

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Abergel
U.S. Patent No.: 8,783,806 Attorney Docket No.: 53689-0003IP1
Issue Date: July 22, 2014
Appl. Serial No.: 13/948,670
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Title: INK JET PRINTER AND METHOD FOR DEPOSITING A
PROTECTIVE LAYER ON A SUBSTRATE

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 8,783,806 PURSUANT TO 35 U.S.C. § 311-319, 37 C.F.R. § 42**

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EXHIBITS

DUPLO-1001	U.S. Patent No. 8,783,806 to Abergel (“the ’806 Patent”)
DUPLO-1002	Excerpts from the Prosecution History of the ’806 patent (Serial No. 13/948,670)
DUPLO-1003	Declaration of Charles Reinholtz
DUPLO-1004	JP2006-240262A to Nagashima (“Nagashima”), including English translation and translator’s declaration
DUPLO-1005	JP2007-76344A to Yoshida (“Ricoh”), including English translation and translator’s declaration
DUPLO-1006	U.S. Patent No. 7,090,323 to Takatsuka (“Takatsuka”)
DUPLO-1007	U.S. Patent No. 6,619,777 to Chang (“Chang”)
DUPLO-1008	U.S. Patent No. 7,207,269 to Yoshida (“Dainippon”)
DUPLO-1009	EP 1749670 to Abergel et al.
DUPLO-1010	U.S. Patent No. 7,332,037 to Abergel et al.
DUPLO-1011	U.S. Patent No. 7,451,698 to Schneider et al. (“Schneider”)
DUPLO-1012	U.S. Patent No. 7,404,849 to Jackson et al. (“Jackson”)
DUPLO-1013	U.S. Patent No. 8,506,031 to Abergel (“the ’031 Patent”)
DUPLO-1014	Excerpts from the Prosecution History of the ’031 patent (Serial No. 12/649,765)
DUPLO-1015-1019	Reserved
DUPLO-1020	Complaint from MGI Digital Tech. S.A. v. Duplo U.S.A. Corp., 8:22-cv-00979 (C.D. Cal.)

DUPLO-1021	Special Master Report and Recommendation on Claim Construction, Case No. 8:22-CV-00979 (C.D. Cal.) (“SM Claim Construction”)
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LISTING OF CLAIMS

Limitation	Claim Language
[1.P.1]	A method of applying a coating of covering ink to a substrate moving relative to an ink jet nozzle arrangement . . .
[1.P.2]	[an ink jet nozzle arrangement] having a piezoelectric actuator for applying droplets of covering ink to the substrate, the method comprising
[1.1.1]	controlling by a computer the shapes of the droplets by controlling the shape of an electric waveform applied to the piezoelectric actuator,
[1.1.2]	said shape being controlled by selecting at least a number of plateaus of the electric waveform,
[1.2]	in response to at least one of the following parameters: viscosity of the ink, composition of the covering ink, temperature of the covering ink, temperature of the substrate, desired thickness of the layer, type of substrate surface to which the droplets are applied, and relative speed of the substrate and the ink jet nozzle arrangement.
[2]	The method of claim 1 wherein the shape of said electric waveform is controlled in response to the viscosity and/or the temperature of the ink, detected as the ink flows from the ink container to the nozzle by at least one detector upstream from a heater included in the nozzle arrangement.
[4.P]	The method of claim 1 wherein the waveform has
[4.1]	(a) neutral value associated with the nozzle arrangement being at rest,
[4.2.1] ¹	(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and
[4.2.2]	the waveform first polarity having an intermediate substantially constant amplitude between the neutral value and a peak value, . . .

¹ Elements of claims 4 and 12 are presented out of order for readability.

	the intermediate value having an amplitude and/or duration dependent on the viscosity of the ink droplet.
[4.2.3]	each peak value causing a droplet to be expelled from the nozzle arrangement,
[4.3]	(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;
[9.P]	Apparatus for applying a coating of covering ink to a substrate, comprising
[9.1]	a transport mechanism for causing relative movement between the substrate and an ink jet nozzle arrangement,
[9.2]	the ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate;
[9.3]	a computer controlling a heater included in the nozzle arrangement heating the covering ink and
[9.4.1]	an electric source for applying an electric waveform to the piezoelectric actuator, said waveform controlling the shapes of the droplets,
[9.4.2]	said apparatus comprising a command device controlling the shape of the electric waveform by selecting at least a number of plateaus of the electric waveform,
[9.5]	in response to at least one of the following parameters: viscosity of the covering ink, composition of the covering ink, temperature of the covering ink, temperature of the substrate, desired thickness of the layer, type of substrate surface to which the droplets are applied, and relative speed of the substrate and the ink jet nozzle arrangement.
[10]	The apparatus of claim 9 further including at least one detector upstream from the heater for detecting the viscosity of the ink and/or a detector for detecting temperature of the ink as the ink flows from the ink container to the nozzle and wherein said command device selects said number of plateaus in response to the viscosity and/or temperature of the covering ink measured by said detector.
[12.P]	The apparatus of claim 9 wherein the waveform has

[12.1]	(a) neutral value associated with the nozzle arrangement being at rest,
[12.2.1]	(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and
[12.2.2]	the waveform first polarity having an intermediate substantially constant amplitude between the neutral value and a peak value, . . . the intermediate value having an amplitude and/or duration dependent on the viscosity of the ink droplet.
[12.2.3]	each peak value causing a droplet to be expelled from the nozzle arrangement,
[12.3]	(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;

Duplo U.S.A. Corporation (“Petitioner” or “Duplo”) petitions for *Inter Partes* Review (“IPR”) of claims 1, 2, 4, 9-10, & 12 (“the Challenged Claims”) of U.S. Patent No. 8,783,806 (“the ’806 Patent”). Compelling evidence presented in this Petition demonstrates at least a reasonable likelihood that Duplo will prevail with respect to one or more of the Challenged Claims. Accordingly, Duplo respectfully requests institution of IPR and cancellation of all Challenged Claims as unpatentable.

I. REQUIREMENTS FOR IPR UNDER 37 C.F.R. § 42.104

A. Standing

Duplo certifies that the ’806 Patent is available for IPR. Duplo is not barred or estopped from requesting IPR of the Challenged Claims.

B. Challenged Claims and Relief Requested

Duplo requests IPR of the Challenged Claims on the grounds set forth below. Additional explanation and support for each ground is set forth in the Declaration of Charles Reinholtz (DUPLO-1003), referenced throughout this Petition.

Ground	Claims	Basis for Unpatentability
1A	1, 2, 9, 10	35 U.S.C. § 103: Nagashima
1B	4, 12	35 U.S.C. § 103: Nagashima in view of Ricoh
2	1, 2, 4, 9, 10, 12	35 U.S.C. § 103: Takatsuka in view of Chang
3	1, 4	35 U.S.C. § 103: Dainippon in view of Chang

The '806 Patent is a divisional of U.S. 8,506,031 (the '031 Patent) that claims priority to a French application filed December 30, 2008 (FR 2940627B1). Petitioner treats (but does not admit) December 30, 2008 as the earliest effective filing date. Each reference applied in the Grounds listed in Table 1 qualifies as prior art to the '806 Patent on at least the bases shown below:

Reference	Publication Number	Publication Date	Prior Art Basis
Nagashima	JP2006-240262A	Sept. 14, 2006	102(a),(b)
Ricoh	JP2007-076344A	March 29, 2007	102(a),(b)
Takatsuka	U.S. 7,090,323	Sept. 1, 2005	102(a),(b)
Chang	U.S. 6,619,777	Sept. 16, 2003	102(a),(b)
Dainippon	U.S. 7,207,269	Oct. 14, 2004	102(a),(b)

Other references discussed herein include U.S. 7,404,849, published Oct. 27, 2005, to Jackson; and U.S. 7,451, 698, published Sept. 8, 2005 to Schneider.

C. 35 U.S.C. § 325(d) Analysis

With the exception of Chang, none of these references were previously before the examiner. Chang was cited in an Information Disclosure Statement, but was not relied on by the examiner to reject the claims of the '806 Patent or the claims of the parent '031 Patent. In fact, the '806 Patent was allowed without any prior art rejections. DUPLO-1002, pp. 38-43 and 58-63. While the parent '031 Patent was substantively rejected, Chang is being used here as a secondary reference for a feature not claimed by the '031 Patent – namely “said shape [of the

electric waveform] being controlled by selecting at least a number of plateaus of the electric waveform.” Grounds 2 and 3, *infra*. Thus, the examiner failed to appreciate that Chang discloses this limitation. Further, Chang is used in this Petition in combination with primary references, Takatsuka and Dainippon, that were not part of the ’806 Patent prosecution (or ’031 Patent prosecution) nor similar to other art before the examiner. *Id.* Thus, because the examiner did not have the benefit of Takatsuka or Dainippon, nor the additional expert testimony submitted herewith, the examiner was unable to formulate a rejection based on Chang. Duplo respectfully submits that discretionary institution denial under 35 U.S.C. § 325(d) is unwarranted under these circumstances. *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 (PTAB Feb. 13, 2020) (precedential).

II. THE ’806 PATENT

The ’806 Patent “relates to ink jet printers and methods for depositing a protective layer on a substrate.” ’806 Patent, 1:18-22. “The protective layer is formed from a material referred to herein as a varnish or ink.” *Id.*, 1:22-24. But, also, the ’806 Patent says the material can be, simply, a “viscous product.” *Id.*, 3:21-22.

The Background of the '806 Patent describes prior art reference EP 1749670 ("EP '670"), which relates to a "digital ink jet machine for laying a coating with medium viscosity on a variable coating substrate by using ink jet nozzles." '806 Patent, 1:42-47. The ink jet nozzles in the prior art operated based on the "vibration by piezoelectric actuator adhesively bonded to a resonator." *Id.* In characterizing the prior art, the '806 Patent states that the "the shape of a droplet of material (i.e., an ink or varnish) deposited by each nozzle on the surface of the substrate, **depend on the duration and amplitude of an electric wave** driving the actuator." '806 Patent, 1:47-50 (emphasis added). In short, the Applicant Admitted Prior Art (AAPA) includes controlling the shape of droplets by controlling the shape of the electric waveform applied to the piezoelectric actuator, and that this technique is common to both ink and varnish. *Id.*

The '806 Patent tries to provide "optimal deposition of a protective ink layer on a surface of a substrate independently of the ink viscosity and the substrate to be covered." '806 Patent, 1:55-59. The '806 Patent purports to do this by, among other things, selecting a number of plateaus of the electric waveform in response to one of a plurality of parameters, as recited in claims 1 and 9.

III. LEVEL OF ORDINARY SKILL IN THE ART

A person of ordinary skill in the art would be a person with a bachelor's degree in mechanical engineering or electrical engineering or a related field and at least two years of practical experience with printer technology. In some instances, more relevant practical experience may compensate for less formal education, and conversely, more relevant formal education may compensate for less practical experience. DUPLO-1003, 27-28.

IV. CLAIM CONSTRUCTION

Except as discussed below, all claim terms are construed according to their plain meaning. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); 37 C.F.R. § 42.100. The remaining claim terms do not require a formal construction for purposes of addressing the Grounds presented in this Petition.

nozzle arrangement (claims 1, 2, 4, 8, 9, & 12)

Petitioner applies the construction that nozzle arrangement means “a structure, or group of structures, that includes one or more ink jet nozzles,” which is the construction provided by the Special Master in the co-pending litigation.

DUPLO-1021, 65.² The Special Master noted that “the significance of the term ‘nozzle arrangement’ is that it includes one or more nozzles and can potentially include other related elements, such as one or more heaters and one or more piezoelectric actuators, as part of some structure.” *Id.* 63.

V. GROUNDS FOR UNPATENTABILITY

A. Ground 1A: Nagashima Renders Claims 1, 2, 9, & 10 Obvious

1. Overview of Nagashima

Nagashima describes “a liquid ejection head and an image formation device that eject a liquid onto a recording medium such as paper to form an image” Nagashima, [0001]. The ink ejection head 50 includes “a plurality of pressure chamber units 54 each configured to include the plurality of nozzles 51 that ejects ink.” *Id.* [0055].

Nagashima describes that piezoelectric body 58 is made of a piezoelectric material, and “changes the volume of the pressure chamber 52 via the diaphragm plate 56.” Nagashima, [0064]. “A drive waveform that is an electric signal for

² Petitioner is challenging Special Master’s construction at the district court, asserting the phrase means “an arrangement of one or more nozzles,” consistent with ’806 Patent, 8:56-58. Nonetheless, both constructions are met by the showings herein.

driving the piezoelectric body 58 is given from the head driver 156 of Fig. 1 to the piezoelectric body 58.” *Id.* “There are various types of drive waveforms given from the head driver 156 to the piezoelectric body 58,” including an ejection drive waveform, a heating drive waveform, a meniscus tickling waveform, and a non-driving waveform. *Id.* [0065]. By using one or more of these waveforms, the piezoelectric body “not only constitutes a pressure generation unit that generates a pressure for ejecting ink from the nozzles 51 but also constitutes a heating unit that heats the ink and a viscosity adjustment unit that adjusts the viscosity of the ink.” *Id.* [0066].

2. Analysis

[1.P.1]

Nagashima describes “a liquid ejection head and an image formation device that eject a liquid onto a recording medium such as paper to form an image.” Nagashima, [0001]. Here, the recording medium (e.g., paper) is the claimed substrate. The “ink ejection head 50” is the claimed nozzle arrangement, because it is a structure that has an arrangement of one or more ink jet nozzles. Nagashima, [0054] (“the ink ejection head 50 has a large number of nozzles 51”); *see also*, *id.*, [0038], [0043], [0208], FIGS. 14 and 15. Nagashima teaches a conveyor (i.e., a transport mechanism) that “moves a recording medium [*i.e.*, substrate] such as paper relative to the ink ejection head 50.” *Id.*, [0043].

A POSITA would understand that Nagashima teaches coating with a covering ink. DUPLO-1003, 57-61. Nagashima does not limit use of its image formation device to any particular type of ink, and expressly teaches different inks identified from an ink identifier (ink ID). Nagashima, [0046]-[0047]. The ink ID is used to identify inks of different characteristics, such as differing volatility and whether meniscus micro-vibration might be needed to control the viscosity. *Id.* [0128]. Although Nagashima expressly mentions “black (K), cyan (C), magenta (M), and yellow (Y),” this example is not said to be limiting. Nagashima, [0039] and [0236] (“the present invention is not limited to the examples described”). A POSITA would understand Nagashima’s explicit, in-depth teachings on how to operate the ink ejection head are applicable for any inks, regardless of type. DUPLO-1003, 57-61.

In addition to different types of ink, Nagashima inks of various viscosities, including viscosities of covering inks. *Id.* [0110] (providing a viscosity-dependent equation for meniscus surface amplitude for ejection). Example ink viscosities in Nagashima are 20 and 30 centipoise, and fall within the “ideal” range of covering ink viscosities described in the ’806 Patent. *See* Nagashima, [0218]; ’806 Patent, 6:44-45 (4-100 centipoise).

Finally, the ’806 Patent defines the term “covering ink” broadly as synonymous with “viscous product.” ’806 Patent, 3:21-22 (“the terms of

“‘covering ink’, ‘viscous product’ and ‘varnish’ are synonyms”). Given that Nagashima discusses example viscosities when discussing inks, such example inks expressly disclosed by Nagashima are “viscous product” and there is little doubt that Nagashima’s inks “cover.” DUPLO-1003, 57-61.

Accordingly, Nagashima teaches applying a coating of covering ink.

Even still, a POSITA would have found it obvious to use Nagashima to apply a covering ink. DUPLO-1003, 62-66. First, it was known at the time that an inkjet could be used to apply a coating of covering ink. DUPLO-1003, 62-66. For example, when discussing the prior art, the ’806 Patent describes “a digital ink jet machine for laying a coating with medium viscosity on a variable coating substrate by using ink jet nozzles” that is “able to deposit varnish.” ’806 Patent, 1:42-54 (characterizing EP1749670); *id.*, 3:21-22 (varnish is synonymous with covering ink.). In another example, Dainippon describes a “varnish coating operation” that may be implemented using an “ink jet printing machine.” Dainippon, 12:52-57. Dainippon explains that the varnish can be coated “in the same way as the ink jet nozzles of an ink jet printer spray ink.” *Id.*, 10:28-32. In yet another example, Schneider describes a coating device that includes an inkjet printer. Schneider, Abstract, 3:21-25, FIG. 8-9.

A POSITA would have recognized that Nagashima’s image recording device was an inkjet printer. DUPLO-1003, 62-66. For example, Nagashima teaches “a

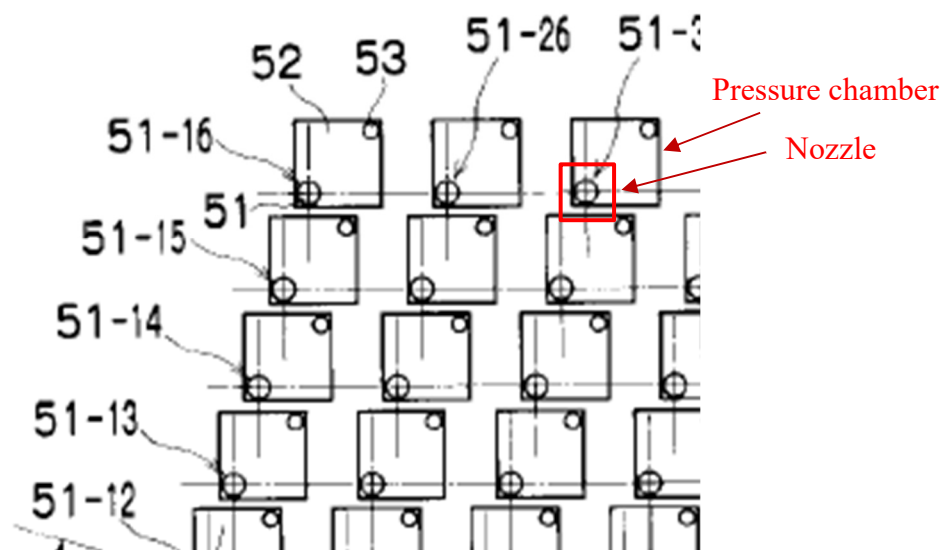
piezo-type ink ejection head . . . in which the volume of a pressure chamber is changed and ink in the pressure chamber is ejected from a nozzle.” Nagashima, [0003], [0061]. A POSITA would recognize that inkjet printers relied on ink ejection by a piezo. DUPLO-1003, 62-66.

