

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Title: INK JET PRINTER AND METHOD FOR DEPOSITING A
PROTECTIVE LAYER ON A SUBSTRATE

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Title: INK JET PRINTER AND METHOD FOR DEPOSITING A
PROTECTIVE LAYER ON A SUBSTRATE

DECLARATION OF CHARLES F. REINHOLTZ, PHD

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I, Charles F. Reinholtz, Ph.D., hereby declare:

I. INTRODUCTION

1. I have been retained by Fish & Richardson, P.C. on behalf of Duplo U.S.A. Corporation (Duplo U.S.A. or “Petitioner”), as an independent consultant in this *inter partes* review (“IPR”) proceeding before the United States Patent and Trademark Office (“PTO”).

2. I have been asked by Petitioner’s counsel (“Counsel”) to consider whether certain references teach or suggest the features recited in claims 1, 2, 4, 8, 9, 10, and 12 of U.S. Patent No. 8,783,806 (“the ’806 Patent”) and claims 1, 7, 12, and 18 of U.S. Patent No. 8,506,031 (“the ’031 Patent”) (I will refer to the ’806 Patent and the ’031 Patent as “the Challenged Patents” when discussing them together). My opinions and the bases for my opinions are set forth below. My opinions are based on my education and experience.

3. In writing this Declaration, I have considered the following: my own knowledge and experience, including my teaching and work experience in the fields of mechanisms, mechanical design, electromechanical systems, and printer design; and my experience working with others involved in those fields.

4. I have no financial interest in either party or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis,

for all tasks involved. My compensation is not dependent on the outcome of these proceedings or on the content of my opinions.

II. QUALIFICATIONS

5. A copy of my curriculum vitae is attached as Appendix A. Below I provide a brief summary of qualifications relevant to my opinions set forth in this Declaration.

6. I earned my bachelor's degree in 1976, my master's degree in 1980, and my Ph.D. in 1983. All my degrees are in mechanical engineering from the University of Florida.

7. As part of my graduate work, I worked on research projects related to the subject matter of the Challenged Patents including, for example, printer-related technologies, including printing and paper-handling mechanisms and techniques. For example, as an undergraduate and graduate student, I worked on a research project sponsored by Burroughs Corporation to increase the print speed of a check imprinting mechanism used in the banking industry. As a master's student, I worked on a research project sponsored by Digital Equipment Corporation to increase the print speed of daisy-wheel printers.

8. One key aspect of my graduate research was the design and analysis of mechanisms for the creation and conversion of motion and forces. My Ph.D. dissertation, entitled "Optimization of Spatial Mechanisms," presented a new

approach for synthesizing mechanisms to produce complex three-dimensional motion while meeting specific practical constraints. This dissertation represented one of the earliest efforts to use computer-programmed numerical optimization tools for the design of three-dimensional mechanisms.

9. My research and work on this technology was guided and informed by my advisor, Dr. George Sandor, who spent the first twenty-one years of his career in industry developing printing technology. His accomplishments include designing the first color press for Life Magazine. Dr. Sandor maintained close ties to this industry, which provided me with the research opportunities described above and provided me with broad exposure to printer technology.

10. My graduate work in the area of printing technology also led to my first engineering position—as a Design Engineer working for Burroughs Corporation in their Non-impact Printing Group. This group was responsible for the early development of what we know today as inkjet and laser printers.

11. As reflected in my CV, in addition to my industry work, I have extensive experience as an academic. For example, I previously held positions at Virginia Tech as an assistant professor (1983-1988 (Tenured)), associate professor (1988-1993), professor (August 1993), W.S. White Chair for Innovation in Engineering Education (Aug. 1996 to Aug. 1999), Assistant Department Head and ABET Review Chair (1996-2002), and Alumni Distinguished Professor (2002-

2007). I am the recipient of the Virginia Tech Wine Award and Alumni Teaching Award, two of the highest honors awarded for teaching excellence at Virginia Tech. I also served as Chair of the Virginia Tech Academy of Teaching Excellence.

