, the control portion determines that the ejection of the liquid from the nozzle is stable.

[0224] With Aspect 5 as well, the ejection stability can be evaluated with high accuracy.

[0225] In the liquid ejecting apparatus according to Aspect 6 that is a specific example of any one of Aspects 3 to 5, the control portion causes the detection portion to detect the residual vibration caused by executing the ejection driving only one time as second residual vibration, and uses a value based on an amplitude of a third peak, which is first among a plurality of peaks of the second residual vibration, as the first threshold value.

[0226] With Aspect 6, the ejection stability can be accurately evaluated, in accordance with a use condition of the liquid ejecting head.

[0227] In the liquid ejecting apparatus according to Aspect 7 that is a specific example of Aspect 4 or 5, the control portion causes the detection portion to detect the residual vibration caused by executing the ejection driving only one time as second residual vibration, uses a value obtained by multiplying an amplitude of a third peak, which is first among a plurality of peaks of the second residual vibration, by a first coefficient, as the first threshold value, and uses a value obtained by multiplying an amplitude of a fourth peak, which is second among the plurality of peaks of the second residual vibration, by a second coefficient less than the first coefficient, as the second threshold value.

[0228] With Aspect 7 as well, the ejection stability can be accurately evaluated, in accordance with the use condition of the liquid ejecting head. Further, with Aspect 7, the ejection stability can be evaluated with higher accuracy, as compared with a case where the ejection stability is evaluated based on only the amplitude of the first peak, which is first of the first residual vibration.

[0229] In the liquid ejecting apparatus according to Aspect 8 that is a specific example of any one of Aspects 1 to 7, the control portion causes the detection portion to detect the residual vibration caused by executing the ejection driving only one time as second residual vibration, and further executes second evaluation for evaluating an ejection state of the nozzle based on the second residual vibration detected by the detection portion.

[0230] With Aspect 8, the ejection state of the nozzle can be appropriately and easily evaluated by using the second residual vibration.

[0231] In the liquid ejecting apparatus according to Aspect 9 that is a specific example of any one of Aspects 1 to 8, the control portion executes the first evaluation for each of a plurality of drive signal candidates having different waveforms for ejecting the liquid from the nozzle, by using one drive signal candidate among the plurality of drive signal candidates as the drive signal, and specifies a drive signal candidate with which the ejection of the liquid from the nozzle is stable and a drive signal candidate with which the ejection of the liquid from the nozzle is unstable, from the plurality of drive signal candidates.

[0232] With Aspect 9, the waveform of the drive signal for driving the piezoelectric element can be appropriately and easily determined by determining the waveform of the drive signal candidate with which the ejection of the liquid from the nozzle is stable as the waveform of the drive signal.

[0233] In the liquid ejecting apparatus according to Aspect 10 that is a specific example of any one of Aspects 1 to 9, in the first evaluation, the control portion causes the detection portion to detect the residual vibration caused by continuously executing the ejection driving 10 times or more as the first residual vibration.

[0234] With Aspect 10 as well, the ejection stability of the liquid from the nozzle can be appropriately and easily evaluated.

[0235] According to Aspect 11 that is another preferred aspect, there is provided a liquid ejecting apparatus including: a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element; and a control portion, in which the control portion causes the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration, and determines a waveform of the drive signal based on the first residual vibration detected by the detection portion.

[0236] With Aspect 11, the waveform of the drive signal for driving the piezoelectric element can be appropriately and easily determined.

[0237] According to Aspect 12 that is still another preferred aspect, there is provided a control method for a liquid ejecting apparatus including a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element, the method including: causing the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration; and evaluating an ejection stability of the liquid from the nozzle based on the first residual vibration detected by the detection portion.

[0238] With Aspect 12, the ejection stability of the liquid from the nozzle can be

[0239] appropriately and easily evaluated, without requiring an external element such as an imaging environment.

[0240] According to Aspect 13 that is still another preferred aspect, there is provided a control method for a liquid ejecting apparatus including a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element, the method including: causing the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration; and determining a waveform of the drive signal based on the first residual vibration detected by the detection portion.

[0241] With Aspect 13, the waveform of the drive signal for driving the piezoelectric element can be appropriately and easily determined.