Given that Nagashima teaches operating its ink ejection head with different ink types and viscosities, including viscosities of covering ink, and inkjet printers were known as capable of coating with a covering ink, a POSITA would have found it obvious to apply a coating of covering ink using the inkjet design of Nagashima. DUPLO-1003, 62-66.

[1.P.2]

Nagashima teaches that the ink ejection head 50 includes a plurality of nozzles 51, as shown in FIGS. 3 and 15 below:

【 図 3 】

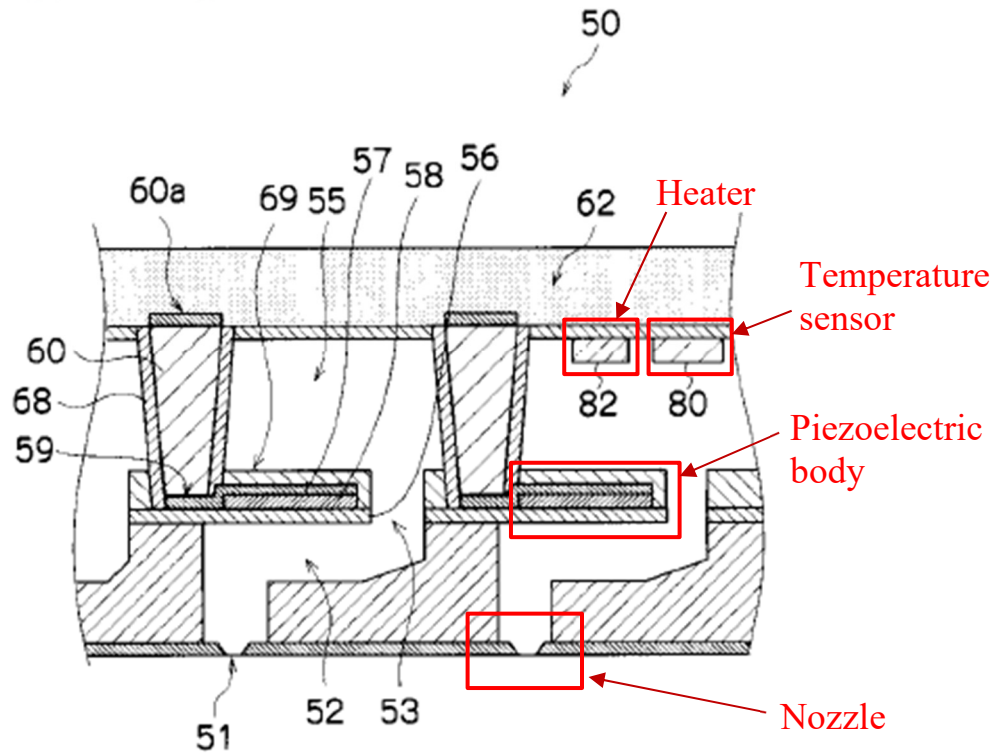


Nagashima, FIG. 3 (annotated).

The “the plurality of nozzles 51 is arrayed in . . . a two-dimensional matrix.”

Nagashima, [0054], [0057]. And as shown in FIG. 15 below, the nozzle arrangement includes a piezoelectric actuator, i.e., “piezoelectric body 58”:

【 図 1 5 】



Nagashima, FIG. 15 (annotated).

According to Nagashima, the piezoelectric body 58 “changes the volume of the pressure chambers 52 via the vibrating plate 56.” Nagashima, [0064]. By changing the volume of the chamber 52 “the ink in the form of drops is continuously ejected from the nozzle 51 toward the recording medium.” *See id.* [0086].

Nagashima teaches that there are “various types of drive waveforms given from the head driver 156 to the piezoelectric body 58.” Nagashima, [0065]. These waveforms are discussed in more detail below.

[1.1.1]

Nagashima describes a print control unit 150, a basic waveform generation unit 154, and a head driver 156 (together, the claimed computer) that work together to control the shape of droplets via a drive waveform applied to the piezoelectric body. Nagashima, [0038], [0085]. The head driver 156 uses the selection waveform from the print controller 152 and the basic waveform from the basic waveform generator 154 to select a drive waveform to output to the ink ejection head 50.” *Id.* [0050]. As described in more detail below, the selection waveform selects “a drive waveform . . . from the basic waveforms.” *Id.* [0133]. Then, the drive waveform selected by the head driver “is supplied to the piezoelectric body 58.” *Id.*

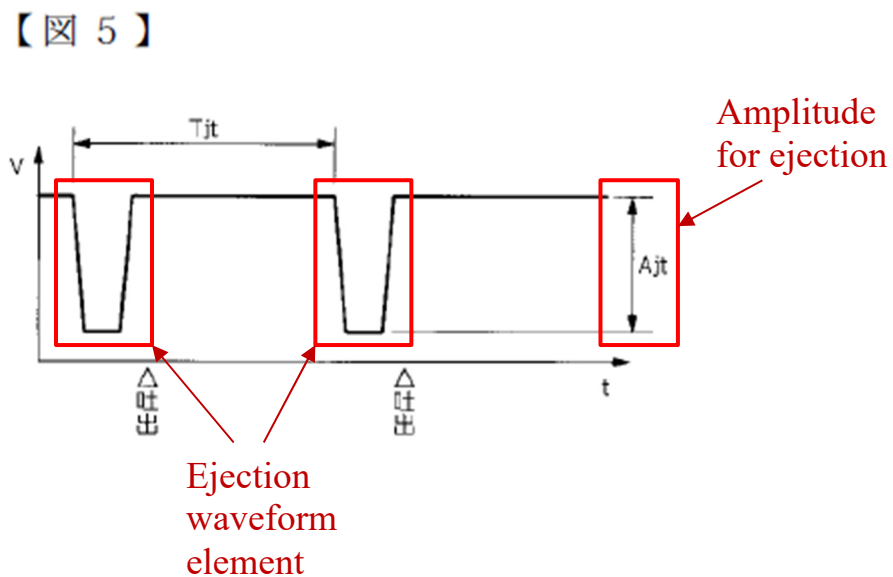
Nagashima teaches “various types of drive waveforms given from the head driver 156 to the piezoelectric body 58,” including an “ejection drive waveform,” a “heating drive waveform,” a “ejection and heating drive waveform,” and a “meniscus tickling waveform.” Nagashima, [0065]. The ejection drive waveforms generate, “in the piezoelectric body 58, ejection vibration for ejecting ink from the nozzles 51.” *Id.* The heating drive waveform “heats ink by heating the piezoelectric body 58 without ejecting the ink from the nozzles.” *Id.* The ejection / heating drive waveform “heats the piezoelectric body 58 in parallel with the ejection vibration.” *Id.* The meniscus tickling waveform that vibrates the meniscus

“to suppress rise in viscosity of the ink without ejecting the ink from the nozzles.”

Id.

The ejection drive waveform and the ejection / heating drive waveforms affect the shapes of the droplets.

The ejection drive waveform is shown in FIG. 5, reproduced below:

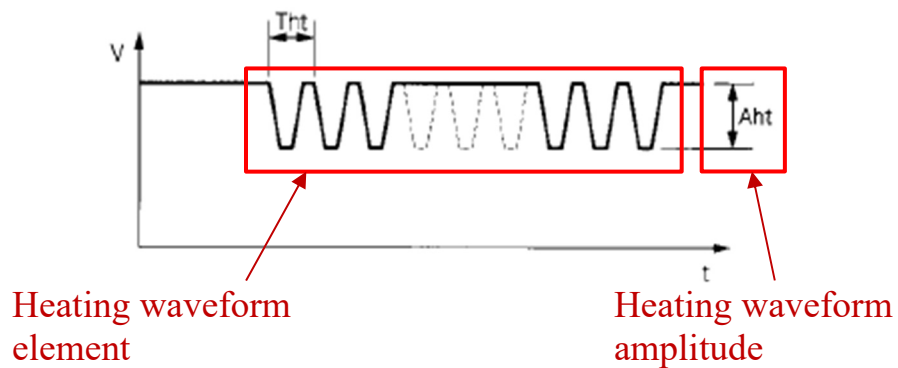


Nagashima, FIG. 5 (annotated).

FIG. 5 illustrates “the ejection drive waveform in the case of continuously ejecting n droplets (for example, $n = 2$) of ink from the same nozzle.” Nagashima, [0086].

FIG. 6 shows the heating drive waveform:

【 図 6 】

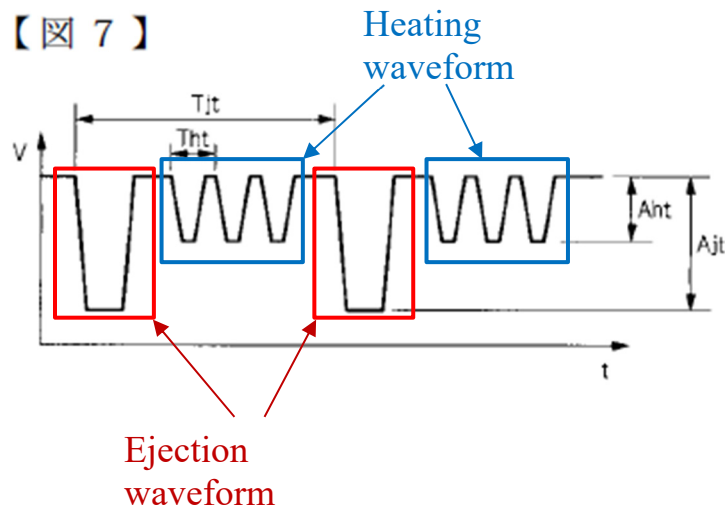


Nagashima, FIG. 6 (annotated).

The heating drive waveform shown in FIG. 6 “a continuous vibration waveform having an amplitude A_{ht} smaller than the amplitude A_{jt} of the ejection drive waveform.” Nagashima, [0122].

And FIG. 7 shows the ejection / heating drive waveform together:

【 図 7 】



Nagashima, FIG. 7 (annotated).

FIG. 7 shows an ejection / heating drive waveform in the case of “heating the ink in the pressure chamber 52 in parallel with the ejection of the ink droplets.”

Nagashima, [0089], [0090], [0143].

A POSITA would understand that, because the nozzle size is not variable, both the droplet volume (size) and the ink viscosity affect the shape of the droplet, such that larger droplets have a different shape than smaller droplets and droplets of higher viscosity produce droplets of different shape than droplets of lower viscosity.³ DUPLO-1003, 82-88, 100.

Nagashima teaches heating the ink to control the droplet size and viscosity. For example, “the dot size is controlled large by raising the ink temperature near the nozzle, and the dot size is made to a desired size.” *Id.* [0219]. “On the contrary, for a nozzle in which the dot size increases, the dot size is controlled small by lowering the ink temperature near the nozzle, and the dot size is made to a desired size.” *Id.* [0220]. The “dot size” is referring to the ink dot formed on the recording medium. Nagashima, [0059]. But, in describing the dot size, Nagashima is also describing the ejected droplet size, because the size of the droplet ejected by the nozzle dictates the dot size. Nagashima, [0219]-[0220]; DUPLO-1003, 82-88, 100. In other words, Nagashima teaches controlling the shapes of the droplets by

³ *E.g.*, ’806 Patent, 5:66-67 (correlating droplet shape with droplet volume).

controlling the ink temperature. DUPLO-1003, 82-84. The referenced temperature control is accomplished, at least partially, by the heating drive waveform, which can be used to heat the ink in the vicinity of the nozzle (*e.g.*, the pressure chamber): “the heating drive waveform that heats the ink in the pressure chamber 52.” *Id.* [0088]. “When heating drive is performed, the switching time of the heating drive waveform . . . is switched based on the ink temperature for each pressure chamber 52” so that “the lower the ink temperature of the pressure chamber 52 has, the longer the time to give the heating drive waveform.” *Id.* [0227].

Nagashima, thus, teaches controlling the shape of the waveform by selecting the number of heating drive waveform peaks (and correspondingly plateaus) to control the temperature of the ink, which Nagashima explains is performed to control the shape of the droplet ejected by the nozzle. Also, Nagashima controls whether the heating drive waveforms are combined with the ejection drive waveform to eject an ink droplet having the desired, controlled, size and shape.

Additionally, or alternatively, the meniscus tickling waveform mitigates viscosity increases in the ink at the nozzle and the resulting effect that viscosity increases have on droplet shape. In particular, Nagashima discloses the meniscus tickling waveform can be selected to suppress “rise in viscosity of the ink by meniscus tickling that stirs the ink near the nozzle 51 . . . due to evaporation of the

solvent from the surface of the ink in the nozzle 51.” Nagashima, [0124]. The meniscus tickling waveform is different from the heating vibration. *Id.* [0129] (the meniscus tickling waveform has a lower frequency and a smaller applied voltage) *Id.* [0129]. Thus, whether the meniscus tickling waveform is included affects the resulting shape of the electric waveform and resulting number of plateaus.

Additionally, the meniscus tickling amplitude h at which ejection occurs is dependent on the viscosity μ and the drive frequency f . Nagashima, [0109]-[0110] (teaching $h \geq 2 (\mu / \rho) \times (\rho / T\pi f)^{1/3}$ where μ is the viscosity [Pa•s], ρ is the density of the liquid [kg / m³], and T is the surface tension [N/m]).

Nagashima teaches that if the viscosity of the ink increases (*e.g.*, because of evaporation of the meniscus solvent), ejection becomes increasingly unstable. Nagashima, [0109]-[0110], [0124]; DUPLO-1003, 82-87, 100. It was well known at the time that increases in viscosity of the ink near the meniscus due to solvent evaporation could adversely affect ejection of the droplet. DUPLO-1003, 82-87, 100; *see also*, Chang, 2:17-19 (“When the ink viscosity of ink at the nozzle openings rises due to evaporation of the ink solvent, a fault such as a splash of ejected ink drops in a direction shifted from the normal direction may be caused.”); Takatsuka, 20:26-29 (describing that ejection failures occur “as a result of the ink in the vicinity of the ejection port of the nozzle 100 having dried and increased in viscosity.”); Ricoh [0010] (describing the effects of viscosity on ejection amount

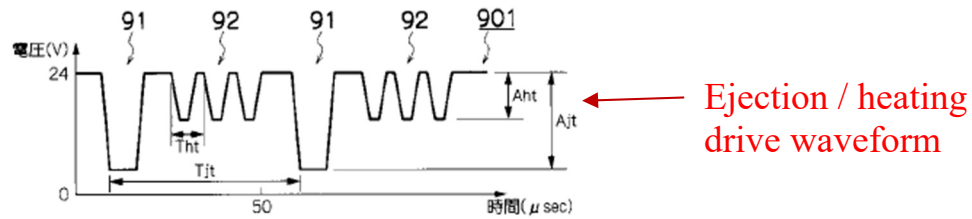
and stability). Therefore, by controlling the shape of the electric waveform to include the ejection drive waveform and the meniscus tickling waveform, the computer controls the shape of the droplet by controlling against “splash” and other effects on the droplet the increases in viscosity can have. DUPLO-1003, 82-87, 100. Accordingly, a POSITA would have appreciated that suppressing the increase in viscosity of the ink of the ink using a meniscus tickling waveform would have affected the shape of the droplet ejected from the nozzle. DUPLO-1003, 82-87, 100.

[1.1.2]

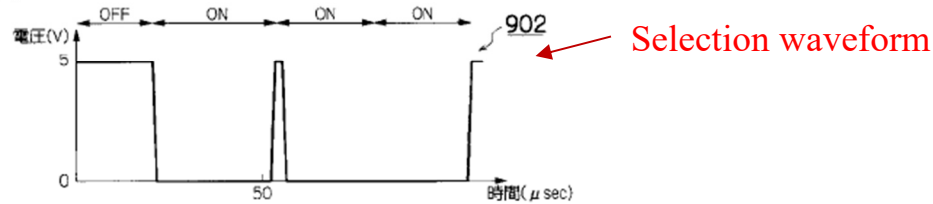
Nagashima controls the shape of the electric waveform by selecting a number of plateaus of the electric waveform. First, FIGS. 9A-C reproduced below show how Nagashima performs the selection of a number of waveforms:

【図 9】

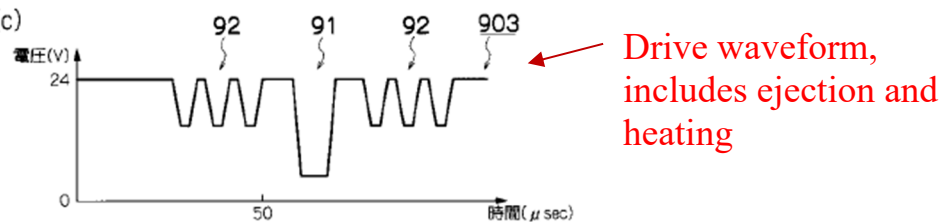
(a)



(b)



(c)



Nagashima, FIGS. 9(a)-(c), annotated.

Waveform 901 shows an example of a basic waveform, which includes an ejection drive waveform 91 and a heating drive waveform 92. Nagashima, [0135]. “The selection waveform 902 illustrated in Fig. 9(b) indicates selection (ON) and non-selection (OFF) of the ejection drive waveform for each cycle.” Nagashima, [0136]. The drive waveform 903 shown in FIG. 9C “does not have the ejection drive waveform 91 and has the heating drive waveform 92 in the first cycle (0 to

50 μ sec), and has the ejection drive waveform 91 and the heating drive waveform 92 in the second cycle (50 to 100 μ sec).” Nagashima, [0137].