12. I am currently Emeritus Professor of Mechanical Engineering at Embry-Riddle Aeronautical University (ERAU) in Daytona Beach, Florida. From 2007 to 2017, I also served as Professor and Chair of the Mechanical Engineering Department at ERAU. In that capacity, I grew the department from an initial enrollment of 29 Bachelor of Science students to a department with an enrollment of over 400 students granting Bachelor's, Master's, and Ph.D. degrees.

13. My teaching and research have generally been focused on the design and analysis of machines, mechanisms, electro-mechanical systems, and robotics. My teaching has included courses on mechanisms and kinematics, mechanical design, controls, electro-mechanical systems, robotics, and project-based capstone design. Among the topics I routinely teach are the design and analysis of linkages, gears, gear trains, screws, clutches, escapements, and rotary-to-linear and linear-to-rotary motion mechanisms. I am also familiar with and teach the strategies used to control electromechanical systems and how to implement such strategies in software. I have authored over 125 journal and conference papers in the areas of mechanisms, kinematics, robotics, and mechanical design. I also have co-founded

three companies in the area of robotics and unmanned vehicle systems. I also served as the lead investigator on a research project sponsored by Boeing to develop digitally manufactured unmanned aerial vehicles. That work included 3-D printing of the aircraft fuselage wings and payload and also printing of electronic traces using conductive ink.

14. I am the co-author of *Mechanisms and Dynamics of Machinery*, a popular textbook published in 1987 by John Wiley. This textbook is focused on the design and analysis of mechanical devices and systems for the creation and transmission of forces and motion. Devices such as cams, linkages, gears, gear trains, screws, and intermittent-motion devices are discussed and analyzed in detail in the text. The text also includes software to implement many of the analytic approaches described in the text.

15. I am a Fellow in the American Society of Mechanical Engineers (ASME) and have held numerous other positions within that organization, including Associate Technical Editor, ASME Journal of Mechanical Design, and Paper Review Chairman and Proceeding Editor for the ASME Mechanisms Conference. I am also a member of the Society of Automotive Engineers (SAE), Tau Beta Pi, Pi Tau Sigma, Sigma Xi, Epsilon Lambda Chi, and the Association for Unmanned Vehicle Systems International (AUVSI). I have received numerous honors and awards during my career in mechanical engineering, including

receiving the Applied Mechanisms Conference Procter and Gamble Best Paper Award on two separate occasions and being awarded the National Applied Mechanism Conference South-Pointing Chariot Award for lifetime contributions to the mechanisms community. Numerous other awards and recognitions are summarized in my CV. I have worked on over 65 funded research projects that have received grants totaling more than \$15 million.

16. I have served as an expert as identified in Appendix B, which lists my consulting work and prior testimony over the past 4 years. I have served as an expert in cases that involved printers, paper handling and related technology, including work for Xerox, Lexmark, Nautilus Hyosung, and Esselte.

17. My education, work, teaching and research have helped me develop a broad base of knowledge regarding machine design and mechanical systems design including a broad understanding of printing, copying, scanning devices, and paper-handling. My knowledge encompasses machines in general, as well as their structural members, components, control algorithms and software. This background qualifies me to evaluate the intellectual property involved in this case from the perspective of a person of ordinary skill in the art (“POSITA”) including under the qualifications identified in Section IV.

18. In the past four years, I have been deposed or testified at trial, ITC, and IPR proceedings in a number of cases representing both plaintiffs and

defendants. These prior proceedings are detailed in Appendix B, attached to this declaration.

III. MATERIALS CONSIDERED

19. I have reviewed the '031 Patent and relevant excerpts from the prosecution history of the '031 Patent. I have reviewed the '806 patent and relevant excerpts of the prosecution history of the '806 patent. I have also reviewed the following prior art references and materials, in addition to other materials I cite in my declaration:

- U.S. Patent No. 8,506,031 to Abergel (“the '031 Patent”)
- Prosecution History of the '031 Patent
- U.S. Patent No. 8,783,806 to Abergel (“the '806 Patent”)
- Prosecution History of the '806 Patent (Serial No. 13/948,670)
- JP2006-240262A to Nagashima (“Nagashima”)
- JP2007-76344A to Yoshida (“Ricoh”)
- U.S. Pat. No. 7,090,323 to Takatsuka (“Takatsuka”)
- U.S. Pat. No. 6,619,777 to Chang (“Chang”)
- U.S. Pat. No. 7,207,269 to Yoshida (“Dainippon”)
- EP 1749670 to Abergel et al.
- U.S. Patent No. 7,332,037 to Abergel et al.