What is claimed is:

1. A liquid ejecting apparatus comprising:

a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element; and

a control portion that executes first evaluation for evaluating an ejection stability of the liquid from the nozzle, wherein

in the first evaluation, the control portion causes the detection portion to detect the residual vibration caused by continuously executing ejection driving of driving the piezoelectric element with a drive signal for ejecting the liquid from the nozzle as first residual vibration, and evaluates the ejection stability of the liquid from the nozzle based on the first residual vibration detected by the detection portion.

2. The liquid ejecting apparatus according to claim **1**, wherein

in the first evaluation, the control portion evaluates the ejection stability of the liquid from the nozzle based on an amplitude of at least one peak among a plurality of peaks of the first residual vibration.

3. The liquid ejecting apparatus according to claim **2**, wherein

in the first evaluation, when an amplitude of a first peak, which is first among the plurality of peaks of the first residual vibration, is more than a first threshold value, the control portion determines that the ejection of the liquid from the nozzle is unstable.

4. The liquid ejecting apparatus according to claim **3**, wherein

in the first evaluation, when an amplitude of a second peak, which is second among the plurality of peaks of the first residual vibration, is more than a second threshold value, the control portion determines that the ejection of the liquid from the nozzle is unstable.

5. The liquid ejecting apparatus according to claim **4**, wherein

in the first evaluation, when the amplitude of the first peak is equal to or less than the first threshold value and the amplitude of the second peak is equal to or less than the second threshold value, the control portion determines that the ejection of the liquid from the nozzle is stable.

6. The liquid ejecting apparatus according to claim **3**, wherein

the control portion

causes the detection portion to detect the residual vibration caused by executing the ejection driving only one time as second residual vibration, and

uses a value based on an amplitude of a third peak, which is first among a plurality of peaks of the second residual vibration, as the first threshold value.

7. The liquid ejecting apparatus according to claim **4**, wherein

the control portion

causes the detection portion to detect the residual vibration caused by executing the ejection driving only one time as second residual vibration,

uses a value obtained by multiplying an amplitude of a third peak, which is first among a plurality of peaks of the second residual vibration, by a first coefficient, as the first threshold value, and

uses a value obtained by multiplying an amplitude of a fourth peak, which is second among the plurality of peaks of the second residual vibration, by a second coefficient less than the first coefficient, as the second threshold value.

8. The liquid ejecting apparatus according to claim **1**, wherein

the control portion causes the detection portion to detect the residual vibration caused by executing the ejection driving only one time as second residual vibration, and further executes second evaluation for evaluating an ejection state of the nozzle based on the second residual vibration detected by the detection portion.

9. The liquid ejecting apparatus according to claim **1**, wherein

the control portion

executes the first evaluation for each of a plurality of drive signal candidates having different waveforms for ejecting the liquid from the nozzle, by using one drive signal candidate among the plurality of drive signal candidates as the drive signal, and specifies a drive signal candidate with which the ejection of the liquid from the nozzle is stable and a drive signal candidate with which the ejection of the liquid from the nozzle is unstable, from the plurality of drive signal candidates.

10. The liquid ejecting apparatus according to claim **1**, wherein

in the first evaluation, the control portion causes the detection portion to detect the residual vibration caused by continuously executing the ejection driving **10** times or more as the first residual vibration.

11. A liquid ejecting apparatus comprising:

a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element; and

a control portion, wherein

the control portion

causes the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration, and

determines a waveform of the drive signal based on the first residual vibration detected by the detection portion.

12. A control method for a liquid ejecting apparatus including a liquid ejecting head that includes a nozzle which ejects a liquid, a piezoelectric element which corresponds to the nozzle, a diaphragm which vibrates by driving the piezoelectric element, and a detection portion which detects residual vibration of the diaphragm caused by driving the piezoelectric element, the method comprising:

causing the detection portion to detect the residual vibration caused by repeating ejection driving of driving the piezoelectric element a plurality of times with a drive signal for ejecting the liquid from the nozzle as first residual vibration; and

evaluating an ejection stability of the liquid from the nozzle based on the first residual vibration detected by the detection portion.

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