Although FIG. 9C shows a state where both the ejection drive waveform and the heating drive waveform are shown, there is “a state where the heating drive waveform is not selected and only the ejection drive waveform is selected.” Nagashima, [0138].

Nagashima selects the number of heating drive waveform plateaus, when used, based on the desired temperature of the ink. “In the case of heating drive, pulse modulation is performed for switching the switching time (the period during which the heating drive waveform 92 is turned on in the selection waveform) according to the amount of temperature rise desired for each pressure chamber 52.” Nagashima, [0142]. As mentioned previously, the “minimum switching time is one wave (or one mountain) of the heating drive waveform. ” *Id.* [0143].

Additionally or alternatively, Nagashima teaches selecting the meniscus fine vibration for viscosity suppression. For example, Nagashima teaches that the meniscus micro-vibration is “performed on ink having high volatility” and based on temperature, and, implicitly, not on other inks. Nagashima, [0042], [0128]; DUPLO-1003, 85-86. “The print controller 150 controls meniscus tickling for preventing rise in viscosity of the ink based on the ink ID input to the ink ID inputter 118 and the surrounding temperature detected by the temperature sensor

80.” *Id.*, [0047]. A “selection waveform” is output “from the print control unit 150 to the head driver 156” when performing meniscus tickling. Nagashima, [0145]. Thus, the print control unit 150 selects to include or not include meniscus tickling waveforms to control the shape of the electric waveform applied to the piezo. DUPLO-1003, 85-86.

[1.2] temperature of the covering ink

As discussed above, Nagashima teaches that the shape of the electric waveform is controlled in response to the temperature of the covering ink by selecting whether to and how long to apply the heating drive waveform.

In more detail, Nagashima discloses that temperatures sensors 80 detect temperature of the ink in the common liquid chamber or in the pressure chamber. *Id.* [0041], [0047], [0067]-[0071]. The temperature of the ink detected by the temperature sensors 80 can be used to determine whether to heat ink in the common liquid chamber or in a pressure chamber. *See id.* [0047], [0068]-[0074], [0080], [0141]-[0142], [0224]; *see also*, §V.A.[2], *infra*. The print control unit “controls temperature adjustment of the ink in the ink ejection head 50 based on the temperature distribution inside the ink ejection head 50 detected by the temperature sensor 80.” *Id.* [0047]. Then, the print control unit “determines whether or not the temperature of the ink in each pressure chamber 52 is a temperature to be heated.” *Id.* [0141]. If the ink is to be heated “the selection

waveform 902 instructing selection (ON) of the heating drive waveform 92 is output” to the piezoelectric body 58. Nagashima, [0141]. In addition, Nagashima teaches that the switching time of the heating drive waveform is temperature dependent, meaning that the period in which the heating driving waveform is turned on is controlled according to the amount of temperature to be raised for each pressure chamber. *Id.* [0143]. As mentioned before, the temperature of the ink (as controlled by the shape of the heating drive waveform) affects the shape of the droplet. *See supra* A . . . [1.1.1].

Thus, Nagashima teaches that the shape of the electric waveform is controlled in response to the temperature of the ink because the temperature of the ink is used to determine whether to apply a heating drive waveform and how many plateaus of the heating drive waveform to use. DUPLO-1003, 101-104.

[1.2] composition of the covering ink

Nagashima teaches that the meniscus tickling waveform is applied based on the volatility (i.e., composition) of the ink. Nagashima teaches that the ink identifier (ID) is read from the ink cartridge and is used “for identifying the type of ink.” *Id.*, [0046] & [0128]. An “ink ID of highly volatile ink that requires meniscus tickling and a temperature threshold for determining whether or not to perform meniscus tickling for each ink ID are stored in advance in the memory 152.” *Id.* [0128]. The meniscus tickling “is performed on ink having high

volatility, and is not performed on ink having low volatility.” Nagashima, [0128].

A POSITA would have known that an ink’s volatility is related to the composition of the ink, and inks with different volatility have different compositions. DUPLO-1003, 105-106. Thus, Nagashima determines whether and when to apply the meniscus tickling waveform (which changes the drive waveform’s shape) based on the composition of the ink. Nagashima, [0128]; DUPLO-1003, 105-106.

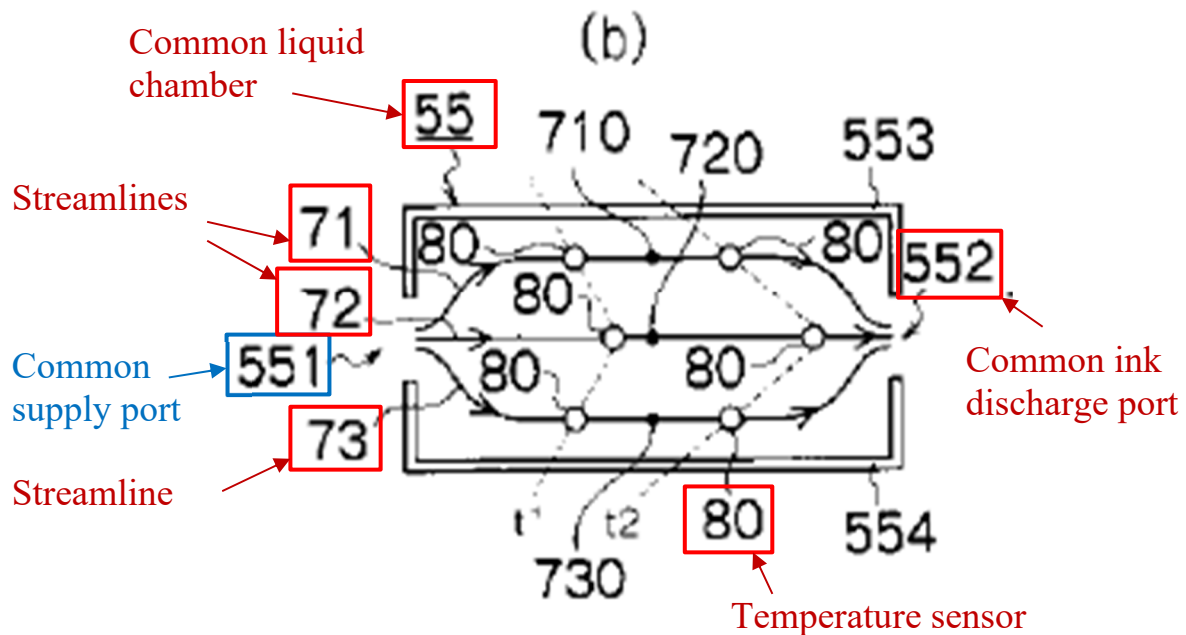
[2]

As discussed above, Nagashima teaches the shape of the waveform is controlled in response to temperature of the ink as measured by temperature sensor 80. *See supra*, Section A ... [1.2] (temperature).

Regarding the claimed ink container, Nagashima teaches an “ink cartridge . . . containing ink,” (*i.e.*, an ink container). Nagashima, [0046]. The ink flows from the ink cartridge, to the “common liquid chamber 55” to the “pressure chambers 52” of the “ink ejection head 50.” *Id.* [0063], [0208].

Regarding the claimed detector, as discussed above, Nagashima teaches that ink temperature is detected by the “temperature sensor 80.” Nagashima, [0211]. Nagashima teaches a plurality of temperature sensors 80 that reside in the common liquid chamber for detecting temperature as the ink flows through the common liquid chamber. For example, Nagashima describes various “arrangement patterns of the temperature sensor 80 in the common liquid chamber 55” in FIGS. 10 (a)-

(e). *Id.* [0146]. FIG. 10 (b)⁴ illustrates a “basic arrangement pattern” by way of example:



Nagashima, FIG. 10 (a)-(b) (annotated).

In the basic arrangement pattern shown in FIG. 10 (b), “[t]he common liquid chamber 55 includes a common ink supply port 551 through which ink is supplied from the outside of the common liquid chamber 55. . . and to the respective pressure chambers 52.” Nagashima, [0148]. “[T]hree representative flow lines 71,

⁴ FIG. 10 (b) has overlapping disclosure as FIG. 10 (a). Nagashima, [0146], [0159].

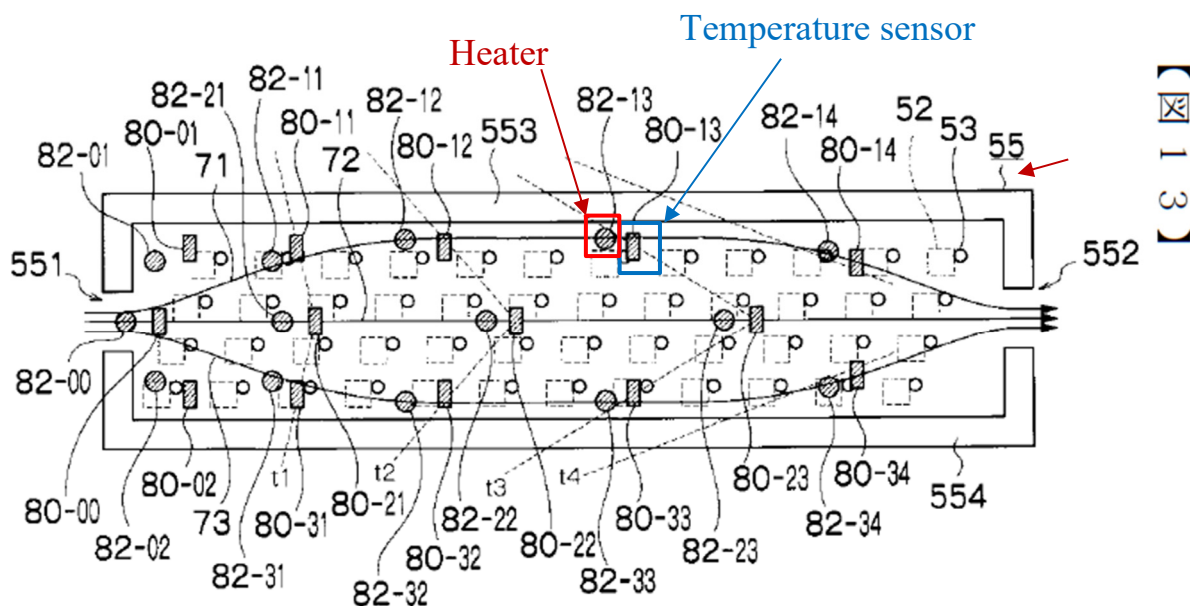
72, and 73 . . . are indicated by arrows.” *Id.* “Two temperature sensors 80 are arranged along each of the plurality of representative flow lines 71, 72, and 73.”

Nagashima, [0162].

Temperature sensors 80 measure temperature of the ink flowing through the common liquid chamber 55. Nagashima, [0041], [0068]. And as explained in [1.2] (temperature), *supra*, the temperature detected by the temperature sensor 80 is used to switch the heating drive waveform. *See, id.* [0141]-[0142].

Nagashima’ temperature sensor 80 is upstream of a heater in the nozzle arrangement. FIG. 13 illustrates an example of a “Specific Structure of Common Liquid Chamber” based off a basic arrangement pattern, described above.

Nagashima, [0179]:

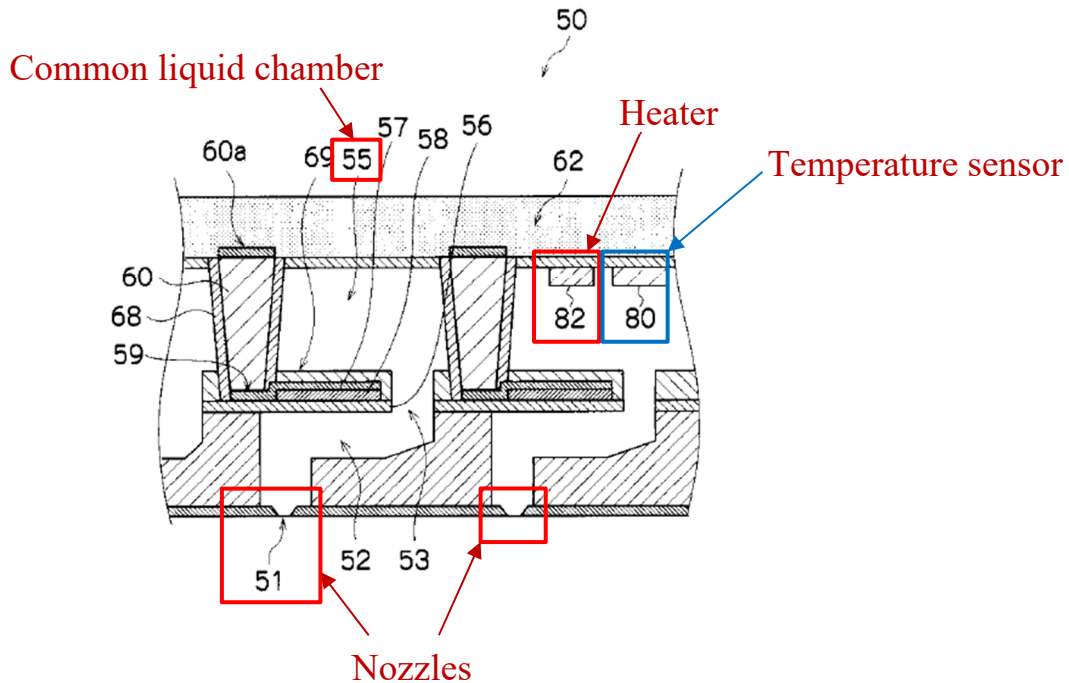


Nagashima, FIG. 13 (annotated).

In FIG. 13, “the heating is not only performed by driving the piezoelectric body 58 but **also** heated by the heating element 82 disposed in the common liquid chamber 55.” Nagashima, [0197] (emphasis added). Although, in FIG. 13 shown above the heating element 82-12 is upstream of the temperature sensor 80-13, Nagashima also teaches that, in the alternative, “[t]he heating element 82. . . may be arranged close to the temperature sensor 80 on the downstream side” of the temperature sensor 80. Nagashima, [0203]. Accordingly, Nagashima teaches that a temperature sensor 80 upstream of the heater 82.

In Nagashima, the temperature sensor 80 and the heater 82 are in the common liquid chamber 55, which is part of the structure that includes the arrangement of ink jet nozzles (*i.e.*, the nozzle arrangement). The nozzle arrangement of Nagashima (showing the nozzles and the common liquid chamber) is shown in FIG. 15:

【図 15】



Nagashima, FIG. 15 (annotated)

FIG. 15, similar to FIG. 13 above, illustrates a heater 82 in the common liquid chamber, which can be downstream of the temperature sensor 80. Nagashima, [0203]. The structure shown in FIG. 15 includes one or more ink jet nozzles, as well as the piezo 57, the temperature sensor 80, and the heater 82.

[9.P]

See, §V.A.[1.P.1]-[1.P.2].

[9.1]

See, §V.A.[1.P.1].

[9.2]

See, §V.A.[1.P.2].

[9.3]

See, §V.A.[1.1.1] (computer), [1.2] (temperature), [2] (heater). Nagashima explains, when used together, the temperature adjustment of the ink “is performed by the heating element 82” and by the piezoelectric body 58. Nagashima, [0205].

[9.4.1]

See, §V.A.[1.1.1]. The basic waveform generating unit 154 generates a basic waveform including an electrical signal and head driver 156 provides the drive waveform to the piezoelectric body. Nagashima, [0049] (basic waveform generating unit) & [0064] (head driver).

[9.4.2]

See, §V.A.[1.1.1]. A print control unit 150 is a command device. Nagashima, [0038], [0085]. *See* [1.1.2]. Print controller 208 selects the number of waveform plateaus using selection waveform.

[9.5]

See, §V.A.[1.2] (temperature and composition).

[10]

See, §V.A.[1.1.1]-[1.1.2] (plateaus), [1.2] (temperature), [2] (sensor).

B. Ground 1B: Nagashima and Ricoh Render Claims 4 & 12 Obvious

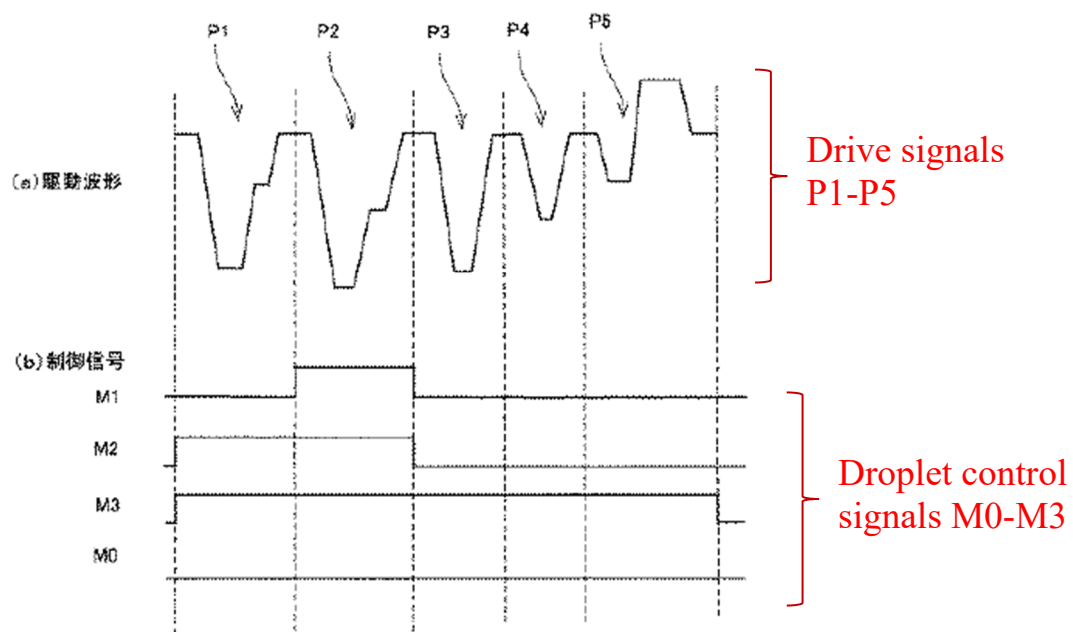
1. Overview of Ricoh

Ricoh relates to “an image formation device including a recording head that ejects a liquid droplet of a recording liquid.” Ricoh [0001]. Ricoh identifies

problems in the prior art associated with being able to perform both low-frequency and high-frequency ejections stably. *Id.* [0010]-[0011]. Ricoh describes waveform features that can “reduce “a difference in ejection droplet amount between during low-frequency driving and during high-frequency driving, performing stable droplet ejection during high-frequency driving, and forming a high-quality image at a high speed.” Ricoh [0013].

