US011472176B2

(12) **United States Patent**
Matsumoto

(10) **Patent No.: US 11,472,176 B2**
(45) **Date of Patent: Oct. 18, 2022**

(54) **LIQUID DISCHARGE APPARATUS AND HEAD UNIT**

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(72) Inventor: **Yusuke Matsumoto**, Nagano (JP)

(73) Assignee: **Seiko Epson Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Dec. 23, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 25, 2019 (JP) JP2019-235062

(51) **Int. Cl.**
B41J 2/045 (2006.01)

(52) **U.S. Cl.**
CPC ***B41J 2/0451*** (2013.01); ***B41J 2/04541*** (2013.01); ***B41J 2/04581*** (2013.01)

(58) **Field of Classification Search**
CPC B41J 2/1433; B41J 2/14209; B41J 2002/14491
See application file for complete search history.

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2016/0167382 A1 6/2016 Date
2019/0009531 A1 1/2019 Furukawa

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* cited by examiner

Primary Examiner — Lam S Nguyen

(74) *Attorney, Agent, or Firm* — Global IP Counselors, LLP

(57) **ABSTRACT**

In a liquid discharge apparatus, a head unit includes a plurality of print heads, and a housing that houses the print heads, in which a first print head in the plurality of print heads includes a substrate that includes a first side, a second side, a first surface, and a second surface, a first nozzle plate, a first integrated circuit that is provided on the first surface, that outputs an abnormality signal indicating presence or absence of abnormality of the first print head, a first flexible wiring substrate that is electrically coupled to the substrate, and a second integrated circuit that is provided on the first flexible wiring substrate, the second integrated circuit is located between the first nozzle plate and the substrate, and the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

20 Claims, 36 Drawing Sheets

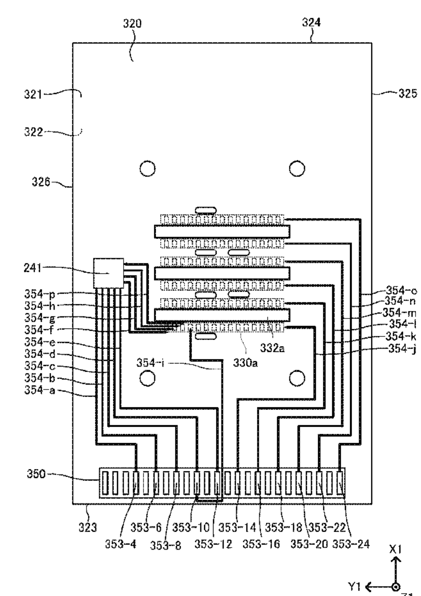
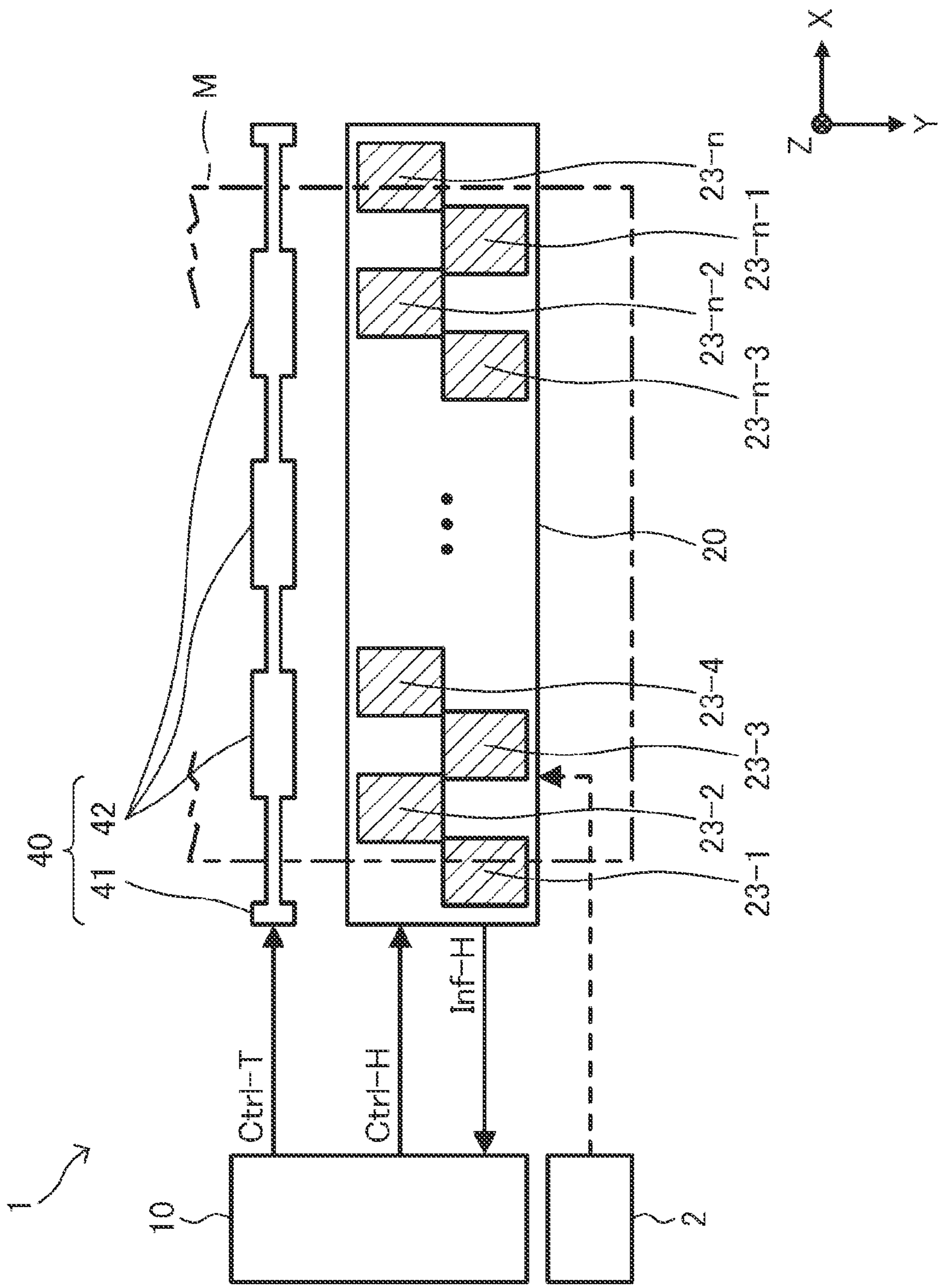
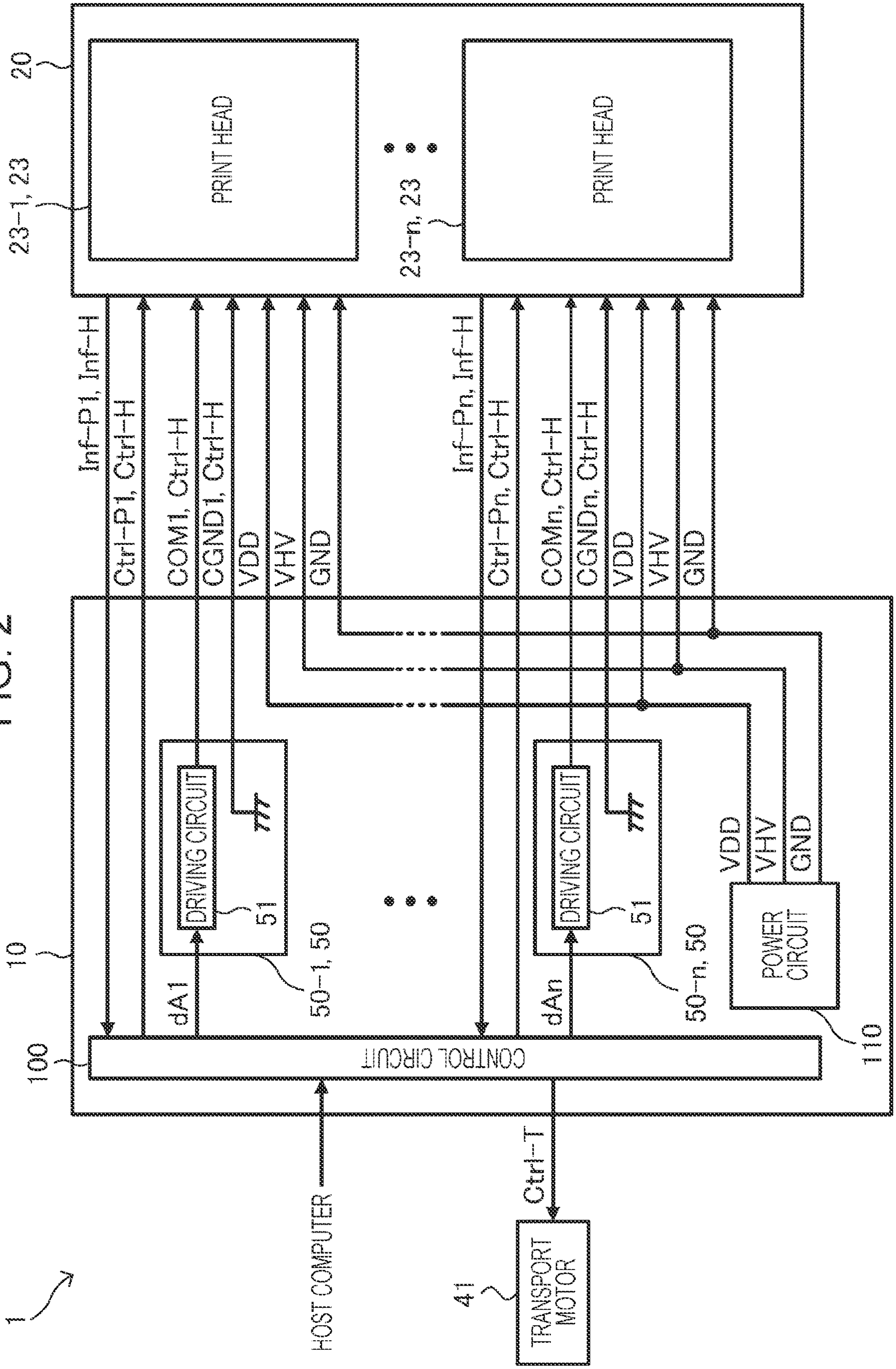


FIG. 1



1
10
2
Ctrl-T
Ctrl-H
Inf-H
40
41
42
M
20
23-1
23-2
23-3
23-4
23-n-3
23-n-2
23-n-1
23-n
X
Y
Z

FIG. 2



1
20
10
100
110
41
23−1, 23
23−n, 23
PRINT HEAD
PRINT HEAD
Inf−P1, Inf−H
Ctrl−P1, Ctrl−H
COM1, Ctrl−H
CGND1, Ctrl−H
VDD
VHV
GND
Inf−Pn, Inf−H
Ctrl−Pn, Ctrl−H
COMn, Ctrl−H
CGNDn, Ctrl−H
VDD
VHV
GND
DRIVING CIRCUIT
51
50−1, 50
dA1
DRIVING CIRCUIT
51
50−n, 50
dAn
VDD
VHV
GND
POWER CIRCUIT
CONTROL CIRCUIT
HOST COMPUTER
Ctrl−T
TRANSPORT MOTOR

FIG. 3A

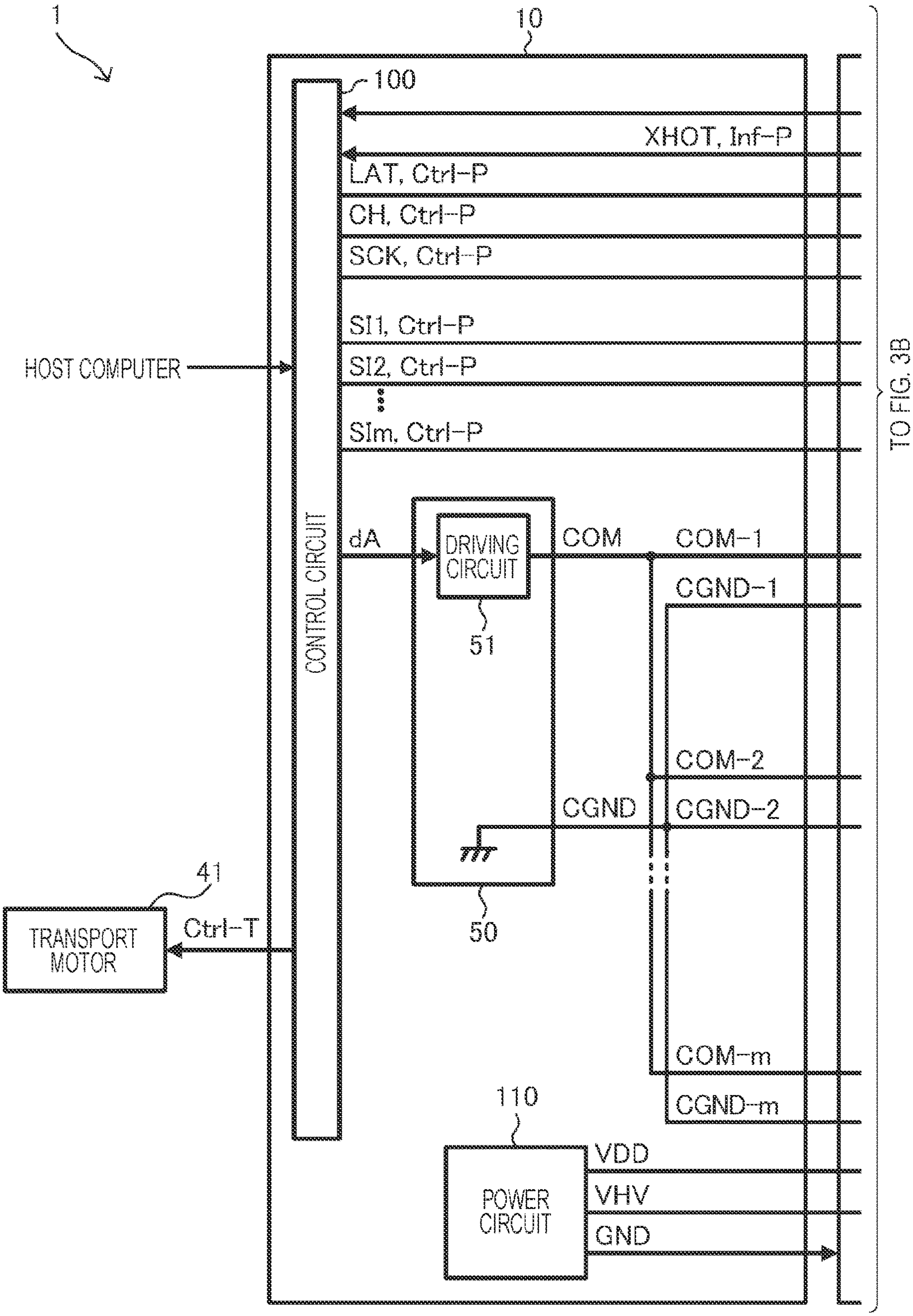

1
10
100
XHOT, Inf-P
LAT, Ctrl-P
CH, Ctrl-P
SCK, Ctrl-P
SI1, Ctrl-P
SI2, Ctrl-P
SIm, Ctrl-P
HOST COMPUTER
CONTROL CIRCUIT
dA
DRIVING CIRCUIT
51
COM
COM-1
CGND-1
COM-2
CGND
CGND-2
50
41
TRANSPORT MOTOR
Ctrl-T
COM-m
CGND-m
110
POWER CIRCUIT
VDD
VHV
GND
TO FIG. 3B

FIG. 3B

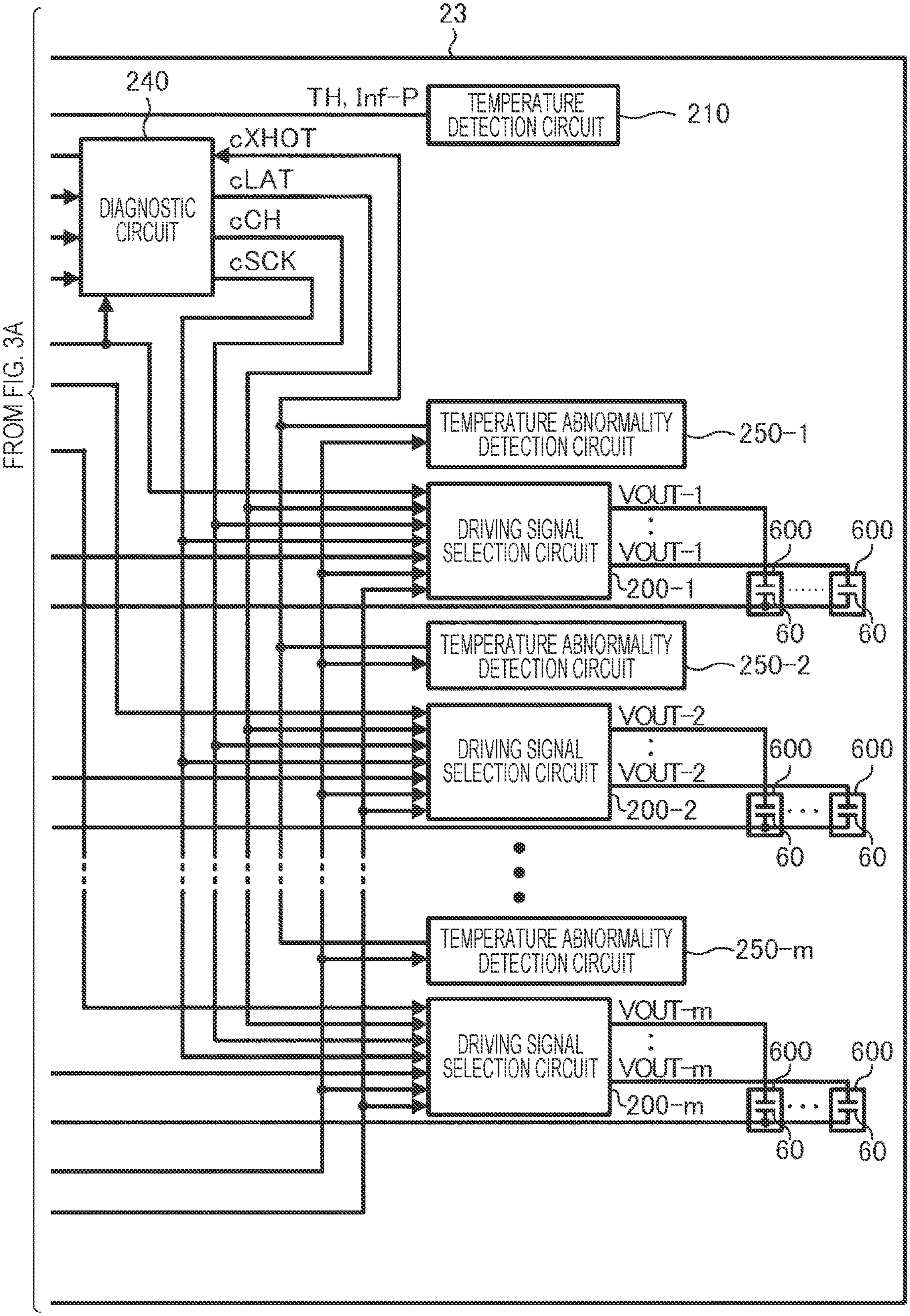

23
240
TH, Inf-P
TEMPERATURE DETECTION CIRCUIT
210
cXHOT
cLAT
cCH
cSCK
DIAGNOSTIC CIRCUIT
FROM FIG. 3A
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-1
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-1
VOUT-1
200-1
600
600
60
60
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-2
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-2
VOUT-2
200-2
600
600
60
60
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-m
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-m
VOUT-m
200-m
600
600
60
60

FIG. 4

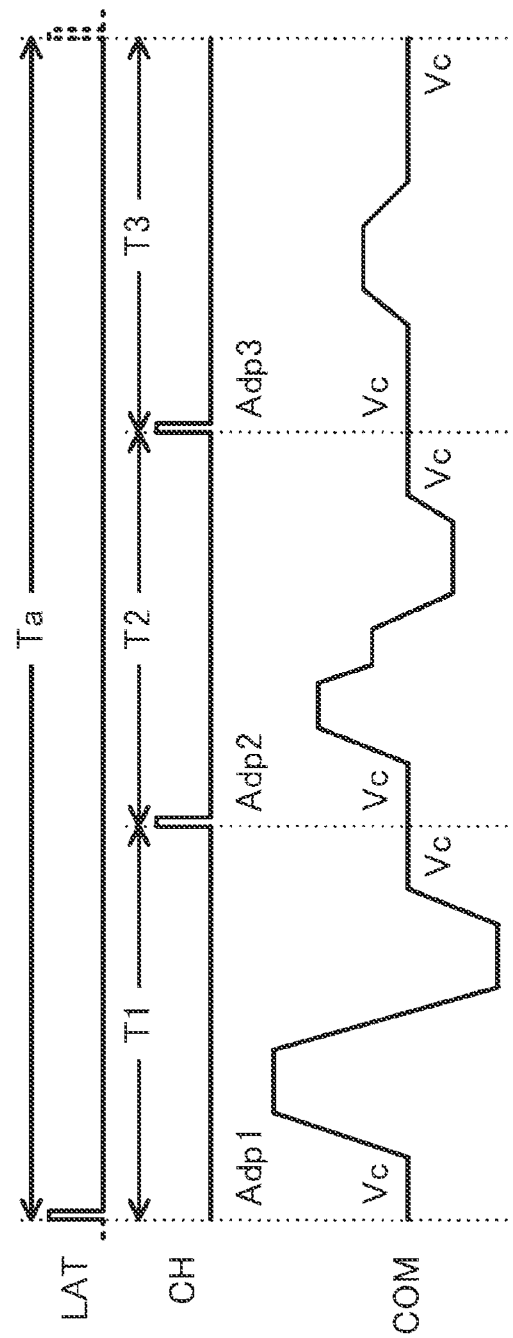
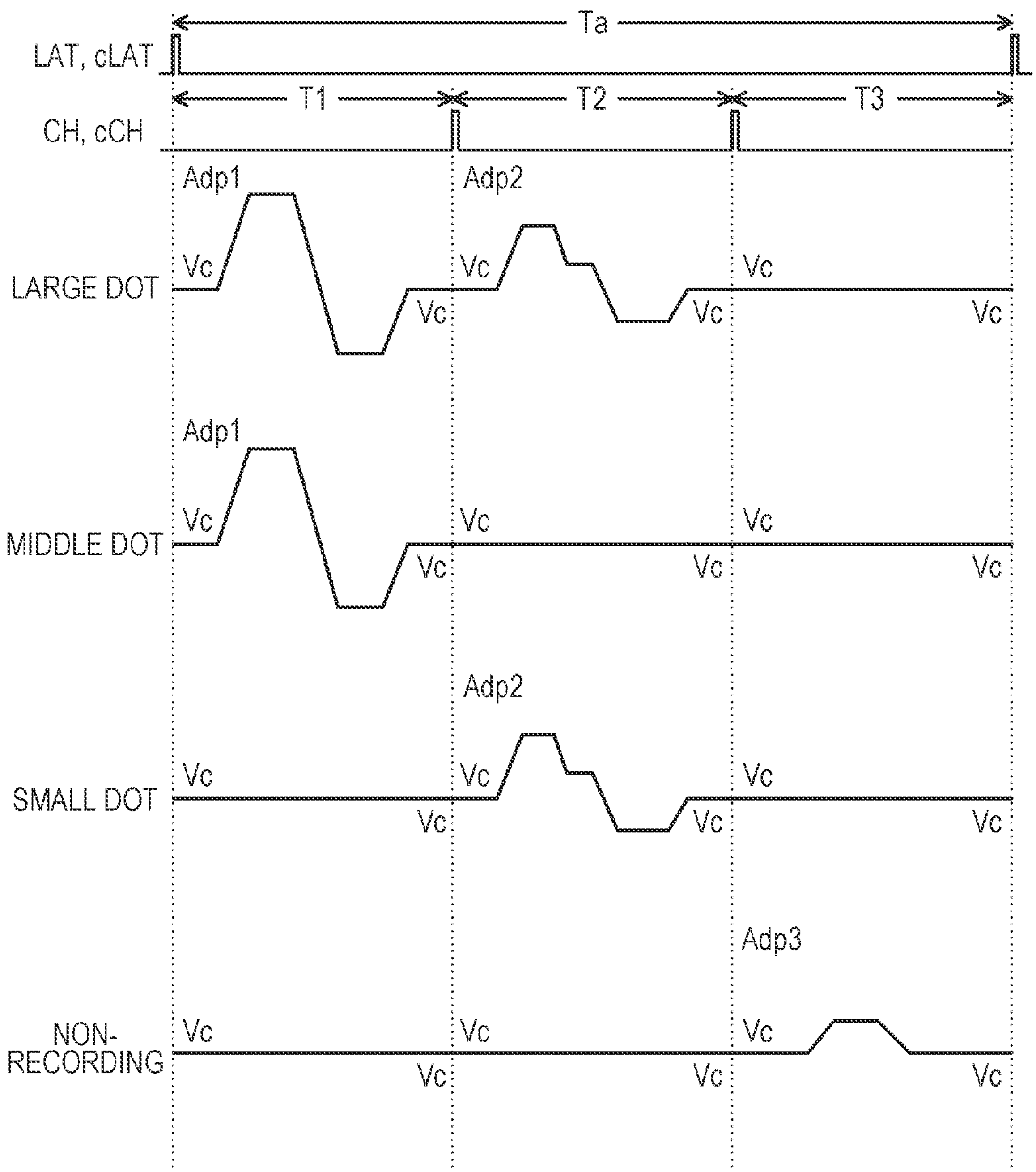
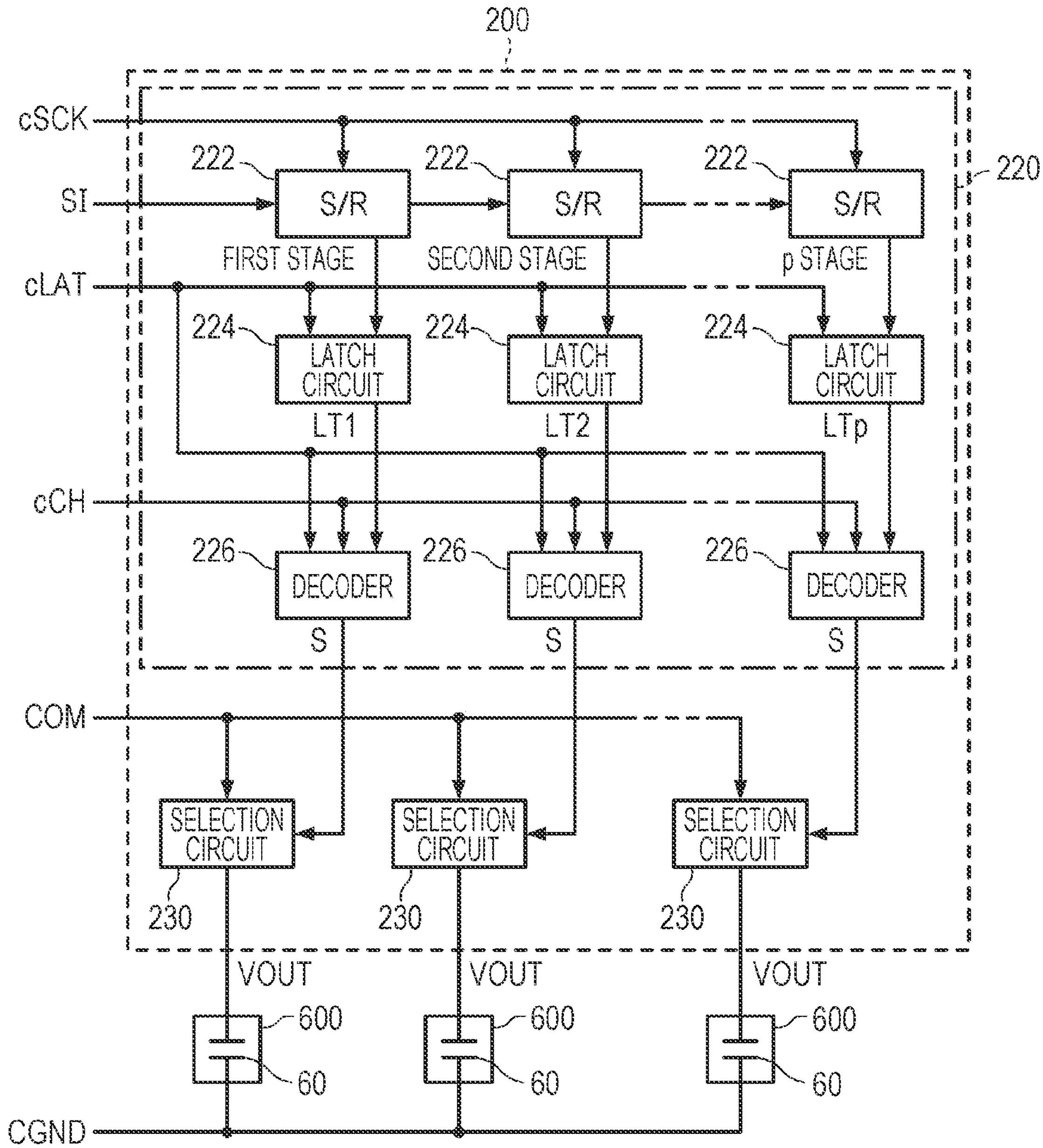


FIG. 5



Ta
LAT, cLAT
T1
T2
T3
CH, cCH
Adp1
Adp2
LARGE DOT
Vc
Adp1
MIDDLE DOT
Vc
Adp2
SMALL DOT
Vc
Adp3
NON-RECORDING
Vc

FIG. 6



200
220
cSCK
SI
cLAT
cCH
COM
CGND
222
S/R
FIRST STAGE
SECOND STAGE
p STAGE
224
LATCH CIRCUIT
LT1
LT2
LTp
226
DECODER
S
SELECTION CIRCUIT
230
VOUT
600
60

FIG. 7

[SIH, SIL]		[1, 1] LARGE DOT	[1, 0] MIDDLE DOT	[0, 1] SMALL DOT	[0, 0] NON-RECORDING
S	T1	H	H	L	L
	T2	H	L	H	L
	T3	L	L	L	H

FIG. 8

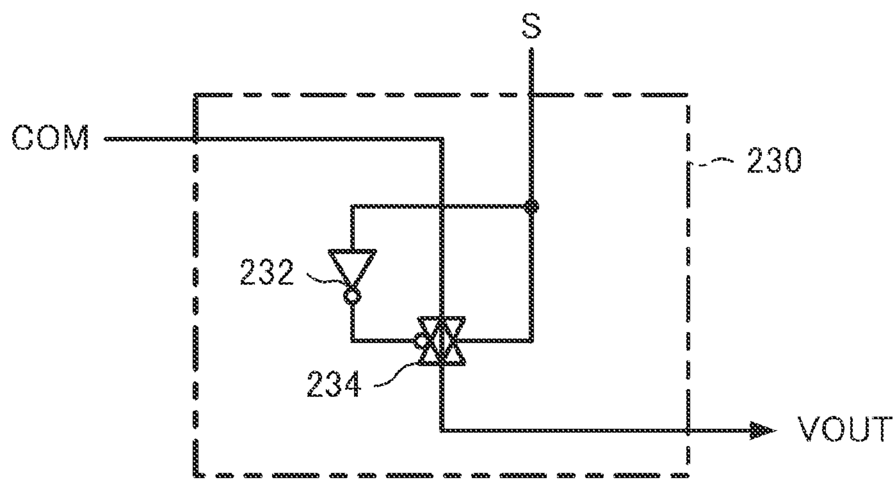


FIG. 9

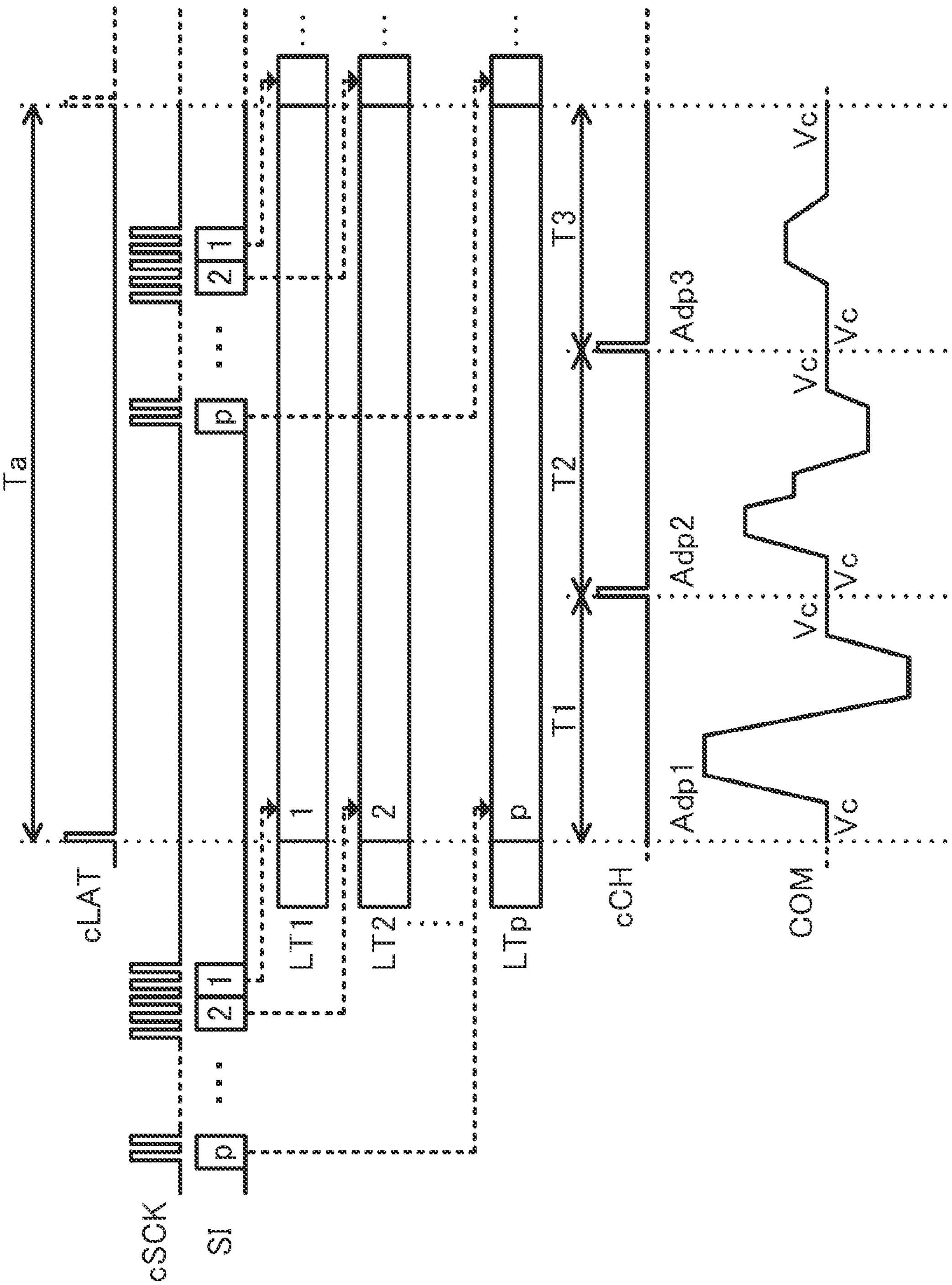

cSCK
SI
cLAT
Ta
p
2
1
LT1
LT2
LTp
cCH
COM
T1
T2
T3
Adp1
Adp2
Adp3
Vc

FIG. 10

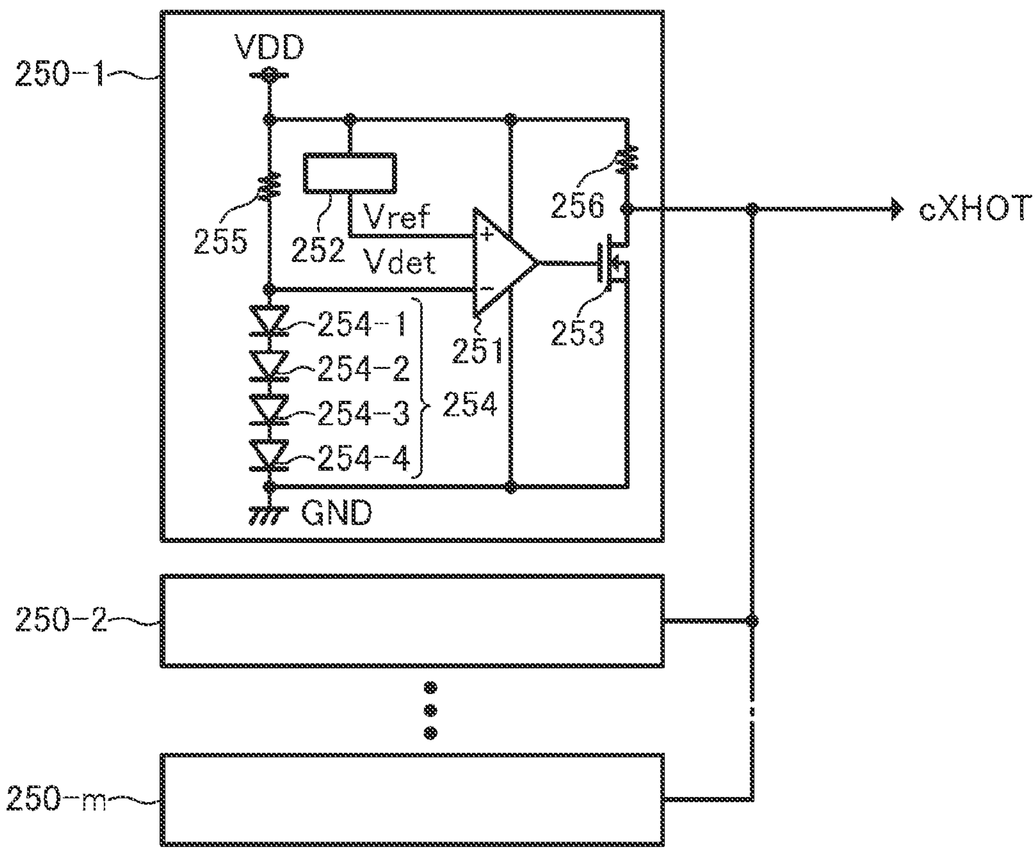

250-1
VDD
255
252
Vref
Vdet
256
cXHOT
251
253
254-1
254-2
254-3
254-4
254
GND
250-2
250-m