- U.S. Patent No. 7,451,698 to Schneider et al. (Schneider)
- U.S. Patent No. 7,404,849 to Jackson et al. (“Jackson”)
- Special Master Report and Recommendation on Claim Construction, Case No. 8:22-CV-00979 (C.D. Cal.) (“SM Claim Construction”)

20. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the Challenged Patents at the time of the earliest possible priority date, and I have done so during my review of these materials. The application leading to the Challenged Patents claims the benefit of priority to a foreign application filed December 30, 2008 (“the Critical Date”). Counsel has informed me that the Critical Date represents the earliest priority date to which the challenged claims of Challenged Patents are entitled, and I have therefore used that Critical Date in my analysis below. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of the Critical Date, or before.

IV. SUMMARY OF CONCLUSIONS

21. This Declaration explains the conclusions that I have formed based on my independent analysis. To summarize those conclusions:

22. For the '031 Patent:

- Claims 1 and 12 are obvious in view of Nagashima (Ground 1A)

- Claims 7 and 18 are obvious in view of Nagashima and Ricoh (Ground 1B)
- Claims 1, 7, 12, and 18 are obvious in view of Takatsuka and Chang
(Ground 2)

23. For the '806 Patent:

- Claims 1, 2, 9, and 10 are obvious in view of Nagashima (Ground 1A)
- Claims 4 and 12 are obvious in view of Nagashima and Ricoh (Ground 1B)
- Claims 1, 2, 4, 8, 9, 10, 12 are obvious in view of Takatsuka and Chang
(Ground 2)
- Claims 1 and 4 are obvious in view of Dainippon and Chang (Ground 3)

V. LEGAL PRINCIPLES

24. In forming my analysis and conclusions expressed in this Declaration, I have applied the legal principles described in the following paragraphs, which were provided to me by counsel for the Petitioner.

A. Obviousness

25. I have been informed that a patent claim is invalid as “obvious” in light of one or more prior art references if it would have been obvious to a person of ordinary skill in the art at the time of the alleged invention (“POSITA”), taking into account (1) the scope and content of the prior art, (2) the differences between

the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-obviousness, which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

26. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason that would have prompted a POSITA to modify or supplement the single prior art reference, or to combine two or more references, in a manner that provides the elements of the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference(s) themselves, the knowledge or “common sense” of a POSITA, or from the nature of the problem to be solved, and this reason may be explicit or implicit from the prior art as a whole. I have been informed that, under the law, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

VI. LEVEL OF ORDINARY SKILL IN THE ART

27. The evidence here confirms that a person of ordinary skill in the art at

the time of the Challenged Patents (a “POSITA”) 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 inkjet and related 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.

28. While I have applied this level of skill throughout my analysis, I would still hold the same opinions even with a different POSITA description. As I explain below, the technology described in the ’031 and ’806 patents was well known by 2008, and the claimed components were also well known and commercially available.

VII. OVERVIEW OF THE CHALLENGED PATENTS

A. The Common Disclosure

29. As mentioned before, the ’031 Patent is the parent to the ’806 Patent. I understand that to mean that the challenged patents share a common disclosure, with differences pertaining to the claims and summary. Here, I summarize the common disclosure between the two patents. Later I describe the differences between the two patents. I also provide a comparisons table to highlight the commonalities and differences between the two claim sets.

30. Here, I cite to the ’806 Patent when discussing the common

disclosure, with the understanding that there is a corresponding disclosure in the '031 Patent.