Ricoh FIG. 7 illustrates a drive signal waveform for driving the piezo:

【図7】

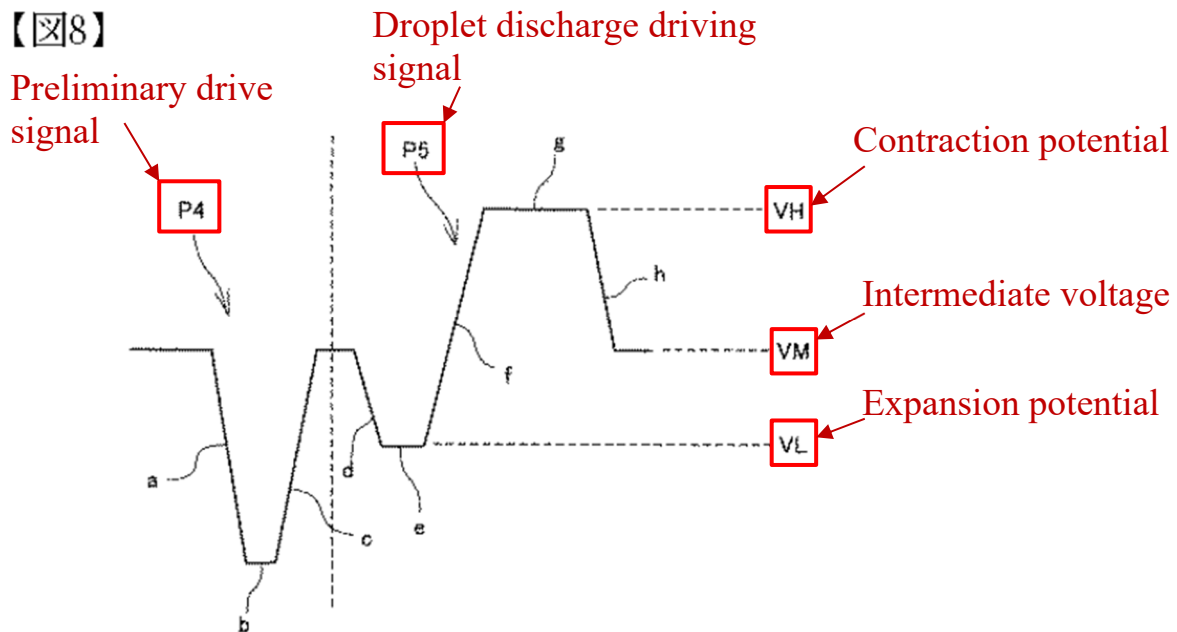


Ricoh, FIG. 7 (annotated).

A “by outputting the droplet control signals M0 to M3 as illustrated in Fig. 7(b) from the data transfer unit 302, it is possible to select and apply, to the

piezoelectric element 121, the plurality of drive signals P1 to P5.” Ricoh [0061].

“The drive signal P4 is a preliminary drive signal in the present invention, and the drive signal P5 is a droplet ejection drive signal,” which are described in more detail in FIGS. 8 and 10 below. *Id.*



Ricoh, FIG. 8 (annotated).

In the first embodiment shown in FIG. 8, waveform element **d** “causes the liquid chamber 106 to expand by falling from the intermediate potential VM. Ricoh [0065]. The waveform element **f** “causes the liquid chamber 106 to contract by rising to the potential VH beyond the intermediate potential VM” to discharge the droplet. *Id.* [0065] (**f** contracts the liquid chamber) & [0076] (**f** discharges the droplet). Namely, by expanding the pressure generation chamber so as to have an

antiphase to the residual vibration of the pressure after the droplet ejection, the residual vibration of the pressure is quickly suppressed, and the stability of the droplet ejection during high-frequency driving is further improved. *Id.* [0071].

Preliminary drive signal P4 is used to expand the pressure chamber to “generate pressure vibration” prior to the droplet discharge signal P5. Ricoh [0068]. The preliminary drive signal P4 also causes ink to flow into the chamber during expansion and causes the meniscus to be raised. *Id.* “By applying the droplet ejection drive signal P5 at this timing, it is possible to eject the ink droplet accumulated in the meniscus.” *Id.*

Ricoh explains that “by using a pressure wave by the preliminary drive signal P4, the droplet ejection drive signal P5 can cause a liquid droplet to be ejected at a required droplet speed even if a falling potential VL of the expansion waveform element **d** that causes the liquid chamber 106 to expand from the intermediate potential VM is decreased.” Ricoh [0069]. Ricoh, therefore, teaches that the preliminary drive signal P4 allows droplet discharge even if the amplitude of the P5 expansion waveform is relatively small. *Id.* Moreover, the preliminary drive signal P4 allows for the droplet to be ejected faster with the discharge drive signal P5, than if P5 were used by itself. *Id.* [0072].

Ricoh explains that “by reducing the refill amount by reducing as much as possible the pulling of the droplet ejection drive signal that causes the final droplet

to be ejected **and** increasing the pushing as much as possible, the preliminary vibration before the final liquid droplet ejection drive signal is used to keep the ejection droplet amount substantially constant, and thus the droplet speed at the time of causing a liquid droplet to be ejected with the droplet ejection drive signal following the preliminary drive signal is made relatively faster than the droplet speed at the time of causing a liquid droplet to be ejected with the droplet ejection drive signal alone.” Ricoh [0072]-[0075] (emphasis added). Therefore, Ricoh can “reduce a difference in ejection droplet amount between during low-frequency driving and during high-frequency driving, and to stably ejection the droplets during high-frequency driving.” *Id.*; *see also id.* [0073].

2. Combination of Nagashima and Ricoh

Nagashima teaches a print head that includes a piezo that is driven by one or more waveforms to eject ink, heat ink, and control viscosity. In the combination, the ejection waveform of Nagashima is modified to include a preliminary drive signal and a droplet discharge drive signal with a second polarity, as an alternative to, or in addition to, one or more of Nagashima’s ejection waveforms, as taught by Ricoh.

3. Reasons to Combine Nagashima and Ricoh

A POSITA would have been motivated to include, in Nagashima's waveform, waveform elements, like Ricoh's, having a preliminary drive signal and discharge drive signal to facilitate consistent, stable high-frequency ink ejection. DUPLO-1003, 153-157. Ricoh teaches an ejection drive signal P5 that can eject consistent ink droplet sizes, even during high-frequency ejection. Ricoh [0069], [0072], [0072]. Ricoh does so, in part, by "increasing the pushing [of the droplet ejection drive signal] as much as possible" with a contraction waveform (f). *Id.* [0072], FIGS. 8. In addition, Ricoh further compensates for high-frequency ejection by including a preliminary drive signal P4. Preliminary drive signal P4 used together with drive signal P5 facilitates a desired droplet ejection speed from the ejection drive signal P5. *Id.* [0072]. Accordingly, a POSITA would have been motivated to modify the ejection drive waveform of Nagashima to include the preliminary drive waveform P4 and the ejection drive waveform P5 described in Ricoh to achieve a consistent, stable ejection of ink during high-frequency ejection. DUPLO-1003, 153-157. Such high-frequency ejection would enable faster coating speeds, thicker coating layers, and/or higher quality coating. DUPLO-1003, 153. Thus, a POSITA would have found it obvious to incorporate a preliminary drive signal and discharge drive signal, like Ricoh's, into Nagashima's waveform.

Additionally or alternatively, a POSITA would have been motivated to include waveform elements, like Ricoh's, having a preliminary drive signal and discharge drive signal to suppress residual pressure vibration in the nozzle assembly after ejection, which leads to further ejection stability. *See*, Ricoh, [0071]; DUPLO-1003, 153-157. As Ricoh explains, because the ejection waveform P5 traverses the intermediate potential VM, it allows the waveform to drive "expans[ion of] so as to have an antiphase to the residual vibration of the pressure after the droplet ejection," and resultantly "the residual vibration of the pressure is quickly suppressed, and the stability of the droplet ejection during high-frequency driving is further improved." Ricoh, [0071]. Nagashima, likewise, appreciates that vibration frequency in the pressure chamber affects discharge stability. *See* Nagashima, [0087]. A POSITA would have been motivated to increase ink ejection stability by utilizing a waveform, like Ricoh's P4 and P5 waveform elements, to expand the pressure generating chamber in a phase opposite the residual pressure vibration. Thus, a POSITA would have found it obvious to incorporate a preliminary drive signal and discharge drive signal, like Ricoh's, into Nagashima's waveform. DUPLO-1003, 153-157.

A POSITA would have had a reasonable expectation of success in using the waveform signals of Ricoh with Nagashima. DUPLO-1003, 153-157. Ricoh's waveform elements offered well-known and predictable solutions for performing

stable high-frequency ink ejection. DUPLO-1003, 153-157. Even Ricoh contemplated use of its P4 and P5 waveforms together with ejection waveforms, such as waveform element P3, resembling Nagashima's ejection waveforms. Ricoh, FIG. 7 (P3 ejection waveform), [0061]-[0062]; Nagashima, FIG. 5 (showing similar ejection waveforms). Ricoh also teaches that the P4 and P5 waveform elements can be used together with multiple other waveform elements that, themselves, lack the a preliminary drive signal and the opposite polarity of the discharge drive signal. *See*, Ricoh, FIG. 7, [0061]-[0062]. Thus, a POSITA would understand that the P4 and P5 waveform elements could be used together with the other drive waveform elements of Nagashima. DUPLO-1003, 153-157. A POSITA would have recognized that the waveforms described by Ricoh would have provided waveforms compatible with the structure described in Nagashima to control the size of the droplets. DUPLO-1003, 153-157. The piezoelectric body of Nagashima includes a piezo, and "changes the volume of the pressure chamber 52 via the diaphragm plate 56." Nagashima, [0064]. The piezoelectric body of Nagashima is a "pressure generation unit that generates a pressure for ejecting ink from the nozzles." Likewise, Ricoh describes "piezoelectric elements 121 as electromechanical transducer elements, which are pressure generation units (actuator units) for deforming the vibrating plate 102 and pressurizing the ink in the liquid chamber 106." Ricoh [0040].

Additionally, Nagashima contemplates that the ejection drive waveform can include different shapes. For example, Nagashima teaches that the “while the ejection drive waveform has a shape that pulls and pushes the meniscus surface” or “a shape for **pulling, pushing and pulling**.” Nagashima, [0122] (emphasis added). A POSITA would have recognized that the “pull” of the meniscus is associated with an expansion of the volume of the pressure chamber and the “push” of the meniscus is associated with a contraction of the volume of pressure chamber, which ejects the ink from the nozzle. DUPLO-1003, 153-157; *see* Ricoh [0063] (discussing pulling and pushing) & [0072] (minimize pull and maximize push). Since Nagashima already contemplates a design that uses a shape of a waveform consistent with a pull, push, and pull operation, a POSITA would have had a reasonable expectation of success applying the elements of a waveform that accomplished the pull, push, and pull operation, such as that described in Ricoh. DUPLO-1003, 153-157. Thus a POSITA would have had a reasonable expectation of success using the waveforms of Ricoh with the design of Nagashima.

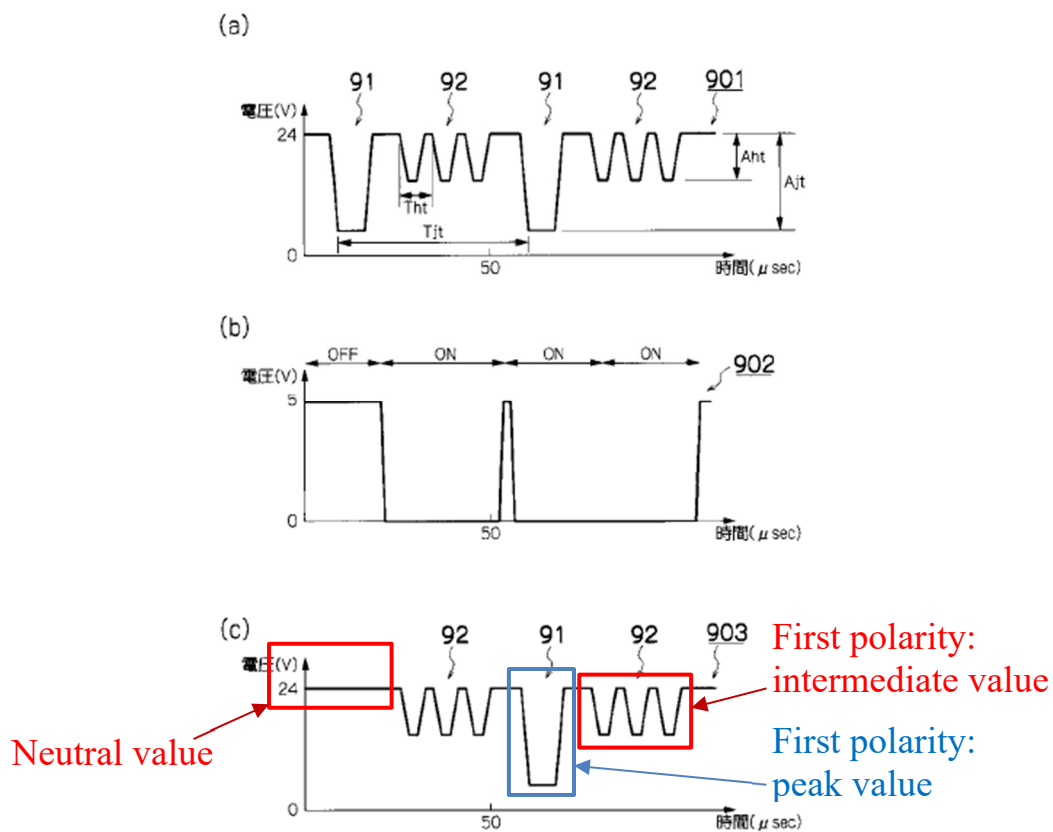
4. Analysis

[4.P] The method of claim 1 wherein the waveform has . . .

Nagashima discloses the elements of claim 1. *See*, §V.A.[1.P.1]-[1.2] and [9.P.1]-[9.5].

Nagashima teaches a waveform that includes 1) a neutral value and 2) a first polarity that includes a peak value for ejecting ink and an intermediate value dependent on the viscosity of the ink. The example waveform is illustrated in FIG. 9:

【図 9】



Nagashima, FIG. 9 (annotated).

Note that the ejection drive amplitude A_{jt} (peak value) is greater than the heating drive amplitude A_{ht} (intermediate amplitude). Nagashima, [0122].

[4.1]

Nagashima teaches a neutral value. For example, Nagashima teaches a non-driving waveform “does not drive the piezoelectric body 58 and does not include any of the ejection drive waveform, the heating drive waveform, and the meniscus tickling waveform.” Nagashima, [0065]. The non-driving waveform “is a waveform for maintaining a constant voltage (for example, 24 [V]).” *Id.* [0131], FIG.9.

The non-driving waveform is the same 24V value as the reference voltage. *Id.* [0144]. The reference voltage represents a waveform value where the piezo is not vibrated (i.e., at rest). DUPLO-1003, 163.

Furthermore, FIG. 9 shows that the ejection driving waveform amplitude A_{jt} and the heating driving waveform amplitude A_{ht} have values relative to the 24V reference voltage. Nagashima, FIG. 9, [0122]. When the amplitudes A_{jt} and A_{ht} are zero (and the meniscus fine vibration is off), the piezo is at rest, even if the 24V reference potential biases the piezo (*e.g.*, the non-driving waveform). *Id.*

Accordingly, the reference voltage represents a neutral value associated with the piezo (and hence nozzle arrangement) at rest. DUPLO-1003, 164.

[4.2.1]

Nagashima illustrates the first polarity relative to the neutral value in FIG. 9 above. The “ejection driving waveform” has “a shape that generates pull and push

of the meniscus surface.” Nagashima, [0086]. “When the ejection drive waveform having an uneven shape (a shape that generates pull and push of the meniscus surface) as illustrated in Fig. 5 is given to the piezoelectric body 58, the piezoelectric body 58 generates vibration according to this uneven shape to change the volume of the pressure chamber 52, the meniscus surface in the nozzle is pulled and pushed with a stroke corresponding to an amplitude A_{jt} , and the ink in the form of drops is continuously ejected from the nozzle 51.” *Id.*

A POSITA would have recognized that the “pull” of the meniscus is associated with an expansion of the volume of the pressure chamber because expansion of the pressure chamber creates a negative pressure that pulls on the meniscus; and the “push” of the meniscus is associated with a contraction of the volume of pressure chamber, which ejects the ink from the nozzle. DUPLO-1003, 166. Thus, Nagashima’s ejection driving waveform causes the nozzle arrangement to have a volume greater than the neutral value.

[4.2.2]

The intermediate value shown in FIG. 9 is the amplitude associated with the heating drive waveform. The heating drive waveform, which has the same polarity as the ejection drive waveform, has “an amplitude A_{ht} smaller than the amplitude A_{jt} of the ejection drive waveform.” Nagashima, [0122]. Thus, the amplitude of

the heating drive waveform (i.e., the intermediate value) is between the neutral value and the peak value.