FIG. 11

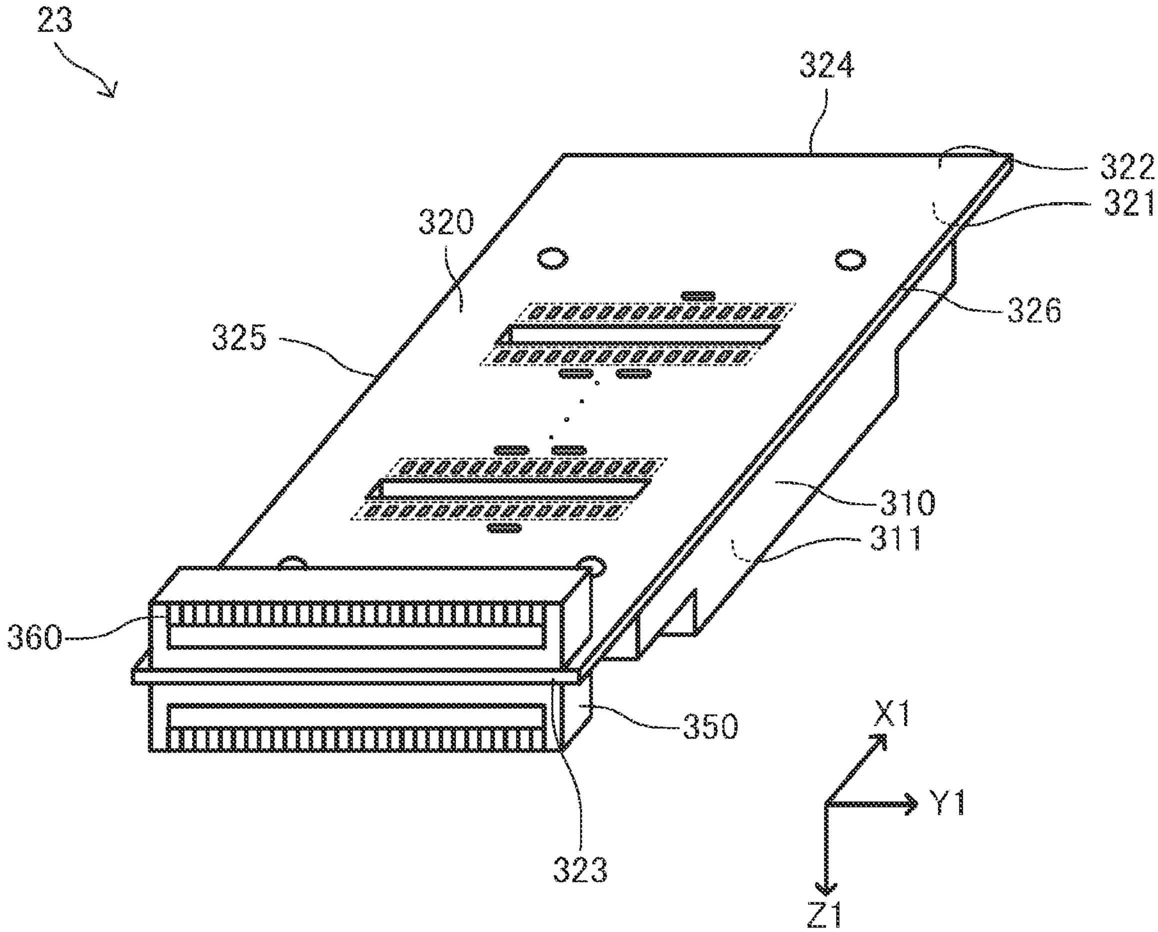


FIG. 12

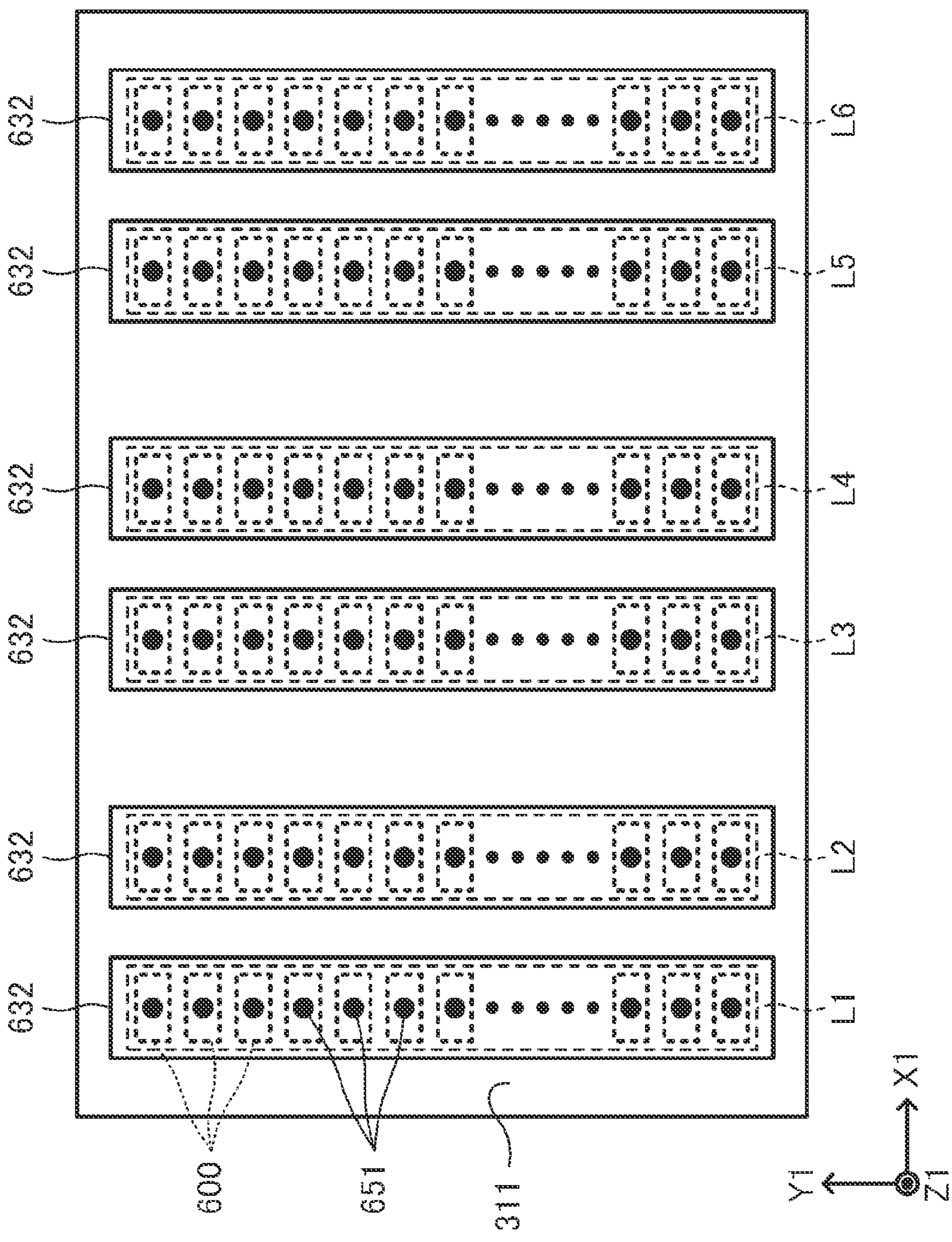


FIG. 13

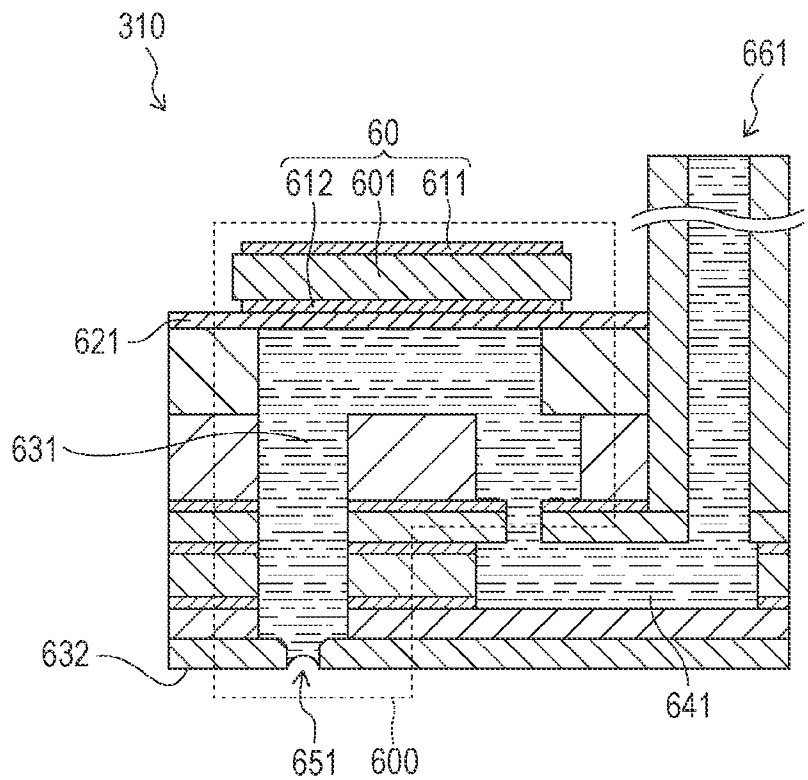


FIG. 14

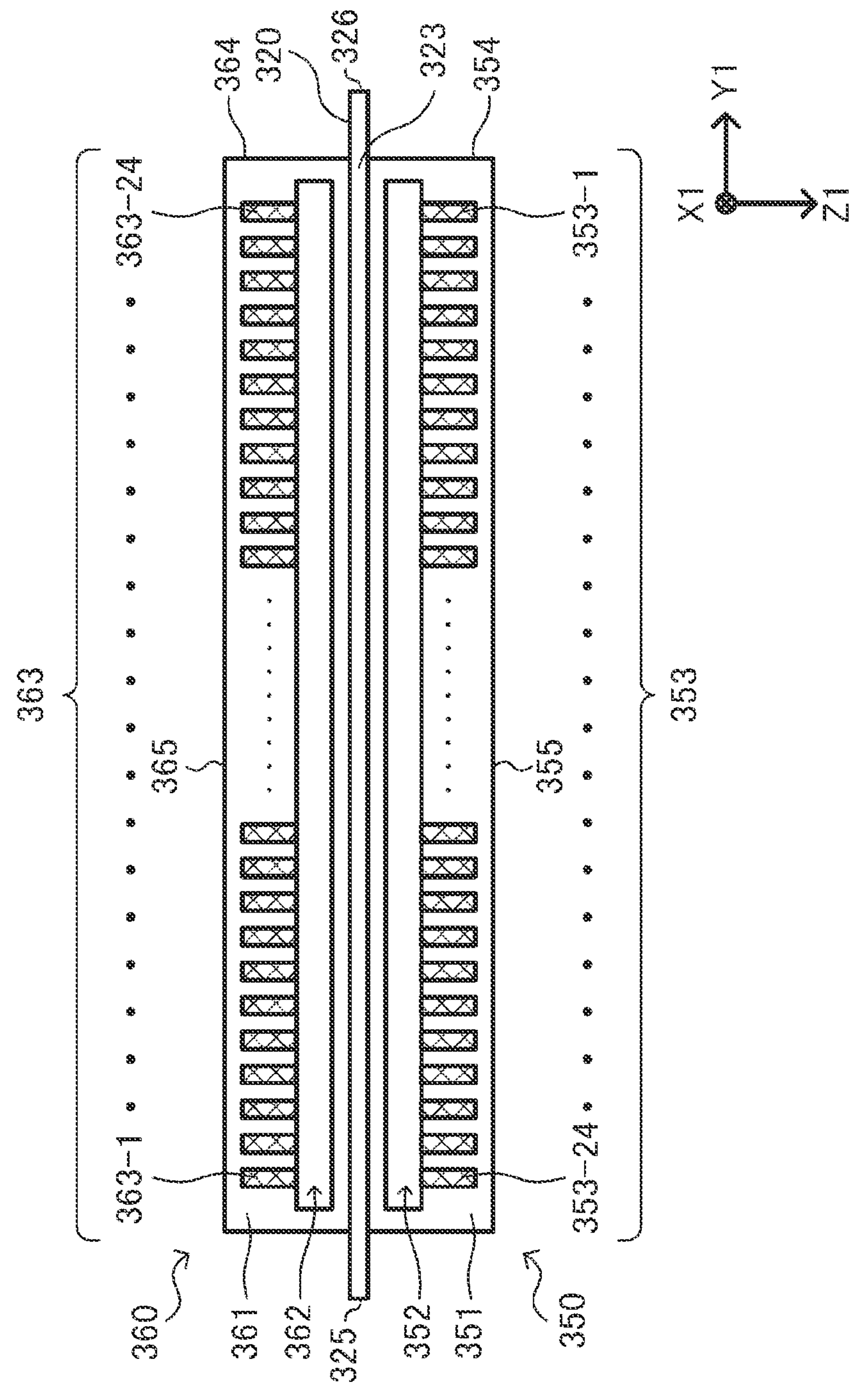

364
320
326
323
354
Y1
X1
Z1
363-24
353-1
363
353
365
355
363-1
353-24
360
361
362
325
352
351
350

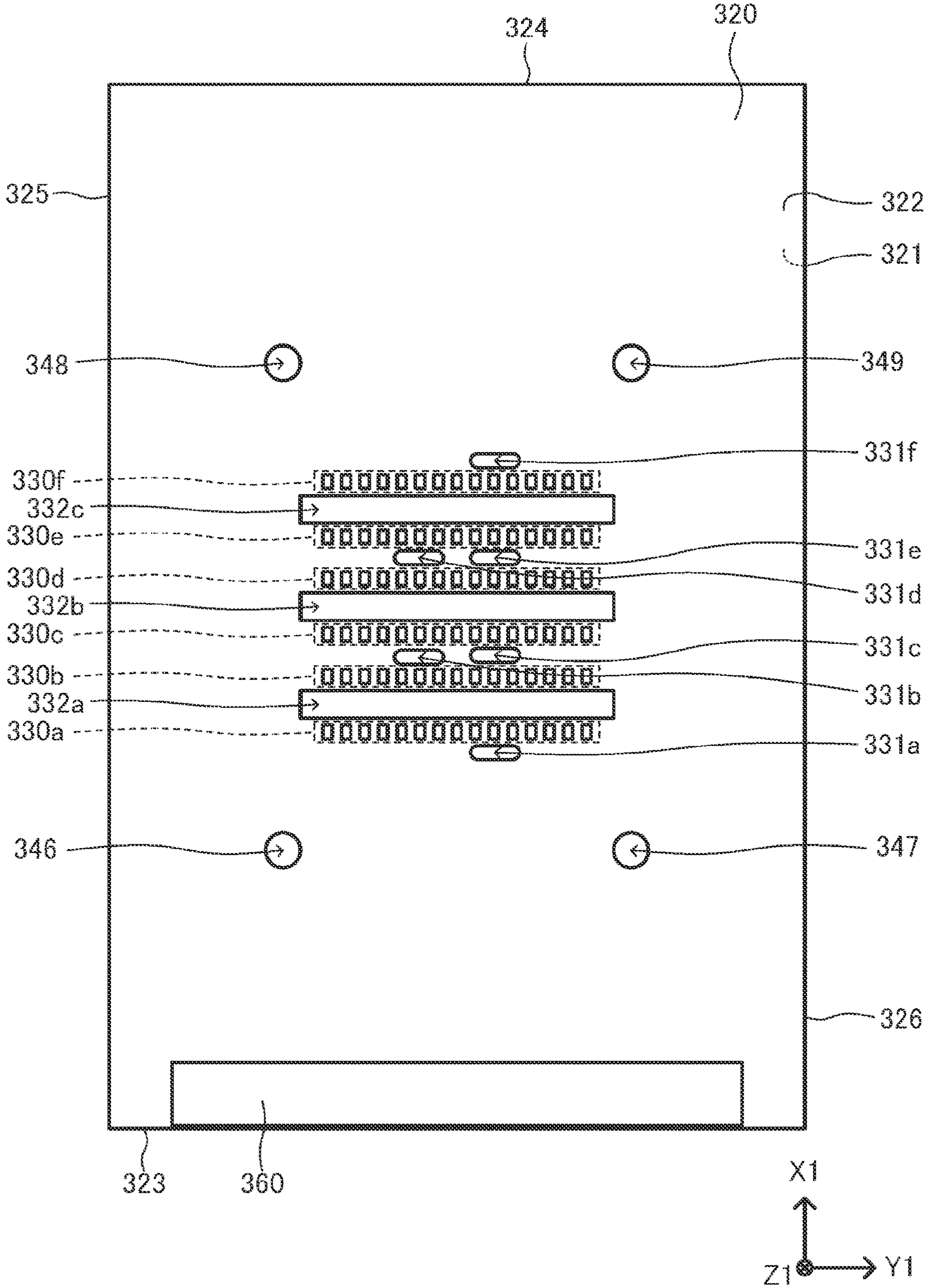
FIG. 15

TERMINAL NUMBER	INPUT SIGNAL
353-1	GND
353-2	TH
353-3	GND
353-4	LAT
353-5	GND
353-6	SCK
353-7	GND
353-8	CH
353-9	GND
353-10	SI1
353-11	GND
353-12	XHOT
353-13	CGND-1
353-14	COM-1
353-15	CGND-2
353-16	COM-2
353-17	CGND-3
353-18	COM-3
353-19	CGND-4
353-20	COM-4
353-21	CGND-5
353-22	COM-5
353-23	CGND-6
353-24	COM-6

FIG. 16

TERMINAL NUMBER	INPUT SIGNAL
363-1	CGND-6
363-2	COM-6
363-3	CGND-5
363-4	COM-5
363-5	CGND-4
363-6	COM-4
363-7	CGND-3
363-8	COM-3
363-9	CGND-2
363-10	COM-2
363-11	CGND-1
363-12	COM-1
363-13	GND
363-14	VHV
363-15	GND
363-16	SI6
363-17	GND
363-18	SI5
363-19	GND
363-20	SI4
363-21	GND
363-22	SI3
363-23	VDD
363-24	SI2

FIG. 17



324
320
325
322
321
348
349
331f
330f
332c
330e
331e
330d
331d
332b
330c
331c
330b
331b
332a
330a
331a
346
347
326
323
360
X1
Z1
Y1

FIG. 18

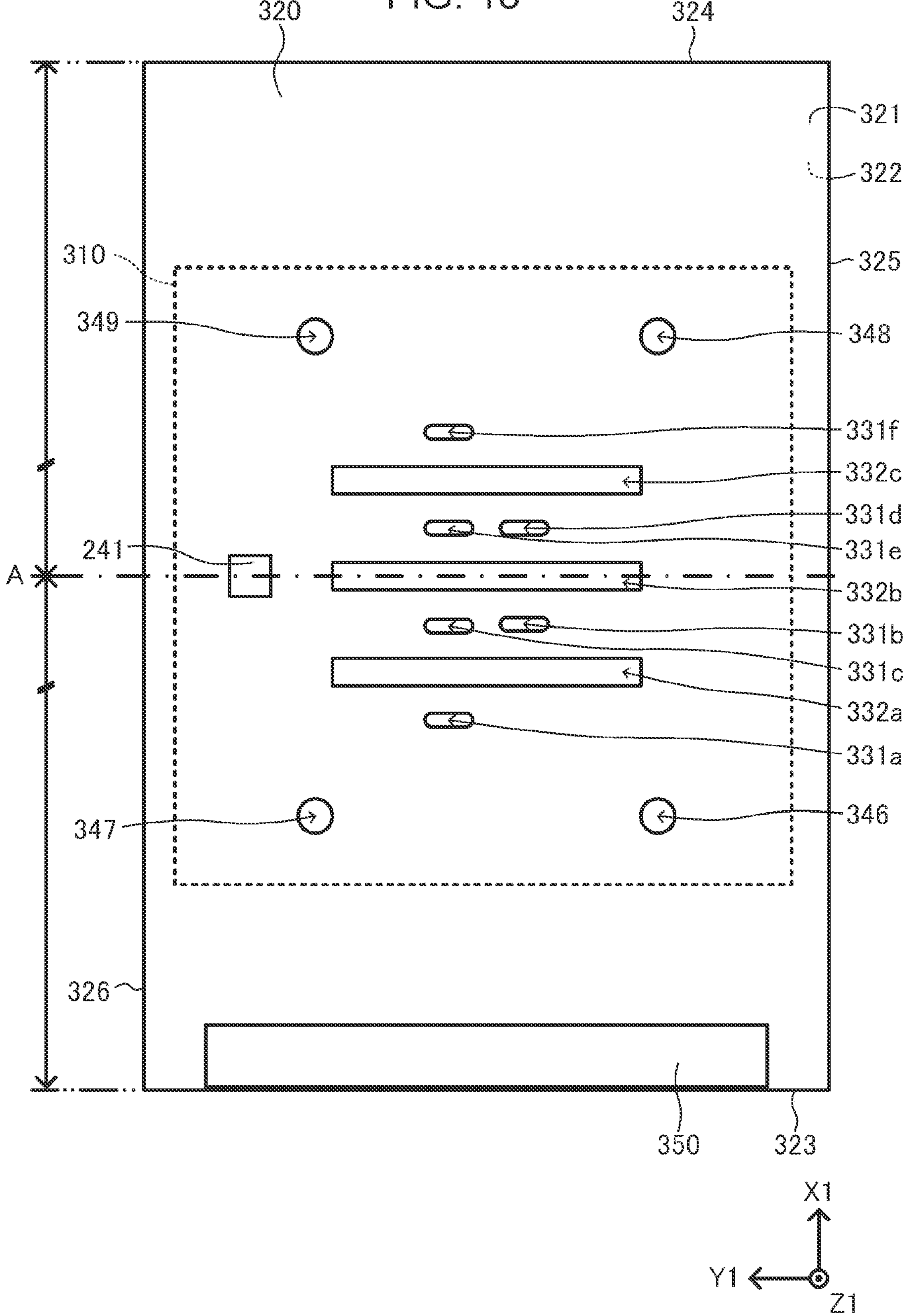
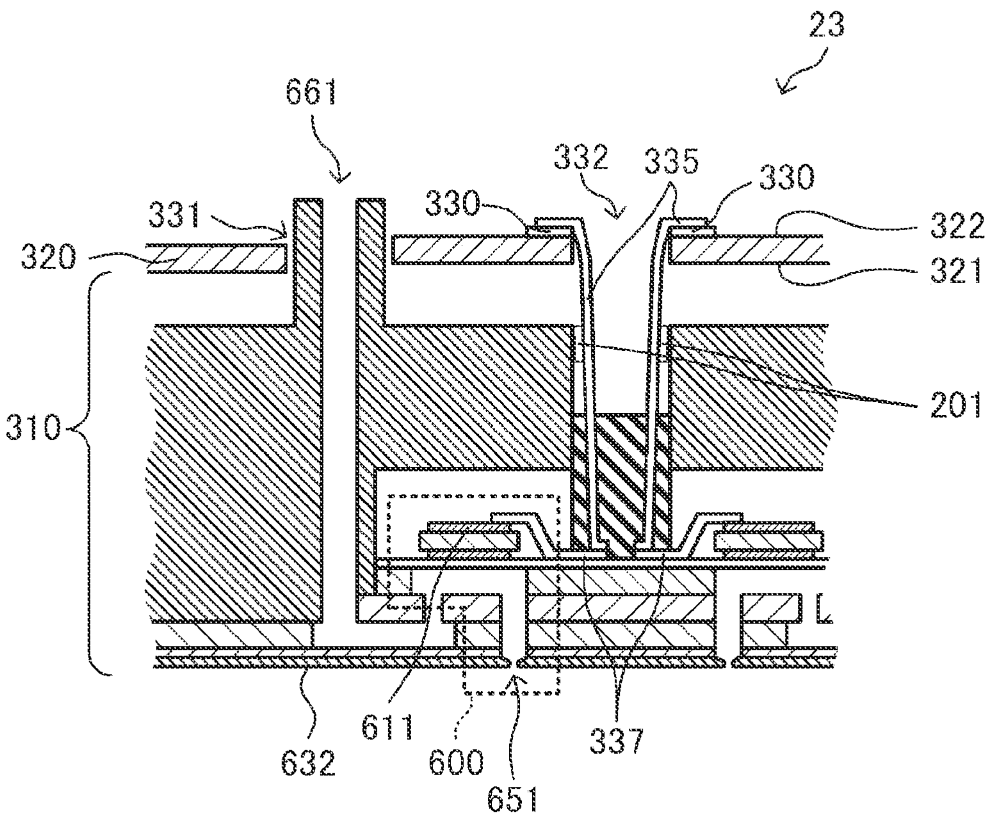
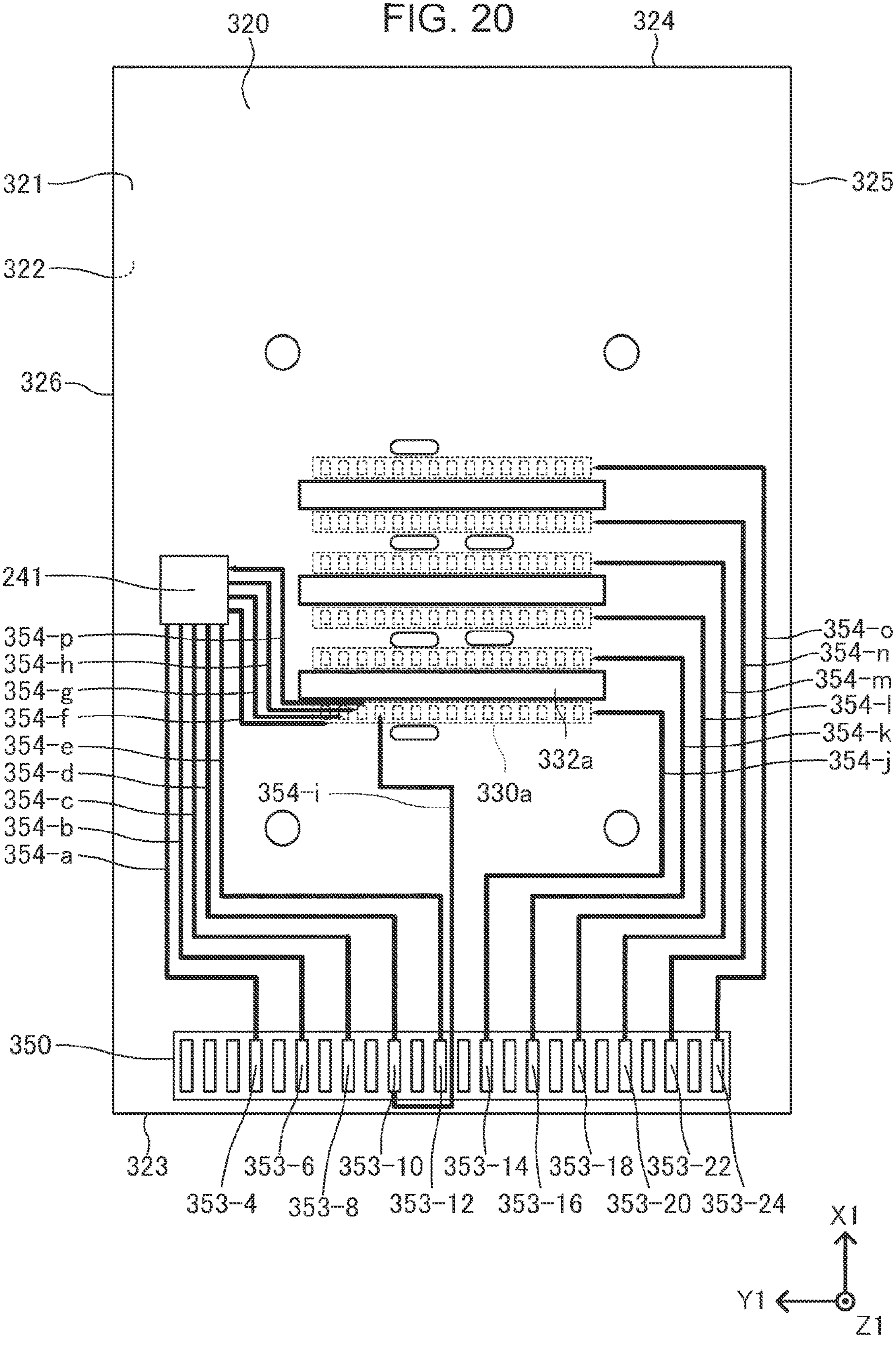

320
324
321
322
310
325
349
348
331f
332c
331d
241
331e
A
332b
331b
331c
332a
331a
347
346
326
350
323
X1
Y1
Z1

FIG. 19



23
661
332
335
330
330
331
322
320
321
310
201
611
632
600
651
337

FIG. 20



320
324
321
325
322
326
241
354-p
354-h
354-g
354-f
354-e
354-d
354-c
354-b
354-a
354-o
354-n
354-m
354-l
354-k
354-j
354-i
332a
330a
350
323
353-4
353-6
353-8
353-10
353-12
353-14
353-16
353-18
353-20
353-22
353-24
X1
Y1
Z1

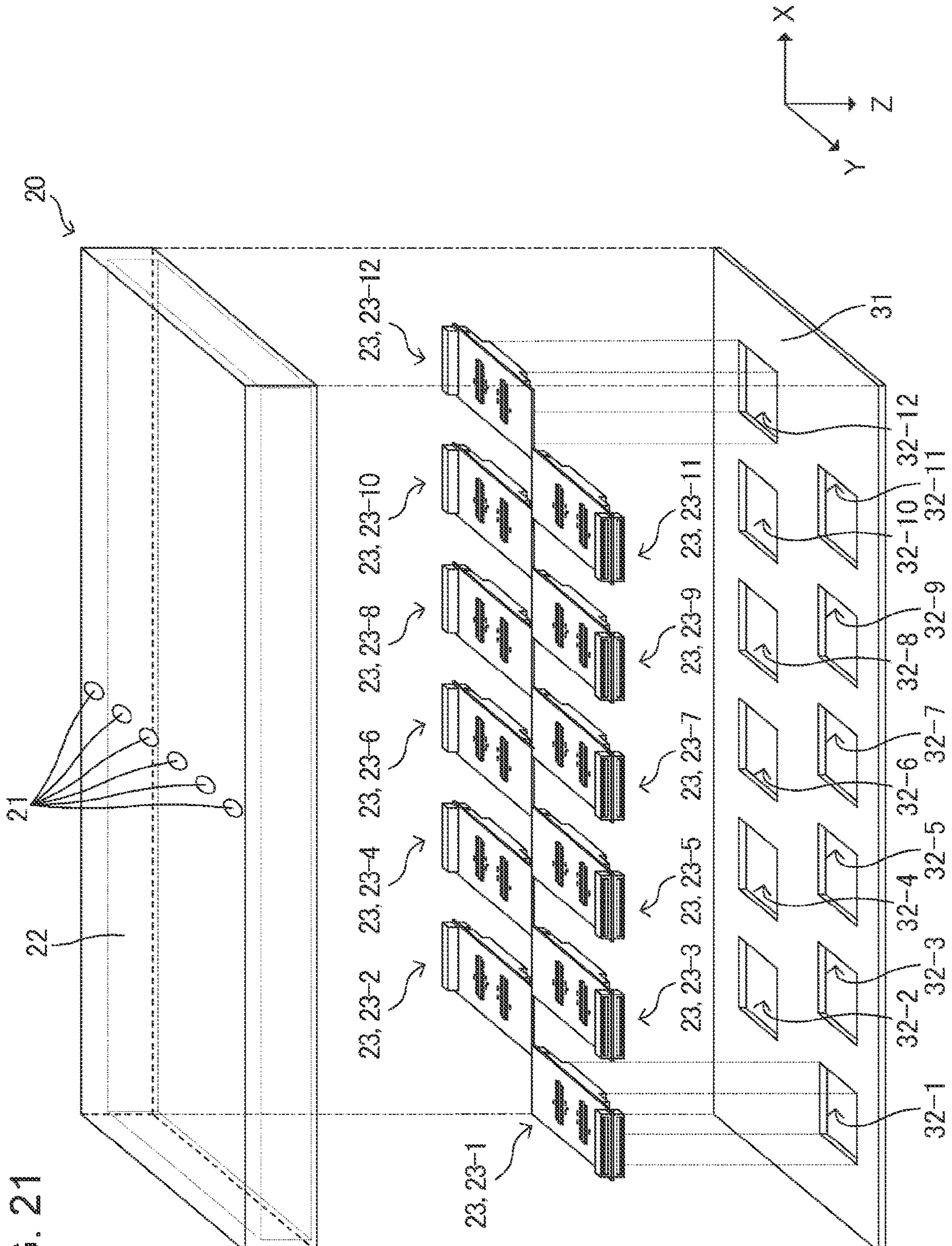

X
Z
Y
20
21
22
31
23, 23-1
23, 23-2
23, 23-3
23, 23-4
23, 23-5
23, 23-6
23, 23-7
23, 23-8
23, 23-9
23, 23-10
23, 23-11
23, 23-12
32-1
32-2
32-3
32-4
32-5
32-6
32-7
32-8
32-9
32-10
32-11
32-12