31. The specification of the common disclosure (“the specification” for short) describes an inkjet printer and associated method for depositing a varnish or ink onto a substrate.” ’806 Patent, 1:18-22. The Background Art section, characterizing the prior art, states that the “protective layer is typically formed of an ink like material that enables creation of different visual effects by printing the ink like material as patterns on certain areas.” *Id.*, 1:34-37. In addition, the specification discusses that it was known at the time “to customize the protective layer by causing some areas of the substrate to have varnish patterns and other areas to not have any varnish.” *Id.*, 39-41. To customize the protective layer, one would use an inkjet printer, as opposed to a screen printing technique, because inkjets gave control over the area on the substrate to apply the ink.

32. The Background Art section also 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.*

33. When discussing the EP ’670 reference, the specification states that the “size and 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. (The Challenged Patents also correlates droplet shape with droplet volume. *Id.*, 5:67.) In short, the Applicant Admitted Prior Art includes controlling the shape of droplets by controlling the shape of the electric waveform applied to the piezoelectric actuator. *Id.*

34. The Challenged Patents state that, if the EP ’670 reference was able to deposit varnish drops with medium or high viscosities, it would not have been suitable for optimum ejection of varnishes with much lower viscosity. ’806 Patent, 1:50-54. With that in mind, the specification states that it discloses a suitable device for optimal deposition of a varnish “independently of the ink viscosity and the substrate to be covered.” *Id.*, 1:55-59.

35. Both the ’031 Patent and the ’806 Patent claim to control the shape of a droplet of ink by controlling an electric waveform applied to a piezoelectric actuator. The shape of the waveform is controlled in response to certain parameters, including temperature or viscosity of the ink. The Challenged Patents both also include dependent claims that recite specific features of the electric waveform that is applied to the piezoelectric actuator.

36. As shown in the claims table below, there is significant overlap between the recited limitations of the claims between the two patents. I have

provided a summary of the claims for each patent below.

B. The '031 Patent

37. The '031 Patent was filed on December 30, 2009 as U.S. Patent Serial Number 12/649,765. The '031 Patent claims priority to a French patent 08-07500, filed on December 30, 2008. It is my understanding that December 30, 2008 is the priority date for the '031 Patent.

38. The '031 Patent claims controlling the shape of droplets by controlling the shape of an electric waveform applied to the piezoelectric actuator in response to viscosity and/or temperature of the ink, detected as the ink flows from an ink container to the nozzle by at least one detector upstream from a heater included in the nozzle arrangement.

C. The '806 Patent

39. The '806 Patent was filed on July 23, 2013, as U.S. Patent Serial Number 13/948,670. The '806 Patent is the child patent of the '031 Patent, and claims priority to the same French patent 08-07500, filed on December 30, 2008. It is my understanding that December 30, 2008 is the priority date for the '806 Patent.

40. The '806 Patent claims a method that includes 1) selecting a number of plateaus of the electric waveform in response to one of a plurality of parameters,

including viscosity of the ink, temperature of the ink, or a desired thickness of the layer.

D. Claims Comparison Table

41. The challenged claims of the '031 Patent and the '806 Patent are recited verbatim and compared in the Claims Comparison Table.

42. The following table shows the challenged claims of the '031 Patent and the '806 Patent side-by-side, to illustrate the similarities and differences between them:

'031 Patent	'806 Patent
Claim 1	Claim 1
A method of applying a coating of covering ink to a substrate moving relative to an ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate, the method comprising	A method of applying a coating of covering ink to a substrate moving relative to an ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate, the method comprising
controlling by a computer the shapes of the droplets by controlling the shape of an electric waveform applied to the piezoelectric actuator,	controlling by a computer the shapes of the droplets by controlling the shape of an electric waveform applied to the piezoelectric actuator,
	said shape being controlled by selecting at least a number of plateaus of the electric waveform,
	in response to <u>at least one of</u> the following parameters: <u>viscosity of the ink</u> , composition of the covering ink, <u>temperature of the covering ink</u> , 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.
Claim 1	Claim 2
	The method of claim 1 wherein the shape of said electric waveform is controlled
in response to <u>at least one of</u> the <u>viscosity and/or the temperature of the ink,</u> 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.	in response to the <u>viscosity and/or the temperature of the ink,</u> 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.
Claim 7	Claim 4
The method of claim 1 wherein the waveform has	The method of claim 1 wherein the waveform has
(a) neutral value associated with the nozzle arrangement being at rest,	(a) neutral value associated with the nozzle arrangement being at rest,
(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and	(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and
(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;	(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;
the waveform first polarity having an intermediate substantially constant amplitude between the neutral value and a peak value,	the waveform first polarity having an intermediate substantially constant amplitude between the neutral value and a peak value,
each peak value causing a droplet to be expelled from the nozzle arrangement,	each peak value causing a droplet to be expelled from the nozzle arrangement,
the intermediate value having an amplitude and/or duration to dependent on the viscosity of the ink droplet.	the intermediate value having an amplitude and/or duration dependent on the viscosity of the ink droplet.