The heating drive waveform has a duration dependent on the viscosity of the ink droplet. The frequency of the heating drive waveform, which dictates the duration each individual plateau value, is set to “an appropriate frequency at which mist ejection does not occur.” Nagashima, [0107]. A POSITA would have understood that a higher frequency waveform meant shorter duration constant amplitudes. DUPLO-1003, 168. Nagashima teaches that the “The relationship between a meniscus surface amplitude h at which mist ejection occurs and the drive frequency f of the piezoelectric body 58 is expressed by”:

$$h \geq 2 (\mu / \rho) \times (\rho / T\pi f)^{1/3},$$

where μ is the viscosity, ρ is the density of the liquid, and T is the surface tension. Nagashima, [0109]-[0110]. Thus, the frequency of the heating drive waveform (which determines the duration of the amplitude of the waveform) is dependent on the viscosity.

Additionally, or alternatively, in the occasion where the nozzles have an initially weak discharge force, the viscosity of the ink can be lowered by increasing the ink temperature near the nozzle. Nagashima, [0126]. As mentioned already, the heating drive waveform can be used to increase the temperature of the ink near the nozzle. To do so, the “the frequency f_{ht} of the heating drive waveform is

preferably as high as possible so as to further increase the heating value P of the piezoelectric body 58.” Nagashima, [0106]-[0107]. Thus, the frequency of the heating drive waveform can be selected to achieve a temperature depending on the desired ink viscosity. Accordingly, the intermediate value has a frequency (which informs the duration of the waveform) that depends on the viscosity of the ink.

Additionally or alternatively, Nagashima teaches a meniscus tickling waveform that has an intermediate value between the peak value and the neutral value. As mentioned before, the meniscus tickling waveform “suppresses [a] rise in viscosity of the ink by meniscus tickling that stirs the ink near the nozzle 51” caused by a “rise in viscosity of the ink due to evaporation of the solvent from the surface of the ink in the nozzle.” *Id.* [0125]. “Compared with the heating drive waveform, the meniscus tickling waveform has a low frequency and a small applied voltage.” *Id.* [0129]. As described above, the frequency for the meniscus tickling should not eject ink, so the frequency is set according to the viscosity dependent equation recited above. Accordingly, the meniscus tickling waveform has a frequency (i.e., duration) that is dependent on the viscosity.

[4.2.3]

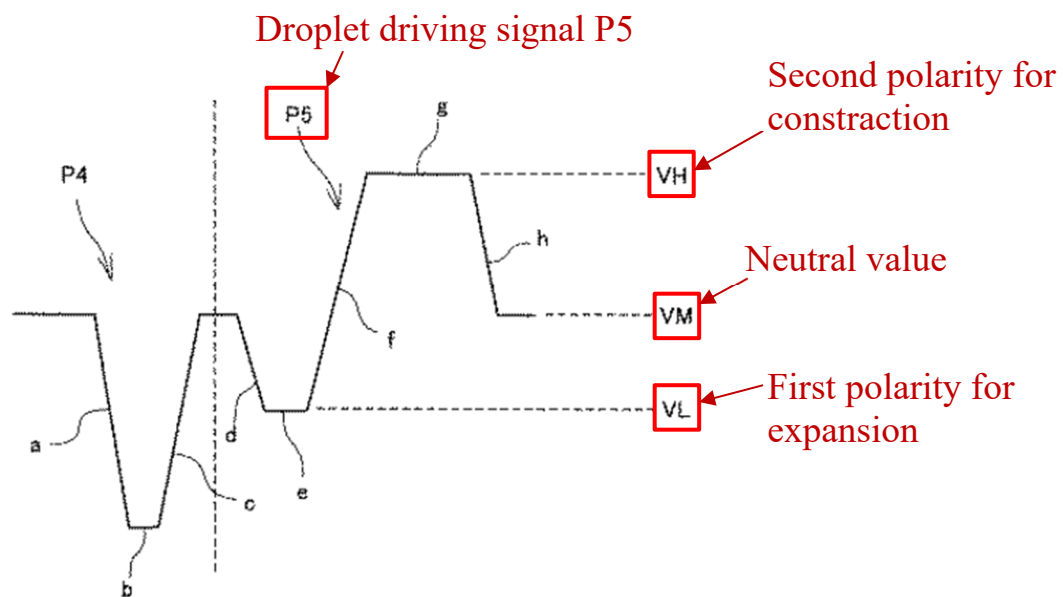
See [4.P], [4.2.1]. Nagashima refers to the Ajt (peak value) as part of the “ejection drive waveform,” which causes a droplet ejection from the nozzle and is

greater than the heating drive waveform amplitude A_{ht} (intermediate plateau value). Nagashima, [0122].

[4.3]

In the combination, the ejection drive waveform of Nagashima includes the droplet driving signal P5 taught by Ricoh, which includes a second polarity relative to a neutral value and causes a contraction of the liquid chamber. The droplet driving signal P5 is illustrated in Ricoh FIG. 8 below:

【図8】



Ricoh, FIG. 8 (annotated).

As shown in FIG. 8 above, waveform element **f** is characterized by a polarity inversion from VL to VH, across VM. *Id.*, FIG. 8. As shown in FIG. 8, the potential difference VH constitutes a second polarity relative to the neutral value VM. *Id.* FIG.8. A POSITA would have recognized the neutral value as VM, which

is a reference potential. *See, id.* [0048] (describing reference potential); DUPLO-1003, 174.

The second polarity of P5 causes the pressure chamber (part of the nozzle arrangement) to have a volume less than the neutral value. *Id.* For example, the waveform element f “that causes the liquid chamber 106 to contract by rising to the potential VH beyond the intermediate potential VM.” *Id.* [0065], [0076]. Thus, the second polarity causes the nozzle arrangement (here liquid chamber) to have a volume less than the neutral value (VM). As discussed above, “the droplet discharge drive signal P5 uses the pressure wave generated by the preliminary drive signal P4” so that droplets are ejected. *Id.* [0069].

[12.P]-[12.3]

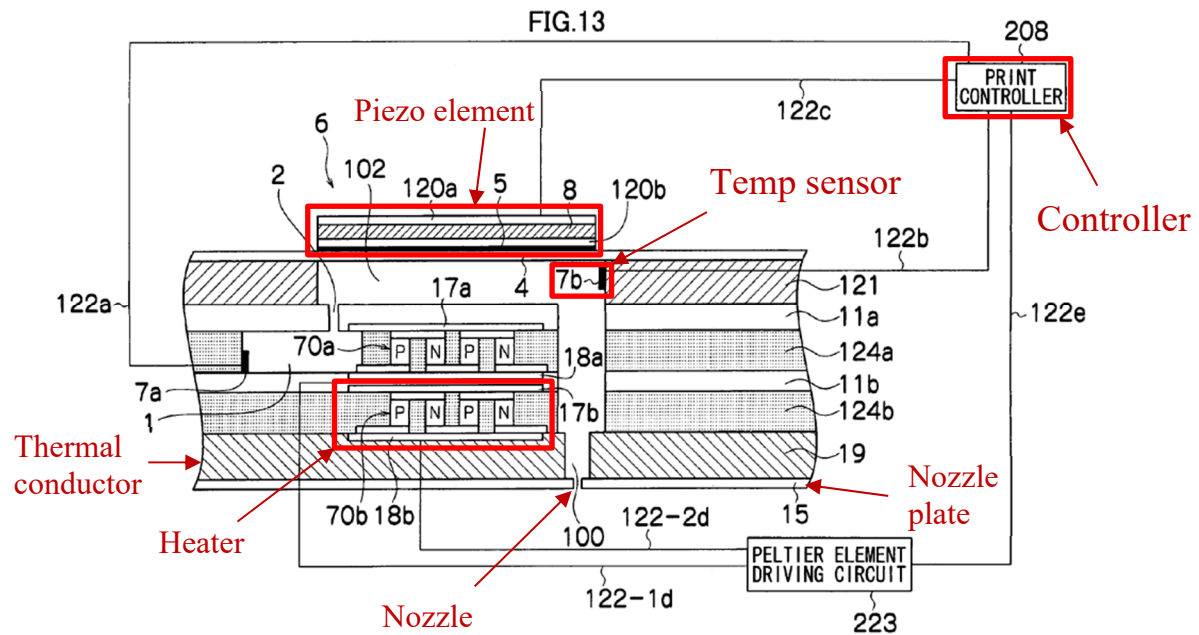
See, §V.B.[4.P]-[4.3].

C. Ground 2: Takatsuka with Chang Render Claims 1, 2, 4, 9, 10, & 12 Obvious

1. Overview of Takatsuka

Takatsuka describes that “inkjet recording apparatus 10 is a printer to record data of an image and the like by ejecting the ink liquid droplet onto the recording paper 14.” Takatsuka, 5:17-19.

Takatsuka describes using a piezo actuator to eject the ink from a nozzle in the inkjet head. *Id.*, 11:46-51, FIG.13. A cross-section of a portion of the inkjet head is shown in example FIG. 13⁵ below:

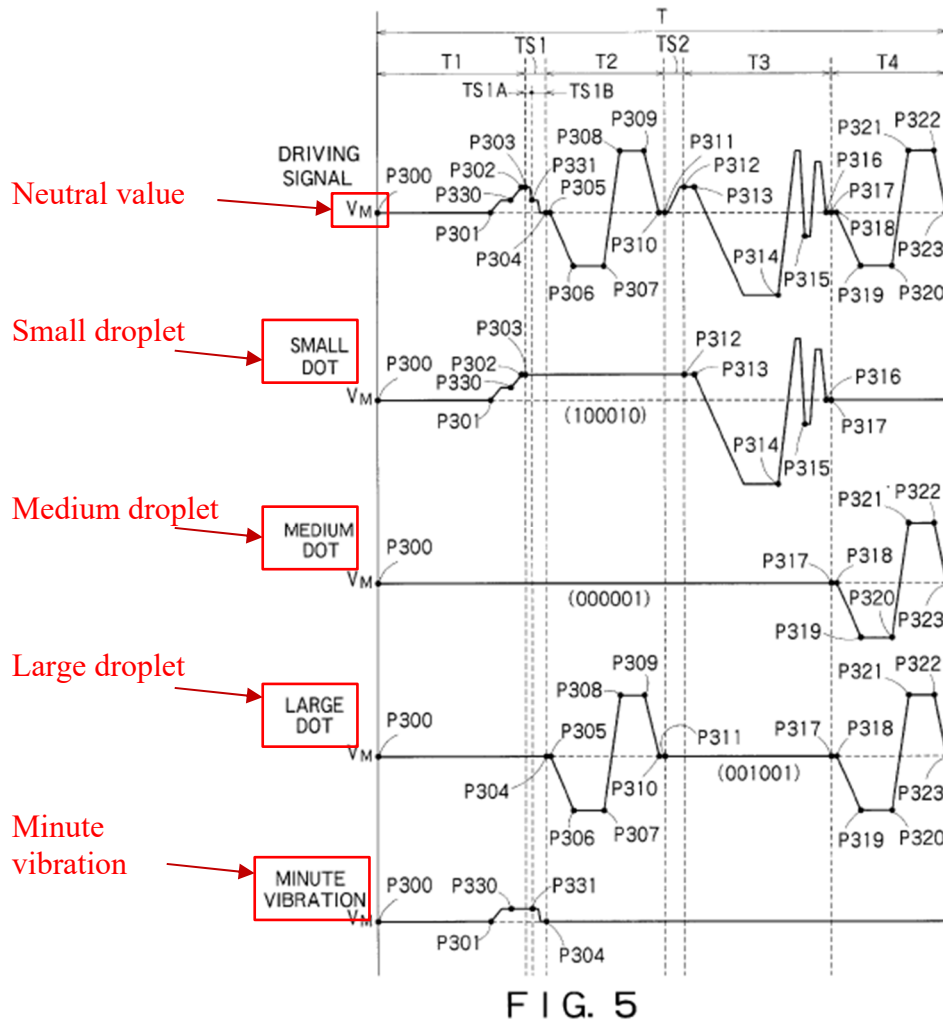


ejected, in such a manner that air bubbles inside the pressure chamber 102 are broken up and the air is caused to become dissolved inside the ink.” *Id.*, 20:52-57.

2. Overview of Chang

Chang describes a “liquid jet apparatus for ejecting liquid drops of a plurality of [kinds] different in volume from the same nozzle opening.” Chang, 1:7-10. Chang describes piezo drive waveform elements for ejecting “large ink drops for forming large dots, medium ink drops for forming medium dots, and small ink drops for forming small dots from the same nozzle opening 13.” *Id.*, 9:1-9 (providing example volume for various sized drops). Additionally, Chang provides a minute vibration pulse drive waveform element that does not eject ink, but rather stirs the meniscus to prevent an increase in ink viscosity at the nozzle openings. *See* Chang, 2:19-21, 9:38-45, 11:54-65, 12:9-25.

Turning now to the drive waveforms that Chang teaches, FIG. 5, reproduced below illustrates ejection waveforms for various droplet volumes and the minute vibration waveform:



Chang, FIG. 5 (annotated).

The waveform applied to the piezo is controlled by supplying selected portions of the “driving signal” to the piezo. Chang, 8:53-65; 11:49-12:33.

Chang refers to “minute vibration pulse” as a “pulse to be applied to the piezo-electric vibrators 25 for finely vibrating the meniscus of ink (liquid) at the nozzle opening 13 of the recording head 1 without ejecting an ink drop.” Chang, 9:21-25. Put differently, the minute vibration pulse is a non-ejection waveform. In the embodiment shown in FIG. 5, “it is possible to generate a minute vibration pulse of relatively high wave height when an ink of high viscosity is used, and to generate a minute vibration pulse of relatively low wave height when an ink of low viscosity is used.” Chang, 12:17-21.

3. Combination of Takatsuka and Chang

The inkjet printer of Takatsuka includes a print controller that controls the temperature differential between the common liquid chamber and the pressure chamber to prevent ejection errors, while also selecting a voltage to drive a piezo element for ink ejection and non-ejection functions. Takatsuka is silent as to the configuration of the waveforms for driving the piezo. In the combination, the controller uses an electrical waveform, such as described in Chang, to perform ink ejection and non-ejection functions.

4. Reasons to Combine Takatsuka and Chang

It would have been obvious to a POSITA to use one of the drive pulse patterns of Chang to control the piezo element of Takatsuka.

Takatsuka describes driving a piezo for ejecting ink and driving the piezo so as to not eject the ink, yet is silent on the specifics of the electrical waveform signal used to drive the piezo. Takatsuka, 11:46-51 (ejection) and 20:52-57 (non-ejection). A POSITA seeking to implement Takatsuka would have sought examples of electrical waveforms, and would have been motivated to implement the waveforms in Chang, because Chang's waveforms provide both ejection and non-ejection shapes, such as described in Takatsuka. *Id.*; DUPLO-1003, 187-197. That Takatsuka does not identify the specifics of the ejection and non-ejection waveforms it contemplates evidences that Takatsuka believed a POSITA could readily select suitable waveforms. DUPLO-1003, 187-197; *Impax Labs., Inc. v. Aventis Pharm., Inc.* 545 F.3d 1312, 1316 (Fed. Cir. 2008) (prior art is presumed enabling). Thus, a POSITA would have found it obvious to implement Chang's waveforms in Takatsuka as a suitable waveform with both ejection and non-ejection elements. DUPLO-1003, 187-197.

Additionally or alternatively, a POSITA would have been motivated to implement the waveforms in Chang, because they offer other features useful in driving Takatsuka's inkjet printer. DUPLO-1003, 187-197. For example, Chang's electrical waveforms are configured to produce ink droplets of different shape (*i.e.*, volume). Chang teaches a "plurality of driving pulses for generating a plurality of kinds of ink drops different in the ink volume," including small, medium and large

droplets. Chang, 14:37-40 (drive pulses) & 9:4-9 (example volume). Such different sizes of ink droplets facilitate a balance between “conflicting requests of improvement in image quality and improvement of the recording speed.” *Id.*, 1:44-56. Thus, a POSITA would have found it obvious to apply Chang’s waveform to benefit from the drop shape and size control it offers. DUPLO-1003, 187-197.

Additionally or alternatively, the structural and functional features described in Takatsuka are applicable to “a droplet ejecting step for coating a processing liquid, a functional liquid, or other type of liquid other than ink onto a medium.” Takatsuka, 21:3-17. A POSITA would have been motivated, therefore, to control the shape of the droplets ejected by Takatsuka using waveforms, such as those described by Chang, to control the thickness of the coating onto the medium. DUPLO-1003, 187-197. It was known at the time that the thickness of the coating of liquid onto the medium could be controlled by controlling the shape of the droplet from the inkjet nozzle. DUPLO-1003, 187-197. For example, Dainippon teaches that “the quantity (droplet size) of the varnish” can be varied, so that “a coating thickness of the varnish applied to the printing paper S may be controlled.” Dainippon, 12:13-19; *see also id.*, 12:20-23 (thickness controlled by varying volume of ink), Schneider, FIGS. 8-9 (showing modified droplet characteristics, including shape of the droplet). As described above, Chang teaches controlling the droplet shape by selecting one or more pulse drive patterns. Chang, 10:7-14

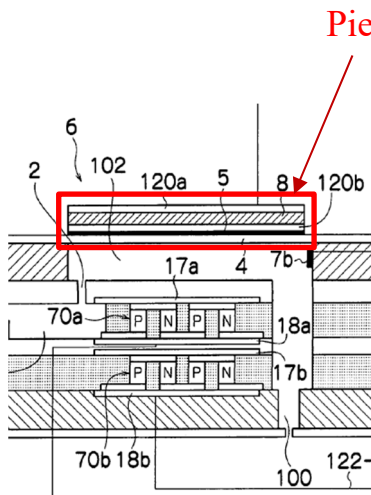
(driving pulse selected for small droplet), 10:16-19 (driving pulse selected for medium droplet), & 10:20-29 (driving pulse for large droplet). Thus, a POSITA would have found it obvious to apply Chang's waveform to control the size (i.e., shape) of the droplet to control the thickness of the "coating a processing liquid, a functional liquid, or other type of liquid" of Takatsuka. DUPLO-1003, 187-197.