FIG. 21

FIG. 22

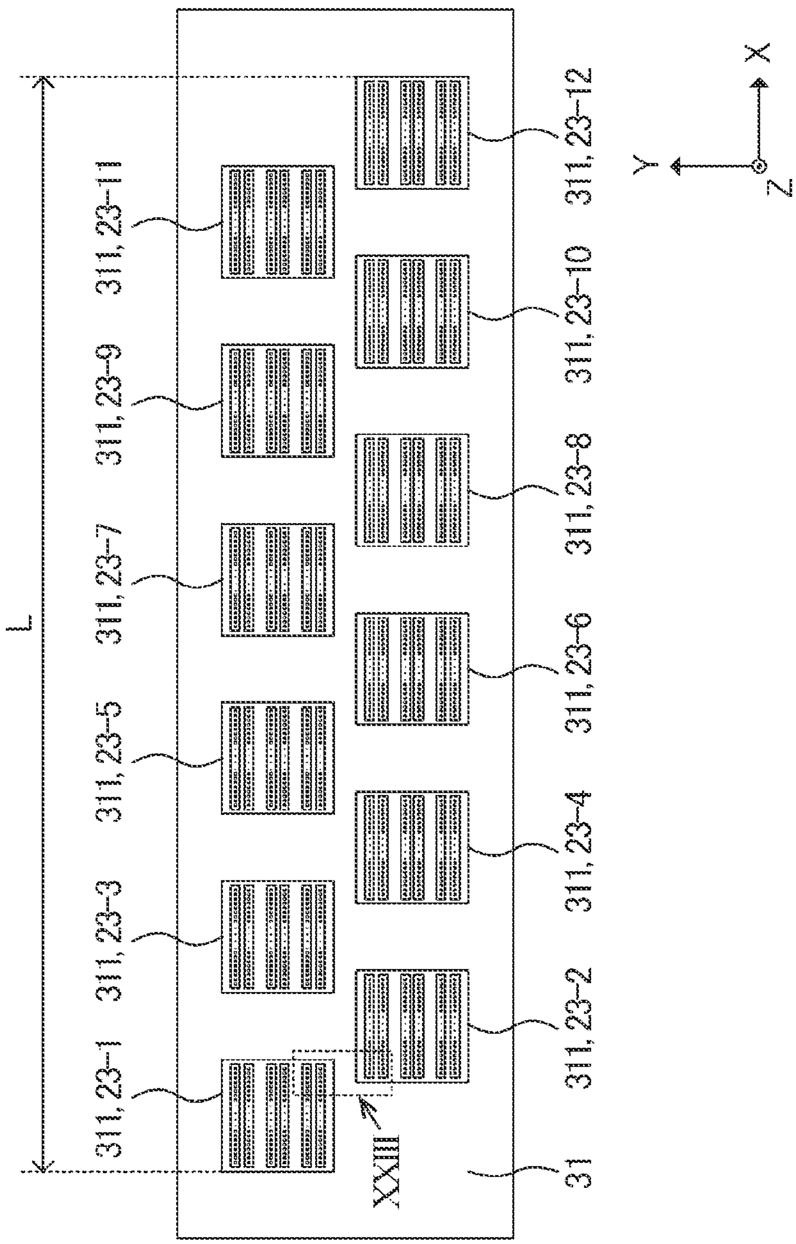
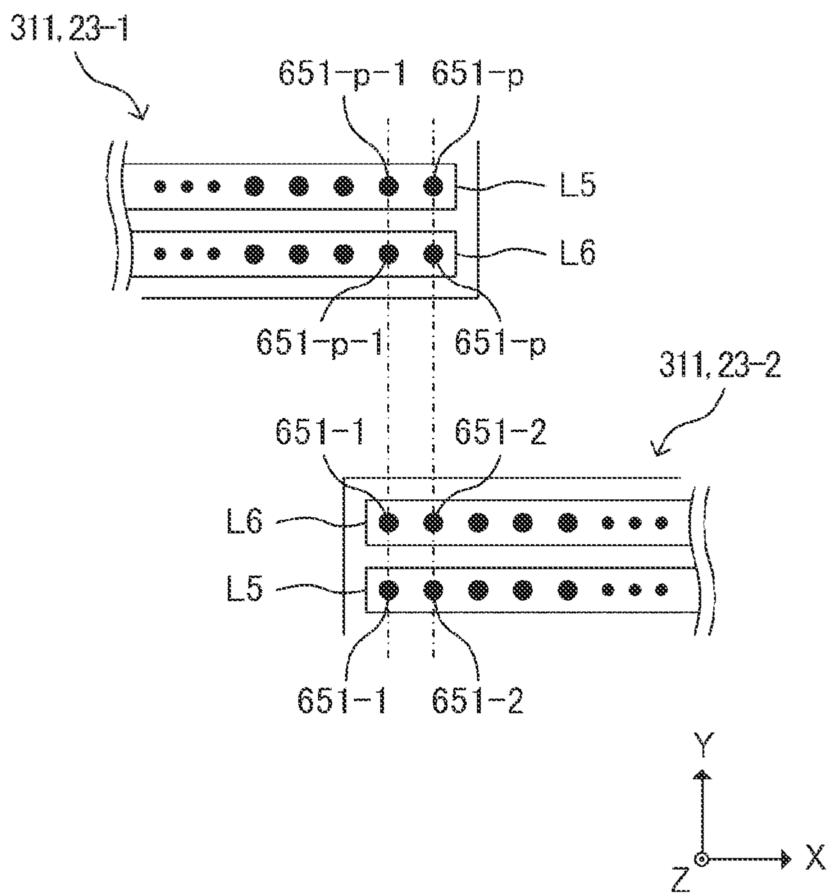
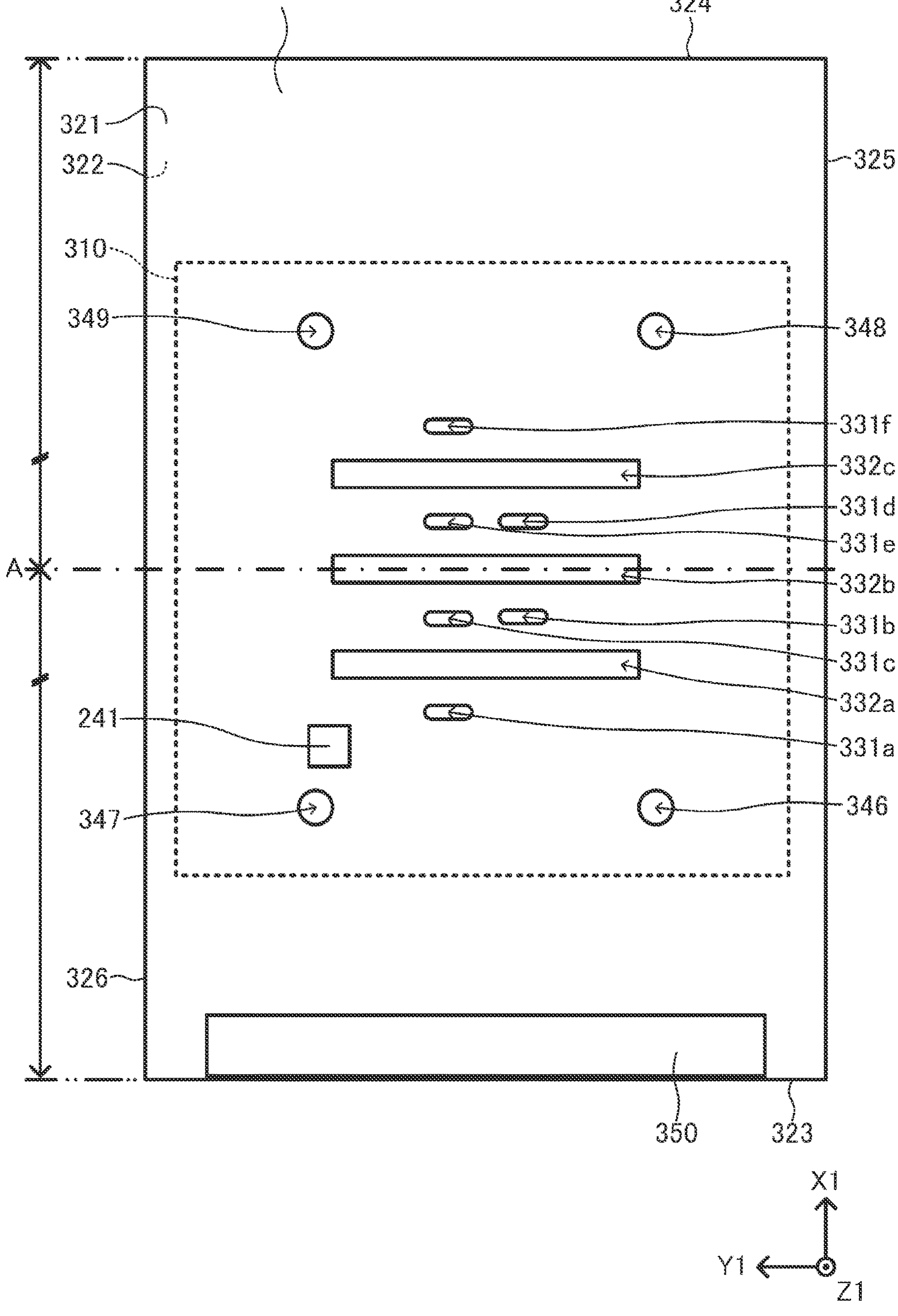

L
311, 23-1
311, 23-2
311, 23-3
311, 23-4
311, 23-5
311, 23-6
311, 23-7
311, 23-8
311, 23-9
311, 23-10
311, 23-11
311, 23-12
31
XXIII
X
Y
Z

FIG. 23



311, 23-1
651-p-1
651-p
L5
L6
651-p-1
651-p
311, 23-2
651-1
651-2
L6
L5
651-1
651-2
Y
X
Z

FIG. 24



320
324
321
322
325
310
349
348
331f
332c
331d
331e
A
332b
331b
331c
332a
241
331a
347
346
326
350
323
X1
Y1
Z1

FIG. 25A

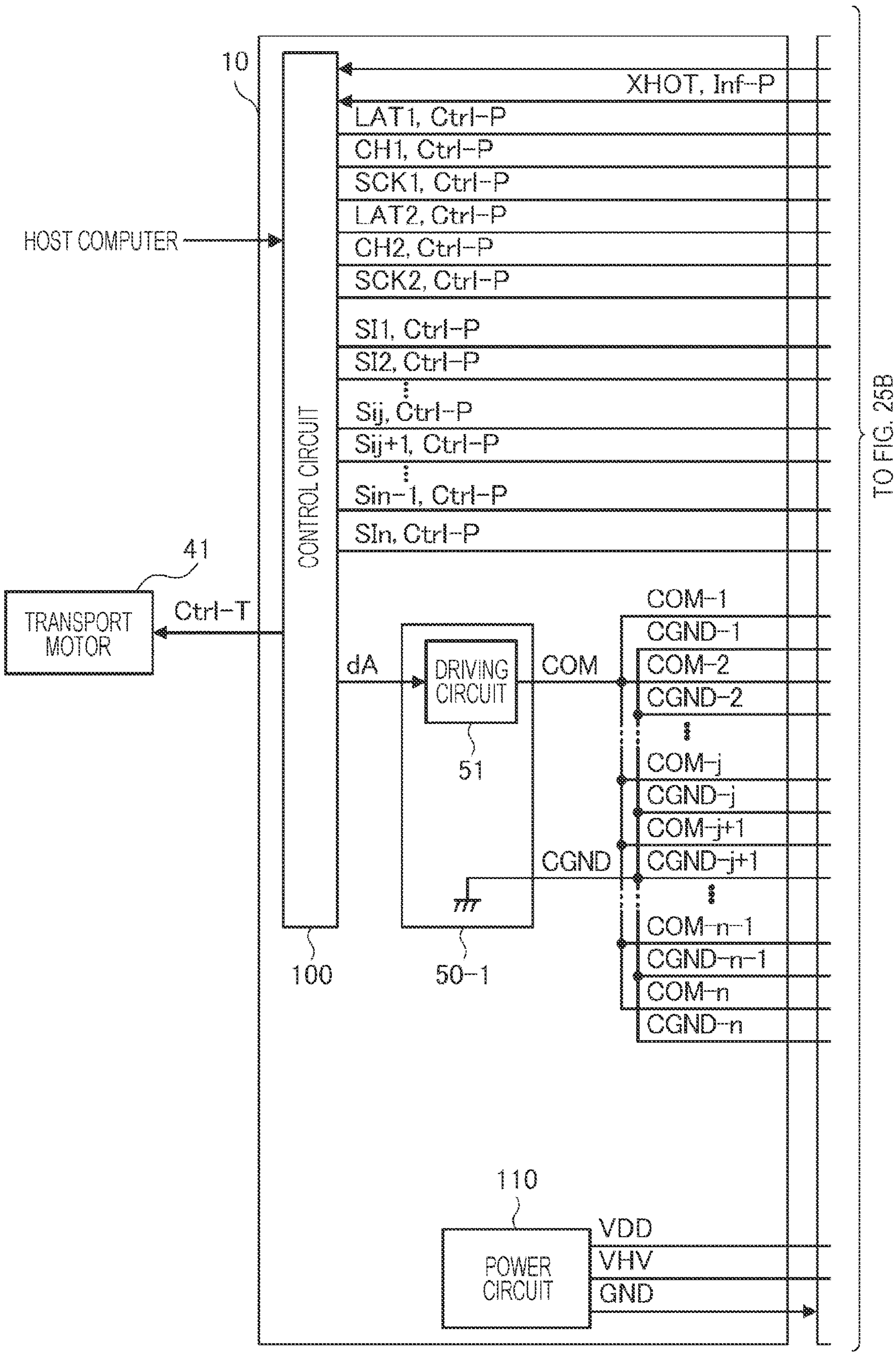

10
XHOT, Inf-P
LAT1, Ctrl-P
CH1, Ctrl-P
SCK1, Ctrl-P
LAT2, Ctrl-P
CH2, Ctrl-P
SCK2, Ctrl-P
SI1, Ctrl-P
SI2, Ctrl-P
Sij, Ctrl-P
Sij+1, Ctrl-P
Sin-1, Ctrl-P
SIn, Ctrl-P
HOST COMPUTER
CONTROL CIRCUIT
TO FIG. 25B
41
TRANSPORT MOTOR
Ctrl-T
dA
DRIVING CIRCUIT
COM
51
CGND
100
50-1
COM-1
CGND-1
COM-2
CGND-2
COM-j
CGND-j
COM-j+1
CGND-j+1
COM-n-1
CGND-n-1
COM-n
CGND-n
110
POWER CIRCUIT
VDD
VHV
GND

FIG. 25B

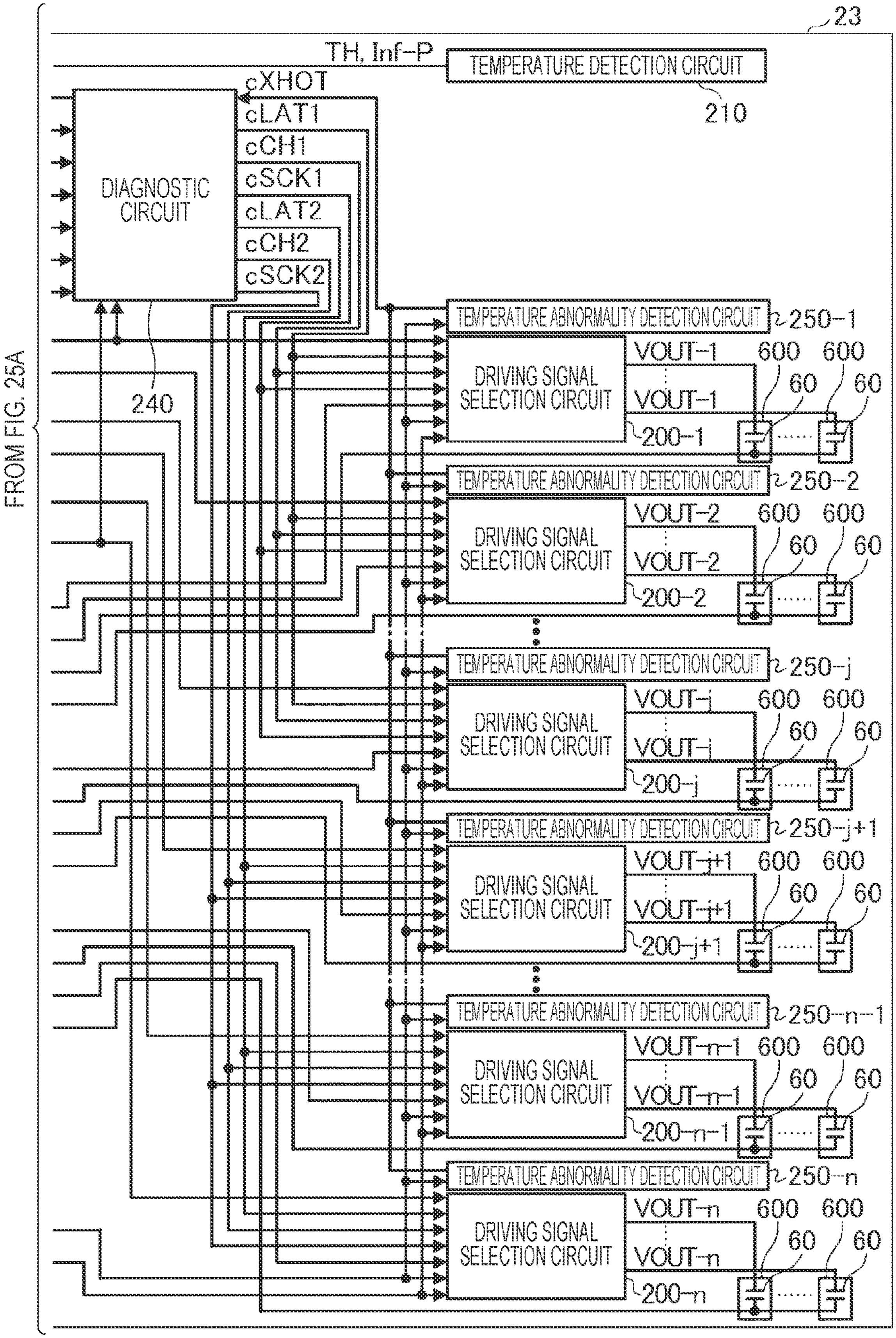

23
TH, Inf-P
TEMPERATURE DETECTION CIRCUIT
210
cXHOT
cLAT1
cCH1
cSCK1
cLAT2
cCH2
cSCK2
DIAGNOSTIC CIRCUIT
240
FROM FIG. 25A
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-1
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-1
VOUT-1
200-1
600
60
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-2
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-2
VOUT-2
200-2
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-j
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-j
VOUT-j
200-j
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-j+1
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-j+1
VOUT-j+1
200-j+1
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-n-1
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-n-1
VOUT-n-1
200-n-1
TEMPERATURE ABNORMALITY DETECTION CIRCUIT
250-n
DRIVING SIGNAL SELECTION CIRCUIT
VOUT-n
VOUT-n
200-n

FIG. 26

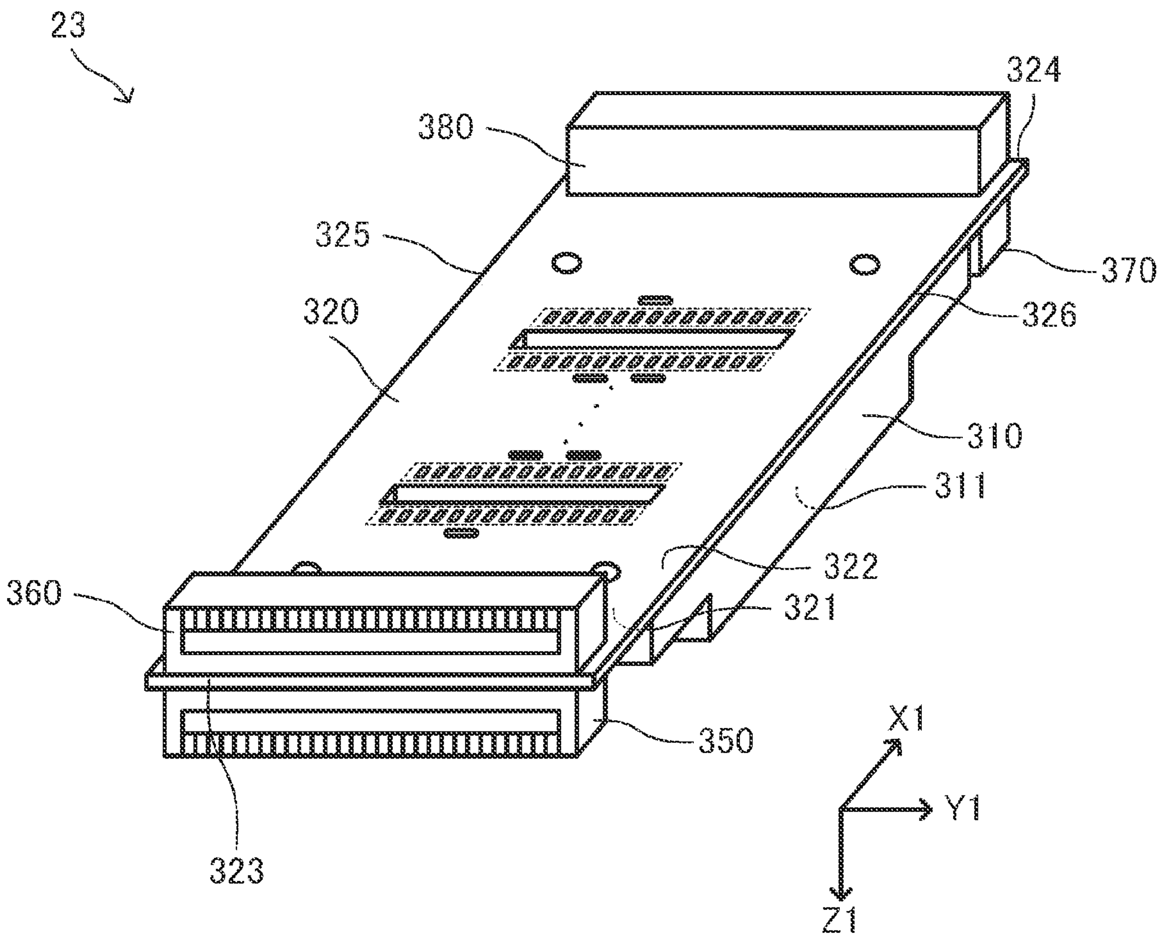


FIG. 27

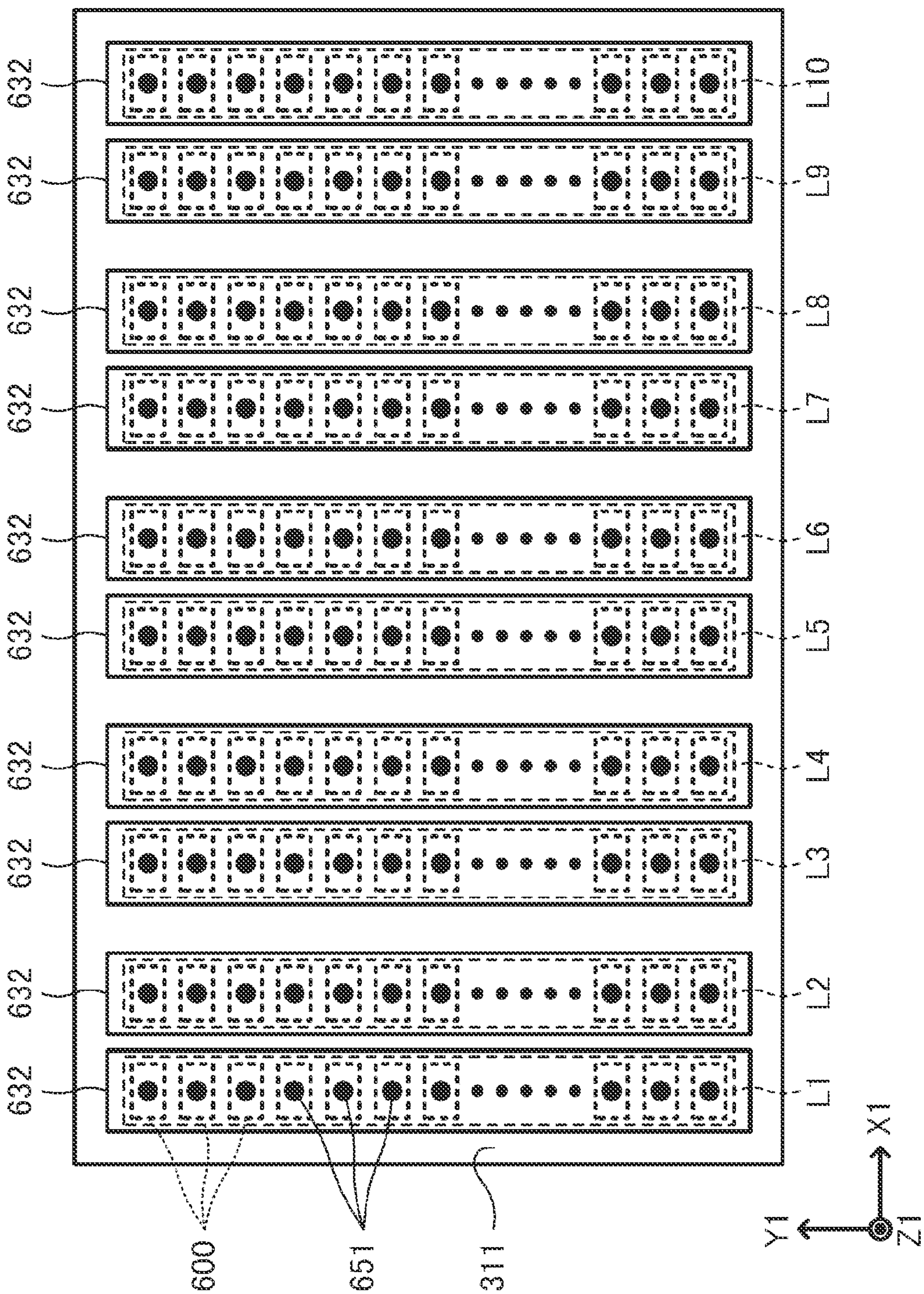


FIG. 28

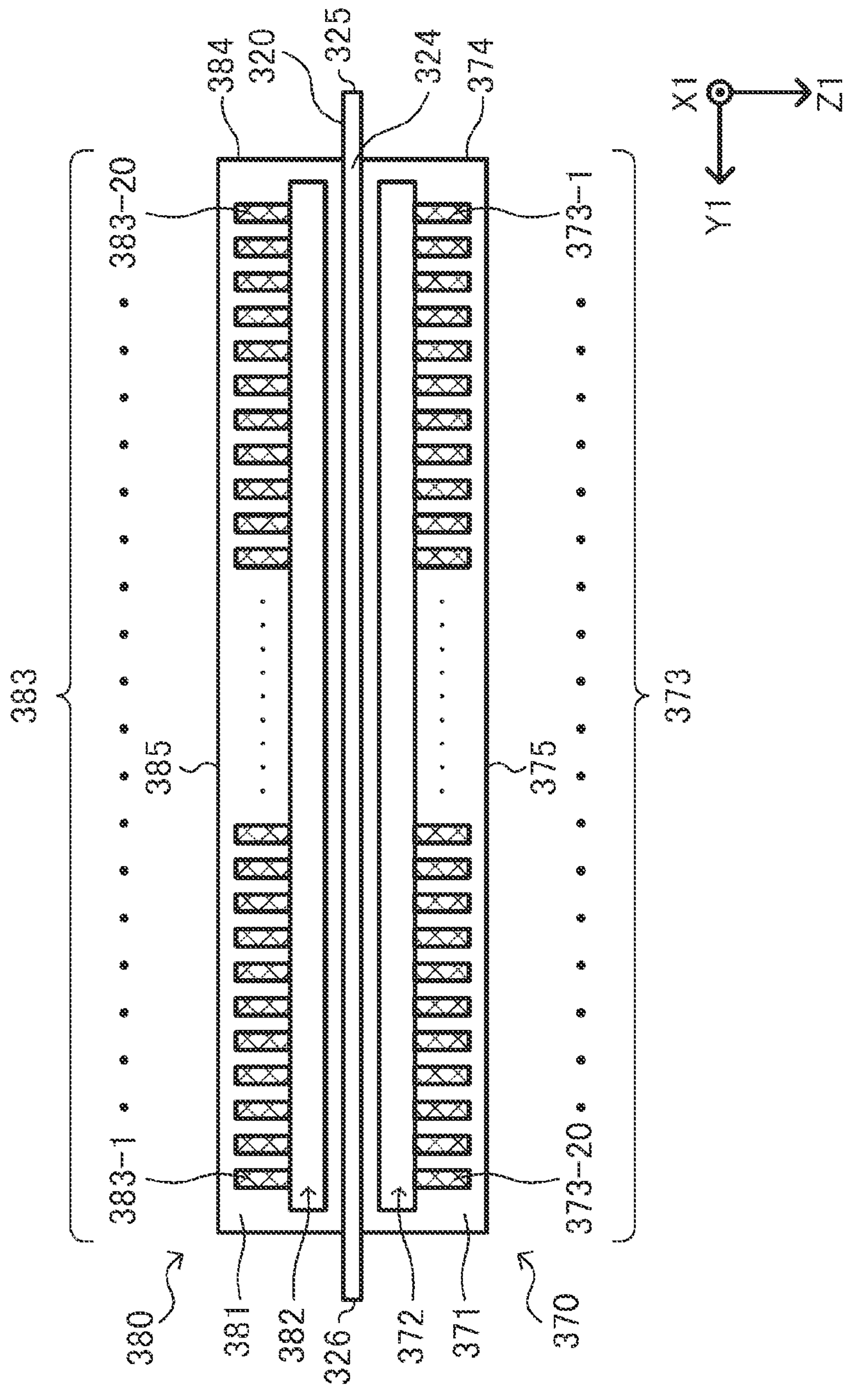

384
320
325
324
374
X1
Z1
Y1
383-20
373-1
383
373
385
375
383-1
373-20
380
381
382
326
372
371
370

FIG. 29

TERMINAL NUMBER	INPUT SIGNAL
353-1	GND
353-2	TH
353-3	GND
353-4	LATa
353-5	GND
353-6	SCKa
353-7	GND
353-8	CHa
353-9	GND
353-10	SI1
353-11	CGND-1
353-12	COM-1
353-13	CGND-2
353-14	COM-2
353-15	CGND-3
353-16	COM-3
353-17	CGND-4
353-18	COM-4
353-19	CGND-5
353-20	COM-5

FIG. 30

TERMINAL NUMBER	INPUT SIGNAL
363-1	CGND-5
363-2	COM-5
363-3	CGND-4
363-4	COM-4
363-5	CGND-3
363-6	COM-3
363-7	CGND-2
363-8	COM-2
363-9	CGND-1
363-10	COM-1
363-11	GND
363-12	SI5
363-13	GND
363-14	SI4
363-15	GND
363-16	SI3
363-17	GND
363-18	SI2
363-19	GND
363-20	VDD

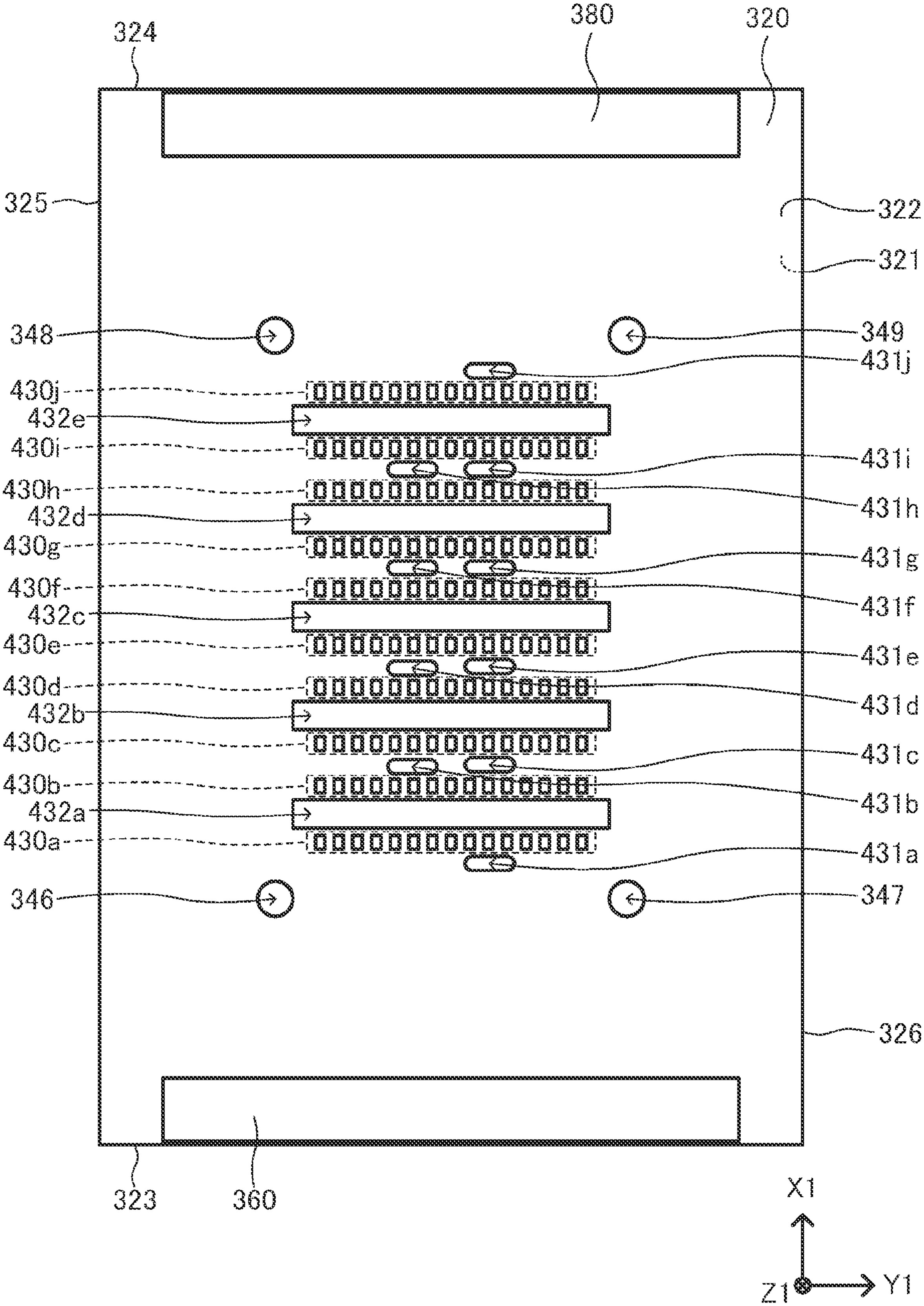
FIG. 31

TERMINAL NUMBER	INPUT SIGNAL
373-1	CGND-6
373-2	COM-6
373-3	CGND-7
373-4	COM-7
373-5	CGND-8
373-6	COM-8
373-7	CGND-9
373-8	COM-9
373-9	CGND-10
373-10	COM-10
373-11	GND
373-12	XHOT
373-13	GND
373-14	LATb
373-15	GND
373-16	SCKb
373-17	GND
373-18	CHb
373-19	GND
373-20	SI10

FIG. 32

TERMINAL NUMBER	INPUT SIGNAL
383-1	GND
383-2	SI9
383-3	GND
383-4	SI8
383-5	VDD
383-6	SI7
383-7	GND
383-8	SI6
383-9	GND
383-10	VHV
383-11	CGND-10
383-12	COM-10
383-13	CGND-9
383-14	COM-9
383-15	CGND-8
383-16	COM-8
383-17	CGND-7
383-18	COM-7
383-19	CGND-6
383-20	COM-6

FIG. 33



324
380
320
325
322
321
348
349
431j
430j
432e
430i
431i
430h
431h
432d
430g
431g
430f
431f
432c
430e
431e
430d
431d
432b
430c
431c
430b
431b
432a
430a
431a
346
347
326
323
360
X1
Z1
Y1