Claim 12	Claim 9
Apparatus for applying a coating of covering ink to a substrate, comprising	Apparatus for applying a coating of covering ink to a substrate, comprising
a transport mechanism for causing relative movement between the substrate and an ink jet nozzle arrangement,	a transport mechanism for causing relative movement between the substrate and an ink jet nozzle arrangement,
the ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate;	the ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate;
a computer controlling a heater included in the nozzle arrangement heating the covering ink	a computer controlling a heater included in the nozzle arrangement heating the covering ink
and an electric source for applying an electric waveform to the piezoelectric actuator, said waveform controlling the shapes of the droplets,	and an electric source for applying an electric waveform to the piezoelectric actuator, said waveform controlling the shapes of the droplets,
	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,
said electric waveform having a shape determined by at least one of the <u>viscosity</u> and/or the <u>temperature of the covering ink</u> ,	in response to at least one of the following parameters: <u>viscosity of the covering ink</u> , composition of the covering ink, <u>temperature of the covering ink</u> , 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.
	Claim 10
the apparatus further including	10. The apparatus of claim 9 further including
at least one detector upstream from the	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 droplets as the ink flows from the ink container to the nozzle.	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.
Claim 18	Claim 12
18. The apparatus of claim 12 wherein the waveform has	12. The apparatus of claim 9 wherein the waveform has
(a) neutral value associated with the nozzle arrangement being at rest,	(a) neutral value associated with the nozzle arrangement being at rest,
(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and	(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and
(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;	(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;
the waveform first polarity having an intermediate substantially constant amplitude between the neutral value and a peak value,	the waveform first polarity having an intermediate substantially constant amplitude between the neutral value and a peak value,
each peak value causing a droplet to be expelled from the nozzle arrangement,	each peak value causing a droplet to be expelled from the nozzle arrangement,
the intermediate value having an amplitude and/or duration dependent on the viscosity of the ink droplet.	the intermediate value having an amplitude and/or duration dependent on the viscosity of the ink droplet.

43. Limitations next to each other represent overlapping features between the Challenged Patents. Likewise, bold/underlined terms are also overlapping between claims of the Challenged Patents.

44. Claims 1, 4, 12, and 18 of the '031 Patent are "the '031 Patent

challenged claims.” Claims 1, 2, 4, 8, 9, 10, and 12 of the ’806 Patent are “the ’806 Patent challenged claims.”

E. Claims Breakdown

Limitation	’031 Patent 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]	in response to at least one of the viscosity and/or the temperature of the ink,
[1.2.1]	detected as the ink flows from the ink container to the nozzle
[1.2.2]	by at least one detector upstream from a heater included in the nozzle arrangement.
[7.P]	7. The method of claim 1 wherein the waveform has
[7.1]	(a) neutral value associated with the nozzle arrangement being at rest,
[7.2.1]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
[7.2.2]	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 to dependent [sic] on the viscosity of the ink droplet.
[7.2.3]	each peak value causing a droplet to be expelled from the nozzle arrangement,

¹ Features of claims 7 and 18 are presented out of order that what appears in the ’031 Patent. I believe this is clearer and more readable for the purposes of my analysis.