Additionally or alternatively, Takatsuka also recognizes that evaporation of solvents from the ink can result in an increase in the viscosity of the ink that affects the consistency of the ink ejection. *See* Takatsuka, 10:2-3, 20:35-44. Takatsuka acknowledges that "ink inside the nozzle in contact with the air (namely the 'meniscus')" can dry, which can result in the "increase of the viscosity of the ink." Takatsuka, 20:35-44. A POSITA would have been motivated to mitigate this increase in viscosity of the ink at the meniscus, and its corresponding impact on ejection consistency. DUPLO-1003, 187-197. Chang's waveform incorporates "minute vibration" non-ejection waveforms that drive the piezo to mitigate this increase in viscosity of the ink at the meniscus, and a POSITA would have been motivated to incorporate Chang's waveform with "minute vibration" to mitigate an increase in viscosity from, evaporation of ink solvent in the vicinity of the nozzle. Chang, 2:19-21 (minute vibration stirs meniscus to prevent increase in ink viscosity) & 2:11-18 (evaporation of ink solvent causes increase in ink viscosity); *accord* Takatsuka, 10:1-3 (evaporation of ink solvent causes increase in ink

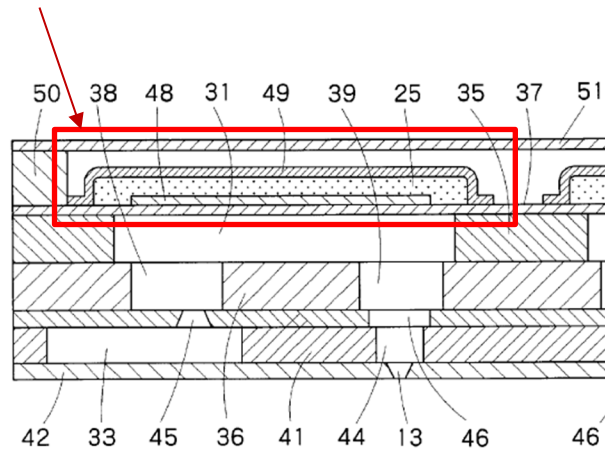
viscosity). Thus, a POSITA would have found it obvious to apply the “minute vibration” non-ejection waveform of Chang to mitigate drying of the ink near the nozzle opening and to prevent an increase in viscosity of the ink. Chang, 2:11-21.

For at least these reasons, it would have been obvious to a POSITA to drive the inkjet piezo structure of Takatsuka with waveforms for ejection and non-ejection operations, such as those described by Chang. A POSITA would have had a reasonable expectation of success using the waveforms of Chang with the piezo of Takatsuka. First, Takatsuka leaves open the specific waveforms for driving the piezo, so a POSITA would have been free to select a waveform that is suitable to achieve the desired results of Takatsuka (namely, ejection and non-ejection actuation of the piezo element). Chang is such an electrical waveform, having both ejection and non-ejection actuation of the piezo element. That Takatsuka is silent as to the waveforms to drive its piezo is indicative that it was within the skill of a POSITA to determine a suitable waveform and, if needed, adapt Chang’s waveform for the particulars of Takatsuka’s structure. DUPLO-1003, 187-197; *Impax Labs*, 545 F.3d at 1316.

Furthermore, the piezo and nozzle structure in Chang and Takatsuka are similar. A comparison between the piezo structures of Takatsuka and Chang are shown below:



Takatsuka, FIG. 13
(annotated)



Chang, FIG. 1
(annotated)

Takatsuka describes that the piezo element “is formed by a lower electrode layer 120b” bonded “to a vibration plate 4.” Takatsuka, 11:42-44. The piezo element also includes “a piezo thin plate 8, and an upper electrode 120a.” *Id.*, 11:45-46.

Chang describes two different piezo structures, but states that the driving pulses are similar for both. Specifically, Chang teaches a piezo-electric that uses deflection mode, as well as a piezo-electric that uses a longitudinal mode. Chang, 13:19-22, FIG.1., 13:22-25, FIG.7. To drive one or the other, driving signals and driving waveforms are interchanged in positive and negative of voltage with respect to the boundary of the intermediate voltage. *See id.*, 14:19-34. A POSITA would have known that the piezoelectric element of Takatsuka could have been driven using a waveform voltage schema as described in Chang, and if needed to adjust the

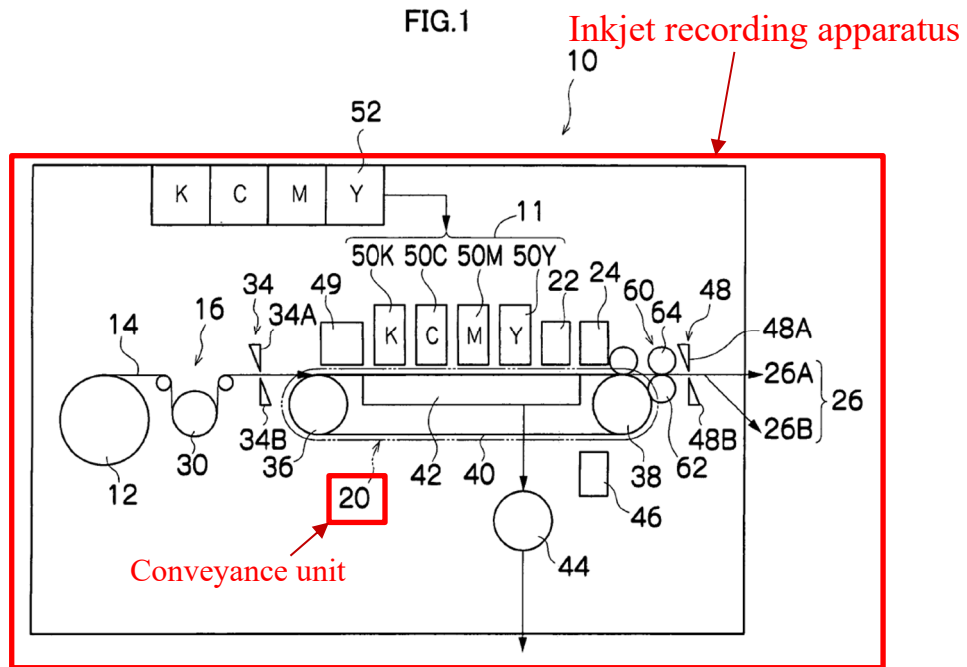
waveform for particulars of Takatsuka, with predictably similar results because of the similarity of the piezo structures described by Chang and Takatsuka and the disclosure of Chang. DUPLO-1003, 187-197.

For at least these reasons, it would have been obvious to a POSITA to drive the inkjet piezo structure of Takatsuka with waveforms for ejection and non-ejection operations such as those described by Chang.

5. Analysis

[1.P.1]

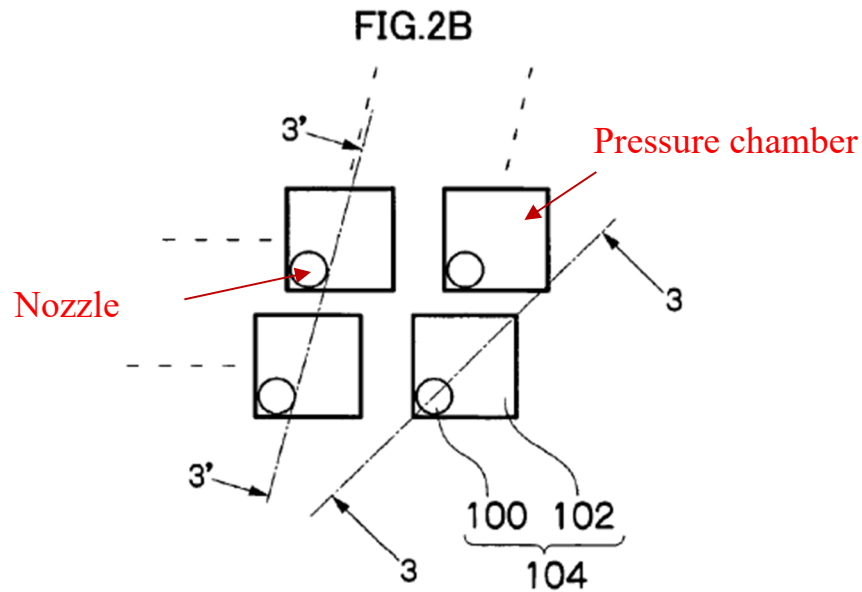
Takatsuka teaches element [1.P.1]. For example, Takatsuka describes “a liquid discharge head and an image recording apparatus.” Takatsuka, 1:7-9. FIG. 1 reproduced below is a general schematic drawing of “an inkjet recording apparatus,” *Id.*, 4:42-44:



Takatsuka, FIG. 1 (annotated).

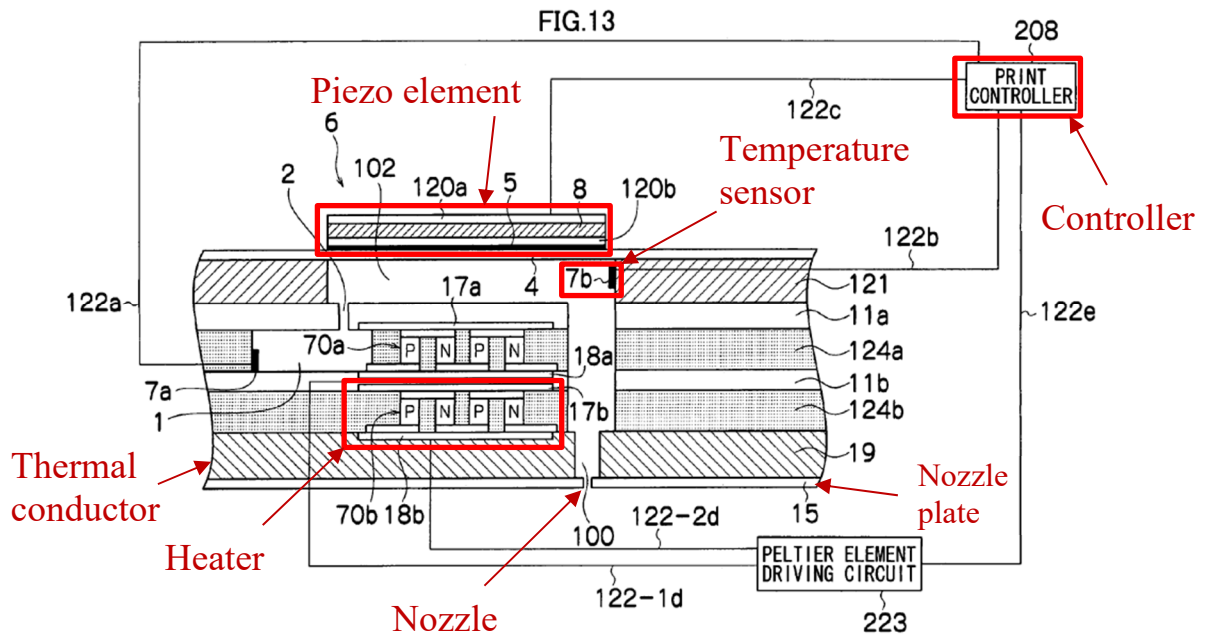
Takatsuka discloses a “conveyance unit 20. . . for conveying the recording paper 14.” Takatsuka, 5:24-27; 6:5-9.

Takatsuka also describes the inkjet nozzle arrangement, illustrated partially in FIG. 2B:



Takatsuka, FIG. 2B (annotated).

As shown in FIG. 2B, the inkjet head has “a plurality of ink chamber units 104 including nozzles 100 for ejecting ink droplets and pressure chambers 102 connecting to the nozzles 100.” Takatsuka, 8:20-24. The “ink ejection head” is the claimed nozzle arrangement, because it is a structure that has an arrangement of one or more ink jet nozzles. Takatsuka, 8:19-25; 1:64-67. FIG. 13 of Takatsuka illustrates a “general schematic drawing of an inkjet head.” Takatsuka, 17:26:



Takatsuka, FIG. 13 (annotated).

FIG. 13 shows that the inkjet head includes one or more nozzles (such as nozzle 100).

Takatsuka discloses coating with a covering ink. Takatsuka does not limit its recording apparatus use to any particular type of liquid, and expressly contemplates use with “various types of liquid” including “ink, developer processing liquid, a functional liquid, or the like.” *Id.*, 4:16-18 and 21:12-17.

Furthermore, Takatsuka advocates its recording apparatus is compatible with viscosities encompassing the viscosities of covering ink. Specifically, Takatsuka says it can accept ink viscosities ranging from 50 mPas to 3000 mPas at 30°C. *Id.*, 13:9-20. This range overlaps the coating ink viscosities described in the ’806

Patent, having an ideal viscosity “from 4 to 100 mPa•s.” ’806 Patent, 6:44-45 (ideal).

Finally, the ’806 Patent broadly defines the term “covering ink” as synonymous with “viscous product.” ’806 Patent, 3:21-22. Given that Takatsuka example viscosities overlap those in the ’806 Patent, Takatsuka’s example inks are “viscous product” as contemplated by the ’806 Patent. DUPLO-1003, 205-209.

Even still, a POSITA would have found it obvious to apply Takatsuka to coat a covering ink. DUPLO-1003, 205-209. Takatsuka makes it clear that the “liquid ejected from the liquid ejection head may be various types of liquid,” and the liquids described in Takatsuka had viscosities that overlapping the covering inks described and claimed in the ’806 Patent. A POSITA would have also known that an inkjet printer could be used to coating a covering ink. DUPLO-1003, 205-209. For example, AAPA from the ’806 Patent includes “a digital ink jet machine for laying a coating . . . by using ink jet nozzles.” ’806 Patent, 1:42-45 (characterizing EP1749670); see also, Dainippon, 10:28-41 (inkjet for varnish); Schneider, Abstract, 3:21-30; 4:40-48 (describing advantages of using inkjet for coating). Thus, a POSITA would have found it obvious to apply a coating of covering ink using the inkjet Takatsuka, 21:15-16; DUPLO-1003, 205-209.

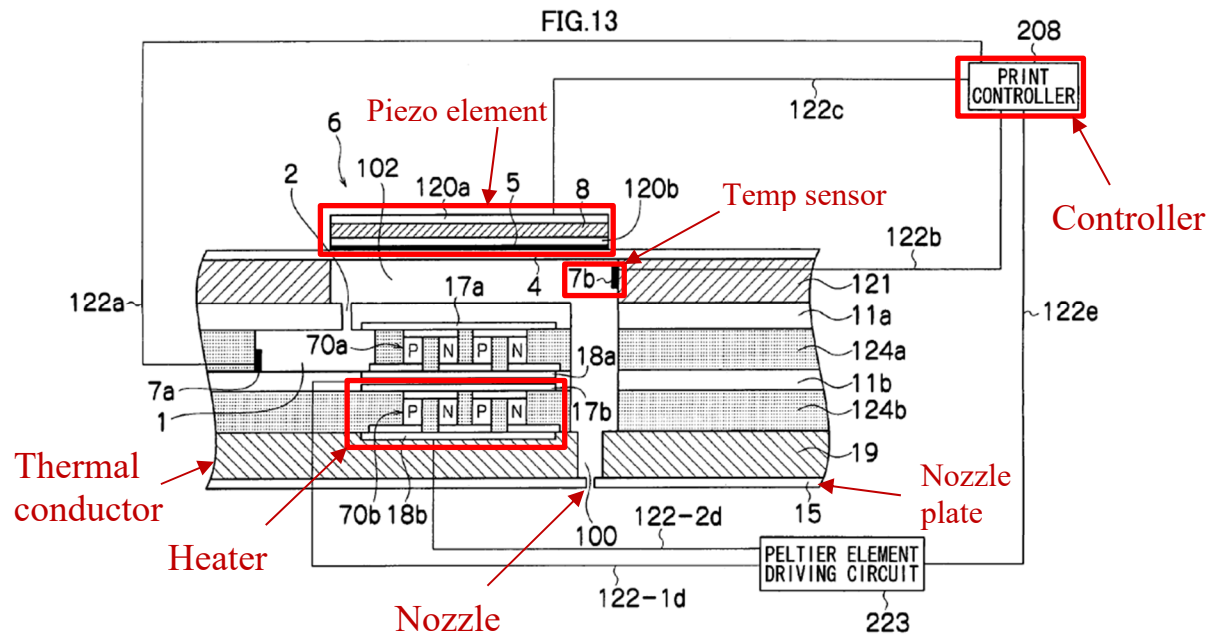
For at least these reasons, Takatsuka teaches or renders obvious element [1.P.1].

[1.P.2]

Takatsuka discloses a “piezo element 6.” Takatsuka, 11:42-46. By applying voltage across the piezo’s electrodes, “a pressure is generated inside the pressure chamber 102 and an ink droplet is ejected from the nozzle 100.” Takatsuka, 11:42-57.

[1.1.1]

Takatsuka’s system control unit 200 (computer) includes a print controller 208 that controls the piezoelectric element 6 using head driver 222. Takatsuka, 11:27-29. More specifically, the amount of ink ejected (*i.e.*, shape of droplet) and the ejection timing are controlled via the head driver 222. Takatsuka, 10:64-67. Takatsuka describes that the print controller 208 controls the piezo element 6, as shown in FIG. 13:



Takatsuka, FIG. 13 (annotated).

Takatsuka describes applying a voltage to the piezo element 6 so that “the piezo element 6 is caused to bend . . . [and] a pressure is generated inside the pressure chamber 102 and an ink droplet is ejected from the nozzle 100.” Takatsuka, 11:46-51.

Takatsuka also describes that “it is also possible for the piezo actuator to apply pressure to the pressure chamber 102 within a range that does not cause ink to be ejected.” Takatsuka, 20:52-57. Thus, Takatsuka describes driving the piezo with a drive signal that does not eject the ink. While Takatsuka is silent on the specific waveforms that are used to control the piezo for ink ejection, a POSITA

would have known that a different waveform would have been selected to perform non-ejection driving of the piezo. DUPLO-1003, 216.