FIG. 34

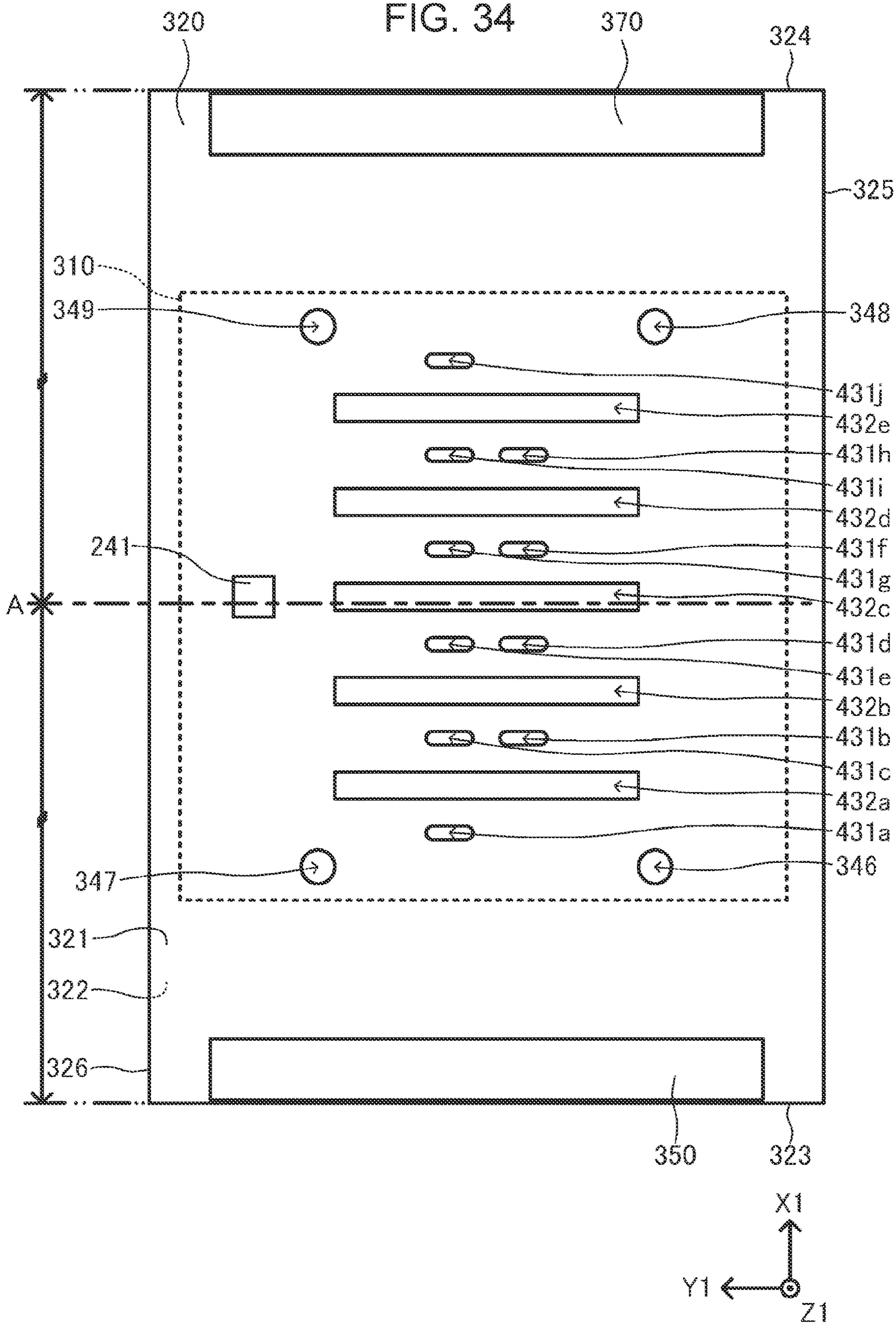
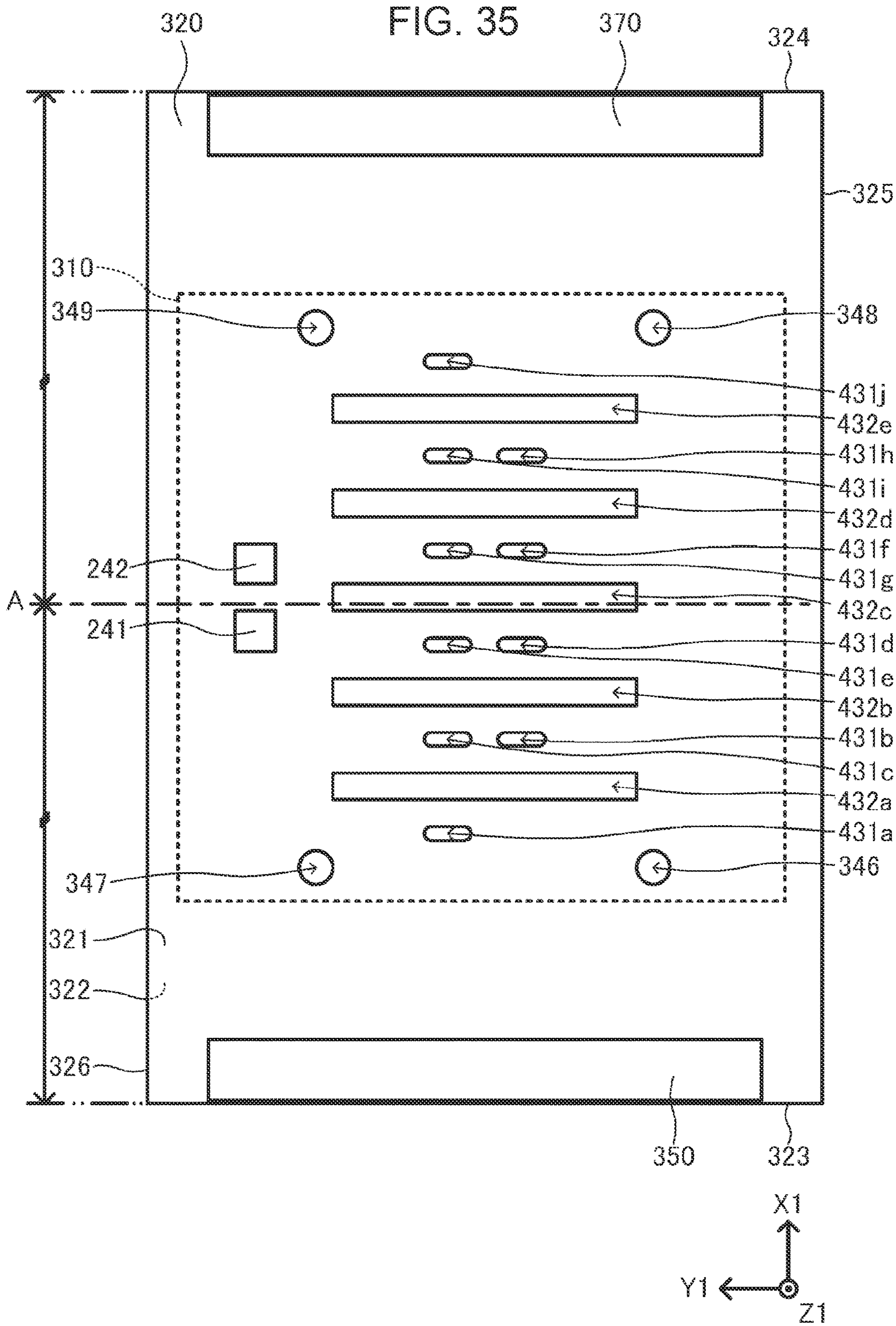

320
370
324
325
310
349
348
431j
432e
431h
431i
432d
241
431f
431g
A
432c
431d
431e
432b
431b
431c
432a
431a
347
346
321
322
326
350
323
X1
Y1
Z1

FIG. 35


320
370
324
325
310
349
348
431j
432e
431h
431i
432d
431f
242
431g
A
432c
241
431d
431e
432b
431b
431c
432a
431a
347
346
321
322
326
350
323
X1
Y1
Z1

LIQUID DISCHARGE APPARATUS AND HEAD UNIT

The present application is based on, and claims priority from JP Application Serial Number 2019-235062, filed Dec. 25, 2019, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

The present disclosure relates to a liquid discharge apparatus and a head unit.

2. Related Art

A liquid discharge apparatus, such as an ink jet printer, discharges liquid, such as ink, with which a cavity is filled, from nozzles by driving piezoelectric elements provided in a print head included a head unit using a driving signal, and forms text and an image on a medium. In the liquid discharge apparatus, when malfunction occurs in the print head, there is a problem in that discharge abnormality occurs in which it is not possible to normally discharge the liquid from the nozzles. Further, when the discharge abnormality occurs, discharge accuracy of the liquid discharged from the nozzles decreases, and dots that satisfy normal print quality are not formed on the medium, and, as a result, a quality of the image formed on the medium deteriorates. A print head is known which has a self-diagnosis function of diagnosing whether or not the quality of the image formed on the medium deteriorates by the print head itself based on the discharge accuracy of the liquid discharged from the print head.

For example, JP-A-2017-114020 discloses a technology for diagnosing, by a print head itself, whether or not it is possible to form dots which satisfy a normal print quality based on a plurality of signals which are input to the print head.

In addition, JP-A-2016-112694 discloses a head unit, which includes an integrated circuit chip for controlling drive of print heads, and a plurality of print heads for discharging liquid when a driving signal controlled by the integrated circuit chip is supplied and in which the plurality of print heads are housed in a case, and a line head type liquid discharge apparatus which includes the head unit.

However, when a self-diagnosis function, which is disclosed in JP-A-2017-114020 and is performed by a print head itself in order to diagnose whether or not it is possible to form dots which satisfy a normal print quality, is applied to a head unit which is disclosed in JP-A-2016-112694 and in which the print head is housed in a case, heat is generated in an integrated circuit chip or the like for controlling drive of the print head, and thus internal temperature of the case rises. Further, in accordance with the rise of the internal temperature, temperature of a component, such as an integrated circuit, for performing the self-diagnosis function of the print head also rises. As a result, there is a problem in that the configuration, such as the integrated circuit, for executing the self-diagnosis function of the print head does not operate normally.

In particular, in a head unit used in a line head type liquid discharge apparatus in which a plurality of print heads are housed as disclosed in JP-A-2017-114020, the plurality of print heads are housed in the case. Therefore, the amount of generated heat increases in the entire head unit, and, as a result, the rise of the internal temperature of the case further increases. Further, in the line head type liquid discharge apparatus as disclosed in JP-A-2017-114020, the print heads discharge ink to the medium in a state in which the head unit is fixed to a housing of the liquid discharge apparatus. Therefore, it is difficult to cool the head unit, and, as a result, the rise of the internal temperature further increases.

As described above, when the self-diagnosis function of the print head is applied to the print head housed in the case, there is room for improvement from a viewpoint of reducing the rise of the temperature of the component, such as the integrated circuit, for executing the self-diagnosis function. In particular, when the self-diagnosis function of the print head is applied to the print head included in the head unit used for the line head type liquid discharge apparatus, a problem becomes more remarkable to reduce the rise of the temperature of the component, such as the integrated circuit, for executing the self-diagnosis function.

SUMMARY

According to an aspect of the present disclosure, there is provided a liquid discharge apparatus including a head unit that discharges liquid, and a digital signal output circuit that outputs a digital signal to the head unit, in which the head unit includes a plurality of print heads that discharge the liquid, and a housing that houses the plurality of print heads, a first print head in the plurality of print heads includes a substrate that includes a first side, a second side which intersects with the first side, a first surface which has the first side and the second side, and a second surface which is different from the first surface, a first nozzle plate that includes a first nozzle row in which a plurality of first nozzles for discharging the liquid are provided in line in a direction along the first side, a connector that is provided in the first surface and to which the digital signal is input, a first integrated circuit that is provided on the first surface, that is electrically coupled to the connector, to which the digital signal is input via the connector, and that outputs an abnormality signal indicating presence or absence of abnormality of the first print head, a first flexible wiring substrate that is electrically coupled to the substrate, and a second integrated circuit that is provided on the first flexible wiring substrate, the second integrated circuit is located between the first nozzle plate and the substrate, and the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

According to another aspect of the present disclosure, there is provided a head unit including a plurality of print heads that discharge liquid, and a housing that houses the plurality of print heads, in which a first print head in the plurality of print heads includes a substrate that includes a first side, a second side which intersects with the first side, a first surface which has the first side and the second side, and a second surface which is different from the first surface, a first nozzle plate that includes a first nozzle row in which a plurality of first nozzles for discharging the liquid are provided in line in a direction along the first side, a connector that is provided in the first surface and to which a digital signal is input, a first integrated circuit that is provided in the first surface, that is electrically coupled to the connector, to which the digital signal is input via the connector, and that outputs an abnormality signal indicating presence or absence of abnormality of the first print head, a first flexible wiring substrate that is electrically coupled to the substrate, and a second integrated circuit that is provided on the first flexible wiring substrate, the second integrated

circuit is located between the first nozzle plate and the substrate, and the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating a schematic configuration of a liquid discharge apparatus.

FIG. **2** is a block diagram illustrating an electrical configuration of the liquid discharge apparatus.

FIG. **3**A is a first half of a block diagram illustrating an electrical configuration of a print head.

FIG. **3**B is a second half of the block diagram illustrating the electrical configuration of the print head.

FIG. **4** is a diagram illustrating an example of a waveform of a driving signal.

FIG. **5** is a diagram illustrating an example of a waveform of a driving signal.

FIG. **6** is a diagram illustrating a configuration of a driving signal selection circuit.

FIG. **7** is a table illustrating decoding content of a decoder.

FIG. **8** is a diagram illustrating a configuration of a selection circuit corresponding to one discharge section.

FIG. **9** is a diagram illustrating an operation of the driving signal selection circuit.

FIG. **10** is a diagram illustrating a configuration of a temperature abnormality detection circuit.

FIG. **11** is a perspective diagram illustrating a configuration of a print head.

FIG. **12** is a plan diagram illustrating a configuration of an ink discharge surface.

FIG. **13** is a diagram illustrating a schematic configuration of the discharge section.

FIG. **14** is a diagram illustrating configurations of a first connector and a second connector.

FIG. **15** is a diagram illustrating examples of signals respectively input to a plurality of terminals.

FIG. **16** is a diagram illustrating examples of signals respectively input to a plurality of terminals.

FIG. **17** is a plan diagram illustrating a case where a substrate is viewed from a surface.

FIG. **18** is a plan diagram illustrating a case where the substrate is viewed from a surface.

FIG. **19** is a diagram illustrating a cross section of the print head when the print head is cut so as to include an FPC insertion hole and an ink supply path insertion hole.

FIG. **20** is a diagram illustrating an example of wiring formed on a surface of the substrate.

FIG. **21** is an exploded perspective diagram illustrating a configuration of the head unit.

FIG. **22** is a diagram illustrating the configuration of the head unit when the head unit is viewed from a +Z side.

FIG. **23** is an enlarged view of a portion XXIII in FIG. **22**.

FIG. **24** is a plan diagram illustrating a case where the substrate is viewed from a surface according to a second embodiment.

FIG. **25**A is a first half of a block diagram illustrating an electrical configuration of a print head according to a third embodiment.

FIG. **25**B is a second half of the block diagram illustrating the electrical configuration of the print head according to the third embodiment.

FIG. **26** is a perspective diagram illustrating a configuration of the print head according to the third embodiment.

FIG. **27** is a plan diagram illustrating an ink discharge surface according to the third embodiment.

FIG. **28** is a diagram illustrating configurations of a third connector and a fourth connector.

FIG. **29** is a diagram illustrating examples of signals respectively input to a plurality of terminals according to the third embodiment.

FIG. **30** is a diagram illustrating examples of signals respectively input to a plurality of terminals according to the third embodiment.

FIG. **31** is a diagram illustrating examples of signals respectively input to a plurality of terminals according to the third embodiment.

FIG. **32** is a diagram illustrating examples of signals respectively input to a plurality of terminals according to the third embodiment.

FIG. **33** is a plan diagram illustrating a case where a substrate is viewed from a surface according to the third embodiment.

FIG. **34** is a plan diagram illustrating a case where the substrate is viewed from a surface according to the third embodiment.

FIG. **35** is a plan diagram illustrating a case where a substrate is viewed from a surface according to a fourth embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, preferable embodiments of the present disclosure will be described with reference to the accompanying drawings. The accompanying drawings are used for convenience of description. Note that, the embodiments which will be described below do not unreasonably limit content of the present disclosure disclosed in aspects. In addition, all configurations which will be described below are not limited to essential components of the present disclosure.

Hereinafter, an ink jet printer, which forms an image by discharging ink as liquid on a medium, will be described as an example of a liquid discharge apparatus. Note that, the liquid discharge apparatus is not limited to the ink jet printer, and it is possible to exemplify, for example, a color material discharge apparatus used to manufacture a color filter of a liquid crystal display or the like, an electrode material discharge apparatus used to form an electrode of an organic EL display or a Field Emission Display (FED), a living organism discharge apparatus used to manufacture a biochip, a solid forming apparatus (a so-called 3D printer), a textile printing apparatus, or the like. In such a case, the liquid discharged from the liquid discharge apparatus is not limited to the ink, and may be, for example, liquid containing an electrode material or a liquid containing a biological organic substance.

1. First Embodiment

1.1 Outline of Liquid Discharge Apparatus

FIG. **1** is a diagram illustrating a schematic configuration of a liquid discharge apparatus **1**. As illustrated in FIG. **1**, the liquid discharge apparatus **1** according to the present embodiment is a so-called line head type ink jet printer that forms a desired image on a medium M in such a way that ink discharged from a head unit **20** provided to be equal to or larger than a width of the medium M lands on the medium M transported by a transport mechanism **40**. Here, in the following description, description will be performed while it is assumed that a width direction of the medium M is an X direction, a direction in which the medium M is transported is a Y direction, and a direction in which the ink is discharged from the head unit **20** is a Z direction. In addition, in the following description, there is a case where a starting point side of an arrow indicating the X direction illustrated in the drawing is referred to as a −X side, and a tip end side is referred to as an +X side, a starting point side of an arrow indicating the Y direction in the drawing is referred to as a −Y side and a tip end side is referred to as a +Y side, and a starting point side of an arrow indicating the Z direction in the drawing is referred to as a −Z side and a tip end side is referred to as a +Z side.

Not that, in the following description, description will be performed while it is assumed that the X direction, the Y direction, and the Z direction are directions orthogonal to each other, but configurations of the liquid discharge apparatus **1** are not limited to being disposed to be orthogonal to each other. In addition, a random printing target, such as printing paper, a resin film, or a fabric, may be used as the medium M. Here, the Z direction is an example of a vertical direction according to the embodiment.

Here, the vertical direction of the liquid discharge apparatus **1** means, in a narrow sense, a direction of gravity in a state in which the liquid discharge apparatus **1** is installed, but, in a broader sense, includes a direction orthogonal to an installation surface of the liquid discharge apparatus **1** in a state in which the liquid discharge apparatus **1** may be installed. For example, when the liquid discharge apparatus **1** includes a housing and the liquid discharge apparatus **1** is installed while one surface of the housing is used as a bottom surface, the bottom surface corresponds to the installation surface, and a direction orthogonal to the bottom surface corresponds to the vertical direction in a broad sense. In addition, for example, when the liquid discharge apparatus **1** includes the housing and a plurality of legs attached to the housing, and the liquid discharge apparatus **1** is installed in a state of being supported by the plurality of legs, a direction orthogonal to a straight line, which connects at least two of the plurality of legs, corresponds to the vertical direction in a broad sense.

Similarly, a vertical direction of the head unit **20** means, in the narrow sense, the direction of gravity in a state in which the head unit **20** is installed, but, in a broader sense, includes a direction orthogonal to an installation surface of the head unit **20** in a state in which the head unit **20** may be installed and, for example, a direction in which the ink is discharged from the head unit **20**.

As illustrated in FIG. **1**, the liquid discharge apparatus **1** includes a liquid container **2**, a control mechanism **10**, a head unit **20**, and a transport mechanism **40**.

The liquid container **2** stores the ink as an example of liquid to be supplied to the head unit **20**. Specifically, a plurality of types of ink discharged to the medium M are stored in the liquid container **2**. A color of black, a color of cyan, a color of magenta, a color of yellow, a color of red, a color of gray, and the like are exemplified as colors of the ink stored in the liquid container **2**. An ink cartridge, a bursiform ink pack formed of a flexible film, an ink tank capable of supplying the ink, or the like is used as the liquid container **2** which stores the ink. The liquid container **2** that supplies ink to the head unit **20** is an example of a liquid storage.

The control mechanism **10** includes, for example, a processing circuit, such as a Central Processing Unit (CPU) or a Field Programmable Gate Array (FPGA), and a storage circuit, such as a semiconductor memory, and controls respective components of the liquid discharge apparatus **1**.

The head unit **20** includes print heads **23-1** to **23-*n***. In the head unit **20**, the print heads **23-1** to **23-*n*** are provided in line to be equal to or larger than the width of the medium M in the X direction which is the width direction of the medium M. Specifically, the print heads **23-1** to **23-*n*** are disposed in a zigzag pattern along the X direction. A length formed by the print heads **23-1** to **23-*n*** disposed in the zigzag pattern in the X direction is equal to or larger than the width of the medium M. Here, a fact that the print heads **23-1** to **23-*n*** are disposed in the zigzag pattern along the X direction means that the print heads **23-1** to **23-*n*** provided in line in the X direction are disposed to be alternately shifted in the Y direction.

A control signal Ctrl-H for controlling each of the print heads **23-1** to **23-*n*** is input to the head unit **20** from the control mechanism **10**. Each of the print heads **23-1** to **23-*n*** discharges the ink to be supplied from the liquid container **2** based on the input control signal Ctrl-H.

In addition, the head unit **20** also generates a state information signal Inf-H indicating a state of the head unit **20**, and outputs the state information signal Inf-H to the control mechanism **10**. The control mechanism **10** recognizes an operating state of the head unit **20** based on the state information signal Inf-H. Further, the control mechanism **10** controls an operation of the head unit **20** by executing various processes, such as a correction process of the control signal Ctrl-H, according to the operating state of the head unit **20**.

The transport mechanism **40** includes a transport motor **41** and a transport roller **42**. The transport motor **41** operates based on a control signal Ctrl-T input from the control mechanism **10**. Further, the transport roller **42** rotates according to an operation of the transport motor **41**. The medium M is transported in the Y direction in accordance with rotation of the transport roller **42**.

As described above, in a case where the ink is discharged from the head unit **20** in association with the transport of the medium M by the transport mechanism **40**, the liquid discharge apparatus **1** causes the ink to be landed at a desired location on a surface of the medium M so that a desired image is formed on the medium M.

1.2 Electrical Configuration of Liquid Discharge Apparatus

1.2.1 Electrical Configuration of Liquid Discharge Apparatus

FIG. **2** is a block diagram illustrating an electrical configuration of the liquid discharge apparatus **1**. The liquid discharge apparatus **1** includes the control mechanism **10**, the head unit **20**, and the transport motor **41**. In addition, the control mechanism **10** includes driving signal output circuits **50-1** to **50-*n***, a control circuit **100**, and a power circuit **110**, and the head unit **20** includes the print heads **23-1** to **23-*n***.

The control circuit **100** includes an integrated circuit having, for example, a processor such as a microcontroller. Further, the control circuit **100** generates and outputs data and various signals for controlling the liquid discharge apparatus **1** based on various signals such as image data input from a host computer.

The control circuit **100** outputs the control signal Ctrl-T to the transport motor **41**. Therefore, the transport of the medium M is controlled. Note that, the control signal Ctrl-T may be input to the transport motor **41** after signal conversion is performed through a not-shown transport motor driver.

In addition, the control circuit **100** generates the control signal Ctrl-H based on the various signals such as the image data input from the host computer, and outputs the control signal Ctrl-H to the head unit **20**. Specifically, the control circuit **100** generates control signals Ctrl-P**1** to Ctrl-Pn corresponding to the respective print heads **23-1** to **23**-*n* included in the head unit **20** as the control signal Ctrl-H, and outputs the control signals Ctrl-P**1** to Ctrl-Pn to the relevant print heads **23-1** to **23**-*n*. That is, the control circuit **100** generates the control signal Ctrl-P**1** as the control signal Ctrl-H based on the various signals such as the image data input from the host computer, and outputs the control signal Ctrl-P**1** to the relevant print head **23-1**. Similarly, the control circuit **100** generates a control signal Ctrl-Pi Ci is any of 1 to n) as the control signal Ctrl-H based on the various signals such as the image data input from the host computer, and outputs the control signal Ctrl-Pi to a relevant print head **23**-*i*.

In addition, the control circuit **100** generates drive control signals dA**1** to dAn corresponding to the respective driving signal output circuits **50-1** to **50**-*n*, and outputs the drive control signals dA**1** to dAn to the relevant driving signal output circuits **50-1** to **50**-*n*. Each of the driving signal output circuits **50-1** to **50**-*n* includes a driving circuit **51**. Further, the driving signal output circuits **50-1** to **50**-*n* respectively generate driving signals COM**1** to COMn corresponding to the input drive control signals dA**1** to dAn, and output the driving signals COM**1** to COMn to the relevant print heads **23-1** to **23**-*n* as the control signal Ctrl-H.

That is, the control circuit **100** generates the drive control signal dA**1**, and outputs the drive control signal dA**1** to the relevant driving signal output circuit **50-1**. After the driving circuit **51** included in the driving signal output circuit **50-1** performs digital/analog conversion on the input drive control signal dA**1**, the driving circuit **51** generates the driving signal COM**1** as the control signal Ctrl-H by performing class D amplification on an analog signal acquired through the conversion, and outputs the driving signal COM**1** to the relevant print head **23-1**. Similarly, the control circuit **100** generates the drive control signal dAi, and outputs the drive control signal dAi to the relevant driving signal output circuit **50**-*i*. After the driving circuit **51** included in the driving signal output circuit **50**-*i* performs the digital/analog conversion on the input drive control signal dAi which is input from the control circuit **100**, the driving circuit **51** generates the driving signal COMi as the control signal Ctrl-H by performing the class D amplification on an analog signal acquired through the conversion, and outputs the driving signal COMi to the relevant print head **23**-*i*.

Here, the driving circuit **51** included in each of the driving signal output circuits **50-1** generates the driving signals COM**1** to COMn by performing the class D amplification on waveforms prescribed by the respective drive control signals dA**1** to dAn. Therefore, the respective drive control signals dA**1** to dAn may be signals that can prescribe the waveforms of the relevant driving signals COM**1** to COMn, and, for example, may be analog signals. In addition, the driving circuit **51** may generate the driving signals COM**1** to COMn by amplifying the waveforms prescribed by the respective drive control signals dA**1** to dAn, and may include circuits for class A amplification, class B amplification, class AB amplification, and the like.

In addition, the respective driving signal output circuits **50-1** to **50**-*n* generate, for example, reference voltage signals CGND**1** to CGNDn of ground potentials (0V) indicating reference potentials of the respective driving signals COM**1** to COMn, and output the reference voltage signals CGND**1** to CGNDn to the relevant print heads **23-1** to **23**-*n* as the control signal Ctrl-H. That is, the driving signal output circuit **50-1** generates the reference voltage signal CGND**1** as the control signal Ctrl-H indicating the reference potential of the driving signal COM**1**, and outputs the reference voltage signal CGND**1** to the relevant print head **23-1**. Similarly, the driving signal output circuit **50**-*i* generates the reference voltage signal CGNDi as the control signal Ctrl-H indicating the reference potential of the driving signal COMi, and outputs the reference voltage signal CGNDi to the relevant print head **23**-*i*.

Note that, voltage values of the reference voltage signals CGND**1** to CGNDn output by the driving signal output circuits **50-1** to **50**-*n* are not limited to the signals having the ground potential, and may be signals having DC voltages such as DC 6 V and DC 5.5 V.

The power circuit **110** generates and outputs a high voltage signal VHV, a low voltage signal VDD, and a ground signal GND. The high voltage signal VHV is, for example, a signal having a voltage value of DC 42 V. In addition, the low voltage signal VDD is, for example, a signal having a voltage value of 3.3 V. In addition, the ground signal GND is a signal indicating reference potentials of the high voltage signal VHV and the low voltage signal VDD, and, for example, is a signal having a voltage value of ground potential (0 V). The high voltage signal VHV is used as a voltage for amplification in each of the driving signal output circuits **50-1** to **50**-*n*. In addition, each of the low voltage signal VDD and the ground signal GND is used for power voltages or the like of various components in the control mechanism **10**.

In addition, the high voltage signal VHV, the low voltage signal VDD, and the ground signal GND are output to each of the print heads **23-1** to **23**-*n* included in the head unit **20**. Note that, the respective voltage values of the high voltage signal VHV, the low voltage signal VDD, and the ground signal GND, which are generated by the power circuit **110**, are not limited to the above-described DC 42 V, DC 3.3 V, and 0 V. In addition, the power circuit **110** may generate and output voltage signals having a plurality of voltage values, other than the high voltage signal VHV, the low voltage signal VDD, and the ground signal GND.

As described above, the control mechanism **10** supplies the relevant control signals Ctrl-P**1** to Ctrl-Pn, the relevant driving signals COM**1** to COMn, and the relevant reference voltage signals CGND**1** to CGNDn as the control signal Ctrl-H with respect to the respective print heads **23-1** to **23**-*n* included in the head unit **20**, and supplies the high voltage signal VHV, the low voltage signal VDD, and the ground signal GND, which are used for the voltage power of the print heads **23-1** to **23**-*n* included in the head unit **20**.

Here, although the liquid discharge apparatus **1** illustrated in FIG. **2** is illustrated as the control mechanism **10** includes one control circuit **100**, and one control circuit **100** outputs the control signals Ctrl-P**1** to Ctrl-Pn, the driving signals COM**1** to COMn, and the reference voltage signals CGND**1** to CGNDn, which correspond to the respective print heads **23-1** to **23**-*n*, the control circuit **100** may be configured to include a plurality of integrated circuits. For example, the control mechanism **10** may include a plurality of integrated circuits including a processor, such as a microcontroller, that generates the control signals Ctrl-P**1** to Ctrl-Pn corresponding to the respective print heads **23-1** to **23**-*n* as the control circuit **100**. In addition, the control mechanism **10** may be configured to include a plurality of circuit substrates and a plurality of circuits. Further, the control mechanism **10** may include a plurality of circuits, such as a filter circuit, a buffer circuit, and a relay circuit, in addition to the processor such as the microcontroller.

The head unit **20** includes the print heads **23-1** to **23**-*n*. Among the control signals Ctrl-P**1** to Ctrl-Pn, the driving signals COM1 to COMn, the reference voltage signals CGND1 to CGNDn, the high voltage signal VHV, the low voltage signal VDD, and the ground signal GND, which are output by the control mechanism **10**, a relevant signal is input to each of the print heads **23-1** to **23**-*n*.

In addition, the respective print heads **23-1** to **32**-*n* generate state information signals Inf-P1 to Inf-Pn as the state information signal Inf-H indicating the state of each of the print heads **23-1** to **32**-*n*, and outputs the state information signals Inf-P1 to Inf-Pn to the control circuit **100**. Specifically, the print head **23-1** generates the state information signal Inf-P1 as the state information signal Inf-H indicating the state of the print head **23-1**, and outputs the state information signal Inf-P1 to the control circuit **100**. Similarly, the print head **23**-*i* generates the state information signal Inf-Pi as the state information signal Inf-H indicating the state of the print head **23**-*i* and outputs the state information signal Inf-Pi to the control circuit **100**.

The control circuit **100** can individually recognize the operating states of the respective print heads **23-1** to **23**-*n* based on the input state information signals Inf-P1 to Inf-Pn. Further, the control circuit **100** performs the correction process or the like on each of the control signals Ctrl-P1 to Ctrl-Pn, the driving signals COM1 to COMn, and the reference voltage signals CGND1 to CGNDn according to the operating states of the respective print heads **23-1** to **23**-*n*, and outputs each of the control signals Ctrl-P1 to Ctrl-Pn, the driving signals COM1 to COMn, and the reference voltage signals CGND1 to CGNDn, on which the correction process is performed, to the relevant print heads **23-1** to **23**-*n*.

Here, the correction process executed by the control circuit **100** based on the state information signals Inf-P1 to Inf-Pn includes output stop of the control signals Ctrl-P1 to Ctrl-Pn, the driving signals COM1 to COMn, and the reference voltage signals CGND1 to CGNDn, and output of the control signals Ctrl-P1 to Ctrl-Pn for stopping the respective print heads **23-1** to **23**-*n*, in addition to the correction of the voltage values, frequencies, pulse widths, and the like of the control signals Ctrl-P1 to Ctrl-Pn, the driving signals COM1 to COMn, and the reference voltage signals CGND1 to CGNDn.

Next, a specific electrical configuration of the print heads **23-1** to **23**-*n* included in the head unit **20** will be described with reference to FIGS. **3**A and **3**B. Note that, in the embodiment, all the print heads **23-1** to **23**-*n* have the same configuration. Therefore, in the following description, when it is not necessary to distinguish the print heads **23-1** to **23**-*n*, there is a case where the print heads **23-1** to **23**-*n* are simply referred to as a print head **23**. Further, there is a case where the control signals Ctrl-P1 to Ctrl-Pn, which are input to the print head **23**, are referred to as a control signal Ctrl-P, the driving signals COM1 to COMn, which are input to the print head **23**, are referred to as a driving signal COM, the reference voltage signals CGND1 to CGNDn, which are input to the print head **23**, are referred to as a reference voltage signal CGND, and the state information signals Inf-P1 to Inf-Pn, which are output from the print head **23**, are referred to as state information signal Inf-P. In addition, there is a case where the driving signal output circuits **50-1** to **50**-*n*, which output the driving signal COM, are referred to as a driving signal output circuit **50**, and the drive control signals dA1 to dAn, which are input to the driving signal output circuit **50**, are referred to as a drive control signal dA.

FIGS. **3**A and **3**B are block diagrams illustrating the electrical configuration of the print head **23**. As illustrated in FIGS. **3**A and **3**B, the control circuit **100** generates print data signals SI1 to SIm, a change signal CH, a latch signal LAT, and a clock signal SCK, which are the digital signals, as the control signal Ctrl-P for controlling the print head **23** based on various signals, such as the image data, which are input from the host computer, and outputs the generated signals to the print head **23**.

Here, the control circuit **100**, which outputs at least any of the print data signals SI1 to SIm, the change signal CH, the latch signal LAT, and the clock signal SCK, which are the digital signals, with respect to the head unit **20** including the print head **23** and discharging the ink, is an example of a digital signal output circuit, and at least any of the print data signals SI1 to SIm, the change signal CH, the latch signal LAT, and the clock signal SCK is an example of the digital signal.

In addition, the driving signal COM and the reference voltage signal CGND, which are output to the print head **23** from the driving signal output circuit **50** included in the control mechanism **10**, are output to the print head **23** after being branched in the control mechanism **10**. Specifically, the driving signal COM is output to the print head **23** after branching off to m number of driving signals COM-1 to COM-m, which respectively correspond to driving signal selection circuits **200-1** to **200**-*m*, which will be described later, in the control mechanism **10**. Similarly, the reference voltage signal CGND is output to the print head **23** after branching off to m number of reference voltage signals CGND-1 to CGND-m in the control mechanism **10**. Note that, in the following description, although the driving signals COM-1 to COM-m are described as signals having the same waveform output from one driving circuit **51**, the driving signals COM-1 to COM-m may be different waveforms. In this case, the driving signal output circuit **50** may include a plurality of driving circuits **51**.

The print head **23** includes m number of driving signal selection circuits **200-1** to **200**-*m*, a temperature detection circuit **210**, m number of temperature abnormality detection circuits **250-1** to **250**-*m*, a plurality of discharge sections **600**, and a diagnostic circuit **240**.

The print data signal SI1, the change signal CH, the latch signal LAT, and the clock signal SCK are input to the diagnostic circuit **240**. The diagnostic circuit **240** diagnoses whether or not it is possible to normally discharge the ink in the print head **23** based on the print data signal SI1, the change signal CH, the latch signal LAT, and the clock signal SCK. In other words, the diagnostic circuit **240** diagnoses presence or absence of abnormality of the print head **23**. Further, the diagnostic circuit **240** outputs an abnormality signal XHOT indicating the presence or absence of the abnormality of the print head **23** as the state information signal Inf-P. That is, the print head **23** has a function of performing self-diagnosis based on the print data signal SI1, the change signal CH, the latch signal LAT, and the clock signal SCK.

For example, the diagnostic circuit **240** may detect the respective voltage values of the print data signal SI1, the change signal CH, the latch signal LAT, and the clock signal SCK, which are input, and may diagnose whether or not electrical coupling between the control mechanism **10** and the print head **23** is normal based on the detected voltage values. In addition, for example, the diagnostic circuit **240** may detect a timing at which the print data signal SI1, the change signal CH, the latch signal LAT, and the clock signal SCK are input, and may diagnose whether or not the waveforms of the print data signal SI1, the change signal CH, the latch signal LAT, and the clock signal SCK, which are input to the print head **23**, are normal based on the detected timing of the signals.

As above, the diagnostic circuit **240** detects whether or not the print data signal SI**1**, the change signal CH, the latch signal LAT, and the clock signal SCK, which are input, are normal, and diagnoses whether or not it is possible to normally discharge the ink in the print head **23** based on a result of the detection. That is, the diagnostic circuit **240** diagnoses whether or not it is possible to normally discharge the ink as the self-diagnosis of the print head **23**. Further, when the abnormality does not occur in the print head **23**, the diagnostic circuit **240** outputs the abnormality signal XHOT at a logical level of one side of a high level and a low level. When the abnormality occurs in the print head **23**, the diagnostic circuit **240** outputs the abnormality signal XHOT at a logical level of the other side of the high level and the low level.

In addition, when the diagnostic circuit **240** diagnoses that the print data signal SI**1**, the change signal CH, the latch signal LAT, and the clock signal SCK are normal, the diagnostic circuit **240** outputs a change signal cCH, a latch signal cLAT, and a clock signal cSCK. Here, the change signal cCH, the latch signal cLAT, and the clock signal cSCK may be signals having waveforms which are the same as those of the change signal CH, the latch signal LAT, and the clock signal SCK which are input to the diagnostic circuit **240**. In addition, the change signal cCH, the latch signal cLAT, and the clock signal cSCK may be signals having waveforms acquired by performing the correction process on the change signal CH, the latch signal LAT, and the clock signal SCK. In addition, the change signal cCH, the latch signal cLAT, and the clock signal cSCK may be signals having waveforms which are different from those of the change signal CH, the latch signal LAT, and the clock signal SCK acquired through conversion based on the change signal CH, the latch signal LAT, and the clock signal SCK. The diagnostic circuit **240** as described above includes, for example, one or a plurality of Integrated Circuit (IC) devices.

In addition, after the print data signal SI**1** in the signals, which are input to the diagnostic circuit **240**, branches off in the print head **23**, one of the branching signals is input to the diagnostic circuit **240**, and the other signal is input to the driving signal selection circuit **200-1** which will be described later. The print data signal SI**1** is a signal having a high transmission rate, compared to the latch signal LAT and the change signal CH. After the print data signal SI**1** branches off in the print head **23**, only one of the branching signals is input to the diagnostic circuit **240**, and thus it is possible to reduce a possibility that distortion occurs in the waveform of the print data signal SI**1** which is input to the driving signal selection circuit **200-1** due to an operation of the diagnostic circuit **240**. That is, it is possible to improve accuracy of diagnosis of whether or not the ink can be normally discharged from the print head **23** in the diagnostic circuit **240**.

The respective driving signal selection circuits **200-1** to **200-*m*** generate driving signals VOUT-**1** to VOUT-m by performing selection or non-selection on the waveforms of the driving signals COM-**1** to COM-m based on the print data signals SI**1** to SIm, the clock signal cSCK, the latch signal cLAT, and the change signal cCH, which are input. Further, the respective driving signal selection circuits **200-1** to **200-*m*** supply the generated driving signals VOUT-**1** to VOUT-m to piezoelectric elements **60** included in relevant discharge sections **600**. The piezoelectric elements **60** are displaced when the driving signals VOUT-**1** to VOUT-m are supplied. Further, an amount of ink according to the displacement is discharged from the discharge sections **600**.

Specifically, the driving signal COM-**1**, the print data signal SI**1**, the latch signal cLAT, the change signal cCH, and the clock signal cSCK are input to the driving signal selection circuit **200-1** included in the print head **23**. Further, the driving signal selection circuit **200-1** generates the driving signal VOUT-**1** by performing selection or non-selection on the waveform of the driving signal COM-**1** based on the print data signal SI**1**, the latch signal cLAT, the change signal cCH, and the clock signal cSCK. The driving signal VOUT-**1** is supplied to one end of the piezoelectric element **60** of the relevantly provided discharge section **600**. In addition, the reference voltage signal CGND-**1** is supplied to the other end of the piezoelectric element **60**. Further, the piezoelectric element **60** displaces according to a potential difference between the driving signal VOUT-**1** and the reference voltage signal CGND-**1**.

Similarly, a driving signal COMj, a print data signal SIj, the latch signal cLAT, the change signal cCH, and the clock signal cSCK are input to a driving signal selection circuit **200-*j*** (j is any one of 1 to m) included in the print head **23**. Further, a driving signal selection circuit **200-*i*** generates and outputs a driving signal VOUT-j by performing selection or non-selection on a waveform of the driving signal COM-j based on a print data signal SIj, the latch signal cLAT, the change signal cCH, and the clock signal cSCK. The driving signal VOUT-j is supplied to one end of the piezoelectric element **60** of the relevantly provided discharge section **600**. In addition, the reference voltage signal CGND-j is supplied to the other end of the piezoelectric element **60**. Further, the piezoelectric element **60** displaces according to a potential difference between the driving signal VOUT-j and the reference voltage signal CGND-j. Each of the driving signal selection circuits **200-1** to **200-*i*** included in the print head **23** described above is configured as, for example, an integrated circuit device.

The temperature detection circuit **210** includes a not-shown temperature sensor such as a thermistor. The temperature sensor detects a temperature of the print head **23**. Further, the temperature detection circuit **210** generates a temperature signal TH which is an analog signal including temperature information of the print head **23**, and outputs the temperature signal TH to the control circuit **100** as the state information signal Inf-P.

The temperature abnormality detection circuits **250-1** to **250-*m*** are provided to correspond to the respective driving signal selection circuits **200-1** to **200-*m***. Further, each of the temperature abnormality detection circuits **250-1** to **250-*m*** diagnoses presence or absence of temperature abnormality of each of the relevant driving signal selection circuits **200-1** to **200-*m***, and outputs digital abnormality signal cXHOT indicating whether or not temperature of each of the relevant driving signal selection circuits **200-1** to **200-*m*** is abnormal. Specifically, each of the temperature abnormality detection circuits **250-1** to **250-*m*** diagnoses whether or not the temperature of each of the relevant driving signal selection circuits **200-1** to **200-*m*** is abnormal. Further, when it is determined that the temperature of each of the relevant driving signal selection circuits **200-1** to **200-*m*** is normal, each of the temperature abnormality detection circuits **250-1** to **250-*m*** generates the abnormality signal cXHOT at an H level and outputs the abnormality signal cXHOT to the diagnostic circuit **240**. In addition, when it is determined that the temperature of each of the relevant driving signal selection circuits **200-1** to **200-*m*** is abnormal, each of the temperature abnormality detection circuits **250-1** to **250-*m*** generates the abnormality signal XHOT at an L level and outputs the abnormality signal XHOT to the diagnostic circuit **240**. Note that, the logical level of the abnormality signal cXHOT is an example. When it is determined that the temperature of the print head **23** is normal, the temperature abnormality detection circuits **250-1** to **250-*m*** may generate the abnormality signal cXHOT at the L level. When it is determined that the temperature of the print head **23** is abnormal, the temperature abnormality detection circuits **250-1** to **250-*m*** may generate the abnormality signal cXHOT at the H level.

The diagnostic circuit **240** diagnoses whether or not the temperatures of the driving signal selection circuits **200-1** to **200-*m*** are normal according to the logical level of the input abnormality signal cXHOT. Further, when the temperatures of the driving signal selection circuits **200-1** to **200-*m*** are normal, the diagnostic circuit **240** outputs the abnormality signal XHOT at a logical level of any one of the high level or the low level to the control circuit **100**, and, when the temperatures of the driving signal selection circuits **200-1** to **200-*m*** are not normal, the diagnostic circuit **240** outputs the abnormality signal XHOT at a logical level of the other one of the high level and the low level to the control circuit **100**. That is, the diagnostic circuit **240** determines the abnormality of the print head **23** based on the logical level of the input abnormality signal cXHOT, and outputs the abnormality signal XHOT according to a result of the determination as the state information signal Inf-P. Note that, the diagnostic circuit **240** may output the abnormality signal cXHOT, which is input, as the abnormality signal XHOT.

The control circuit **100** performs various processes, such as stop of the operation of the liquid discharge apparatus **1** and correction of the waveform of the driving signal COM, according to the temperature signal TH and the abnormality signal XHOT, which are input. That is, the abnormality signal XHOT is an example of an abnormality signal indicating presence or absence of the abnormality of the print head **23** and the driving signal selection circuits **200-1** to **200-*m***. Therefore, it is possible to increase a discharge accuracy of the ink from the discharge section **600**, and it is possible to prevent, in a print state, the operation abnormality, a failure, and the like of the print head **23** and the driving signal selection circuits **200-1** to **200-*m*** from occurring in advance. That is, the diagnosis, which performed by the temperature abnormality detection circuits **250-1** to **250-*m***, of whether or not the temperatures of the print head **23** and the driving signal selection circuits **200-1** to **200-*m*** are abnormal, is one of the self-diagnoses of the print head **23**. Note that, each of the temperature abnormality detection circuits **250-1** to **250-*m*** may be configured as an integrated circuit device. In addition, as described above, the respective temperature abnormality detection circuits **250-1** to **250-*m*** are provided to correspond to the respective driving signal selection circuits **200-1** to **200-*m***. Therefore, each of the driving signal selection circuits **200-1** to **200-*m*** and the relevant temperature abnormality detection circuits **250-1** to **250-*m*** may be configured as one integrated circuit device.

As described above, the liquid discharge apparatus **1** according to the embodiment includes the control mechanism **10** and the head unit **20** having the print heads **23-1** to **23-*n***. The control mechanism **10** outputs, as the control signal Ctrl-P**1**, the print data signals SI**1** to SIm, the change signal CH, the latch signal LAT, the clock signal SCK, the driving signal COM**1** including the driving signals COM-**1** to COM-m, and the reference voltage signal CGND**1** including the reference voltage signals CGND-**1** to CGND-m with respect to the print head **23-1**. The print head **23-1** discharges the ink to the medium M based on the control signal Ctrl-P**1**, the driving signal COM**1**, and the reference voltage signal CGND**1**, which are input.

Similarly, the control mechanism **10** outputs, as the control signal Ctrl-Pi, the print data signals SI**1** to SIm, the change signal CH, the latch signal LAT, the clock signal SCK, the driving signal COMi including the driving signals COM-**1** to COM-m, and the reference voltage signal CGNDi including the reference voltage signals CGND-**1** to CGND-m, with respect to the print head **23-*i***. The print head **23-*i*** discharges the ink to the medium M based on the control signal Ctrl-Pi, the driving signal COMi, and the reference voltage signal CGNDi, which are input. As a result, the ink lands on a desired location of the medium M transported by the transport mechanism **40**, and a desired image is formed on the medium M.

Here, the driving signal selection circuits **200-1** to **200-*n*** have the same circuit configuration. Therefore, in the description below, when it is not necessary to distinguish between the driving signal selection circuits **200-1** to **200-*n***, there is a case where the driving signal selection circuits **200-1** to **200-*n*** are referred to as a driving signal selection circuit **200**. In this case, description will be performed while it is assumed that the driving signal selection circuit **200** selects the waveform of the driving signal COM based on the print data signal SI to generate the driving signal VOUT to be supplied to the relevant piezoelectric element **60**.

1.2.2 Electrical Configuration of Driving Signal Selection Circuit

Next, an electrical configuration of the driving signal selection circuit **200** will be described. When the electrical configuration of the driving signal selection circuit **200** is described, an example of the waveform of the driving signal COM input to the driving signal selection circuit **200** and an example of the waveform of the driving signal VOUT generated based on the driving signal COM will be described first.

FIG. **4** is a diagram illustrating the example of the waveform of the driving signal COM. As illustrated in FIG. **4**, the driving signal COM is a waveform acquired by succeeding a trapezoid waveform Adp**1** disposed in a period T**1** from when the latch signal LAT rises to when the change signal CH rises, a trapezoid waveform Adp**2** disposed in a period T**2** until the change signal CH subsequently rises after the period T**1**, and a trapezoid waveform Adp**3** disposed in a period T**3** until the latch signal LAT subsequently rises after the period T**2**. Further, when the trapezoid waveform Adp**1** is supplied to one end of the piezoelectric element **60**, an intermediate amount of ink is discharged from the discharge section **600** corresponding to the piezoelectric element **60**. In addition, when the trapezoid waveform Adp**2** is supplied to one end of the piezoelectric element **60**, a small amount, which is less than the intermediate amount, of ink is discharged from the discharge section **600** corresponding to the piezoelectric element **60**. In addition, when the trapezoid waveform Adp**3** is supplied to one end of the piezoelectric element **60**, the ink is not discharged from the discharge section **600** corresponding to the piezoelectric element **60**. Here, the trapezoid waveform Adp**3** is a waveform for preventing ink viscosity from increasing by slightly vibrating the ink in a vicinity of a nozzle opening section of the discharge section **600**.

Here, a cycle Ta, from when the latch signal LAT illustrated in FIG. **4** rises to when the latch signal LAT subsequently rises, corresponds to a print cycle at which a new dot is formed on the medium M. That is, the latch signal LAT is also a signal for prescribing an ink discharge timing. In other words, the latch signal LAT serves both as a signal for performing the self-diagnosis of the print head **23** and a signal for prescribing the ink discharge timing. In addition, the change signal CH is also a signal for prescribing a waveform switching timing of the trapezoid waveforms Adp**1**, Adp**2**, and Adp**3** included in the driving signal COM. In other words, the change signal CH serves both as the signal for performing the self-diagnosis of the print head **23** and a signal for prescribing a waveform switching timing of the driving signal COM.

Note that, all voltages at timings, at which the respective trapezoid waveforms Adp**1**, Adp**2**, and Adp**3** start and end, are common to a voltage Vc. That is, the respective trapezoid waveforms Adp**1**, Adp**2**, and Adp**3** are waveforms which start with the voltage Vc and end with the voltage Vc. Note that, the driving signal COM may be, at the cycle Ta, a signal having a waveform acquired by succeeding one or two trapezoid waveforms or may be a signal having a waveform acquired by succeeding four or more trapezoid waveforms.

FIG. **5** is a diagram illustrating an example of a waveform of the driving signal VOUT corresponding to each of a "large dot", a "middle dot", a "small dot", and a "non-recording".

As illustrated in FIG. **5**, the driving signal VOUT corresponding to the "large dot" has a waveform acquired by succeeding, at the cycle Ta, the trapezoid waveform Adp**1** disposed in the period T**1**, the trapezoid waveform Adp**2** disposed in the period T**2**, and a voltage waveform disposed in the period T**3** to be fixed at the voltage Vc. When the driving signal VOUT is supplied to one end of the piezoelectric element **60**, an intermediate amount of ink and a small amount of ink are discharged from the discharge section **600** corresponding to the piezoelectric element **60** at the cycle Ta. Therefore, the ink lands and coalesces on the medium M, and thus the large dot is formed.

The driving signal VOUT corresponding to the "middle dot" is a waveform acquired by succeeding, at the cycle Ta, the trapezoid waveform Adp**1** disposed in the period T**1** and a voltage waveform disposed in the periods T**2** and T**3** to be fixed at the voltage Vc. When the driving signal VOUT is supplied to one end of the piezoelectric element **60**, an intermediate amount of ink is discharged from the discharge section **600** corresponding to the piezoelectric element **60** at the cycle Ta. Therefore, the ink lands on the medium M, and thus the middle dot is formed.

The driving signal VOUT corresponding to the "small dot" is a waveform acquired by succeeding, at the cycle Ta, the voltage waveforms disposed in the periods T**1** and T**3** to be fixed at the voltage Vc and the trapezoid waveform Adp**2** disposed in the period T**2**. When the driving signal VOUT is supplied to one end of the piezoelectric element **60**, a small amount of ink is discharged from the discharge section **600** corresponding to the piezoelectric element **60** at the cycle Ta. Therefore, the ink lands on the medium M, and thus the small dot is formed.

The driving signal VOUT corresponding to the "non-recording" is a waveform acquired by succeeding, at the cycle Ta, the voltage waveforms disposed in the periods T**1** and T**2** to be fixed at the voltage Vc and the trapezoid waveform Adp**3** disposed in the period T**3**. When the driving signal VOUT is supplied to one end of the piezoelectric element **60**, the ink in the vicinity of the nozzle opening section of the discharge section **600** corresponding to the piezoelectric element **60** only slightly vibrates at the cycle Ta, and thus the ink is not discharged. Therefore, the ink does not land on the medium M, and thus the dot is not formed.

Here, the voltage waveform fixed at the voltage Vc is a waveform having a voltage, in which an immediately before voltage Vc is maintained by a capacity component of the piezoelectric element **60**, when none of the trapezoid waveforms Adp**1**, Adp**2**, and Adp**3** is selected as the driving signal VOUT. Therefore, when none of the trapezoid waveforms Adp**1**, Adp**2**, and Adp**3** is selected as the driving signal VOUT, the voltage waveform fixed at the voltage Vc is supplied, as the driving signal VOUT, to the piezoelectric element **60**.

Note that, the driving signal COM and the driving signal VOUT, which are illustrated in FIGS. **4** and **5**, are only examples, and a combination of various waveforms may be used according to a physical property of the ink to be supplied to the print head **23**, a material of the medium M, a transport speed, and the like.

Next, a configuration and an operation of the driving signal selection circuit **200** will be described with reference to FIGS. **6** to **9**. FIG. **6** is a diagram illustrating a configuration of the driving signal selection circuit **200**. As illustrate in FIG. **6**, the driving signal selection circuit **200** includes a selection control circuit **220** and a plurality of selection circuits **230**.

The print data signal SI, the latch signal cLAT, the change signal cCH, and the clock signal cSCK are input to the selection control circuit **220**. In addition, in the selection control circuit **220**, a set of a shift register (SIR) **222**, a latch circuit **224**, and a decoder **226** is provided to correspond to p number of discharge sections **600**. That is, the driving signal selection circuit **200** includes p number of sets of the shift register **222**, the latch circuit **224**, and the decoder **226**, the number of sets being the same as a total number of the relevant discharge sections **600**. Here, the print data signal SI is also a signal for prescribing waveform selection of the trapezoid waveforms Adp**1**, Adp**2**, and Adp**3** included in the driving signal COM. That is, the print data signal SI**1** in the print data signal SI serves both as the signal for performing the self-diagnosis of the print head **23** and the signal for prescribing the waveform selection of the driving signal COM. In addition, the clock signal SCK and the clock signal cSCK prescribe timing at which the print data signal SI is input to the selection control circuit **220**. That is, the clock signal SCK serves both as the signal for performing the self-diagnosis of the print head **23** and a clock signal SCK for inputting the print data signal SI.

Specifically, the print data signal SI is a signal synchronized with the clock signal SCK, and is a total 2p-bit signal including 2-bit print data [SIH, SIL] for selecting any of the "large dot", the "middle dot", the "small dot", and the "non-recording" with respect to each of the p number of discharge sections **600**. The print data signal SI is maintained in the shift register **222** for each 2-bit print data [SIH, SIL] included in the print data signal SI to be correspond to the discharge section **600**. Specifically, the stage shift registers **222** in p stages corresponding to the discharge sections **600** are cascade coupled to each other, and the serially-input print data signal SI is sequentially transmitted to a subsequent stage according to the clock signal cSCK. Note that, in FIG. **6**, in order to distinguish the shift registers **222**, a first stage, a second stage, . . . , a p-th stage are sequentially described from upstream to which the print data signal SI is input. Here, the print data signal SI may be a signal which includes, in the 2-bit print data [SIH, SIL], the print data [SIH] corresponding to each of the p number of discharge sections **600** in serial and which includes, subsequent to the print data [SIH] corresponding to each of the p number of discharge sections **600**, the print data [SIL] corresponding to each of the m number of discharge sections **600** in serial.

Each of the p number of latch circuits **224** latches the 2-bit print data [SIH, SIL] maintained in each of the p number of shift registers **222** when the latch signal cLAT rises.

Each of the p number of decoders **226** decodes the 2-bit print data [SIH, SIL] latched by each of the p number of latch circuits **224**. Further, the decoder **226** outputs a selection signal S for each of the periods T**1**, T**2**, and T**3** prescribed by the latch signal cLAT and the change signal cCH.

FIG. **7** is a table illustrating decoding content of the decoder **226**. The decoder **226** outputs the selection signal S according to the latched 2-bit print data (SIH, SIM. For example, when the 2-bit print data [SIH, SIL] is [1, 0], the decoder **226** outputs the selection signal S while setting the logical level of the selection signal to H, H, and L levels in the respective periods T**1**, T**2**, and T**3**.

The selection circuits **230** are provided to correspond to the respective discharge sections **600**. That is, the number of selection circuits **230** included in the driving signal selection circuit **200** is the same as the total number p of the relevant discharge sections **600**. FIG. **8** is a diagram illustrating a configuration of the selection circuit **230** corresponding to one discharge section **600**. As illustrated in FIG. **8**, the selection circuit **230** includes an inverter **232** which is a NOT circuit and a transfer gate **234**.

The selection signal S is input to a positive control end, to which a round mark is not attached, in the transfer gate **234**, and is input to a negative control end, to which the round mark is attached, in the transfer gate **234** by being logically inverted by the inverter **232**. In addition, the driving signal COM is supplied to an input end of the transfer gate **234**. Specifically, when the selection signal S is at the H level, the transfer gate **234** conducts (on) between the input end and the output end. When the selection signal S is at the L level, the transfer gate **234** does not conduct (off) between the input end and the output end. Further, the driving signal VOUT is output from the output end of the transfer gate **234**.

Here, an operation of the driving signal selection circuit **200** will be described with reference to FIG. **9**. FIG. **9** is a diagram illustrating the operation of the driving signal selection circuit **200**. The print data signal SI is serially input in synchronization with the clock signal cSCK, and is sequentially transmitted in the shift registers **222** corresponding to the discharge sections **600**. Further, when the input of the clock signal cSCK stops, the 2-bit print data [SIH, SIL] corresponding to each of the discharge sections **600** is maintained in each of the shift registers **222**. Note that, the print data signal SI is input in order which corresponds to the discharge sections **600** at the p-th stage, . . . , the second stage, and the first stage of the shift registers **222**.

Further, when the latch signal cLAT rises, the respective latch circuits **224** simultaneously latch the 2-bit print data [SIH, SIL] maintained in the shift registers **222**. Note that, in FIG. **9**, LT**1**, LT**2**, . . . , LTp indicate the 2-bit print data [SIH, SIL] latched by the latch circuits **224** corresponding to the first stage, the second stage, . . . , the p-th stage shift registers **222**.

The decoder **226** outputs the logical levels of the selection signal S with the content illustrated in FIG. **7** in the respective periods T**1**, T**2**, T**3** according to the size of the dot prescribed by the latched 2-bit print data [SIH, SIL].

Specifically, when the print data [SIH, SIL] is [**1**, **1**], the decoder **226** sets the selection signal S to H, H, and L levels in the periods T**1**, T**2**, and T**3**. In this case, the selection circuit **230** selects the trapezoid waveform Adp**1** in the period T**1**, selects the trapezoid waveform Adp**2** in the period T**2**, and does not select the trapezoid waveform Adp**3** in the period T**3**. As a result, the driving signal VOUT corresponding to the "large dot" illustrated in FIG. **5** is generated.

In addition, when the print data [SIH, SIL] is [1, 0], the decoder **226** sets the selection signal S to H, L, and L levels in the periods T**1**, T**2**, and T**3**. In this case, the selection circuit **230** selects the trapezoid waveform Adp**1** in the period T**1**, does not selects the trapezoid waveform Adp**2** in the period T**2**, and does not select the trapezoid waveform Adp**3** in the period T**3**. As a result, the driving signal VOUT corresponding to the "middle dot" illustrated in FIG. **5** is generated.

In addition, when the print data [SIH, SIL] is [0, 1], the decoder **226** sets the selection signal S to L, H, and L levels in the periods T**1**, T**2**, and T**3**. In this case, the selection circuit **230** does not select the trapezoid waveform Adp**1** in the period T**1**, selects the trapezoid waveform Adp**2** in the period T**2**, and does not select the trapezoid waveform Adp**3** in the period T**3**. As a result, the driving signal VOUT corresponding to the "small dot" illustrated in FIG. **5** is generated.

In addition, when the print data [SIH, SIL] is [0, 0], the decoder **226** sets the selection signal S to L, L, and H levels in the periods T**1**, T**2**, and T**3**. In this case, the selection circuit **230** does not select the trapezoid waveform Adp**1** in the period T**1**, does not select the trapezoid waveform Adp**2** in the period T**2**, and selects the trapezoid waveform Adp**3** in the period T**3**. As a result, the driving signal VOUT corresponding to the "non-recording" illustrated in FIG. **5** is generated.

As above, the driving signal selection circuit **200** selects the waveform of the driving signal COM based on the print data signal SI, the latch signal cLAT, the change signal cCH, and the clock signal cSCK, and outputs the driving signal VOUT. That is, in the driving signal selection circuit **200**, the driving signal VOUT is generated through the selection or non-selection of the waveform of the driving signal COM.

1.2.3 Electrical Configuration of Temperature Abnormality Detection Circuit

Next, the electrical configurations and the operations of the temperature abnormality detection circuits **250-1** to **250-*m*** will be described with reference to FIG. **10**. FIG. **10** is a diagram illustrating the configurations of the temperature abnormality detection circuits **250-1** to **250-*m***. As illustrated in FIG. **10**, the temperature abnormality detection circuit **250-1** includes a comparator **251**, a reference voltage output circuit **252**, a transistor **253**, a plurality of diodes **254**, and resistors **255** and **256**. Note that, all the temperature abnormality detection circuits **250-1** to **250-*m*** have the same configuration. Therefore, in FIG. **10**, only the detailed configuration of the temperature abnormality detection circuit **250-1** is illustrated, and detailed configurations of the temperature abnormality detection circuits **250-2** to **250-*m*** are not illustrated.

The low voltage signal VDD is input to the reference voltage output circuit **252**. The reference voltage output circuit **252** generates a voltage Vref by transforming the low voltage signal VDD, and supplies the voltage Vref to a + side input terminal of the comparator **251**. The reference voltage output circuit **252** is configured with, for example, a voltage regulator circuit or the like. Note that, the voltage Vref may be generated based on a Band Gap Reference (BGR) of the integrated circuit device included in the temperature abnormality detection circuit **250-1**.

The plurality of diodes **254** are coupled to each other in series. Further, the low voltage signal VDD is supplied to an anode terminal of the diode **254**, which is located on a highest potential side of the plurality of diodes **254** which are coupled in series, through the resistor **255**, and the ground signal GND is supplied to a cathode terminal of the diode **254** which is located on a lowest potential side. Specifically, the temperature abnormality detection circuit **250-1** includes diodes **254-1**, **254-2**, **254-3**, and **254-4** as the plurality of diodes **254**. The low voltage signal VDD is supplied to an anode terminal of the diode **254-1** through the resistor **255**, and the anode terminal of the diode **254-1** is coupled to a − side input terminal of the comparator **251**. A cathode terminal of the diode **254-1** is coupled to an anode terminal of the diode **254-2**. A cathode terminal of the diode **254-2** is coupled to an anode terminal of the diode **254-3**. A cathode terminal of the diode **254-3** is coupled to an anode terminal of the diode **254-4**. The ground signal GND is supplied to a cathode terminal of the diode **254-4**. A voltage Vdet, which is the sum of forward voltages of the plurality of respective diodes **254**, is supplied to a − side input terminal of the comparator **251** by the resistor **255** and the plurality of diodes **254**, which are configured as described above. Note that, the number of plurality of diodes **254** included in the temperature abnormality detection circuit **250-1** is not limited to four.

The comparator **251** operates due to potential difference between the low voltage signal VDD and the ground signal GND. Further, the comparator **251** compares the voltage Vref supplied to the + side input terminal with the voltage Vdet supplied to the − side input terminal, and outputs a signal, based on a result of the comparison, from the output terminal.

The low voltage signal VDD is supplied to a drain terminal of the transistor **253** through the resistors **256**. In addition, the transistor **253** includes a gate terminal coupled to the output terminal of the comparator **251** and a source terminal to which the ground signal GND is supplied. A voltage supplied to the drain terminal, which is coupled as above, of the transistor **253** is output, as the abnormality signal cXHOT, from the temperature abnormality detection circuit **250-1**.

A voltage value of the voltage Vref generated by the reference voltage output circuit **252** is lower than the voltage Vdet which is acquired when the temperatures of the plurality of diodes **254** are included in a prescribed range. In this case, the comparator **251** outputs a signal at the L level. Therefore, control is performed such that the transistor **253** is off, and, as a result, the temperature abnormality detection circuit **250-1** outputs the abnormality signal cXHOT at the H level.

The forward voltage of the diode **254** has a characteristic of being lowered when the temperature rises. Therefore, when the temperature abnormality occurs in the print head **23**, the temperature of the diode **254** rises, and thus the voltage Vdet lowers in accordance the rise of the temperature. Further, when the voltage Vdet is lower than the voltage Vref because the temperature rises, the output signal of the comparator **251** changes from the L level to the H level. Therefore, control is performed such that the transistor **253** is on. As a result, the temperature abnormality detection circuit **250-1** outputs the abnormality signal cXHOT at the L level. That is, when the control is performed such that the transistor **253** is on or off based on the temperature of the driving signal selection circuit **200**, the temperature abnormality detection circuit **250-1** outputs, as the abnormality signal cXHOT at the H level, the low voltage signal VDD supplied as a pull-up voltage of the transistor **253**, and outputs, as the abnormality signal cXHOT at the L level, the ground signal GND.

Here, as illustrated in FIG. **10**, wiring, through which the abnormality signal cXHOT is output from each of the temperature abnormality detection circuits **250-1** to **250-*m***, is commonly coupled. Therefore, the temperature abnormality detection circuits **250-1** to **250-*m*** are wired-OR coupled with each other. Therefore, when the temperature abnormality occurs in any of the temperature abnormality detection circuits **250-1** to **250-*m***, the abnormality signal cXHOT, which indicates the temperature abnormality, is input to the diagnostic circuit **240**.

1.3 Configuration of Print Head

Next, a configuration of the print head **23** included in the head unit **20** will be described. Note that, in the description below, description is performed while it is assumed that the print head **23** includes 6 number of driving signal selection circuits **200-1** to **200-6**. Therefore, in the print head **23** according to the first embodiment, the 6 number of print data signals SI**1** to SI**6**, the 6 number of driving signals COM-**1** to COM-**6**, and the 6 number of reference voltage signals CGND-**11** to CGND-**6**, which correspond to the 6 number of driving signal selection circuits **200-1** to **200-6**, respectively, are input. In addition, in the following description, X1, Y1, and Z1 directions that are independent of the above-described X, Y, and Z directions and are orthogonal to each other will be illustrated and described. In addition, a starting point side of an arrow indicating the X1 direction illustrated in the drawing is referred to as a −X1 side, a tip end side is referred to as a +X1 side, a starting point side of an arrow indicating the Y1 direction illustrated in the drawing is referred to as a −Y1 side, and a tip end side is referred to as a +Y1 side, a starting point side of an arrow indicating the Z1 direction illustrated in the drawing is referred to as a −Z1 side, and a tip end side is referred to as a +Z1 side.

FIG. **11** is a perspective view illustrating the configuration of the print head **23**. As illustrated in FIG. **11**, the print head **23** includes a head **310** and a substrate **320**. In addition, an ink discharge surface **311**, which is formed with the plurality of discharge sections **600**, is located on a surface of the +Z1 side of the head **310**. Further, the substrate **320** and the head **310** are fixed by an adhesive.

FIG. **12** is a plan diagram illustrating a configuration of the ink discharge surface **311** located on the +Z1 side of the head **310**. As illustrated in FIG. **12**, in the ink discharge surface **311**, six number of nozzle plates **632**, which each include a plurality of nozzles **651** for discharging the ink, are provided in line along a X1 direction. In addition, the plurality of nozzles **651** are provided in line along the Y1 direction in each of the nozzle plates **632**. ‘That is, in the ink discharge surface **311**, the six nozzle plates **632**, in which the plurality of nozzles **651** for discharging the ink are provided in line in a direction along a side **323** of the substrate **320** extending along the Y1 direction, are provided in line in order of nozzle rows L1 to L6 along the X1 direction. Note that, in FIG. **12**, in the nozzle rows L**1** to L**6** formed on the respective nozzle plates **632**, the nozzles **651** are provided in one line along the Y1 direction. However, the nozzles **651** may be provided in two or more lines along the Y1 direction.

The nozzle rows L**1** to L**6** are provided to correspond to the respective driving signal selection circuits **200-1** to **200-6**. Specifically, the driving signal VOUT-**1**, which is output by the driving signal selection circuit **200-1**, is supplied to one ends of the piezoelectric elements **60** included in the plurality of discharge sections **600** provided in the nozzle row L**1**. In addition, the reference voltage signal CGND-**1** is supplied to the other ends of the piezoelectric elements **60**. Similarly, the driving signals VOUT-**2** to VOUT-**6** output by the respective driving signal selection circuits **200-2** to **200-6** are supplied to one ends of the piezoelectric elements **60** included in the plurality of respective discharge sections **600** provided in the relevant nozzle rows L**2** to L**6**, and the relevant reference voltage signals CGND-**2** to CGND-**6** are supplied to the other ends of the piezoelectric elements **60**.

Next, a configuration of the discharge section **600** included in the head **310** will be described with reference to FIG. **13**. FIG. **13** is a diagram illustrating a schematic configuration of one of the plurality of discharge sections **600** included in the head **310**. As illustrated in FIG. **13**, the head **310** includes the discharge section **600** and a reservoir **641**.

The reservoir **641** is provided in each of the nozzle rows L**1** to L**6**. Further, the ink is introduced from an ink supply port **661** to the reservoir **641**.

The discharge section **600** includes the piezoelectric element **60**, a vibration plate **621**, a cavity **631**, and a nozzle **651**. The vibration plate **621** varies in accordance with displacement of the piezoelectric element **60** provided on an upper surface in FIG. **13**. Further, the vibration plate **621** functions as a diaphragm which enlarges/reduces an internal volume of the cavity **631**. An inside of the cavity **631** is filled with the ink. Further, the cavity **631** functions as a pressure chamber in which the internal volume changes according to the displacement of the piezoelectric element **60**. The nozzle **651** is an opening section which is formed on the nozzle plate **632** and which communicates with the cavity **631**. Further, the nozzle **651** communicates with the cavity **631**, and discharges the ink on the inside of the cavity **631** according to the change in the internal volume of the cavity **631**.

The piezoelectric element **60** has a structure in which a piezoelectric substance **601** is interposed between a pair of electrodes **611** and **612**. In the piezoelectric substance **601** of the structure, according to a voltage which is supplied to the electrodes **611** and **612**, central parts of the electrodes **611** and **612** and the vibration plate **621** are bent in upper and lower directions with respect to both end parts in FIG. **13**. Specifically, the driving signal VOUT is supplied to the electrode **611**, and the reference voltage signal CGND is supplied to the electrode **612**. Further, when the voltage of the driving signal VOUT becomes high, a central part of the piezoelectric element **60** is bent in an upper direction. When the voltage of the driving signal VOUT becomes low, the central part of the piezoelectric element **60** is bent in a lower direction. That is, when the piezoelectric element **60** is bent in the upper direction, the internal volume of the cavity **631** is enlarged. Therefore, the ink is drawn from the reservoir **641**. In addition, when the piezoelectric element **60** is bent in the lower direction, the internal volume of the cavity **631** is reduced. Therefore, an amount of ink according to a degree of reduction in the internal volume of the cavity **631** is discharged from the nozzle **651**. As above, the nozzle **651** discharges the ink based on the driving signal VOUT and the driving signal COM which is the basis of the driving signal VOUT.

Note that, the piezoelectric element **60** is not limited to the illustrated structure, and may be a type which is capable of discharging the ink in accordance with the displacement of the piezoelectric element **60**. In addition, the piezoelectric element **60** is not limited to flexural vibration, and may have a configuration using longitudinal vibration. Here, the head **310**, which includes the nozzle plate **632**, the ink supply port **661**, the reservoir **641**, and the cavity **631**, is an example of a discharge module.

Returning to FIG. **11**, the substrate **320** includes a side **323** and a side **324**, which are provided in parallel to each other, a side **325** and a side **326**, which are provided in parallel to each other, a surface **321**, and a surface **322** which is different from the surface **321**. The substrate **320** has a shape in which the side **323** is orthogonal to the side **325** and the side **326**, and in which the side **324** is orthogonal to the side **325** and the side **326**. In other words, the substrate **320** has the side **323**, the side **326** which intersects with the side **323**, the surface **321** including the side **323** and the side **326**, and the surface **322** different from the surface **321**. Further, the substrate **320** includes the side **324** provided to be parallel to the side **323**, and the side **325** provided to be parallel to the side **326**, and the surface **321** has a rectangular shape which includes the side **323**, the side **324**, the side **325**, and the side **326**.