Takatsuka discloses that the print controller 208 controls the “amount of ink ejected” through the head driver 222. In the combination, Chang teaches that the volume of a droplet ejected from a nozzle is based on the waveform driving the piezo-vibrator, as shown in example FIG. 5:

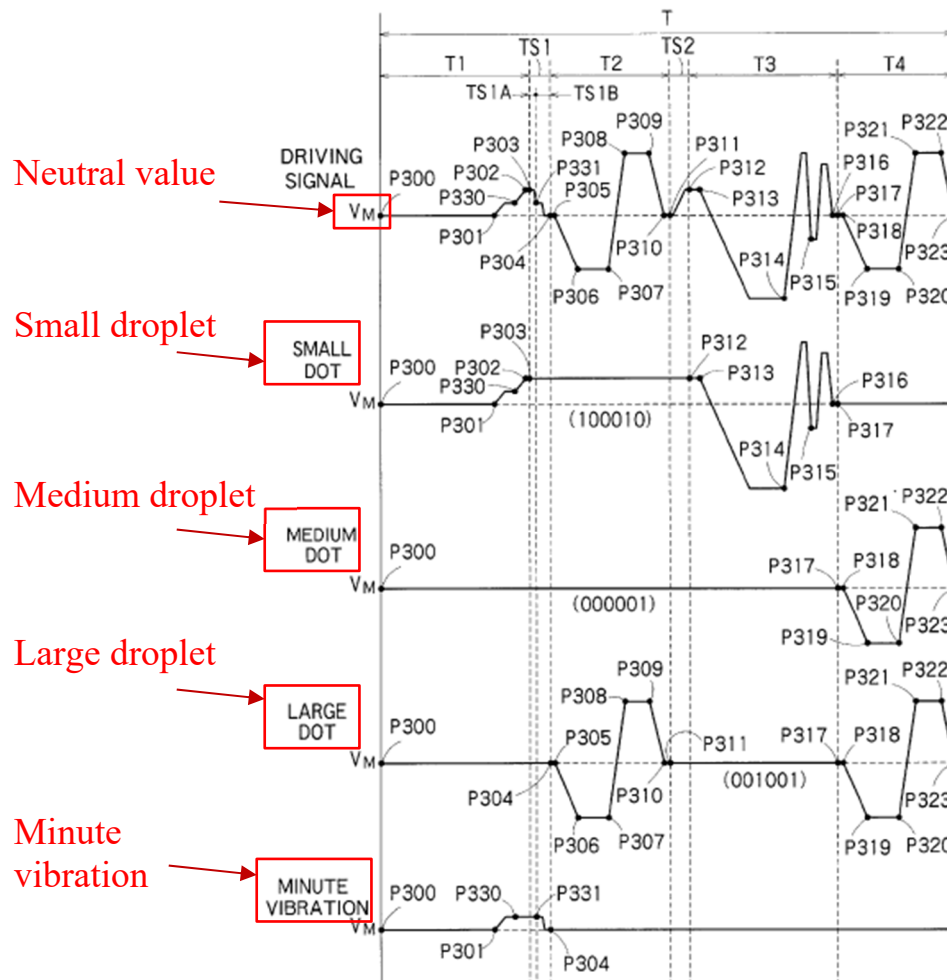


FIG. 5

Chang, FIG. 5 (annotated).

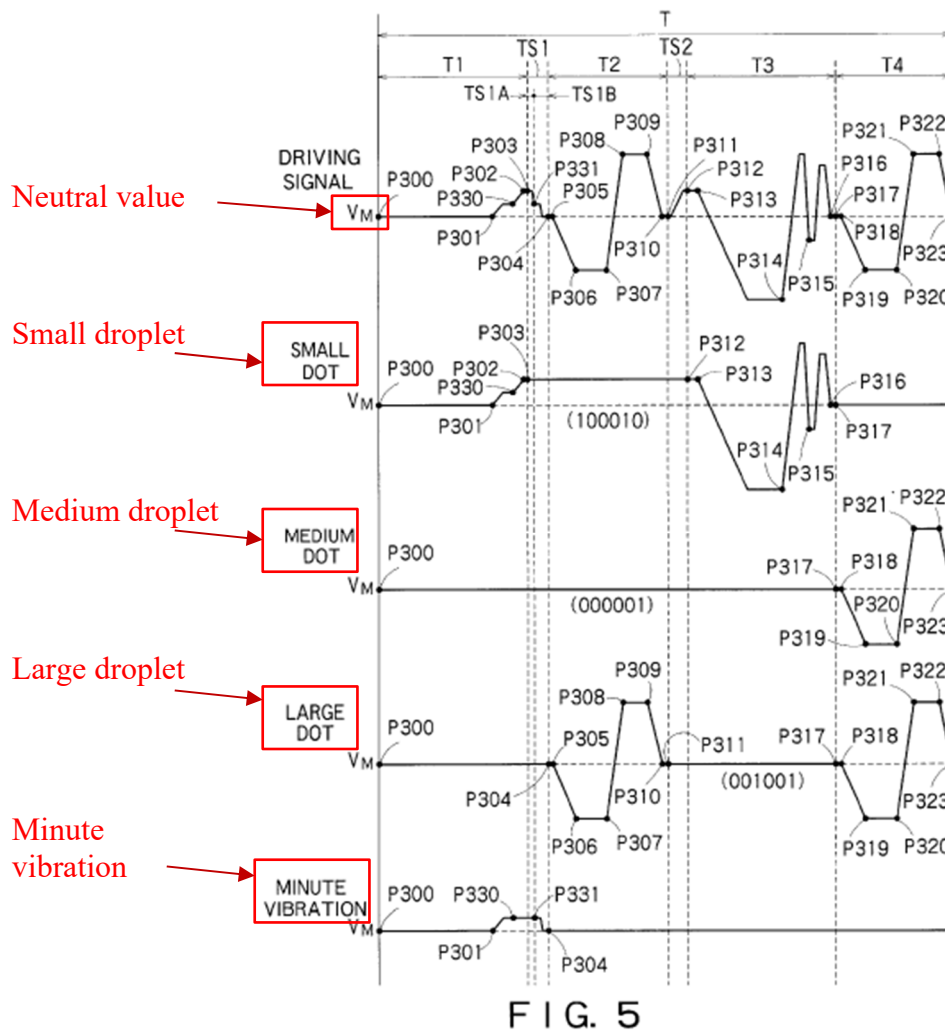
Chang discloses that the different shapes of the electrical waveform applied to the piezo is generated by applying only a portion of the “driving signal” to the piezo. Chang, 10:7-29. The waveform can be used to eject “large ink drops for forming large dots, medium drops for forming medium dots, and small ink drops for forming small dots from the same nozzle opening 13.” Chang, 9:1-4. Large dots are “formed from large ink drops of about 20 pL (picoliter) in volume.” *Id.*, 9:4-6. Medium dots are “formed from medium ink drops of about 8 pL in volume.” *Id.*, 9:6-7. Small dots are “formed from small ink drops of about 4 pL in volume.” *Id.*, 9:8-9. In each instance, because the volume of the drop is different, the shape of the drop is different. DUPLO-1003, 219.

In addition to ejection driving pulses, Chang describes a minute vibration pulse, which is “a preparatory waveform element which contracts said pressure chamber of waiting condition without ejecting said liquid drop.” Chang, 3:26-29. The minute vibration pulse is “applied to said pressure generating element so as to finely vibrate a meniscus of said liquid.” *Id.*, 3:67-4:2.

Accordingly, the combination of Takatsuka and Chang renders this limitation obvious.

[1.1.2]

In the combination, Chang teaches that the shape of the waveforms are controlled by selecting at least a number of plateaus, as shown in example FIG. 5:



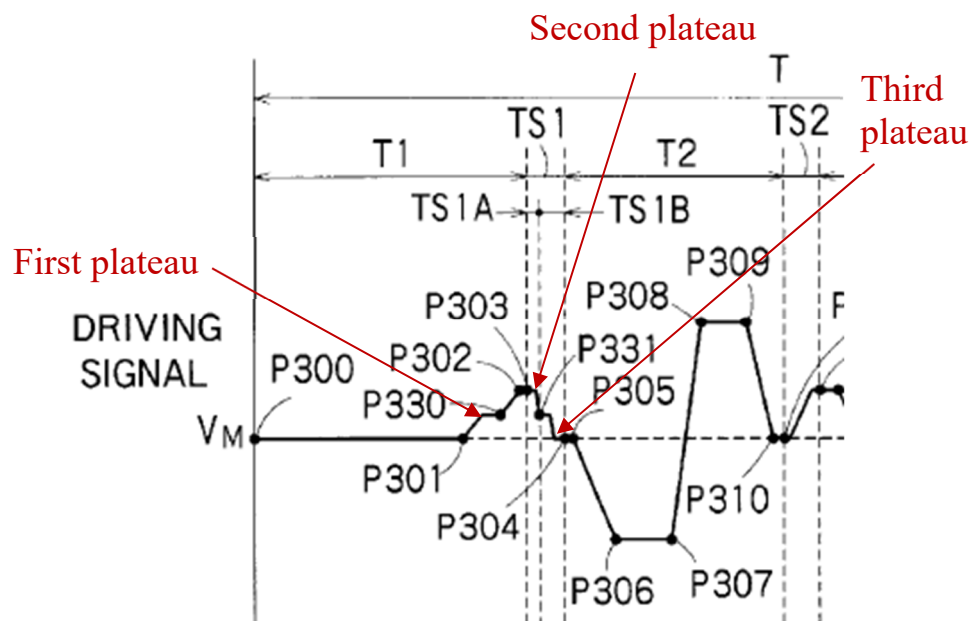
Chang, FIG. 5 (annotated).

As mentioned above, Chang discloses how to eject large, medium and small ink drops. To generate a small drop, Chang “selects the first waveform element and the third waveform element and connects the selected waveform elements” and sends them to the piezo. Chang, 10:7-14. To generate a medium drop, Chang selects the fourth waveform element. *Id.*, 10:15-18. “Namely, the fourth waveform element constitutes a medium dot driving pulse independently.” *Id.*, 10:18-19. And to

generate a large drop, Chang “selects the second waveform element and the fourth waveform element.” *Id.*, 10:20-29.

Chang also teaches that a minute vibration pulse “can be generated by a combination of a waveform element and a connection element,” and that the particular minute vibration waveform is generated based on the viscosity of the ink. Chang 12:4-17 (connection element);11:66-12:3.

FIG. 5 is reproduced below to show a close-in view of the step-shaped minute vibration waveform:

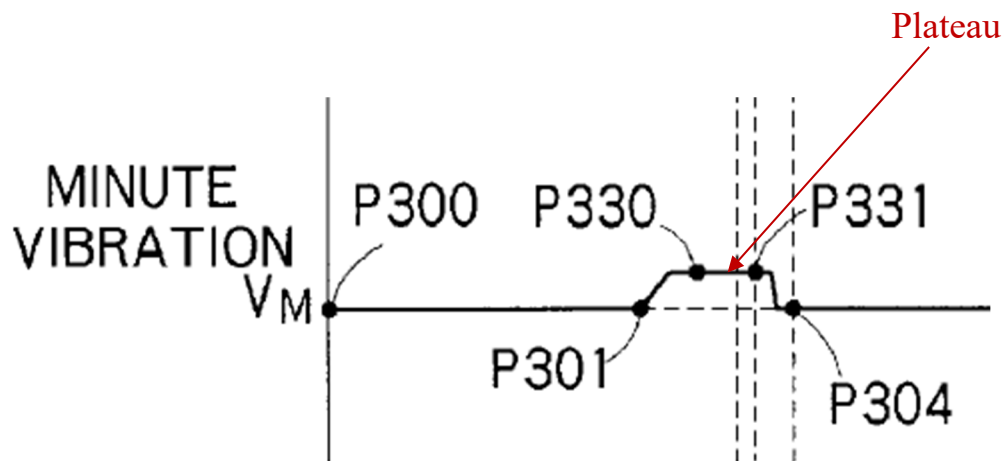


Chang, FIG. 5 (annotated).

Specifically, when an ink of high viscosity is used, “the pulse generation means selects the whole of the first waveform element (P300 to P303) and the whole of

the first connection element (P303 to P304) to generate a minute vibration pulse of relatively high wave height.” Chang, 11:66-12:3. The resulting waveform has three plateaus.

The minute vibration pulse of lower height can be generated by “forming step-shaped parts having the same voltage level at the waveform element and a connection element, respectively.” Chang, 12:26-34. This lower height pulse is shown in this close-in view of FIG. 5 shown below:



Chang, FIG. 5 (annotated).

This close-in view of FIG. 5 show how the first waveform element P300 to P330 and the latter half of the connection element P330 to P304 are used to generate the minute vibration pulse; while P302 and P303 are omitted. Chang, 11:42-53, FIG.

5; *see also id.*, 12:66-13:3 (describing low wave height but for FIG. 6 modifications). The lower height pulse, thus, has only one plateau.

“Therefore, it is possible to generate a minute vibration pulse of relatively high wave height when an ink of high viscosity is used, and to generate a minute vibration pulse of relatively low wave height when an ink of low viscosity is used.” *Id.*, 12:17-21.

The shape of the ejected droplet would have been affected by the viscosity of the droplet. DUPLO-1003, 82-88, 100. Accordingly, a POSITA would have recognized that selecting a minute vibration waveform based on the viscosity of the ink would have affected the shape of the resulting droplet. *Id.*

Accordingly, the combination of Takatsuka and Chang renders this limitation obvious.

[1.2] viscosity of the ink

See [1.1.2] (showing different plateaus for different viscosity inks). Chang states that “minute vibrations of a suitable level of intensity can be applied to an ink in accordance with its viscosity.” Chang, 12:21-23. Specifically, “a wave height of a minute vibration pulse can be set at two level selectively for the sake of these step-shaped parts.” *Id.*, 15-17. For example, “a minute vibration pulse of relatively high wave height when an ink of high viscosity is used, and to generate a minute vibration pulse of relatively low wave height when an ink of low viscosity

is used.” *Id.*, 12:18-21. The selection of the minute vibration pulses in the drive signal that is provided to the piezo is controlling the number of plateaus.

Accordingly, Chang describes that the number of plateaus is selected in response to the viscosity of the ink.

[2]

In the combination, Chang determines the viscosity of the ink to generate a minute vibration pulse based on the temperature of the ink, as determined from a temperature sensor, such as that described by Takatsuka.

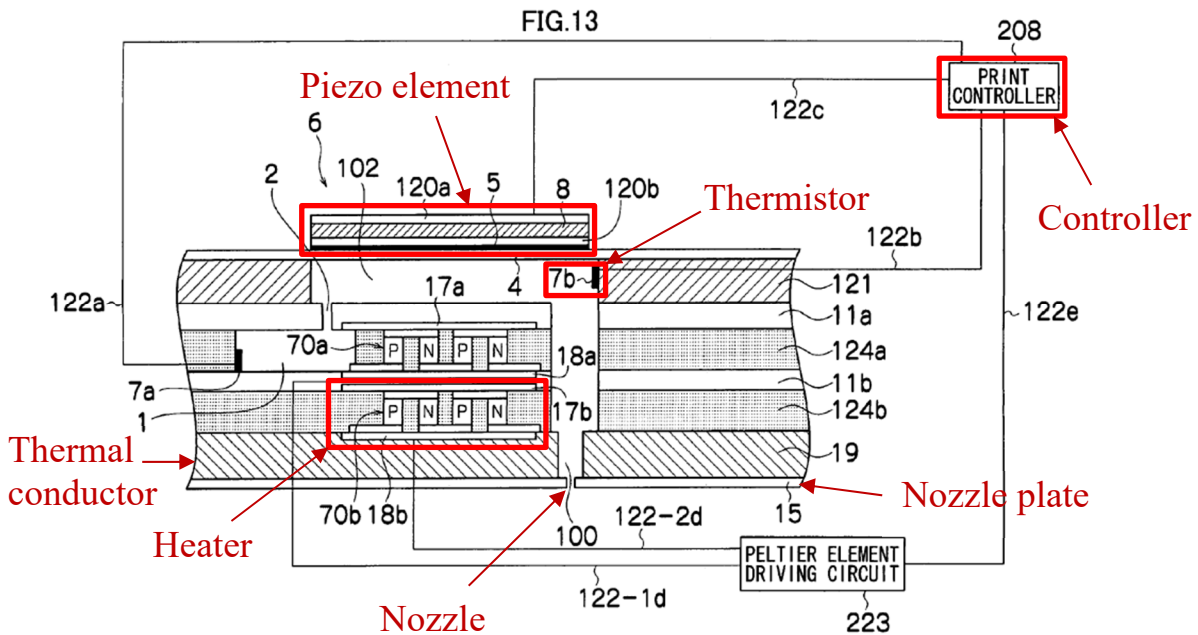
As described above, Chang describes controlling the shape of the electric waveform based on the viscosity of the ink. *See* [1.1.1]-[1.2]. Chang is silent, however, on how to determine the viscosity of the ink. A POSITA would have found it obvious to use the temperature of the ink, as measured by a temperature sensor of Takatsuka, to determine the viscosity of the ink, so as to generate an appropriate waveform dynamically. Takatsuka explains that the thermistor 7b is used to measure temperature of the ink, so as to control the viscosity of the ink. Takatsuka, 4:22-29, 14:32-45 (viscosity of ink can be controlled to prevent reflex), FIG. 7 (showing relationship between viscosity and temperature). Thus, the temperature of the ink was known (e.g., by Takatsuka) to be a proxy for viscosity. Thus, a POSITA would have found it obvious to rely on the temperature

measurement from thermistor 7b to determine a corresponding viscosity of the ink for controlling the shape of the electric waveform.

Further, Chang already contemplates altering the waveform dynamically. *See*, Chang, 12:27-30 (describing altering the minute vibration waveform when it is found to be “too high”). Thus, a POSITA would have found it obvious to use the temperature information to dynamically adjust the shape of the electric waveform to compensate for corresponding changes in viscosity. DUPLO-1003.