Here, the surface **321** and the surface **322** of the substrate **320** are surfaces which are located to face each other through a base material of the substrate **320**, in other words, the surface **321** and the surface **322** are front and back surfaces of the substrate **320**. Further, the substrate **320** is provided so that the surface **321** is on the +Z1 side and the surface **322** is on the −Z1 side in the print head **23**. Here, the surface **321** of the substrate **320** is an example of a first surface, and the surface **322** which is different from the surface **321** is an example of a second surface. In addition, the side **323** is an example of a first side, the side **326** is an example of a second side, the side **324** is an example of a third side, and the side **325** is an example of a fourth side.

In addition, in the print head **23**, the substrate **320** is provided on an opposite side of the ink discharge surface **311**, from which the ink is discharged, with respect to the nozzle plate **632**, that is, the substrate **320** is provided so that the surface **321** is on a side of the nozzle plate **632**. In other words, in the print head **23**, the substrate **320** is located on the −Z1 side of the head **310** which has the nozzle plates **632**, and is provided so that the surface **321** is on the +Z side and the surface **322** is on the −Z1 side.

A first connector **350** and a second connector **360** are provided in the substrate **320**. The first connector **350** is provided on a side of the surface **321** of the substrate **320** along the side **323**. Further, at least any of the print data signals SI**1** to SIn, the change signal CH, the latch signal LAT, and the clock signal SCK is input to the first connector **350**. In addition, the second connector **360** is provided on a side of the surface **322** of the substrate **320** along the side **323**. Further, at least any of the print data signals SI**1** to SIn, the change signal CH, the latch signal LAT, and the clock signal SCK is input to the second connector **360**. Note that, detailed examples of the signals, which are input to the print head **23** through the first connector **350** and the second connector **360**, will be described later. Here, the first connector **350**, which is provided in the surface **321** of the substrate **320** and to which at least one of the print data signals SI**1** to SIn, the change signal CH, the latch signal LAT, and the clock signal SCK is input from the control circuit **100**, is an example of a connector.

Next, configurations of the first connector **350** and the second connector **360**, which are provided in the substrate **320**, will be described with reference to FIG. **14**. FIG. **14** is a diagram illustrating the configurations of the first connector **350** and the second connector **360**.

The first connector **350** has a substantially rectangular parallelepiped shape including a plurality of sides having a side **354** and a side **355**, which is orthogonal to the side **354** and is longer than the side **354**, and a plurality of surfaces which are formed by the plurality of sides. Further, the first connector **350** is provided so that the side **355** of the first connector **350** is parallel to the side **323** of the substrate **320**. The first connector **350** includes a housing **351**, a cable attachment section **352**, and a plurality of terminals **353**. The cable attachment section **352** is a long and narrow opening along the side **355**. A not-shown cable, which electrically couples the control mechanism **10** to the print head **23** included in the head unit **20**, is attached to the cable attachment section **352**. In addition, the plurality of terminals **353** are provided in line in a direction along the side **355**. That is, the plurality of terminals **353** are provided in line in the direction along the side **323** of the substrate **320**.

Further, when the cable is attached to the cable attachment section **352**, each of the plurality of terminals included in the cable is electrically coupled to each of the plurality of terminals **353** included in the first connector **350**. Therefore, the various signals output from the control mechanism **10** are input to the print head **23**. Note that, in the first embodiment, description is performed while it is assumed that 24 number of terminals **353** are provided in parallel along the side **323** in the first connector **350**. In addition, in the following description, there is a case where 24 number of terminals **353** provided in parallel are sequentially referred to as terminals **353-1**, **353-2**, . . . , **353-24** toward the side **325** from a side of the side **326** in the direction along the side **323**. Here, the side **354** is an example of a fifth side, and the side **355** is an example of a sixth side.

The second connector **360** has a substantially rectangular parallelepiped shape including a plurality of sides having a side **364** and a side **365**, which is orthogonal to the side **364** and is longer than the side **364**, and a plurality of surfaces which are formed by the plurality of sides. Further, the second connector **360** is provided in the substrate **320** such that the side **365** of the second connector **360** is parallel to the side **323** of the substrate **320**. The second connector **360** includes a housing **361**, a cable attachment section **362**, and a plurality of terminals **363**. The cable attachment section **362** is a long and narrow opening along the side **365**. A not-shown cable, which electrically couples the control mechanism **10** to the print head **23** included in the head unit **20**, is attached to the cable attachment section **362**. The plurality of terminals **363** are provided in line in the direction along the side **323**. Further, when the cable is attached to the cable attachment section **362**, the plurality of respective terminals included in the cable are electrically coupled to the plurality of respective terminals **363** included in the second connector **360**. Therefore, the various signals output by the control mechanism **10** are input to the print head **23**. Note that, in the first embodiment, description is performed while it is assumed that 24 number of terminals **363** are provided in parallel along the side **323** in the second connector **360**. In addition, in the following description, there is a case where the 24 number of terminals **363** are referred to as terminals **363-1**, **363-2**, . . . , **363-24** sequentially from the side of the side **325** toward the side of the side **326** in the direction along the side **323**.

Next, examples of signals which are input to each of the first connector **350** and the second connector **360** will be described with reference to FIGS. **15** and **16**. FIG. **15** is a diagram illustrating examples of the signals respectively input to the plurality of terminals **353** included in the first connector **350**. In addition, FIG. **16** is a diagram illustrating examples of signals respectively input to the plurality of terminals **363** included in the second connector **360**.

As illustrated in FIG. **15**, the print data signal SI**1**, the change signal CH, the latch signal LAT, the clock signal SCK, the temperature signal TH, the abnormality signal XHOT, and the plurality of ground signals GND are input to the terminals **353-1** to **353-12** in order to control the discharge of the ink. In addition, the driving signals COM-**1** to COM-**6** and the reference voltage signals CGND-**1** to CGND-**6** are input to the terminals **353-13** to **353-24** in order to drive the piezoelectric elements **60**. That is, a control signal of a low voltage and a signal, which indicates a reference potential of the control signal, are input to the plurality of terminals **353** provided on the side of the side **326** of the first connector **350**, and a driving signal of the high voltage and a signal, which indicates a reference potential of the driving signal, are input to the plurality of terminals **353** provided on the side of the side **325** of the first connector **350**. As above, the terminals, to which the signal of the high voltage is input, and the terminals, to which the signal of the low voltage is input, are separately provided in the first connector **350**, and thus it is possible to reduce a problem in that the signal of the high voltage interferes in the control signal which is the signal of the low voltage.

Further, the terminals, to which the ground signal GND is input, are located between the terminals **353** to which the print data signal SI**1**, the change signal CH, the latch signal LAT, the clock signal SCK, the temperature signal TH, and the abnormality signal XHOT are respectively input. Specifically, the terminal **353-3**, to which the ground signal GND is input, is located between the terminal **353-2**, to which the temperature signal TH is input, and the terminal **353-4** to which the latch signal LAT is input. In addition, the terminal **353-5**, to which the ground signal GND is input, is located between the terminal **353-4**, to which the latch signal LAT is input, and the terminal **353-6** to which the clock signal SCK is input. In addition, the terminal **353-7**, to which the ground signal GND is input, is located between the terminal **353-6**, to which the clock signal SCK is input, and the terminal **353-8** to which the change signal CH is input. In addition, the terminal **353-9**, to which the ground signal GND is input, is located between the terminal **353-8**, to which the change signal CH is input, and the terminal **353-10** to which the print data signal SI**1** is input. In addition, the terminal **353-11**, to which the ground signal GND is input, is located between the terminal **353-10**, to which the print data signal SI**1** is input, and the terminal **353-12** to which the abnormality signal XHOT is input.

As described above, each of the print data signal SI**1**, the change signal CH, the latch signal LAT, and the clock signal SCK serves both as the signal for performing the self-diagnosis of the print head **23** in the diagnostic circuit **240** and a signal for controlling the discharge of the ink. When the terminal **353**, to which the ground signal GND that is a signal of the reference potential is input, is located between the terminals **353** to which the important signals are input, it is possible to reduce a problem in that the print data signal SI**1**, the change signal CH, the latch signal LAT, and the clock signal SCK interfere in each other.

As illustrated in FIG. **16**, the driving signals COM-**1** to COM-**6** and the reference voltage signals CGND-**1** to CGND-**6** are input to the terminals **363-1** to **363-12** in order to drive the piezoelectric elements **60**. In addition, the high voltage signal VHV, which is the signal of the high voltage, is input to the terminal **363-14**. In addition, the print data signals SI**2** to SI**6**, the low voltage signal VDD which is the signal of the low voltage, and the plurality of ground signals

GND are input to the terminals **363-15** to **363-24** in order to control the discharge of the ink. That is, the control signal of the low voltage and a signal, which indicates the reference potential of the control signal, are input to the plurality of terminals **363** provided on the side of the side **326** of the second connector **360**, and the driving signal of the high voltage and a signal, which indicates the reference potential of the driving signal, are input to the plurality of terminals **363** provided on the side of the side **325** of the second connector **360**. As above, when the terminals, to which the signal of the high voltage is input, and the terminals, to which the signal of the low voltage is input, are separately provided in the second connector **360**, it is possible to reduce a problem in that the high voltage signal interferes in the signal of the low voltage.

Next, a configuration of the substrate **320** included in the print head **23** will be described. As illustrated in FIGS. **17** to **18**, the substrate **320** is provided so that the side **323** and the side **324** are located along the Y1 direction, and the side **325** and the side **326** are located along the X1 direction. Here, a length of the side **323** of the substrate **320** is shorter than a length of the side **326**. That is, the substrate **320** is a substantially rectangular shape having the side **323** as a short side and the side **326** as a long side.

FIG. **17** is a plan diagram illustrating a case where the substrate **320** is viewed from the surface **322**. In addition, FIG. **18** is a plan diagram illustrating a case where the substrate **320** is viewed from the surface **321**. Note that, in FIG. **18**, a location of the head **310** provided on the side of the surface **321** of the substrate **320** is illustrated using broken lines.

As illustrated in FIGS. **17** and **18**, the surface **322** of the substrate **320** includes ink supply path insertion holes **331***a* to **331***f*, into which the ink supply ports **661** for introducing the ink to the discharge sections **600** corresponding to the respective nozzle rows L1 to L6 are inserted, electrode groups **330***a* to **330***f* to which a flexible wiring substrates (Flexible Printed Circuits (FPC)) **335**, which will be described later, is electrically coupled, and FPC insertion holes **332***a* to **332***c* into which the flexible wiring substrates **335** are inserted. Here, the ink supply path insertion holes **331***a* to **331***f* and the FPC insertion holes **332***a* to **332***c* are through holes which pass through the surface **321** and the surface **322** of the substrate **320**.

Each of the electrode groups **330***a* to **330***f* includes a plurality of electrodes disposed in line to be parallel to the side **323** along the Y1 direction, and is disposed to be parallel to the side **325** along the X1 direction. Specifically, the electrode group **330***a* includes the plurality of electrodes provided in parallel along the Y1 direction. In addition, the electrode group **330***b* is located on a side of the side **324** of the electrode group **330***a*, and includes a plurality of electrodes provided in parallel along the Y1 direction. In addition, the electrode group **330***c* is located on the side of the side **324** of the electrode group **330***b*, and includes a plurality of electrodes provided in parallel along the Y1 direction. In addition, the electrode group **330***d* is located on the side of the side **324** of the electrode group **330***c*, and includes a plurality of electrodes provided in parallel along the Y1 direction. In addition, the electrode group **330***e* is located on the side of the side **324** of the electrode group **330***d*, and includes a plurality of electrodes provided in parallel along the Y1 direction. In addition, the electrode group **330***f* is located on the side of the side **324** of the electrode group **330***e*, and includes a plurality of electrodes provided in parallel along the Y1 direction.

Further, the flexible wiring substrates **335** which will be described later are electrically coupled to the respective electrode groups **330***a* to **330***f*. That is, the print head **23** includes the plurality of flexible wiring substrates **335** electrically coupled to the substrate **320**, and each of the plurality of flexible wiring substrates **335** is electrically coupled to each of the electrode groups **330***a* to **330***f* provided in the surface **322** of the substrate **320**. In other words, the flexible wiring substrates **335** are electrically coupled to the surface **322** of the substrate **320**.

Here, each of the FPC insertion holes **332***a* to **332***c* is an insertion hole into which the substrate **320** is inserted, and a width of each of the FPC insertion holes **332***a* to **332***c* in a direction parallel to the side **323** which is the Y1 direction is larger than a width in a direction parallel to the side **326** which is the X1 direction. Further, the respective FPC insertion holes **332***a* to **332***c* are located in line to be parallel to the side **325** which is the X1 direction. That is, the substrate **320** includes the FPC insertion hole **332***a* through which the flexible wiring substrate **335** is inserted and the FPC insertion hole **332***b* through which the flexible wiring substrate **335** is inserted. A width in a direction along the side **323** of the FPC insertion hole **332***a* is larger than a width in a direction along the side **326**, and the FPC insertion hole **332***a* and the FPC insertion hole **332***b* are located so that at least portions thereof overlap in the direction along the side **326**.

The flexible wiring substrates **335** are inserted into the respective FPC insertion holes **332***a* to **332***c* which are located as above. Specifically, the FPC insertion hole **332***a* is located between the electrode group **330***a* and the electrode group **330***b* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to the electrode group **330***a* and the flexible wiring substrate **335** electrically coupled to the electrode group **330***b* are inserted into the FPC insertion hole **332***a*. In addition, the FPC insertion hole **332***b* is located between the electrode group **330***c* and the electrode group **330***d* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to the electrode group **330***c* and the flexible wiring substrate **335** electrically coupled to the electrode group **330***d* are inserted into the FPC insertion hole **332***b*. In addition, the FPC insertion hole **332***c* is located between the electrode group **330***e* and the electrode group **330***f* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to the electrode group **330***e* and the flexible wiring substrate **335** electrically coupled to the electrode group **330***f* are inserted into the FPC insertion hole **332***c*.

Here, the FPC insertion hole **332***a* is an example of a first FPC insertion hole, and the FPC insertion hole **332***b* is an example of a second FPC insertion hole. Further, the flexible wiring substrate **335** electrically coupled to the substrate **320** and inserted into the FPC insertion hole **332***a* is an example of a first flexible wiring substrate, and the flexible wiring substrate **335** electrically coupled to the substrate **320** and inserted into the FPC insertion hole **332***b* is an example of a second flexible wiring substrate.

The ink supply path insertion hole **331***a* is located on a side of the side **323** of the electrode group **330***a* in the X1 direction. In addition, the ink supply path insertion holes **331***b* and **331***c* are located between the electrode group **330***b* and the electrode group **330***c* in the X1 direction, and are located in line along the Y1 direction such that the ink supply path insertion hole **331***b* is on the side of the side **325** and the ink supply path insertion hole **331***c* is on the side of the side **326**. The ink supply path insertion holes **331***d* and **331***e* are located between the electrode group **330***d* and the electrode group **330***e* in the X1 direction, and are located in line along the Y1 direction such that the ink supply path insertion hole **331***d* is on the side of the side **325** and the ink supply path insertion hole **331***e* is on the side of the side **326**. The ink supply path insertion hole **331***f* is located on the side of the side **324** of the electrode group **330***f* in the X1 direction.

The ink supply ports **661**, which introduce the ink to the discharge sections **600** corresponding to the respective nozzle rows L**1** to L**6**, are inserted into the respective ink supply path insertion holes **331***a* to **331***f* which are provided as above.

Here, a relationship between the flexible wiring substrates **335**, which are inserted into the FPC insertion holes **332***a* to **332***c*, the ink supply ports **661**, which are inserted into the ink supply path insertion holes **331***a* to **331***f*, and the substrate **320** will be described with reference to FIG. **19**. FIG. **19** is a diagram illustrating a cross section of the print head **23** when cutting is performed such that the print head **23** includes at least any of the FPC insertion holes **332***a* to **332***c* or at least any of the ink supply path insertion holes **331***a* to **331***f*. Note that, in description with reference to FIG. **19**, the FPC insertion holes **332***a* to **332***c* are simply referred to as the FPC insertion hole **332**, the ink supply path insertion holes **331***a* to **331***f* are simply referred to as the ink supply path insertion hole **331**, and the electrode groups **330***a* to **330***f* are simply referred to as the electrode group **330**.

As illustrated in FIG. **19**, the flexible wiring substrate **335** is inserted into the FPC insertion hole **332**. The flexible wiring substrate **335** has one end coupled to the electrode group **330** provided in the surface **322** of the substrate **320** and another end coupled to one end of the electrode wiring **337**. Further, another end of the electrode wiring **337** is coupled to the electrode **611** of the piezoelectric element **60**. In addition, an integrated circuit device **201** is mounted on the flexible wiring substrate **335** in a Chip On Film (COF) manner. That is, the integrated circuit device **201** is located between the nozzle plate **632** and the substrate **320**. The integrated circuit device **201** includes the driving signal selection circuit **200** and the temperature abnormality detection circuit **250**. Further, when the print data signal SI1, the change signal CH, the latch signal LAT, the clock signal SCK, and the driving signal COM are input to the integrated circuit device **201** through the electrode group **330**, the driving signal selection circuit **200** included in the integrated circuit device **201** generates and outputs the driving signal VOUT.

Further, the integrated circuit device **201** supplies the generated driving signal VOUT to the electrode **611** of the piezoelectric element **60** through the electrode wiring **337**. Here, although not illustrated in FIG. **19**, an integrated circuit device **241** including the diagnostic circuit **240** which will be described later is provided in the surface **321** of the substrate **320** in a space formed between the substrate **320** and the head **310**. That is, the integrated circuit device **241** is located between the nozzle plate **632** and the substrate **320**. For example, the space in which the integrated circuit device **241** is located is formed in such a way that the head **310** has a recess in a part of the surface fixed to the substrate **320**. Here, the integrated circuit device **201**, which includes the driving signal selection circuit **200** and is provided on the flexible wiring substrate **335**, is an example of a second integrated circuit.

In addition, the ink supply port **661** that supplies the ink to the print head **23** is inserted through the ink supply path insertion hole **331** of the substrate **320**. That is, the ink supply port **661** is located on the side of the surface **322** of the substrate **320**, and the discharge section **600** is located on the side of the surface **321** of the substrate **320**. Further, the substrate **320** is located between the nozzle plate **632**, on which the nozzles **651** are formed, and the ink supply port **661**. In other words, the substrate **320** includes the ink supply path insertion hole **331** through which the ink supply port **661** is inserted, and the print head **23** includes the ink supply port **661** through which the ink is supplied. Further, the substrate **320** is provided in a location where the shortest distance between the ink supply port **661** and the surface **321** is longer than the shortest distance between the ink supply port **661** and the surface **322**. That is, the ink supply port **661** is located on the side of the surface **322** of the substrate **320** and on the −Z1 side corresponding to the upper side than the substrate **320** in a direction along the Z1 direction. Here, the ink supply port **661** is an example of a liquid supply port, and the ink supply path insertion hole **331** is an example of a liquid supply port insertion hole.

Returning to FIGS. **17** and **18**, the substrate **320** includes fixing holes **346** to **349** for fixing the substrate **320** included in the print head **23**. The fixing holes **346** to **349** are through holes which pass through the surface **321** and the surface **322** of the substrate **320**. Further, not-shown fixing members are inserted into the fixing holes **346** to **349**. That is, the print head **23** includes the fixing members for fixing the substrate **320**, and the substrate **320** includes the fixing holes **346** to **349** into which the fixing members are inserted. Further, when the substrate **320** is fixed by the fixing members, the print head **23** is incorporated in the head unit **20**.

Here, for example, screws can be used as the fixing members that fix the substrate **320**. Specifically, when the screws are inserted through the fixing holes **346** to **349** and the screws are tightened, the print head **23** including the substrate **320** is fixed to the head unit **20**. In addition, when the head unit **20** has protrusions serving as the fixing members that fix the substrate **320**, and the protrusions are inserted through the fixing holes **346** to **349** and fitted to each other, the print head **23** including the substrate **320** may be fixed to the head unit **20**. Further, the print head **23** including the substrate **320** may be incorporated in the head unit **20** by using the above-mentioned screw and the protrusion as the fixing member. Here, any of the fixing holes **346** to **349** is an example of a fixing member insertion hole. Note that, in the following description, description will be performed while it is assumed that the fixing hole **347** in the fixing holes **346** to **349** corresponds to the fixing member insertion hole of the present embodiment.

The fixing holes **346** and **347** are located on the side of the side **323** of the ink supply path insertion hole **331***a* in the X1 direction, and are provided in line along the Y1 direction such that the fixing hole **346** is on the side of the side **325** and the fixing hole **347** is on the side of the side **326**. In addition, the fixing holes **348** and **349** are located on the side of the side **324** of the ink supply path insertion hole **331***f* in the X1 direction, and are provided in line along the Y1 direction such that the fixing hole **348** is on the side of the side **325** and the fixing hole **349** is on the side of the side **326**.

In addition, as illustrated in FIG. **18**, the integrated circuit device **241**, the first connector **350**, and the head **310** are provided in the surface **321** of the substrate **320**. The integrated circuit device **241** includes the diagnostic circuit **240** illustrated in FIG. **2**. Further, the integrated circuit device **241** diagnoses whether or not it is possible to normally discharge the ink from the nozzles **651** based on the latch signal LAT, the change signal CH, the print data signal SI1, and the clock signal SCK. In other words, the integrated circuit device **241** diagnoses the presence or absence of the operation abnormality of the print head **23** based on the latch signal LAT, the change signal CH, the print data signal SI1, and the clock signal SCK, which are the digital signals input from the first connector **350**. In addition, the abnormality signal cXHOT is input to the integrated circuit device **241** from the temperature abnormality detection circuits **250-1** to **250-***m*. Further, the integrated circuit device **241** determines the presence or absence of the temperature abnormality of the print head **23** based on the abnormality signal cXHOT. Further, the integrated circuit device **241** outputs the abnormality signal XHOT indicating presence or absence of the abnormality of the print head **23** based on at least any one of whether or not it is possible to normally discharge the ink from the nozzle **651** and whether or not temperature abnormality exists in the print head **23**.

That is, the integrated circuit device **241** is provided in the surface **321** of the substrate **320**, and is electrically coupled to the first connector **350** through the first connector **350** so that the digital signals, such as the latch signal LAT, the change signal CH, the print data signal SI1, and the clock signal SCK, are input and the abnormality signal XHOT indicating the presence or absence of the abnormality of the print head **23** is output. The integrated circuit device **241** is an example of a first integrated circuit.

In addition, the integrated circuit device **241** includes a plurality of electrodes to which the digital signals, such as the latch signal LAT, the change signal CH, the print data signal SI1, and the clock signal SCK, are input. Further, the integrated circuit device **241** is electrically coupled to the substrate **320** via the plurality of electrodes. That is, the integrated circuit device **241** includes the plurality of electrodes electrically coupled to the substrate **320**. In this case, it is preferable that the integrated circuit device **241** is a surface mount component mounted on the surface **321** of the substrate **320**. In this case, it is preferable that the integrated circuit device **241** and the substrate **320** are electrically coupled via bump electrodes. That is, it is preferable that the plurality of electrodes included in the integrated circuit device **241** are not inserted into the surface **322** of the substrate **320**. Therefore, it possible to effectively utilize the mounting area on the side of the surface **322** of the substrate **320**, and, as a result, it is possible to reduce a size of the substrate **320** and the print head **23** including the substrate **320**.

As above, in the print head **23**, the integrated circuit device **241** including the diagnostic circuit **240** is provided in the surface **321** of the substrate **320**, similarly to the head **310**. That is, the shortest distance between the surface **321** of the substrate **320**, on which the integrated circuit device **241** including the diagnostic circuit **240** is provided, the head **310**, and the nozzle plate **632** included in the head **310** is shorter than the shortest distance between the surface **322** of the substrate **320**, the head **310**, and the nozzle plate **632** included in the head **310**. In other words, in the print head **23**, the substrate **320** is provided so that the surface **322** is located on the −Z1 side, which is upstream in the ink discharge direction, along the Z1 direction that is the discharge direction in which ink is discharged, and the surface **321** is located on the +Z1 side which is downstream in the ink discharge direction. Further, the integrated circuit device **241**, which includes the diagnostic circuit **240**, and the head **310** are provided in the surface **321** of the substrate **320** provided downstream the discharge direction.

In addition, as illustrated in FIG. **18**, the integrated circuit device **241** is provided on the side of the surface **321** of the substrate **320** at a place which is not adjacent to the first connector **350**, and on the side of the side **326** rather than any of areas of the FPC insertion holes **332***a* to **332***c*. That is, the shortest distance between the integrated circuit device **241** and the side **326** is shorter than the shortest distance between the FPC insertion hole **332***a* and the side **326**, and the shortest distance between the integrated circuit device **241** and the side **326** is shorter than the shortest distance between the FPC insertion hole **332***b* and the side **326**. In other words, the integrated circuit device **241** is located in an area other than between the FPC insertion holes **332***a* to **332***c* of the substrate **320** in the Y1 direction.

Further, the integrated circuit device **241** is located in an area in which the shortest distance between a virtual line A, which has an equal distance from the side **323** and the side **324**, and the integrated circuit device **241** is shorter than the shortest distance between the side **323** and the integrated circuit device **241** and the shortest distance between the virtual line A and the integrated circuit device **241** is shorter than the shortest distance between the side **324** and the integrated circuit device **241**. That is, the integrated circuit device **241** is located in a vicinity of a center of the substrate **320**.

Further, the integrated circuit device **241** is located between the substrate **320** and the head **310**. Specifically, as illustrated in FIG. **18**, when the print head **23** is viewed from the +Z1 side, the integrated circuit device **241** is provided in a location which overlaps the head **310** and is, for example, as illustrated in FIG. **19**, a space formed by the substrate **320** and the head **310**. Note that, the space formed by the substrate **320** and the head **310** is not limited to the space formed by only the substrate **320** and the head **310**, and may be, for example, a space formed to include the substrate **320**, the head **310**, and an adhesive for fixing the head **310** to the substrate **320**.

Next, an example of a wiring pattern, which is provided in the surface **321** of the substrate **320** and which propagates the latch signal LAT, the change signal CH, the print data signal SI1, the clock signal SCK, and the abnormality signal XHOT, will be described with reference to FIG. **20**. FIG. **20** is a diagram illustrating an example of wiring formed in the surface **321** of the substrate **320**. Note that, in FIG. **20**, a part of the wiring pattern formed in the substrate **320** is not illustrated. In addition, in FIG. **20**, the electrode groups **330***a* to **330***f* formed in the surface **322** of the substrate **320** are illustrated using broken lines.

As illustrated in FIG. **20**, wirings **354-***a* to **354-***p* are provided in the surface **321** of the substrate **320**.

The terminal **353-4** is electrically coupled to the wiring **354-***a*. After the latch signal LAT, which is input from the terminal **353-4**, is propagated through the wiring **354-***a*, the latch signal LAT is input to the integrated circuit device **241**. That is, the wiring **354-***a* electrically couples the terminal **353-4** to the electrodes of the integrated circuit device **241**, and the latch signal LAT is propagated therethrough.

The terminal **353-6** is electrically coupled to the wiring **354-***b*. After the clock signal SCK, which is input from the terminal **353-6**, is propagated through the wiring **354-***b*, the clock signal SCK is input to the integrated circuit device **241**. That is, the wiring **354-***b* electrically couples the terminal **353-6** to the electrodes of the integrated circuit device **241**, and the clock signal SCK is propagated therethrough.

The terminal **353-8** is electrically coupled to the wiring **354-***c*. After the change signal CH, which is input from the terminal **353-8**, is propagated through the wiring **354**-*c*, the change signal CH is input to the integrated circuit device **241**. That is, the wiring **354**-*c* electrically couples the terminal **353-8** to the electrodes of the integrated circuit device **241**, and the change signal CH is propagated therethrough.

The terminal **353-10** is electrically coupled to the wiring **354**-*d*. The print data signal SI**1**, which is input from the terminal **353-10**, is propagated through the wiring **354**-*d*, and, thereafter, is input to the integrated circuit device **241**. That is, the wiring **354**-*d* electrically couples the terminal **353-10** to the electrodes of the integrated circuit device **241**, and the print data signal SI**1** is propagated therethrough.

The integrated circuit device **241** diagnoses whether or not it is possible to normally discharge the ink in the print head **23** based on the latch signal LAT, the change signal CH, the print data signal SI**1**, and the clock signal SCK which are input. In other words, the integrated circuit device **241** diagnoses the presence or absence of the abnormality of the print head **23**. Further, when the integrated circuit device **241** diagnoses that it is possible to normally discharge the ink in the print head **23**, the integrated circuit device **241** outputs the latch signal LAT, the clock signal SCK, and the change signal CH, which are input, as the latch signal cLAT, the clock signal cSCK, and the change signal cCH, to the electrode groups **330***a* to **330***f*, respectively.

Specifically, the electrodes of the integrated circuit device **241** are electrically coupled to the respective wirings **354**-*f* to **354**-*h*. After the latch signal cLAT, the clock signal cSCK, and the change signal cCH, which are output from the integrated circuit device **241**, are respectively propagated through the respective wirings **354**-*f* to **354**-*h*, the latch signal cLAT, the clock signal cSCK, and the change signal cCH are input to any of the electrodes included in the electrode group **330***a* through not-shown via or the like. Note that, FIG. **20** illustrates only the wirings **354**-*f* to **354**-*h*, through which the latch signal cLAT, the clock signal cSCK, and the change signal cCH that are input to the electrode group **330***a* are propagated, and does not illustrate a wiring pattern through which the latch signal cLAT, the clock signal cSCK, and the change signal cCH that are output from the integrated circuit device **241** and are input to the respective electrode groups **330***b* to **330***f* are propagated.

In addition, any of the electrodes included in the electrode group **330***a* is electrically coupled to the electrodes of the integrated circuit device **241** through the wiring **354**-*p*. The abnormality signal cXHOT, which is output from the temperature abnormality detection circuit **250**, is propagated through the wiring **354**-*p*. Further, the abnormality signal cXHOT is input to the integrated circuit device **241**. The integrated circuit device **241** generates the abnormality signal XHOT according to at least one of the presence or absence of the temperature abnormality of the print head **23** based on the abnormality signal cXHOT and the presence or absence of the abnormality of the print head **23** based on the latch signal LAT, the change signal CH, the print data signal SI**1**, and the clock signal SCK. The abnormality signal XHOT, which is output from the integrated circuit device **241**, is propagated through the wiring **354**-*e* which is electrically coupled to the terminal **353-12**. Further, after the abnormality signal XHOT is propagated through the wiring **354**-*d*, the abnormality signal XHOT is input to the terminal **353-12**. That is, the wiring **354**-*e* electrically couples the terminal **353-12** to the electrodes of the integrated circuit device **241**, and the abnormality signal XHOT is propagated therethrough.

Further, as illustrated in FIG. **20**, the terminal **353-10** is also electrically coupled to the wiring **354**-*i*. The print data signal SI**1**, which is input from the terminal **353-10**, is propagated through the wiring **354**-*i*, and, thereafter, is input to any of the electrodes included in the electrode group **330***a* through the not-shown via or the like.

The terminal **353-14**, to which the driving signal COM-**1** is input, is electrically coupled to the wiring **354**-*j*. The driving signal COM-**1**, which is input from the terminal **353-14**, is propagated through the wiring **354**-*j*, and, thereafter, input to any of the electrodes included in the electrode group **330***a* through the not-shown via or the like. Similarly, the respective terminals **353-16**, **353-18**, **353-20**, **353-22**, and **353-24**, to which the driving signals COM-**2** to COM-**6** are input, are electrically coupled to the respective wirings **354**-*k* to **354**-*o*. Further, the respective driving signals COM-**2** to COM-**6** are propagated through the wirings **354**-*k* to **354**-*o*, and, thereafter, input to any of the electrodes included in each of the electrode groups **330***b* to **330***f* through not-shown via or the like.

In the print head **23** configured as above, a plurality of signals including the driving signals COM-**1** to COM-**6**, the reference voltage signals CGND-**1** to CGND-**6**, the print data signals SI**1** to SI**6**, the latch signal LAT, the change signal CH, and the clock signal SCK, which are output from the control mechanism **10**, are input to the print head **23** through the first connector **350**. Further, the driving signals COM-**1** to COM-**6** and the reference voltage signals CGND-**1** to CGND-**6**, which are input to the first connector **350**, are input to the respective electrode groups **330***a* to **330***f* through the wirings **354**-*j* to **354**-*o*.

In addition, the latch signal LAT, the change signal CH, and the clock signal SCK, which are input to the first connector **350**, are input to the integrated circuit device **241** through the wirings **354**-*a* to **354**-*c*. In this case, the wirings **354**-*a* to **354**-*c*, through which the latch signal LAT, the change signal CH, and the clock signal SCK are respectively propagated, are formed only in the surface **321** which is a surface on a side of the ink discharge surface **311** of the substrate **320**. In other words, a via wiring, which electrically couples the surface **321** to the surface **322**, is not formed in the wiring pattern through which the latch signal LAT, the change signal CH, and the clock signal SCK are respectively propagated.

In addition, the print data signal SI**1**, which is input to the first connector **350**, branches off in the surface **321** of the substrate **320**. Further, one signal of the branching print data signal SI**1** is input to the integrated circuit device **241** through the wiring **354**-*d* formed in the surface **321**, and another signal of the branching print data signal SI**1** is input to the electrode group **330***a* through the wiring **354**-*i* which is formed in the surface **321** and the surface **322** of the substrate **320**.

The integrated circuit device **241** performs the self-diagnosis of the print head **23** based on the latch signal LAT, the change signal CH, the clock signal SCK, and the print data signal SI**1** which are input. Further, the integrated circuit device **241** detects voltages, timings, and the like of the print data signal SI**1**, the change signal CH, the latch signal LAT, and the clock signal SCK. When it is diagnosed that a result of the detection is in a normal range, the integrated circuit device **241** outputs the change signal cCH, the latch signal cLAT, and the clock signal cSCK. The change signal cCH, the latch signal cLAT, and the clock signal cSCK, which are output from the integrated circuit device **241**, are respectively input to the electrode groups

330*a* to 330*f* through the wirings 354-*f* to 354-*h* formed in the surface 321 and the surface 322 of the substrate 320.

In addition, the temperature signal TH is input to the first connector 350 from the temperature detection circuit 210 illustrated in FIG. 2 through a not-shown wiring pattern formed in the surface 321 and the surface 322 of the substrate 320. Note that, the temperature detection circuit 210 which outputs the temperature signal TH may be provided on any of the surface 321 and the surface 322 of the substrate 320, and may be provided on the inside of the head 310.

The driving signals COM-1 to COM-6, the reference voltage signals CGND-1 to CGND-6, the high voltage signal VHV, and the low voltage signal VDD, which are input to the second connector 360, are input to the respective electrode groups 330*a* to 330*f* through the not-shown wiring pattern formed in the surface 321 and the surface 322 of the substrate 320.

In addition, the respective print data signals SI2 to SI6 which are input to the second connector 360 are input to the respective electrode groups 330*b* to 330*f* through the not-shown wiring pattern formed in the surface 321 and the surface 322 of the substrate 320.

The various signals which are input to the respective electrode groups 330*a* to 330*f* are input to the driving signal selection circuits 200-1 to 200-6 corresponding to the respective nozzle rows L1 to L6 through the flexible wiring substrate 335 electrically coupled to each of the electrode groups 330*a* to 330*f*. Further, the driving signal selection circuits 200-1 to 200-6 generate the driving signals VOUT-1 to VOUT-6 based on the input signals, and supply the driving signals VOUT-1 to VOUT-6 to the piezoelectric elements 60 included in the respective relevant nozzle rows L1 to L6. Therefore, the driving signals VOUT are supplied to the piezoelectric elements 60 included in the plurality of discharge sections 600 based on the various signals which are input to the first connector 350 and the second connector 360.

As described above, when the wiring, through which the latch signal LAT, the change signal CH, the print data signal SI1, the clock signal SCK, and the abnormality signal XHOT are propagated, is located in the surface 321 of the substrate 320, a problem is reduced in that noise or the like is superimposed on the latch signal LAT, the change signal CH, the print data signal SI1, the clock signal SCK, and the abnormality signal XHOT. As a result, accuracy of diagnosis of presence or absence of the operation abnormality of the print head 23 is improved.

1.4 Configuration of Head Unit

Next, a configuration of the head unit 20 including the plurality of print heads 23 will be described. FIG. 21 is an exploded perspective diagram illustrating the configuration of the head unit 20. As illustrated in FIG. 21, the head unit 20 includes a supply unit 22, a head fixing plate 31, and a plurality of print heads 23. Here, in FIG. 21, description will be performed while it is assumed that the head unit 20 includes 12 number of print heads 23. Further, in the following description, there is a case where the 12 number of print heads 23 included in the head unit 20 is referred to as print heads 23-1 to 23-12. Note that, the number of print heads 23 included in the head unit 20 is not limited to 12.

The supply unit 22 has a plurality of ink supply ports 21. The plurality of ink supply ports 21 are opening sections provided on the −Z side of the supply unit 22. Further, each of the plurality of ink supply ports 21 is inserted into an ink channel provided inside the supply unit 22. In addition, each of the plurality of ink supply ports 21 is coupled to the liquid container 2 illustrated in FIG. 1 by a not-shown ink supply pipe or the like. The not-shown ink supply pipe is configured with, for example, a tube through which ink flows. As a result, the ink stored in the liquid container 2 is supplied to the ink channel formed inside the supply unit 22.

In addition, after the ink channel provided inside the supply unit 22 branches off inside the supply unit 22, the ink channel is coupled to the plurality of ink supply ports 661 included in each of the print heads 23-1 to 23-12. That is, the ink supplied from the liquid container 2 to the supply unit 22 via the ink supply ports 661 branches off to correspond to each of the print heads 23-1 to 23-12 in the ink channel provided inside the supply unit 22, and is supplied to each of the print heads 23-1 to 23-12 via the plurality of ink supply ports 661 included in each of the print heads 23-1 to 23-12. As described above, the head unit 20 includes the supply unit 22 that supplies the ink to each of the print heads 23-1 to 23-12.

In each of the print heads 23-1 to 23-12, the side 323 of the substrate 320 is located along the X direction orthogonal to the Z direction on the +Z side of the supply unit 22, and the side 326 is located along the Y direction orthogonal to the Z direction. That is, the substrate 320 included in each of the print heads 23-1 to 23-12 is provided so that the side 323 is orthogonal to the vertical direction and the side 326 is orthogonal to the vertical direction.

Further, the print heads 23-1 to 23-12 are disposed in the zigzag pattern along the X direction. Specifically, the print heads 23-1, 23-3, 23-5, 23-7, 23-9, and 23-11 face the +X side from the −X side and are located in line along the X direction in order of the print heads 23-1, 23-3, 23-5, 23-7, 23-9, and 23-11. In addition, the print heads 23-2, 23-4, 23-6, 23-8, 23-10, 23-12 ace the +X side from the −X side and are located in line along the X direction in order of the print heads 23-2, 23-4, 23-6, 23-8, 23-10, and 23-12 on the −Y side of the print heads 23-1, 23-3, 23-5, 23-7, 23-9, 23-11 which are located in line along the X direction. In other words, in the X direction which is a direction along the side 323 of the substrate 320 included in the print head 23-1, at least portions of the print heads 23-1, 23-3, 23-5, 23-7, 23-9, and 23-11 overlap, and, in the X direction which is a direction along the side 323 of the substrate 320 included in the print head 23-2, at least portions of the print heads 23-2, 23-4, 23-6, 23-8, 23-10 and 23-12 overlap.

In addition, when the print heads 23-1 to 23-12 disposed along the X direction are viewed from the +Y side, the print head 23-2 is located between the print heads 23-1 and 23-3, the print head 23-4 is located between the print head 23-3 and the print head 23-5, the print head 23-6 is located between the print head 23-5 and the print head 23-7, the print head 23-8 is located between the print heads 23-7 and 23-9, the print head 23-10 is located between the print heads 23-9 and 23-11, and the print head 23-12 is located on the +X side of the print head 23-11.

Here, FIG. 21 illustrates that, for each of the print heads 23-1, 23-3, 23-5, 23-7, 23-9, and 23-11 disposed along the X direction, the side 323 of the substrate 320 included in each of the print heads 23-1, 23-3, 23-5, 23-7, 23-9, and 23-11 is located on the +Y side of the head unit 20, and, for each of the print heads 23-2, 23-4, 23-6, 23-8, 23-10, and 23-12 disposed along the X direction, the side 323 of the substrate 320 included in each of the print heads 23-2, 23-4, 23-6, 23-8, 23-10, and 23-12 is located on the −Y side of the head unit 20. That is, in FIG. 21, each of the print heads 23-1, 23-3, 23-5, 23-7, 23-9, and 23-11 and each of the print heads 23-2, 23-4, 23-6, 23-8, 23-10, and 23-12 are assembled in the head fixing plate 31 in a state of being rotated by 180 degrees. Note that, in the head unit **20**, the print heads **23-1** to **23-12** disposed along the X direction may be assembled in the head unit **20** in the same direction without being rotated by 180 degrees.

The head fixing plate **31** is provided on the +Z side of the print heads **23-1** to **23-12** disposed in the zigzag pattern as described above. The head fixing plate **31** includes discharge surface insertion holes **32-1** to **32-12**. The ink discharge surface **311** of the head **310** included in each of the print heads **23-1** to **23-12** is inserted into each of the discharge surface insertion holes **32-1** to **32-12**. In other words, each of the print heads **23-1** to **23-12** is fixed in a state in which the ink discharge surface **311** of the head **310** is inserted into each of the discharge surface insertion holes **32-1** to **32-12**.

Specifically, the ink discharge surface **311** of the head **310** included in the print head **23-1** is inserted into the discharge surface insertion hole **32-1** included in the head fixing plate **31**. Similarly, the ink discharge surface **311** of the head **310** of each of the print heads **23-2** to **23-12** is inserted into each of the discharge surface insertion holes **32-2** to **32-12** of the head fixing plate **31**. Further, each of the print heads **23-1** to **23-12** is fixed to the head fixing plate **31** by a fixing member which is inserted through the fixing holes **346** to **349** included in the substrate **320**.

In addition, the supply unit **22** is fixed to the head fixing plate **31** using a screw, an adhesive, or the like. As a result, the print heads **23-1** to **23-12** are housed in a space formed by the head fixing plate **31** and the supply unit **22**. That is, the head unit **20** includes a case configured with the print heads **23-1** to **23-12** that discharges the ink, the head fixing plate **31** that houses the print heads **23-1** to **23-12**, and the supply unit **22**. Here, the case configured with the head fixing plate **31** and the supply unit **22** is an example of a housing.

As described above, in the head unit **20**, each of the print heads **23-1** to **23-12** is provided so that the ink discharge surface **311** of the head **310** faces the head fixing plate **31** located on the +Z side of the print heads **23-1** to **23-12**. That is, the surface **321** of the substrate **320** included in each of the print heads **23-1** to **23-12** faces downward in the direction along the Z direction, and the surface **322** of the substrate **320** faces upward in the direction along the Z direction. In other words, the substrate **320** included in each of the print heads **23-1** to **23-12** is provided so that the surface **321** faces downward and the surface **322** faces upward in the direction along the vertical direction.

The integrated circuit device **201**, which includes the driving signal selection circuit **200** and the temperature abnormality detection circuit **250**, generates the driving signal VOUT to be supplied to the plurality of piezoelectric elements **60**, and thus the amount of generated heat is larger than that of the integrated circuit device **241** including the diagnostic circuit **240**. In the print head **23** included in the head unit **20** included in the liquid discharge apparatus **1** according to the embodiment, the heat generated in the integrated circuit device **201** is transferred to the flexible wiring substrate **335** and the substrate **320** and is emitted from the substrate **320**. In this case, the surface **321** of the substrate **320**, on which the integrated circuit device **241** including the diagnostic circuit **240** is provided, faces downward in the direction along the vertical direction, and the surface **322** different from the surface **321** faces upward in the direction along the vertical direction, and thus the heat emitted from the substrate **320** is emitted in a direction different from that of the surface **321** of the substrate **320**. Therefore, a problem is reduced in that the integrated circuit device **241** provided in the surface **321** of the substrate **320** is affected by the heat generated by the integrated circuit device **201**. As a result, temperature rise of the integrated circuit device **241**, which includes the diagnostic circuit **240**, is reduced.

Further, in this case, it is preferable that the substrate **320** of each of the print heads **23-1** to **23-12** included in the head unit **20** is provided so that the side **323** is orthogonal to the Z direction which is the vertical direction and the side **326** is orthogonal to the Z direction which is the vertical direction. In other words, it is preferable that a normal direction of the surface **321** of the substrate **320** is a direction along the Z direction which is the vertical direction.

In a case where the substrate **320** is located so that the surface **321** of the substrate **320** is orthogonal to the vertical direction, a problem is further reduced in that the heat emitted from the substrate **320** affects the surface **321** of the substrate **320**. As a result, the problem is further reduced in that the heat generated in the integrated circuit device **201** affects the integrated circuit device **241** provided in the surface **321** of the substrate **320**, and the temperature rise of the integrated circuit device **241** including the diagnostic circuit **240** is further reduced.

Here, disposition of the nozzle rows L**1** to L**6** included in each of the print heads **23-1** to **23-12** in the head unit **20** will be described.

FIG. **22** is a diagram illustrating the configuration of the head unit **20** when the head unit **20** is viewed from the +Z side. As illustrated in FIG. **22**, all the nozzle rows L**1** to L**6** included in each of the print heads **23-1** to **23-12** in the head unit **20** extend along the X direction. Specifically, the plurality of nozzles **651** configuring each of the nozzle rows L**1** to L**6** included in the print head **23-1** are located in line in a direction along the X direction. Similarly, the plurality of nozzles **651** configuring each of the nozzle rows L**1** to L**6** included in each of the print heads **23-2** to **23-12** are also located in line in the direction along the X direction.

Here, as described above, each of the print heads **23-1** to **23-12** includes the nozzle rows L**1** to L**6** in which the plurality of nozzles **651** are provided in line in the direction along the side **323** of the substrate **320**. Further, in each of the print heads **23-1** to **23-12** of the head unit **20**, the side **323** of the substrate **320** is located along the X direction orthogonal to the Z direction. That is, the plurality of nozzles **651** configuring each of the nozzle rows L**1** to L**6** included in each of the print heads **23-1** to **23-12** are provided to be disposed in the direction along the side **323** of the substrate **320** included in the print head **23-1**.

In this case, when the print heads **23-1** to **23-12** disposed in the zigzag pattern along the X direction are viewed from the +Y side, the nozzle rows L**1** to L**6** included in each of the print heads **23-1** to **23-12** are provided t so that at least portions thereof overlap.

Specifically, when the print heads **23-1** to **23-12** disposed in the zigzag pattern along the X direction are viewed from the +Y side, the print heads **23-1** and **23-2** are located so that at least portions of the nozzle rows L**1** to L**6** included in the print head **23-1** and the nozzle rows L**1** to L**6** included in the print head **23-2** overlap. Similarly, the print heads **23-2** and **23-3** are located so that at least portions of the nozzle rows L**1** to L**6** included in each of the print heads **23-2** and **23-3** overlap. Similarly, the print heads **23-3** and **23-4** are located so that at least portions of the nozzle rows L**1** to L**6** included in each of the print heads **23-3** and **23-4** overlap. Similarly, the print heads **23-4** and **23-5** are located so that at least portions of the nozzle rows L**1** to L**6** included in each of the print heads **23-4** and **23-5** overlap. Similarly, the print heads **23-5** and **23-6** are located so that at least portions of the nozzle rows L1 to L6 of the print heads 23-5 and 23-6 overlap. Similarly, the print heads 23-6 and 23-7 are located so that at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-6 and 23-7 overlap. Similarly, the print heads 23-7 and 23-8 are located so that at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-7 and 23-8 overlap. Similarly, the print heads 23-8 and 23-9 are located so that at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-8 and 23-9 overlap. Similarly, the print heads 23-9 and 23-10 are located so that at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-9 and 23-10 overlap. Similarly, the print heads 23-10 and 23-11 are located so that at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-10 and 23-11 overlap. Similarly, the print heads 23-11, 23-12 are located so that at least portions of the nozzle rows L1 to L6 of the print heads 23-11 and 23-12 overlap.

Here, details of overlapping portions where at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-1 to 23-12 overlap will be described with reference to FIG. 23. FIG. 23 is an enlarged view of a portion XXIII in FIG. 22. All the overlapping portions where at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-1 to 23-12 overlap have the same configuration. Therefore, in FIG. 22, only the portion XXIII in which at least portions of the nozzle rows L5 and L6 included in the print head 23-1 and the nozzle rows L5 and L6 included in the print head 23-2 overlap will be described, and other portions will not be described. In addition, in the description with reference to FIG. 22, description will be performed while it is assumed that each of the nozzle rows L1 to L6 is configured to include p number of nozzles 651. Therefore, the p number of nozzles 651 are referred to as nozzles 651-1, 651-2, . . . , 651-*p*-1, and 651-*p*.

As illustrated in FIG. 22, in the portion XXIII, the nozzle 651-*p*-1 of the plurality of nozzles 651 included in the nozzle row L5 included in the print head 23-1 is located to overlap the nozzle 651-1 of the plurality of included nozzles 651 included in the nozzle row L5 included in the print head 23-2 in the Y direction. In addition, the nozzle 651-*p* of the plurality of nozzles 651 included in the nozzle row L5 included in the print head 23-1 is located to overlap the nozzle 651-2 of the plurality of nozzles 651 included in the nozzle row L5 included in the print head 23-2 in the Y direction. Similarly, the nozzle 651-*p*-1 of the plurality of nozzles 651 included in the nozzle row L6 included in the print head 23-1 is located to overlap the nozzle 651-1 of the plurality of nozzles 651 included in the nozzle row L6 included in the print head 23-2 in the Y direction. In addition, the nozzle 651-*p* of the plurality of nozzles 651 included in the nozzle row L6 included in the print head 23-1 is located to overlap the nozzle 651-2 of the plurality of nozzles 651 included in the nozzle row L6 included in the print head 23-2 in the Y direction.

That is, in the overlapping portions where at least portions of the nozzle rows L1 to L6 included in each of the print heads 23-1 to 23-12 overlap, some of the plurality of nozzles 651 configuring each of the nozzle rows L1 to L6 included in each of the print heads 23-1 to 23-12 are located to overlap in the Y direction. As a result, the nozzle rows L1 to L6 included in each of the print heads 23-1 to 23-12 form nozzle rows which are continuous in pseudo manner in a width L in the X direction. Further, in a case where the width L of the nozzle row formed in the pseudo manner is set to be equal to or larger than the width of the medium M, the head unit 20 can discharge the ink continuously in the width L.

Here, the print head 23-1 in the print heads 23-1 to 23-*n* included in the head unit 20 is an example of a first print head, the plurality of nozzles 651 included in the print head 23-1 is an example of a plurality of first nozzles, any of the nozzle rows L1 to L6 formed by the plurality of nozzles 651 included in the print head 23-1 is an example of a first nozzle row, and the nozzle plate 632 included in the print head 23-1 is an example of a first nozzle plate. In addition, the print head 23-3 in the print heads 23-1 to 23-*n* included in the head unit 20 is an example of a second print head, the plurality of nozzles 651 included in the print head 23-3 is an example of a plurality of second nozzles, any of the nozzle rows L1 to L6 formed by the plurality of nozzles 651 included in the print head 23-3 is an example of a second nozzle row, and the nozzle plate 632 included in the print head 23-3 is an example of a second nozzle plate.

1.5 Effects

In the liquid discharge apparatus 1 and the head unit 20, which are configured as described above, according to the first embodiment, the print head 23 included in the head unit 20 is provided with the integrated circuit device 201 that includes the driving signal selection circuit 200 is provided in the flexible wiring substrate 335, and the integrated circuit device 241 that includes the diagnostic circuit 240 which outputs the abnormality signal XHOT indicating presence or absence of the abnormality of the print head 23 is provided in the surface 321 of the substrate 320. Further, the substrate 320 included in the print head 23 is provided so that the surface 321 faces downward in the vertical direction and the surface 322 faces upward in the vertical direction.

In the head unit 20 configured as described above and the liquid discharge apparatus 1 including the head unit 20, the heat generated in the integrated circuit device 201 is transferred to the flexible wiring substrate 335 and the substrate 300. Further, the heat, which is generated in the integrated circuit device 201 and reaches the substrate 300, is emitted from the side of the surface 322 which is upward the substrate 300 in the vertical direction. Therefore, a problem is reduced in that the heat generated in the integrated circuit device 201 affects the integrated circuit device 241 provided in the surface 321 of the substrate 320. As a result, a problem is reduced in that the integrated circuit device 241 for executing the self-diagnosis function of the print head 23 does not operate normally.

In addition, in the liquid discharge apparatus 1 and the head unit 20 according to the first embodiment, the substrate 320 is provided so that the side 323 is orthogonal to the vertical direction and the side 326 is orthogonal to the vertical direction in the print head 23 included in the head unit 20. That is, the normal direction of the surface 321 of the substrate 320 is a direction along the vertical direction. In other words, the substrate 320 is provided so that the surface 321 and the surface 322 are orthogonal to the vertical direction. As a result, the heat, which is generated in the integrated circuit device 201 and reaches the substrate 300, is more efficiently emitted from the side of the surface 322 of the substrate 320. As a result, the problem is further reduced in that the heat, which is generated in the integrated circuit device 201 affects the integrated circuit device 241 provided in the surface 321 of the substrate 320, and the problem is further reduced in that the integrated circuit device 241 for executing the self-diagnosis function of the print head 23 does not operate normally.

In addition, in the liquid discharge apparatus **1** and the head unit **20** according to the first embodiment, the flexible wiring substrate **335** provided with the integrated circuit device **201** is electrically coupled to the surface **322** of the substrate **320**. Therefore, a problem is further reduced in that the heat, which is generated in the integrated circuit device **201** and reaches the substrate **300**, is given to the side of the surface **321** of the substrate **320**. As a result, the problem is further reduced in that the heat, which is generated in the integrated circuit device **201** affects the integrated circuit device **241** provided in the surface **321** of the substrate **320**, and the problem is further reduced in that the integrated circuit device **241** for executing the self-diagnosis function of the print head **23** does not operate normally.

In addition, in the liquid discharge apparatus **1** and the head unit **20** according to the first embodiment, the flexible wiring substrate **335** provided with the integrated circuit device **201** is inserted through the FPC insertion holes **332***a* to **332***c* included in the substrate **320**, and is electrically coupled to the surface **322** of the substrate **320**. That is, the substrate **320** includes the through holes which pass through the surface **321** and the surface **322** in the vicinity of the flexible wiring substrate **335**. Therefore, radiant heat generated in the integrated circuit device **201** is emitted to the side of the surface **322** of the substrate **320** via the FPC insertion holes **332***a* to **332***c*. As a result, the problem is further reduced in that the heat, which is generated in the integrated circuit device **201** affects the integrated circuit device **241** provided in the surface **321** of the substrate **320**, and the problem is further reduced in that the integrated circuit device **241** for executing the self-diagnosis function of the print head **23** does not operate normally.

In the liquid discharge apparatus **1** and the head unit **20**, which are configured as described above, according to the first embodiment, even in the head unit **20** used for the so-called line head type liquid discharge apparatus **1** in which the print heads **23-1** to **23-12** are housed in the case and the print heads **23-1** to **23-12** are provided in line in the head unit **20** so that the nozzle rows L**1** to L**6** included in each of the print heads **23-1** to **23-12** are disposed to be equal to or larger than the width of the medium M, the problem is further reduced in that the heat generated in the integrated circuit device **201** affects the integrated circuit device **241**, and, as a result, the problem is further reduced in that the integrated circuit device **241** for executing the self-diagnosis function of the print head **23** does not operate normally.

2. Second Embodiment

Next, a liquid discharge apparatus **1** and a head unit **20** according to a second embodiment will be described. Note that, when the liquid discharge apparatus **1** and the head unit **20** according to the second embodiment are described, the same reference symbols are attached to the components which are the same as in the first embodiment, and description thereof will not be repeated or simplified. In addition, the liquid discharge apparatus **1** and the head unit **20** according to the second embodiment is different from those of the first embodiment in a fact that disposition of the integrated circuit device **241** provided in the substrate **320** of the print head **23** included in the head unit **20**.

FIG. **24** is a plan diagram illustrating a case where the substrate **320** included in the print head **23** included in the head unit **20** is viewed from the surface **321** according to the second embodiment. As illustrated in FIG. **24**, in the print head **23** according to the second embodiment, at least a part of the integrated circuit device **241** is provided in a location overlapping the fixing hole **347**, to which the fixing member is inserted, in the X1 direction along the side **325** or the side **326**. That is, in the print head **23** included in the head unit **20** according to the second embodiment, at least a part of the integrated circuit device **241** overlaps the fixing member in the X1 direction.

More specifically, in the substrate **320**, the first connector **350**, the fixing hole **347**, and the integrated circuit device **241** are located in order of the first connector **350**, the fixing hole **347**, and the integrated circuit device **241** in the X1 direction along the side **325** or the side **326**, and at least a part of the integrated circuit device **241** overlaps the fixing member which is inserted into the fixing hole **347**. Further, the fixing hole **347** is located between the first connector **350** and at least a part of the integrated circuit device **241**. That is, the location of the integrated circuit device **241** is a location which is not adjacent to the first connector **350**.

That is, in the liquid discharge apparatus **1** and the print head **23**, which is included in the head unit **20**, according to the second embodiment, the integrated circuit device **241** including the diagnostic circuit **240** is provided so that the shortest distance between the virtual line A, in which a distance from the side **323** and the side **324** of the substrate **320** is equal, and the integrated circuit device **241** is shorter than the shortest distance between the side **323** and the integrated circuit device **241** and the shortest distance between the virtual line A and the integrated circuit device **241** is shorter than the shortest distance between the side **324** and the integrated circuit device **241**. Further, the integrated circuit device **241** is provided so that the shortest distance between the side **323** and the integrated circuit device **241** is shorter than the shortest distance between the side **324** and the integrated circuit device **241**.

Even in the head unit **20**, which includes the print head **23** configured as described above, and the liquid discharge apparatus **1**, which includes the head unit **20**, the substrate **320** included in the print head **23** is provided so that the surface **321** faces downward and the surface **322** faces upward in the direction along the vertical direction, and thus it is possible to exhibit the same effects as in the liquid discharge apparatus **1** and the head unit **20** according to the first embodiment.

Note that, in FIG. **24**, the integrated circuit device **241** is located in a vicinity of the fixing hole **347**. However, at least a part of the integrated circuit device **241** may be provided in a location overlapping the fixing member which is inserted into the fixing hole **347** in the direction along the side **325** or the side **326** and may be provided, for example, at a center of the substrate **320**.

3. Third Embodiment

Next, a liquid discharge apparatus **1** and a head unit **20** according to a third embodiment will be described. Note that, when the liquid discharge apparatus **1** and the head unit **20** according to the third embodiment are described, the same reference symbols are attached to the components which are the same as in the first embodiment and the second embodiment, and description thereof will not be repeated or simplified. In addition, the liquid discharge apparatus **1** and the head unit **20** according to the third embodiment is different from those of the first embodiment and the second embodiment in a fact that a print head **23** included in the head unit **20** includes four connectors electrically coupled to the control mechanism **10**.

FIGS. **25**A and **25**B are block diagrams illustrating an electrical configuration of the print head **23** according to the third embodiment in a block diagram illustrating an electrical configuration of the liquid discharge apparatus **1** according to the third embodiment. Note that, the electrical configurations of the control mechanism **10** and the head unit **20** according to the third embodiment are the same as those of the liquid discharge apparatus **1** according to the first embodiment illustrated in FIG. **2**, and the description thereof will not be repeated.

As illustrated in FIGS. **25**A and **25**B, a control circuit **100** according to the third embodiment generates, as a control signal Ctrl-P for controlling the print head **23** based on various signals, such as image data, which are input from a host computer, two latch signals LATa and LATb for prescribing ink discharge timing, two change signals CHa and CHb for prescribing timing at which a waveform of a driving signal COM is switched, two clock signals SCKa and SCKb for inputting a print data signal SI, and outputs the generated signals to the print head **23**. Here, the two latch signals LATa and LATb, the two change signals CHa and CHb, and the two clock signals SCKa and SCKb respectively serve as the signals for performing the self-diagnosis of the print head **23**.

The latch signals LATa and LATb, the change signals CHa and CHb, the clock signals SCKa and SCKb, and print data signals SI**1** and Sin are input to a diagnostic circuit **240** included in the print head **23**. Further, the diagnostic circuit **240** diagnoses whether or not it is possible for the print head **23** to normally discharge the ink based on the latch signals LATa and LATb, the change signals CHa and CHb, the clock signals SCKa and SCKb, and the print data signals SI**1** and Sin.

Specifically, the diagnostic circuit **240** performs the diagnosis of whether or not it is possible for the print head **23** to normally discharge the ink based on the print data signal SI**1**, the change signal CHa, the latch signal LATa, and the clock signal SCKa. Further, when it is determined that it is possible for the print head **23** to normally discharge the ink, the diagnostic circuit **240** outputs a change signal cCHa, a latch signal cLATa, and a clock signal cSCKa. In addition, the diagnostic circuit **240** performs the diagnosis of whether or not it is possible for the print head **23** to normally discharge the ink based on the print data signal SIn, the change signal CHb, the latch signal LATb, and the clock signal SCKb. Further, when it is determined that it is possible for the print head **23** to normally discharge the ink, the diagnostic circuit **240** outputs the change signal cCHb, the latch signal cLATb, and the clock signal cSCKb. The change signal cCHa, the latch signal cLATa, and the clock signal cSCKa, which are output from the diagnostic circuit **240**, are input to any of n number of driving signal selection circuits **200**, and the change signal cCHb, the latch signal cLATb, and the clock signal cSCKb are input to any of another n number of driving signal selection circuits **200**.

In addition, the diagnostic circuit **240** generates an abnormality signal XHOT based on a result of the diagnosis of whether or not it is possible for the print head **23** to normally discharge the ink, and outputs the abnormality signal XHOT to the control circuit **100**.

The driving signal selection circuit **200** generates driving signals VOUT-**1** to VOUT-n based on any of the print data signals SI**1** to SIn, one of the change signals cCHa and cCHb, one of the latch signals cLATa and cLATb, and one of the clock signals cSCKa and cSCKb, which are output from the diagnostic circuit **240**.

Next, a configuration of the print head **23** according to the third embodiment will be described. Note that, description will be performed while it is assumed that the print head **23** according to the third embodiment includes 10 number of driving signal selection circuits **200-1** to **200-10**. Therefore, the 10 number of print data signals SI**1** to SI**10**, the 10 number of driving signals COM-**1** to COM-**10**, and the 10 number of reference voltage signals CGND-**1** to CGND-**10**, which correspond to the 10 number of driving signal selection circuits **200-1** to **200-10** are input to the print head **23** according to the third embodiment.

FIG. **26** is a perspective diagram illustrating the configuration of the print head **23** according to the third embodiment. As illustrated in FIG. **26**, the print head **23** includes a head **310** and a substrate **320**. In addition, FIG. **27** is a plan diagram illustrating an ink discharge surface **311** of the head **310** according to the third embodiment. As illustrated in FIG. **27**, in the ink discharge surface **311** according to the third embodiment, ten number of nozzle plates **632**, which each are formed with a plurality of nozzles **651**, are provided in line along the X1 direction. In addition, nozzle rows L**1** to L**10**, which are provided in line along the X1 direction, are formed in the respective nozzle plates **632**. The respective nozzle rows L**1** to L**10** are provided to correspond to the respective driving signal selection circuits **200-1** to **200-10**.

Returning to FIG. **26**, the substrate **320** has a substantially rectangular shape formed with a surface **321** and a surface **322** which faces the surface **321**, a side **323**, a side **324** which faces the side **323** in the X1 direction, a side **325**, and a side **326** which faces the side **325** in the Y1 direction. In other words, the substrate **320** includes the side **323**, the side **324** which is different from the side **323**, the side **325** which is orthogonal to the side **323** and the side **324**, and the side **326** which is different from the side **325** that is orthogonal to the side **323** and the side **324**.

A first connector **350**, a second connector **360**, a third connector **370**, and a fourth connector **380** are provided in the substrate **320**. The first connector **350** is provided on a side of the surface **321** of the substrate **320** along the side **323**. In addition, the second connector **360** is provided on a side of the surface **322** of the substrate **320** along the side **323**. Note that, the first connector **350** and the second connector **360** according to the third embodiment are different from those of the first embodiment in a fact that the number of a plurality of terminals included in each of the first connector **350** and the second connector **360** is 20, and the other configurations are the same as in the first embodiment. Therefore, detailed description of the first connector **350** and the second connector **360** according to the third embodiment will not be repeated. Note that, there is a case where 20 number of terminals **353**, which are provided in parallel to the first connector **350** according to the third embodiment, are sequentially referred to as terminals **353-1**, **353-2**, . . . , **353-20** toward the side **325** from the side **326** in the direction along the side **323**. Similarly, there is a case where 20 number of terminals **363**, which are provided in parallel to the second connector **360** according to the third embodiment, are sequentially referred to as terminals **363-1**, **363-2**, . . . , **363-20** toward the side **326** from the side **325** in the direction along the side **323**.

The third connector **370** is provided on the side of the surface **321** of the substrate **320** along the side **324**. In addition, the fourth connector **380** is provided on the side of the surface **322** of the substrate **320** along the side **324**.

Configurations of the third connector **370** and the fourth connector **380** will be described with reference to FIG. **28**. FIG. **28** is a diagram illustrating the configurations of the third connector **370** and the fourth connector **380**. The third connector **370** has a substantially rectangular parallelepiped shape including a plurality of sides having a side **374** and a side **375**, which is orthogonal to the side **374** and is longer than the side **374**, and a plurality of surfaces which are formed by the plurality of sides. Further, the third connector **370** is provided in the substrate **320** such that the side **375** of the third connector **370** is parallel to the side **324** of the substrate **320**. The third connector **370** includes a housing **371**, a cable attachment section **372**, and a plurality of terminals **373**. A not-shown cable, which electrically couples the control mechanism **10** to the print head **23**, is attached to the cable attachment section **372**. In addition, the plurality of terminals **373** are provided in parallel along the side **324**. Further, when the cable is attached to the cable attachment section **372**, the plurality of respective terminals included in the cable are electrically coupled to the plurality of respective terminals **373** included in the third connector **370**. Therefore, the various signals output by the control mechanism **10** are input to the print head **23**. Note that, in the embodiment, description will be performed while it is assumed that 20 number of terminals **373** are provided in parallel along the side **324** in the third connector **370**. In addition, there is a case where the 20 number of terminals **373** provided in parallel are sequentially referred to as terminals **373-1**, **373-2**, . . . , **373-20** toward as side of the side **326** from a side of the side **325** in a direction along the side **324**.

The fourth connector **380** has a substantially rectangular parallelepiped shape including a plurality of sides having a side **384** and a side **385**, which is orthogonal to the side **384** and is longer than the side **384**, and a plurality of surfaces which are formed by the plurality of sides. Further, the fourth connector **380** is provided in the substrate **320** such that the side **385** of the fourth connector **380** is parallel to the side **324** of the substrate **320**. The fourth connector **380** includes a housing **381**, a cable attachment section **382**, and a plurality of terminals **383**. A not-shown cable, which electrically couples the control mechanism **10** to the print head **23**, is attached to the cable attachment section **382**. In addition, the plurality of terminals **383** are provided in parallel along the side **324**. Further, when the cable is attached to the cable attachment section **382**, the plurality of respective terminals included in the cable are electrically coupled to the plurality of respective terminals **383** included in the fourth connector **380**. Therefore, the various signals output by the control mechanism **10** are input to the print head **23**. Note that, in the embodiment, description will be performed while it is assumed that 20 number of terminals **383** are provided in parallel along the side **324** in the fourth connector **380**. In addition, there is a case where 20 number of terminals **383** provided in parallel are sequentially referred to as terminals **383-1**, **383-2**, . . . , **383-20** toward the side of the side **326** from the side of the side **325** in the direction along the side **324**.

Next, examples of the signals respectively input to the first connector **350**, the second connector **360**, the third connector **370**, and the fourth connector **380** will be described with reference to FIGS. **29** to **32**. In addition, FIG. **29** is a diagram illustrating examples of signals respectively input to the plurality of terminals **353** according to the third embodiment. In addition, FIG. **30** is a diagram illustrating examples of signals respectively input to the plurality of terminals **363** according to the third embodiment. In addition, FIG. **31** is a diagram illustrating examples of signals respectively input to the plurality of terminals **373** according to the third embodiment. In addition, FIG. **32** is a diagram illustrating examples of signals respectively input to the plurality of terminals **383** according to the third embodiment.

As illustrated in FIG. **29**, the print data signal SI**1** for controlling discharge of the ink, the change signal CHa, the latch signal LATa, the clock signal SCKa, the temperature signal TH, and a plurality of ground signals GND are input to the terminals **353-1** to **353-10** in order to control the discharge of the ink. In addition, in order to drive the piezoelectric elements **60**, the driving signals COM-**1** to COM-**5** and the reference voltage signals CGND-**1** to CGND-**5** are input to the terminals **353-11** to **353-20**. That is, a control signal of a low voltage and a signal, which indicates a reference potential of the control signal, are input to the plurality of terminals **353** provided on the side of the side **326** of the first connector **350**, and a driving signal of the high voltage and a signal, which indicates a reference potential of the driving signal, are input to the plurality of terminals **353** provided on the side of the side **325** of the first connector **350**.

Further, the terminals, to which the ground signal GND is input, are located between the terminals **353** to which the print data signal SI**1**, the change signal CHa, the latch signal LATa, the clock signal SCKa, and the temperature signal TH are respectively input in order to control the discharge of the ink. Specifically, the terminal **353-3**, to which the ground signal GND is input, is located between the terminal **353-2**, to which the temperature signal TH is input, and the terminal **353-4** to which the latch signal LATa is input. In addition, the terminal **353-5**, to which the ground signal GND is input, is located between the terminal **353-4**, to which the latch signal LATa is input, and the terminal **353-6** to which the clock signal SCKa is input. In addition, the terminal **353-7**, to which the ground signal GND is input, is located between the terminal **353-6**, to which the clock signal SCKa is input, and the terminal **353-8** to which the change signal CHa is input. In addition, the terminal **353-9**, to which the ground signal GND is input, is located between the terminal **353-8**, to which the change signal CHa is input, and the terminal **353-10** to which the print data signal SI**1** is input.

As illustrated in FIG. **30**, in order to drive the piezoelectric elements **60**, the driving signals COM-**1** to COM-**5** and the reference voltage signals CGND-**1** to CGND-**5** are input to the terminals **363-1** to **363-10**. In addition, the print data signals SI**2** to SIS, a low voltage signal VDD which is a signal of the low voltage, and the plurality of ground signals GND are input to the terminals **363-11** to **363-20** of the second connector **360** in order to control the discharge of the ink. That is, the control signal of the low voltage and a signal, which indicates the reference potential of the control signal, are input to the plurality of terminals **363** provided on the side of the side **326** of the second connector **360**, and the driving signal of the high voltage and a signal, which indicates the reference potential of the driving signal, are input to the plurality of terminals **363** provided on the side of the side **325** of the second connector **360**.

As illustrated in FIG. **31**, the driving signals COM-**6** to COM-**10** and the reference voltage signals CGND-**6** to CGND-**10** are input to the terminals **373-1** to **373-10** in order to drive the piezoelectric elements **60**. In addition, the print data signal SI**10**, the change signal CHb, the latch signal LATb, the clock signal SCKb, the abnormality signal XHOT, and the plurality of ground signals GND are input to the terminals **353-11** to **353-20** in order to control the discharge of the ink. That is, the control signal of the low voltage and the signal, which indicates the reference potential of the control signal, are input to the plurality of terminals **373** provided on the side of the side **326** of the third connector **370**, and the driving signal of the high voltage and the signal, which indicates the reference potential of the driving signal, are input to the plurality of terminals **373** provided on the side of the side **325** of the third connector **370**.

Further, the terminals, to which the ground signal GND is input, are located between terminals **373** to which the print data signal SI**10**, the change signal CHb, the latch signal LATb, the clock signal SCKb, and the abnormality signal XHOT are respectively input in order to control the discharge of the ink. Specifically, the terminal **373-13**, to which the ground signal GND is input, is located between the terminal **373-12**, to which the abnormality signal XHOT is input, and the terminal **373-14** to which the latch signal LATb is input. In addition, the terminal **373-15**, to which the ground signal GND is input, is located between the terminal **373-14**, to which the latch signal LATb is input, and the terminal **373-16** to which the clock signal SCKb is input. In addition, the terminal **373-17**, to which the ground signal GND is input, is located between the terminal **373-16**, to which the clock signal SCKb is input, and the terminal **373-18** to which the change signal CHb is input. In addition, the terminal **373-19**, to which the ground signal GND is input, is located between the terminal **373-18**, to which the change signal CHb is input, and the terminal **373-20** to which the print data signal SI**10** is input.