Recall that Takatsuka describes a thermistor 7b upstream from a heater in the nozzle arrangement. For example, Takatsuka FIG. 13 shows 7b in relation to the Peltier element 70b, the thermal conducting member 19, and the nozzle plate 15:⁶

⁶ “FIG. 13 is a general schematic drawing of an inkjet head according to another preferred embodiment of the present invention. Parts which are the same as those in the first embodiment are labeled with the same reference numerals as FIG. 6.” Takatsuka, 17:26-30.



Takatsuka, FIG. 13 (annotated).

Thermistor 7b is installed “on the inside” of the pressure chamber. The thermistor 7b determines the temperature in the pressure chamber. Takatsuka, 11:65-12:3. A POSITA would have recognized that the thermistor 7b placed “on the inside” of the pressure chamber would measure temperature of the ink inside the pressure chamber. DUPLO-1003, 241. Thus, the thermistor 7b is a detector.

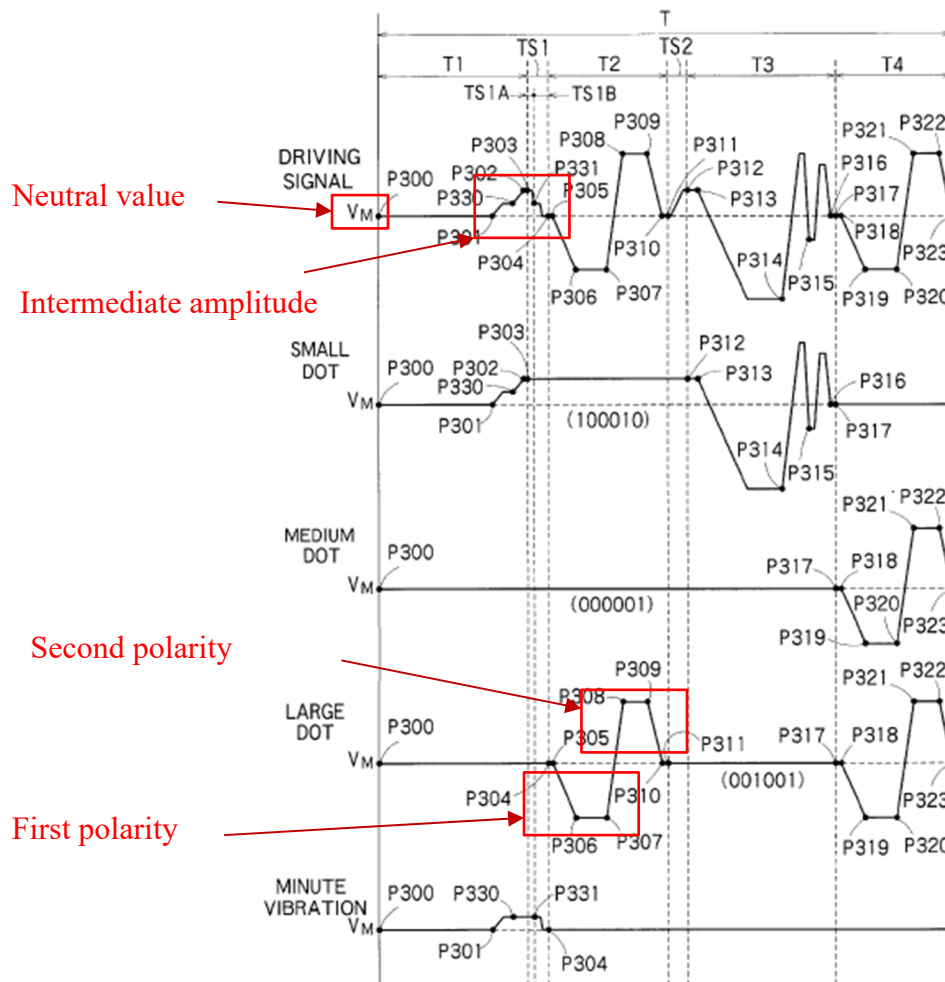
The controller 208 controls the Peltier element 70b “to heat the nozzle plate 15 by means of the second joint section 18b of the Peltier element 70b, via the thermal conducting member 19.” Takatsuka, 17:64-67, 18:36-42. The Peltier element 70b and the thermal conducting member 19 are a heater in the nozzle

arrangement. The thermistor 7b, for example, is a detector upstream from the heater.

Accordingly the combination teaches claim 2.

[4.P]

Chang discloses claim 4, as illustrated by example FIG. 5:



Chang, FIG. 5 (annotated).

As shown in FIG. 5 above, Chang teaches (a) a neutral value (V_m), (b) a first polarity with an intermediate value and a peak value, and (c) a second polarity, as recited in the claim.

In one example, the pressure chamber is “filled with ink by increasing the voltage. In the same way, ink drops are ejected by decreasing the voltage.” Chang, 14:29-32. When a driving pulse is input, “a voltage difference occurs between the upper electrode 49 and the lower electrode 48.” Chang, 6:44-46. “By this voltage difference, the piezo-electric vibrator 25 is contracted perpendicularly to the electric field.” *Id.*, 6:46-48. “The pressure chambers 31 are expanded and contracted in correspondence to deformations of the piezo-electric vibrators 25 to change the ink pressure in the pressure chambers 31.” *Id.*, 5:56-58. Chang describes contracting the pressure chamber when “an ink drop is to be ejected from the nozzle opening 13.” *Id.*, 55-58. And when the voltage difference is eliminated, “the piezo-electric vibrator 25 and the diaphragm 37 are returned to their original conditions” and the pressure chamber “is expanded” and “ink is fed into the pressure chamber.” *Id.*, 6:60-67.

[4.1]

Chang recites a neutral value (i.e., voltage V_m). Voltage V_m represents a boundary voltage for positive and negative polarities of the voltages of the driving pulse. *See* Chang, 14:24-30. Voltage V_m is associated with the nozzle

arrangement at rest because “when the voltage difference between the upper electrode 49 and the lower electrode 48 is eliminated, the piezo-electric vibrator 25 and the diaphragm 37 are returned to their original conditions.” *Id.*, 6:60-64.

[4.2.1]

Chang teaches element [4.2.1]. In FIG. 5 above, the first polarity is illustrated by the annotations. The “ejection waveform element” is “a signal element for operating the piezo-electric vibrators 25 so as to eject ink drops from the nozzle openings 13.” Chang, 10:1-3. An example of an ejection waveform element includes a first charge waveform element (P305 to P307), a first ejection waveform element (P307 to P309). Chang, 9:49-52, FIG.5. During the first charge waveform element, the pressure chamber is expanded. *See, id.*, 11:8-9 (polarity for expanding pressure chamber).

As mentioned previously, the relation between the voltage level and the expansion and contraction of the pressure chamber due to charge and discharge of the piezo-electric vibrator can be inversed, and the positive and negative of voltage with respect to a boundary voltage can be interchanged. Chang, 11:10-13, 14:19-30.

[4.2.2]

Chang describes that a driving pulse for the “minute vibration pulse is generated by a combination of at least a part of waveform elements and at least a

part of a connection element.” Chang, 11:59-62. Specifically, “when an ink of high viscosity is used, the pulse generation means selects the whole of the first waveform element (P300 to P303) and the whole of the first connection element (P303 to P304) to generate a minute vibration pulse of relatively high wave height.” *Id.*, 11:66-12:3. In addition, “when an ink of low viscosity is used, the pulse generation means selects the whole of the first waveform element (P300 to P330) and the latter half (P331 to P304) of the first connection element (P330 to P304) to generate a minute vibration pulse of relatively low wave height.” *Id.*, 12:66-13:3.

In Chang, “it is possible to generate a minute vibration pulse of relatively high wave height when an ink of high viscosity is used, and to generate a minute vibration pulse of relatively low wave height when an ink of low viscosity is used.” *Id.*, 12:17-21. “Since minute vibrations of a suitable level of intensity can be applied to an ink in accordance with its viscosity, a generation of an ink mist due to an excessive vibration can be prevented, and also an insufficient stirring of an ink due to too little vibration can be prevented.” *Id.*, 12:21-25.

Notably, Chang recognizes that the ink stirring effect can be realized using contraction followed by expansion, as well as expansion followed by contraction. *See* Chang, 11:10-13. Thus, Chang teaches that the intermediate waveform for minute vibrations are in either the first polarity or the second polarity. *Id.*

Accordingly, Chang describes that the number of waveforms is in response to the viscosity of the ink.

[4.2.3]

Chang teaches element [4.2.3]. In FIG. 5 above, the first polarity is illustrated by the annotations. The “ejection waveform element” is “a signal element for operating the piezo-electric vibrators 25 so as to eject ink drops from the nozzle openings 13.” Chang, 10:1-3. An example of an ejection waveform element includes P307 to P309 and P320 to P322. Chang, 10:25-29, FIG.5.

As mentioned previously, the relation between the voltage level and the expansion and contraction of the pressure chamber due to charge and discharge of the piezo-electric vibrator can be inverse, and the positive and negative of voltage with respect to a boundary voltage can be interchanged. Chang, 14:19-30.

[4.3]

Chang, FIG. 5 above, illustrates the second polarity. The second polarity can include a charge waveform element. Chang, 9:50-56. The “‘contraction waveform element’ is a signal element for operating the piezo-electric vibrators 25 so as to reduce the volume of the pressure chambers 31.” *Id.*, 9:65-67.

As mentioned previously, the relation between the voltage level and the expansion and contraction of the pressure chamber due to charge and discharge of

the piezo-electric vibrator can be inverse, and the positive and negative of voltage with respect to a boundary voltage can be interchanged. Chang, 14:4-30.

[9.P]

See, §V.C.[1.P.1]-[1.P.2].

[9.1]

See, §V.C.[1.P.1]-[1.P.2].

[9.2]

See, §V.C.[1.P.2].

[9.3]

See, §V.C.[2]. In Takatsuka, computer is the system control unit 200, which includes a print controller 208 controls the Peltier element 70b. Takatsuka, 17:62-18:42. The Peltier element 70b can “heat the nozzle plate 15 . . . via the thermal conducting member 19.” *Id.*, 18:36-39. Thus, the controller 208 is a computer that controls the Peltier element 70b to heat the nozzle plate 15 via the thermally conducting member 19. *Id.*

[9.4.1]

See, §V.C.[1.1.1], [2], describing Takatsuka’s print controller 208 for controlling the amount of ink ejected and head driver 222 applying voltage to piezoelectric element for ejection of ink, and describing Chang controlling the shape of the droplet by controlling the shape of the waveform.

[9.4.2]

See, §V.C.[1.1.1], *see*, §V.C.[1.1.2], describing Chang’s control over ink droplet size by selection of waveform plateau number (which is done by a controller 82).

[9.5] viscosity of the covering ink

See, §V.C.[1.2].

[10]

See, §V.C.[1.2], [2].

[12]

See, §V.C.[4.P].

[12.1]-[12.3]

See, §V.C.[4.1]-[4.3].

D. Ground 3: Dainippon with Chang Render Claims 1 and 4 Obvious

1. Overview of Dainippon

Dainippon describes a “printing machine for applying a coating material such as a varnish to surfaces of prints.” Dainippon, 1:12-16. The printing machine can include an “ink jet printing machine” that uses piezoelectric elements for droplet spraying. *Id.* 12:52-57 (ink jet printing machine) & 10:40-41 (piezoelectric elements). Dainippon controls the “coating thickness of the varnish” by varying the quantity (droplet size) of the varnish sprayed from the nozzles. *Id.*, 12:12-19.

2. Combination of Dainippon and Chang

Dainippon teaches an ink jet printing machine with piezoelectric elements for controlling the thickness of an applied varnish by varying the size of the droplets sprayed from the nozzles. In the combination, the piezoelectric elements are driven by an electric waveform having a shape that controls the size of the droplet, such as the waveforms described in Chang.

3. Reasons to Combine

A POSITA would have been motivated to use waveforms to drive the piezoelectric elements of Dainippon to control the quantity (droplet size) sprayed from the nozzles to control the thickness of the varnish. DUPLO-1003, 289-290. Dainippon is silent as to the waveforms to drive the piezoelectric elements. A POSITA would have sought examples of waveforms, and would have been motivated to implement the waveforms in Chang, because Chang's waveforms provide control over the droplet size. Chang, 9:4-9, FIGS. 4-6.

A POSITA would have had a reasonable expectation of success driving the piezoelectric elements of Dainippon with the waveforms described in Chang. Both Dainippon and Chang describe ink jet printers that use piezoelectric elements to eject ink. Additionally, Chang teaches waveform generation for handling inks of different viscosities, which a POSITA would have recognized include the viscosity of a varnish. '806 Patent, describing ideal viscosities of varnish in the range of 4

to 100 mPa•s. Chang, 12:17-21 (waveforms for high and low viscosities) & '806 Patent, 6:44-45 (ideal viscosity range).

4. Analysis

[1.P.1]

Dainippon teaches a coating material applying apparatus that includes a guide board 53 for stabilizing transport of printing paper and a droplet spray nozzle head 50. Dainippon, 9:58-61. The printing paper moves “to a position opposed to the droplet spray nozzle head 50.” *Id.*, 10:5-7. “Then, droplet spray nozzles 54 . . . of the droplet spray nozzle head 50 spray the ultraviolet-curable varnish on the printing paper S.” *Id.*, 7-9.

Dainippon discloses that droplet spray nozzles 54 of the droplet spray nozzle head 50 spray varnish onto the printing paper. Dainippon, 3:47-49, 10:7-9. The “droplet spray nozzle head” structure is the nozzle arrangement because it is an arrangement of droplet spray nozzles. *Id.* As explained by Dainippon, in response to “a signal from the controller 140, varnish is allowed to flow from the varnish tank unit 52 into the droplet spray nozzle head 50. Selected nozzles 54 among the numerous droplet spray nozzles 54 spray varnish toward a particular portion of the printing paper S to be coated with the varnish, in the same way as the inkjet nozzles of an inkjet printer spray ink.” *Id.* 10:25-32.

[1.P.2]

Dainippon teaches a “droplet spraying mode may be employed such as by using piezoelectric elements.” Dainippon, 10:40-41. Dainippon explains that varnish is pressurized and consequently, “selected droplet spray nozzles 54 spray droplets of the varnish onto the printing paper” in the same way as the inkjet nozzles of an inkjet printer spray ink. *Id.*, 10:32-39. A POSITA would have recognized that the nozzle arrangement would include piezoelectric elements to pressurize the varnish for spraying from the nozzles. DUPLO-1003, 293.

[1.1.1]

For a bubble jet embodiment, Dainippon teaches that “the quantity (droplet size) [i.e., shape] of the varnish sprayed from the droplet spray nozzles 54 may be varied according to an amount of energization of resistors” by a drive controller 56 (computer). Dainippon, 12:13-18. Dainippon, however, explains that the bubble jet embodiment sprays the varnish “in the same way as the inkjet nozzles of an inkjet printer spray ink.” 10:25-31. Dainippon is silent on the energizing signal used to drive the different spraying mode using piezoelectric elements.

In the combination, Chang teaches an electric waveform for controlling the size (i.e., shape) of the droplet. *See, supra*, §V.C.[1.1.1]-[1.1.2] (describing Chang waveforms to control shape of droplet).

[1.1.2]

In the combination, Chang teaches controlling the size (i.e., shape) of the droplet by selecting a number of plateaus of the electric waveform. *See, supra*, §V.C.[1.1.1]-[1.1.2] (describing Chang waveforms to control shape of droplet).

[1.2] *desired thickness of the layer.*

Dainippon teaches that “coating conditions including a coating thickness” may be preset. Dainippon 11:13-17. The “coating conditions” are converted into control data and “transmitted to a drive controller 56,” which converts the coating condition set for coating thickness into a signal for controlling the droplet spray nozzles 54. *Id.*, 11:40-43 (coating condition) & 12:13-15 (signal). The “coating thickness of the varnish applied to the printing paper” was controlled by the “quantity (droplet size) [*i.e.*, shape] of the varnish sprayed from the droplet spray nozzles.” *Id.*, 12:15-19. Thus, the shape of the waveform (and thus the shape of the droplet) is controlled in response to a desired thickness of the layer of varnish.

[4.P]-[4.3]

See, §V.C.[4.P]-[4.3].

VI. FINTIV ANALYSIS

Petitioner projects the final written decision will issue after the District Court's estimated trial date of February 6, 2024. Regardless, to whatever extent Factors 2 (Trial Date), 3 (Investment) and 5 (Parties) favor denial, Factor 6 (Merits) more than compensates in favor of institution.

Factor 1 (Stay): The Board's guidance in *Sotera* and *Sand Revolution* indicates this factor is neutral because the Board "will not attempt to predict" how a district court will adjudicate a future motion to stay. (*Sand Revolution II, LLC v. Continental Intermodal Group-Trucking LLC*, IPR2019-01393, Paper 24 at 7 (PTAB Jun. 16, 2020); *see also Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019 Paper 12 at 14 (PTAB Dec. 1, 2020).)

Factor 6 (Merits): The strength of the obviousness analysis detailed in §V strongly favors institution.

VII. FEES

Petitioner authorizes the Patent and Trademark Office to charge Deposit Account No. 06-1050 for the fee set in 37 C.F.R. § 42.15(a) for any additional fees.

VIII. CONCLUSION

Accordingly, Petitioner respectfully requests IPR and cancelation of the Challenged Claims.

IX. MANDATORY NOTICES

A. Real Party-In-Interest

Duplo Corporation is identified as a real party-in-interest.

B. Related Matters

Petitioner is not aware of any disclaimers, reexamination certificates or other IPR petitions for the '806 patent. The '806 patent is the subject of a civil action *MGI Digital Technology S.A. v. Duplo U.S.A. Corporation*, 8:22-cv-00979, C.D. Cal. (Pending).

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D. Service Information

Please address all correspondence and service to the address listed above.

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CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,900 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on May 19, 2023, a complete and entire copy of this Petition for *Inter partes* Review and all supporting exhibits were provided by Federal Express, to the Patent Owner by serving the correspondence address of record as follows:

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