As illustrated in FIG. **32**, the print data signals SI**6** to SI**9** and the plurality of ground signals GND are input to the terminals **383-1** to **383-9** in order to control the discharge of the ink. In addition, a high voltage signal VHV, which is the signal of the high voltage, is input to the terminal **383-10**. In addition, in order to drive the piezoelectric elements **60**, the driving signals COM-**6** to COM-**10** and the reference voltage signals CGND-**6** to CGND-**10** are input to the terminals **383-11** to **383-20**. That is, the control signal of the low voltage and the signal, which indicates the reference potential of the control signal, are input to the plurality of terminals **383** provided on the side of the side **326** of the fourth connector **380**, and the driving signal of the high voltage and the signal, which indicates the reference potential of the driving signal, are input to the plurality of terminals **383** provided on the side of the side **325** of the fourth connector **380**.

Next, the configuration of the substrate **320** included in the print head **23** will be described with reference to FIGS. **33** and **34**. FIG. **33** is a plan diagram illustrating a case where the substrate **320** according to the third embodiment is viewed from the surface **322**. In addition, FIG. **34** is a plan diagram illustrating a case where the substrate **320** according to the third embodiment is viewed from the surface **321**. Note that, in FIG. **33**, a location of the head **310** provided on the side of the surface **321** of the substrate **320** is illustrated using broken lines.

As illustrated in FIGS. **33** and **34**, electrode groups **430***a* to **430***j* are provided in the surface **322** of the substrate **320**. In addition, the substrate **320** is formed with ink supply path insertion holes **431***a* to **431***j* and FPC insertion holes **432***a* to **432***e*. The ink supply path insertion holes **431***a* to **431***j* and the FPC insertion holes **432***a* to **432***e* are through holes which pass through the surface **321** the surface **322** of the substrate **320**. Note that, configurations of the electrode groups **430***a* to **430***j*, the ink supply path insertion holes **431***a* to **431***j*, and the FPC insertion holes **432***a* to **432***e* are the same as those of the electrode groups **330***a* to **330***c*, the ink supply path insertion holes **331***a* to **331***f*, and the FPC insertion holes **332***a* to **332***c* according to the first embodiment, only other than the numbers thereof provided in the substrate **320**.

Each of the electrode groups **430***a* to **430***j* includes a plurality of electrodes provided in parallel along the Y1 direction. Further, the electrode groups **430***a* to **430***j* face a side of the side **324** from a side of the side **323** along the X1 direction, and are located in order of the electrode groups **430***a*, **430***b*, **430***c*, **430***d*, **430***e*, **430***f*, **430***g*, **430***h*, **430***i*, and **430***j*. A flexible wiring substrate **335** is coupled to each of the electrode groups **430***a* to **430***j*.

The FPC insertion hole **432***a* is located between the electrode group **430***a* and the electrode group **430***b* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to each of the electrode groups **430***a* and **430***b* is inserted into the FPC insertion hole **432***a*. The FPC insertion hole **432***b* is located between the electrode group **430***c* and the electrode group **430***d* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to each of the electrode groups **430***c* and **430***d* is inserted into the FPC insertion hole **432***b*. The FPC insertion hole **432***c* is located between the electrode group **430***e* and the electrode group **430***f* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to each of the electrode groups **430***e* and **430***f* is inserted into the FPC insertion hole **432***c*. The FPC insertion hole **432***d* is located between the electrode group **430***g* and the electrode group **430***h* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to each of the electrode groups **430***g* and **430***h* is inserted into the FPC insertion hole **432***d*. The FPC insertion hole **432***e* is located between the electrode group **430***i* and the electrode group **430***j* in the X1 direction. Further, the flexible wiring substrate **335** electrically coupled to each of the electrode groups **430***i* and **430***j* is inserted into the FPC insertion hole **432***e*.

The ink supply path insertion hole **431***a* is located on a side of the side **323** of the electrode group **430***a* in the X1 direction. The ink supply path insertion holes **431***b* and **431***c* are located between the electrode group **430***b* and the electrode group **430***c* in the X1 direction, and are located in line along the Y1 direction such that the ink supply path insertion hole **431***b* is on the side of the side **325** and the ink supply path insertion hole **431***c* is on the side of the side **326**. The ink supply path insertion holes **431***d* and **431***e* are located between the electrode group **430***d* and the electrode group **430***e* in the X1 direction, and are located in line along the Y1 direction such that the ink supply path insertion hole **431***d* is on the side of the side **325** and the ink supply path insertion hole **431***e* is on the side of the side **326**. The ink supply path insertion holes **431***f* and **431***g* are located between the electrode group **430***f* and the electrode group **430***g* in the X1 direction, and are located in line along the Y1 direction such that the ink supply path insertion hole **431***f* is on the side of the side **325** and the ink supply path insertion hole **431***g* is on the side of the side **326**. The ink supply path insertion holes **431***h* and **431***i* are located between the electrode group **430***h* and the electrode group **430***i* in the X1 direction, and are located in line along the Y1 direction such that the ink supply path insertion hole **431***h* is on the side of the side **325** and the ink supply path insertion hole **431***i* is on the side of the side **326**. The ink supply path insertion hole **431***j* is located on the side of the side **324** of the electrode group **430***j* in the X1 direction.

The ink supply ports **661**, which introduce the ink to the discharge sections **600** corresponding to the respective nozzle rows L1 to L**10**, are inserted into the respective ink supply path insertion holes **431***a* to **431***j* which are provided as above.

In addition, as illustrated in FIG. **34**, the integrated circuit device **241** is provided on the side of the surface **321** of the substrate **320**. The integrated circuit device **241** is the integrated circuit device included in the diagnostic circuit **240** illustrated in FIG. **2**, performs diagnosis of whether or not it is possible to normally discharge the ink from the nozzles **651** based on the latch signal LATa, the change signal CHa, the print data signal SI**1**, and the clock signal SCKa, which are input from the first connector **350**, and performs diagnosis of whether or not it is possible to normally discharge the ink from the nozzles **651** based on the latch signal LATb, the change signal CHb, the print data signal SI**10**, and the clock signal SCKb, which are input from the third connector **370**.

The integrated circuit device **241** is provided on the side of the side **326** of the FPC insertion holes **432***a* to **432***f* between the side **323** and the side **324** on the side of the surface **321** of the substrate **320**. In this case, it is preferable that the integrated circuit device **241** is provided at a center between the side **323** and the side **324**. Here, the center between the side **323** and the side **324** is not limited to a spot at which a distance from the side **323** is equal to a distance from the side **324**. Specifically, when it is assumed that a line acquired by connecting dots at which the distance from the side **323** is equal to the distance from the side **324** is the virtual line A, the integrated circuit device **241** may be located on a side of the virtual line A rather than the side **323**, and may be located on the side of the virtual line A rather than the side **324**. In other words, the shortest distance between the virtual line A and the integrated circuit device **241** is shorter than the shortest distance between the side **323** and the integrated circuit device **241**, and the shortest distance between the virtual line A and the integrated circuit device **241** is shorter than the shortest distance between the side **324** and the integrated circuit device **241**.

In the head unit **20** including the print head **23** and the liquid discharge apparatus **1** including the head unit **20**, which are configured as described above, according to the third embodiment, the number of nozzles **651** included in the head unit **20** is increased. Therefore, even though the number of signals propagated from the control mechanism **10** to the head unit **20** increases, it is possible to diagnose the presence or absence of an operation abnormality of the print head **23**.

Further, in the head unit **20**, which includes the print head **23** configured as described above, and the liquid discharge apparatus **1** which includes the head unit **20**, the substrate **320** included in the print head **23** is provided so that the surface **321** faces downward and the surface **322** faces upward in the direction along the vertical direction, and thus it is possible to exhibit the same effects as in the liquid discharge apparatuses **1** and the head units **20** according to the first embodiment and the second embodiment.

4. Fourth Embodiment

Next, a liquid discharge apparatus **1** and a head unit **20** according to a fourth embodiment will be described. Note that, when the liquid discharge apparatus **1** and the head unit **20** according to the fourth embodiment are described, the same reference symbols are attached to the components which are the same as in the first embodiment, the second embodiment, and the third embodiment, and description thereof will not be repeated or simplified. The liquid discharge apparatus **1** and the head unit **20** according to the fourth embodiment are different from those according to the third embodiment in a fact that the diagnostic circuit **240** is configured to include two integrated circuit devices with respect to the print head **23** included in the head unit **20** according to the third embodiment.

FIG. **35** is a plan diagram illustrating a case where the substrate **320** included in the print head **23** is viewed from the surface **321** according to the fourth embodiment. Two integrated circuit devices **241** and **242** are provided in line along the X1 direction in the surface **321** of the substrate **320** according to the fourth embodiment.

A print data signal SI**1**, a change signal CHa, a latch signal LATa, and a clock signal SCKa are input from a first connector **350** to the integrated circuit device **241**. Further, the integrated circuit device **241** diagnoses whether or not it is possible for the print head **23** to normally discharge ink based on the print data signal SI**1**, the change signal CHa, the latch signal LATa, and the clock signal SCKa.

In addition, a print data signal SI**10**, a change signal CHb, a latch signal LATb, and a clock signal SCKb are input from a third connector **370** to the integrated circuit device **242**. Further, the integrated circuit device **242** diagnoses whether or not it is possible for the print head **23** to normally discharge the ink based on the print data signal SI**10**, the change signal CHb, the latch signal LATb, and the clock signal SCKb.

On a side of the surface **321** of the substrate **320**, the integrated circuit devices **241** and **242** are located on a side of a side **326** of FPC insertion holes **432***a* to **432***e* between a side **323** and a side **324**, and are provided in line such that the integrated circuit device **241** is on a side of the side **323** and the integrated circuit device **242** is on a side of the side **324**. Further, the integrated circuit devices **241** and **242** are located on the side of the side **326** of the FPC insertion holes **432***a* to **432***e* between the first connector **350** and the third connector **370**, and the integrated circuit devices **241** and **242** are provided in line such that the integrated circuit device **241** is on the side of side **323** and the integrated circuit device **242** is on the side of the side **324**. In other words, the integrated circuit device **241**, which performs diagnosis of whether or not it is possible for the print head **23** to normally discharge ink based on various signals input from the first connector **350** provided along the side **323**, is provided on the side of the side **323**, and the integrated circuit device **242**, which performs the diagnosis of whether or not it is possible for the print head **23** to normally discharge ink based on various signals input from the third connector **370** provided along the side **324**, is provided on the side of the side **324**.

Here, it is preferable that the integrated circuit devices **241** and **242** are provided at the center between the side **323** and the side **324**. Note that, the center between the side **323** and the side **324** is not limited to a spot at which a distance from the side **323** is equal to a distance from the side **324**. Specifically, when it is assumed that a line acquired by connecting dots at which the distance from the side **323** is equal to the distance from the side **324** is a virtual line A, the integrated circuit device **241** may be located on a side of the virtual line A rather than the side **323** and may be located on the side of the virtual line A rather than the side **324**. Further, the integrated circuit device **242** may be located on the side of the virtual line A rather than the side **323** and may be located on the side of the virtual line A rather than the side **324**. In other words, the shortest distance between the virtual line A and the integrated circuit device **241** is shorter than the shortest distance between the side **323** and the integrated circuit device **241**, and the shortest distance between the virtual line A and the integrated circuit device **241** is shorter than the shortest distance between the side **324** and the integrated circuit device **241**. Further, the shortest distance between the virtual line A and the integrated circuit device **242** is shorter than the shortest distance between the side **323** and the integrated circuit device **242**, and the shortest distance between the virtual line A and the integrated circuit device **242** is shorter than the shortest distance between the side **324** and the integrated circuit device **242**.

The liquid discharge apparatus **1** and the head unit **20**, which are configured as above, according to the fourth embodiment includes the two integrated circuit devices **241** and **242** in the print head **23**. Further, the integrated circuit device **241** performs the diagnosis of whether or not it is possible for the print head **23** to normally discharge the ink based on the print data signal SI**1**, the change signal CHa, the latch signal LATa, and the clock signal SCKa, which are input from the first connector **350**, and the integrated circuit device **242** performs the diagnosis of whether or not it is possible for the print head **23** to normally discharge the ink based on the print data signal SI**10**, the change signal CHb, the latch signal LATb, and the clock signal SCKb which are input from the third connector **370**. In this manner, even in a configuration in which the signals input from the first connector **350** and the third connector **370** are detected by using the two integrated circuit devices **241** and **242** and it is diagnosed whether or not the print head **23** can perform normal discharge, in the head unit **20** including the print head **23** and the liquid discharge apparatus **1** including the head unit **20**, the substrate **320** included in the print head **23** is provided so that the surface **321** faces downward and the surface **322** faces upward in the direction along the vertical direction, and thus it is possible to exhibit the same effects as in the liquid discharge apparatus **1** and the head unit **20** according to the first embodiment, the second embodiment, and the third embodiment.

5. Modified Example

In the above-described liquid discharge apparatus **1**, the driving signal output circuit **50** may include two driving circuits **51***a* and **51***b* which generate and output driving signals COMA and COMB having different waveforms.

For example, the driving signal COMA may be a waveform acquired by succeeding two trapezoid waveforms which cause an intermediate amount of ink to be discharged from the nozzle **651**, and the driving signal COMB may be a waveform acquired by succeeding a trapezoid waveform which causes a small amount of ink to be discharged from the nozzle **651** and a trapezoid waveform which causes a vicinity of an opening section of the nozzle **651** to slightly vibrate. In this case, a driving signal selection circuit **200** may select any of the trapezoid waveforms included in the driving signal COMA and at least any of the trapezoid waveforms included in the driving signal COMB at a cycle Ta, and may output the selected trapezoid waveform as a driving signal VOUT.

That is, when the driving signal selection circuit **200** selects and combines the plurality of trapezoid waveforms included in each of the two driving signals COMA and COMB, the driving signal selection circuit **200** may generate and output the driving signal VOUT. Therefore, the number of combinations of the trapezoid waveforms, which can be output as the driving signal VOUT, increases without making the cycle Ta long. Therefore, it is possible to increase a range of selection of a dot size of the ink which is discharged to a medium M. Accordingly, the liquid discharge apparatus **1** can increase grayscale of the dots formed on the medium M. That is, it is possible to improve printing quality of the liquid discharge apparatus **1**.

In addition, when the driving signal output circuit **50** includes the two driving circuits **51***a* and **51***b* which generate and output the driving signals COMA and COMB of different trapezoid waveforms, for example, the driving signal COMA may be a waveform acquired by succeeding a trapezoid waveform which causes an intermediate amount of ink to be discharged from the nozzle **651**, a trapezoid waveform which causes a small amount of ink to be discharged from the nozzle **651**, and a trapezoid waveform which causes the vicinity of the opening section of the nozzle **651** to slightly vibrate, and the driving signal COMB may be acquired by succeeding a trapezoid waveform, which is different from the trapezoid waveform included in the driving signal COMA and causes an intermediate amount of ink to be discharged from the nozzle **651**, the trapezoid waveform which causes a small amount of ink to be discharged from the nozzle **651**, and the trapezoid waveform which causes the vicinity of the opening section of the nozzle **651** to slightly vibrate. Further, the driving signal COMA and the driving signal COMB are input to the driving signal selection circuits **200** which respectively correspond to different nozzle rows. Therefore, in a case where the ink of different characteristics is supplied to each nozzle row formed in the print head **23**, it is possible to supply the optimal driving signal VOUT to each individual nozzle row with respect to a difference in a shape of the channel to which the ink is supplied. Therefore, it is possible to reduce dispersion of the dot size for each nozzle row, and it is possible to improve the printing quality of the liquid discharge apparatus **1**.

Hereinabove, the embodiments and the modified example are described. The present disclosure is not limited to the embodiments and the modified example, and various forms are possible in a scope without departing from the gist of the present disclosure. For example, it is possible to appropriately combine the above-described embodiments.

In addition, the present disclosure includes a configuration (for example, a configuration in which a function, a method, and a result are the same or a configuration in which an object and effects are the same) which is substantially the same as the configuration described in the embodiments and the modified example. In addition, the present disclosure includes a configuration in which a non-essential part of the configuration described in the embodiments and the modified example is replaced. In addition, the present disclosure includes a configuration which accomplishes the same effects as the configuration described in the embodiments and the modified example, or a configuration in which it is possible to accomplish the same object. In addition, the present disclosure includes a configuration in which a well-known technology is added to the configuration described in the embodiments and the modified example.

The following contents are derived from the above-described embodiments and the modified example.

According to an aspect, there is provided a liquid discharge apparatus including a head unit that discharges liquid, and a digital signal output circuit that outputs a digital signal to the head unit, in which the head unit includes a plurality of print heads that discharge the liquid, and a housing that houses the plurality of print heads, a first print head in the plurality of print heads includes a substrate that includes a first side, a second side which intersects with the first side, a first surface which has the first side and the second side, and a second surface which is different from the first surface, a first nozzle plate that includes a first nozzle row in which a plurality of first nozzles for discharging the liquid are provided in line in a direction along the first side, a connector that is provided in the first surface and to which the digital signal is input, a first integrated circuit that is provided in the first surface, that is electrically coupled to the connector, to which the digital signal is input via the connector, and that outputs an abnormality signal indicating presence or absence of abnormality of the first print head, a first flexible wiring substrate that is electrically coupled to the substrate, and a second integrated circuit that is provided on the first flexible wiring substrate, the second integrated circuit is located between the first nozzle plate and the substrate, and the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

According to the liquid discharge apparatus, heat generated in the second integrated circuit provided on the first flexible wiring substrate electrically coupled to the substrate is transferred to the first flexible wiring substrate and the substrate. Further, the heat transferred to the substrate is emitted upward in the direction along the vertical direction. In this case, the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head is provided in the first surface that faces downward in the direction along the vertical direction. Therefore, a problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head. As a result, it is possible to reduce temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to reduce a problem in that the integrated circuit for executing a self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, the substrate may be provided so that the first side is orthogonal to the vertical direction and the second side is orthogonal to the vertical direction.

According to the liquid discharge apparatus, in the substrate included in the print head, the first side and the second side are orthogonal to the vertical direction in a state in which the first surface faces downward in a direction along the vertical direction and the second surface faces upward in the direction along the vertical direction. That is, in the substrate, a normal direction of the first surface is the direction along the vertical direction. As a result, the heat transferred to the substrate is efficiently emitted from the second surface which faces upward in the vertical direction. Therefore, a problem is further reduced in that the heat generated in the second integrated circuit affects the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head. As a result, it is possible to further reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to further reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, the substrate may include a third side provided to be parallel to the first side, and a fourth side provided to be parallel to the second side, and the first surface may have a rectangular shape that includes the first side, the second side, the third side, and the fourth side.

In the liquid discharge apparatus, the first integrated circuit may be provided so that a shortest distance between a virtual line, which has an equal distance from the first side and the third side, and the first integrated circuit is shorter than a shortest distance between the first side and the first integrated circuit, and the shortest distance between the virtual line and the first integrated circuit is shorter than a shortest distance between the third side and the first integrated circuit.

In the liquid discharge apparatus, the first integrated circuit may be provided so that a shortest distance between the first side and the first integrated circuit is shorter than the shortest distance between the third side and the first integrated circuit.

In the liquid discharge apparatus, a length of the first side may be shorter than a length of the second side.

In the liquid discharge apparatus, the first flexible wiring substrate may be electrically coupled to the second surface of the substrate.

According to the liquid discharge apparatus, the first flexible wiring substrate is electrically coupled to the second surface which faces upward in the vertical direction, and thus a problem is reduced in that the heat generated in the second integrated circuit transferred by the first flexible wiring substrate affects the first surface of the substrate. Therefore, the problem is further reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface. As a result, it is possible to further reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to further reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, the first print head may include a second flexible wiring substrate that is electrically coupled to the substrate, the substrate may include a first FPC insertion hole through which the first flexible wiring substrate is inserted, and a second FPC insertion hole through which the second flexible wiring substrate is inserted, a width of the first FPC insertion hole in the direction along the first side may be larger than a width of the first FPC insertion hole in a direction along the second side, and the first FPC insertion hole and the second FPC insertion hole may be located so that at least portions thereof overlap in the direction along the second side.

According to the liquid discharge apparatus, the radiant heat generated in the second integrated circuit provided on the first flexible wiring substrate is emitted to the side of the second surface of the substrate which faces upward in the vertical direction via the first FPC insertion hole through which the first flexible wiring substrate is inserted. Therefore, the problem is further reduced in that the radiant heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface. As a result, it is possible to further reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to further reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, a shortest distance between the first integrated circuit and the second side may be shorter than a shortest distance between the first FPC insertion hole and the second side, and the shortest distance between the first integrated circuit and the second side may be shorter than shortest distance between the second FPC insertion hole and the second side.

In the liquid discharge apparatus, a second print head in the plurality of print heads may include a second nozzle plate that includes a second nozzle row in which a plurality of second nozzles which discharge the liquid are provided in line, and the second print head may be provided so that the plurality of second nozzles included in the second nozzle row are disposed in the direction along the first side.

Even in a line head type liquid discharge apparatus, in which the nozzle rows included in the plurality of print heads are provided in line, as in the liquid discharge apparatus, a problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface, and thus it is possible to reduce temperature rise of the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head, and it is possible to reduce a problem in that the integrated circuit for executing a self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, the first print head and the second print head may be provided so that at least portions thereof overlap in the direction along the first side.

Even in the line head type liquid discharge apparatus, which is provided in such a way that the plurality of print heads are disposed in line, as the liquid discharge apparatus, the problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface, and thus it is possible to reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head, and it is possible to reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, the first print head may include a liquid supply port through which the liquid is supplied, and a shortest distance between the liquid supply port and the first surface may be longer than a shortest distance between the liquid supply port and the second surface.

In the liquid discharge apparatus, the liquid supply port may be located above the substrate in the direction along the vertical direction.

In the liquid discharge apparatus, the substrate may include a liquid supply port insertion hole through which the liquid supply port is inserted.

In the liquid discharge apparatus, the first print head may include a fixing member that fixes the substrate, the substrate may include a fixing member insertion hole through which the fixing member is inserted, the first integrated circuit may be located to overlap at least a part of the fixing member in a direction along the second side, and the fixing member may be located between the connector and the first integrated circuit in the direction along the second side.

In the liquid discharge apparatus, the connector may include a plurality of terminals.

In the liquid discharge apparatus, the plurality of terminals may be provided in line in the direction along the first side.

In the liquid discharge apparatus, the connector may include a fifth side and a sixth side which is longer than the fifth side, and the plurality of terminals may be provided in line in a direction along the sixth side.

In the liquid discharge apparatus, the connector may be provided so that the sixth side is parallel to the first side.

In the liquid discharge apparatus, the first print head may include a discharge module having the first nozzle plate, and the discharge module and the substrate may be fixed using an adhesive.

In the liquid discharge apparatus, the first integrated circuit may be located between the substrate and the discharge module.

Even in a case where the first integrated circuit is provided in an area surrounded by the discharge module and the substrate as in the liquid discharge apparatus, the problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface, and thus it is possible to reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head, and it is possible to reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the liquid discharge apparatus, the head unit may include a supply unit that supplies the liquid to the plurality of print heads.

In the liquid discharge apparatus, the first integrated circuit may include a plurality of electrodes electrically coupled to the substrate.

In the liquid discharge apparatus, the first integrated circuit may be a surface mount component.

In the liquid discharge apparatus, the first integrated circuit may be electrically coupled to the substrate via a bump electrode.

In the liquid discharge apparatus, the first integrated circuit may output an abnormality signal at a high level when an abnormality occurs in the first print head.

In the liquid discharge apparatus, the first integrated circuit may output an abnormality signal at a low level when the abnormality occurs in the first print head.

The liquid discharge apparatus may further include a liquid storage that stores the liquid.

In the liquid discharge apparatus, the liquid storage may store ink to be supplied to the head unit.

According to another aspect, there is provided a head unit including a plurality of print heads that discharge liquid, and a housing that houses the plurality of print heads, in which a first print head in the plurality of print heads includes a substrate that includes a first side, a second side which intersects with the first side, a first surface which has the first side and the second side, and a second surface which is different from the first surface, a first nozzle plate that includes a first nozzle row in which a plurality of first nozzles for discharging the liquid are provided in line in a direction along the first side, a connector that is provided in the first surface and to which a digital signal is input, a first integrated circuit that is provided in the first surface, that is electrically coupled to the connector, to which the digital signal is input via the connector, and that outputs an abnormality signal indicating presence or absence of abnormality of the first print head, a first flexible wiring substrate that is electrically coupled to the substrate, and a second integrated circuit that is provided on the first flexible wiring substrate, the second integrated circuit is located between the first nozzle plate and the substrate, and the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

According to the head unit, heat generated in the second integrated circuit provided on the first flexible wiring substrate electrically coupled to the substrate is transferred to the first flexible wiring substrate and the substrate. Further, the heat transferred to the substrate is emitted upward in the direction along the vertical direction. In this case, the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head is provided in the first surface that faces downward in the direction along the vertical direction. Therefore, a problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head. As a result, it is possible to reduce temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to reduce a problem in that the integrated circuit for executing a self-diagnosis function of the print head does not operate normally.

In the head unit, the substrate may be provided so that the first side is orthogonal to the vertical direction and the second side is orthogonal to the vertical direction.

According to the head unit, in the substrate included in the print head, the first side and the second side are orthogonal to the vertical direction in a state in which the first side faces downward in the direction along the vertical direction and the second side faces upward in the direction along the vertical direction. That is, in the substrate, a normal direction of the first surface is the direction along the vertical direction. As a result, the heat transferred to the substrate is efficiently emitted from the second surface which faces upward in the vertical direction. Therefore, a problem is further reduced in that the heat generated in the second integrated circuit affects the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head. As a result, it is possible to further reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to further reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the head unit, the substrate may include a third side provided to be parallel to the first side, and a fourth side provided to be parallel to the second side, and the first surface may have a rectangular shape that includes the first side, the second side, the third side, and the fourth side.

In the head unit, the first integrated circuit may be provided so that a shortest distance between a virtual line, which has an equal distance from the first side and the third side, and the first integrated circuit is shorter than a shortest distance between the first side and the first integrated circuit, and the shortest distance between the virtual line and the first integrated circuit is shorter than a shortest distance between the third side and the first integrated circuit.

In the head unit, the first integrated circuit may be provided so that a shortest distance between the first side and the first integrated circuit is shorter than the shortest distance between the third side and the first integrated circuit.

In the head unit, a length of the first side may be shorter than a length of the second side.

In the head unit, the first flexible wiring substrate may be electrically coupled to the second surface of the substrate.

According to the head unit, the first flexible wiring substrate is electrically coupled to the second surface which faces upward in the vertical direction, and thus a problem is reduced in that the heat generated in the second integrated circuit transferred by the first flexible wiring substrate affects the first surface of the substrate. Therefore, the problem is further reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface. As a result, it is possible to further reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to further reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the head unit, the first print head may include a second flexible wiring substrate that is electrically coupled to the substrate, the substrate may include a first FPC insertion hole through which the first flexible wiring substrate is inserted, and a second FPC insertion hole through which the second flexible wiring substrate is inserted, a width of the first FPC insertion hole in the direction along the first side may be larger than a width of the first FPC insertion hole in a direction along the second side, and the first FPC insertion hole and the second FPC insertion hole may be located so that at least portions thereof overlap in the direction along the second side.

According to the head unit, the radiant heat generated in the second integrated circuit provided on the first flexible wiring substrate is emitted to the side of the second surface of the substrate which faces upward in the vertical direction via the first FPC insertion hole through which the first flexible wiring substrate is inserted. Therefore, the problem is further reduced in that the radiant heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface. As a result, it is possible to further reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating presence or absence of the abnormality of the first print head, and thus it is possible to further reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the head unit, a shortest distance between the first integrated circuit and the second side may be shorter than a shortest distance between the first FPC insertion hole and the second side, and the shortest distance between the first integrated circuit and the second side may be shorter than shortest distance between the second FPC insertion hole and the second side.

In the head unit, a second print head in the plurality of print heads may include a second nozzle plate that includes a second nozzle row in which a plurality of second nozzles which discharge the liquid are provided in line, and the second print head may be provided so that the plurality of second nozzles included in the second nozzle row are disposed in the direction along the first side.

Even in a head unit, which can be used for the line head type liquid discharge apparatus in which the nozzle rows included in a plurality of print heads are disposed in line, as the head unit, the problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface, and thus it is possible to reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head, and it is possible to reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the head unit, the first print head and the second print head may be provided so that at least portions thereof overlap in the direction along the first side.

Even in a head unit, which is used for the line head type liquid discharge apparatus in which a plurality of print heads are disposed in line, as the head unit, the problem is reduced in that the heat generated in the second integrated circuit affects the first integrated circuit provided in the first surface, and thus it is possible to reduce the temperature rise of the first integrated circuit that outputs the abnormality signal indicating the presence or absence of the abnormality of the first print head, and it is possible to reduce the problem in that the integrated circuit for executing the self-diagnosis function of the print head does not operate normally.

In the head unit, the first print head may include a liquid supply port through which the liquid is supplied, and a shortest distance between the liquid supply port and the first surface may be longer than a shortest distance between the liquid supply port and the second surface.

In the head unit, the liquid supply port may be located above the substrate in the direction along the vertical direction.

In the head unit, the substrate may include a liquid supply port insertion hole through which the liquid supply port is inserted.

In the head unit, the first print head may include a fixing member that fixes the substrate, the substrate may include a fixing member insertion hole through which the fixing member is inserted, the first integrated circuit may be located to overlap at least a part of the fixing member in a direction along the second side, and the fixing member may be located between the connector and the first integrated circuit in the direction along the second side.

In the head unit, the connector may include a plurality of terminals.

In the head unit, the plurality of terminals may be provided in line in the direction along the first side.

In the head unit, the connector may include a fifth side and a sixth side which is longer than the fifth side, and the plurality of terminals may be provided in line in a direction along the sixth side.

In the head unit, the connector may be provided so that the sixth side is parallel to the first side.

In the head unit, the first print head may include a discharge module having the first nozzle plate, and the discharge module and the substrate may be fixed using an adhesive.

In the head unit, the first integrated circuit may be located between the substrate and the discharge module.

The head unit may further include a supply unit that supplies the liquid to the plurality of print heads.

In the head unit, the first integrated circuit may include a plurality of electrodes electrically coupled to the substrate.

In the head unit, the first integrated circuit may be a surface mount component.

In the head unit, the first integrated circuit may be electrically coupled to the substrate via a bump electrode.

In the head unit, the first integrated circuit may output an abnormality signal at a high level when an abnormality occurs in the first print head.

In the head unit, the first integrated circuit may output an abnormality signal at a low level when the abnormality occurs in the first print head.

What is claimed is:

1. A liquid discharge apparatus comprising:

a head unit that discharges liquid; and

a digital signal output circuit that outputs a digital signal to the head unit, wherein

the head unit includes

a plurality of print heads that discharge liquid, and

a housing that houses the plurality of print heads,

a first print head in the plurality of print heads includes

a substrate that includes a first side, a second side which intersects with the first side, a first surface which has the first side and the second side, and a second surface which is different from the first surface,

a first nozzle plate that includes a first nozzle row in which a plurality of first nozzles for discharging the liquid are provided in line in a direction along the first side,

a connector that is provided in the first surface and to which the digital signal is input,

a first integrated circuit that is provided on the first surface, that is electrically coupled to the connector, to which the digital signal is input via the connector, and that outputs an abnormality signal indicating presence or absence of abnormality of the first print head,

a first flexible wiring substrate that is electrically coupled to the substrate, and

a second integrated circuit that is provided on the first flexible wiring substrate,

the second integrated circuit is located between the first nozzle plate and the substrate, and

the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

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

the substrate is provided so that the first side is orthogonal to the vertical direction and the second side is orthogonal to the vertical direction.

3. The liquid discharge apparatus according to claim **1**, wherein

the substrate includes a third side provided to be parallel to the first side, and a fourth side provided to be parallel to the second side, and

the first surface has a rectangular shape including the first side, the second side, the third side, and the fourth side.

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

the first integrated circuit is provided so that a shortest distance between a virtual line, which has an equal distance from the first side and the third side, and the first integrated circuit is shorter than a shortest distance between the first side and the first integrated circuit, and the shortest distance between the virtual line and the first integrated circuit is shorter than a shortest distance between the third side and the first integrated circuit.

5. The liquid discharge apparatus according to claim **3**, wherein

the first integrated circuit is provided so that a shortest distance between the first side and the first integrated circuit is shorter than a shortest distance between the third side and the first integrated circuit.

6. The liquid discharge apparatus according to claim **1**, wherein

a length of the first side is shorter than a length of the second side.

7. The liquid discharge apparatus according to claim **1**, wherein

the first flexible wiring substrate is electrically coupled to the second surface of the substrate.

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

the first print head includes

a second flexible wiring substrate that is electrically coupled to the substrate,

the substrate includes a first FPC insertion hole through which the first flexible wiring substrate is inserted, and a second FPC insertion hole through which the second flexible wiring substrate is inserted,

a width of the first FPC insertion hole in the direction along the first side is larger than a width of the first FPC insertion hole in a direction along the second side, and

the first FPC insertion hole and the second FPC insertion hole are located so that at least portions thereof overlap in the direction along the second side.

9. The liquid discharge apparatus according to claim **8**, wherein

a shortest distance between the first integrated circuit and the second side is shorter than a shortest distance between the first FPC insertion hole and the second side, and

the shortest distance between the first integrated circuit and the second side is shorter than a shortest distance between the second FPC insertion hole and the second side.

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

a second print head in the plurality of print heads includes

a second nozzle plate that includes a second nozzle row in which a plurality of second nozzles which discharge the liquid are provided in line, and

the second print head is provided so that the plurality of second nozzles included in the second nozzle row are disposed in the direction along the first side.

11. The liquid discharge apparatus according to claim **10**, wherein

the first print head and the second print head are provided so that at least portions thereof overlap in the direction along the first side.

12. The liquid discharge apparatus according to claim **1**, wherein

the first print head includes a liquid supply port through which the liquid is supplied, and

a shortest distance between the liquid supply port and the first surface is longer than a shortest distance between the liquid supply port and the second surface.

13. The liquid discharge apparatus according to claim **12**, wherein

the liquid supply port is located above the substrate in the direction along the vertical direction.

14. The liquid discharge apparatus according to claim **12**, wherein

the substrate includes a liquid supply port insertion hole through which the liquid supply port is inserted.

15. The liquid discharge apparatus according to claim **1**, wherein

the first print head includes a fixing member that fixes the substrate,

the substrate includes a fixing member insertion hole through which the fixing member is inserted,

the first integrated circuit is located to overlap at least a part of the fixing member in a direction along the second side, and

the fixing member is located between the connector and the first integrated circuit in the direction along the second side.

16. The liquid discharge apparatus according to claim **1**, wherein

the connector includes a plurality of terminals.

17. The liquid discharge apparatus according to claim **16**, wherein

the plurality of terminals are provided in line in the direction along the first side.

18. The liquid discharge apparatus according to claim **16**, wherein

the connector includes a fifth side, and a sixth side which is longer than the fifth side, and

the plurality of terminals are provided in line in a direction along the sixth side.

19. The liquid discharge apparatus according to claim **18**, wherein

the connector is provided so that the sixth side is parallel to the first side.

20. A head unit comprising:

a plurality of print heads that discharge liquid; and

a housing that houses the plurality of print heads, wherein

a first print head in the plurality of print heads includes

a substrate that includes a first side, a second side which intersects with the first side, a first surface which has the first side and the second side, and a second surface which is different from the first surface,

a first nozzle plate that includes a first nozzle row in which a plurality of first nozzles for discharging the liquid are provided in line in a direction along the first side,

a connector that is provided in the first surface and to which a digital signal is input,

a first integrated circuit that is provided in the first surface, that is electrically coupled to the connector, to which the digital signal is input via the connector, and that outputs an abnormality signal indicating presence or absence of abnormality of the first print head,

a first flexible wiring substrate that is electrically coupled to the substrate, and

a second integrated circuit that is provided on the first flexible wiring substrate,

the second integrated circuit is located between the first nozzle plate and the substrate, and

the substrate is provided so that the first surface faces downward and the second surface faces upward in a direction along a vertical direction.

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