Limitation	'031 Patent Claim Language
[7.3]	(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;
[12.P]	Apparatus for applying a coating of covering ink to a substrate, comprising
[12.1]	a transport mechanism for causing relative movement between the substrate and an ink jet nozzle arrangement,
[12.2]	the ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate;
[12.3.1]	a computer controlling a heater included in the nozzle arrangement heating the covering ink and
[12.3.2]	an electric source for applying an electric waveform to the piezoelectric actuator,
[12.4.1]	said waveform controlling the shapes of the droplets,
[12.4.2]	said electric waveform having a shape determined by at least one of the viscosity and/or the temperature of the covering ink,
[12.5]	the apparatus 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 droplets as the ink flows from the ink container to the nozzle.
[18.P]	18. The apparatus of claim 12 wherein the waveform has
[18.1]	(a) neutral value associated with the nozzle arrangement being at rest,
[18.2.1]	(b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and
[18.2.2]	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.
[18.2.3]	each peak value causing a droplet to be expelled from the nozzle arrangement,

Limitation	'031 Patent Claim Language
[18.3]	(c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value;

Limitation	'806 Patent 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] ²	(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, . . . the intermediate value having an amplitude and/or duration dependent on the viscosity of the ink droplet.

² Features of claims 4 and 12 are presented out of order that what appears in the '806 Patent. I believe this is clearer and more readable for the purposes of my analysis..

Limitation	'806 Patent Claim Language
[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;
[8]	The method of claim 1 wherein the parameter includes viscosity of the covering ink measured by a probe upstream from the piezoelectric actuator and/or from a heater heating the covering ink.
[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

Limitation	'806 Patent Claim Language
	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;

VIII. CLAIM CONSTRUCTION

45. I understand that, for purposes of my analysis in this *inter partes* review proceeding, the terms appearing in the patent claims should generally be interpreted according to their plain and ordinary meaning.

46. I have been informed that the term nozzle arrangement has been construed by the Special Master to mean:

“a structure, or group of structures, that includes one or more ink jet nozzles.”

47. I have been informed that the Petitioner is objecting to this construction and advancing a different construction:

“an arrangement of one or more nozzles.”

48. I have reviewed the claims and the prior art with these constructions in mind. Where applicable, I provide an analysis with both constructions in mind.

IX. OBVIOUSNESS IN VIEW OF NAGASHIMA³

Obviousness by Nagashima	
Patent	Claims
'031 Patent	1 & 12
'806 Patent	1, 2, 9, 10

³ Independent claims are shown in boldface in the summary tables.

A. Overview of Nagashima

49. I have reviewed a certified translation of Nagashima and find that it renders certain claims of the Challenged Patents obvious. Nagashima was published on September 14, 2006. I understand that Nagashima is prior art based on its publication date.

50. 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].

51. 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 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 fine vibration 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].

B. Analysis

52. Nagashima renders claims 1 and 12 of the ’031 Patent obvious and renders claims 1, 2, 9, and 10 of the ’806 Patent obvious:

53. The following analysis breaks the claims into limitations, each of which is addressed in view of Nagashima.

[COMMON] A method of applying a coating of covering ink to a substrate moving relative to an ink jet nozzle arrangement . . .

Patent	Limitation
’031 Patent	1.P.1
’806 Patent	1.P.1

54. This limitation is common to the ’031 Patent and the ’806 Patent.

55. Nagashima is directed to “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 is the claimed substrate, which can be paper. The “ink ejection head 50” is the claimed nozzle arrangement under both constructions because it is a structure that includes 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. The ink ejection head 50 satisfies both constructions because it

is a structure that includes one or more nozzles. Within the ink ejection head are an arrangement of nozzles, as shown as a two-dimensional array in FIG. 3 of Nagashima, for example.

56. Nagashima teaches a conveyor that “moves a recording medium such as paper relative to the ink ejection head 50.” *Id.*, [0043]. The conveyor is the transport mechanism because it moves the paper relative to the ink ejection head (i.e., the nozzle arrangement).

57. Nagashima teaches coating with a covering ink. Nagashima provides an explanation about how to operate the ejection head using inks of different types and viscosities. Nagashima does not limit use of its image formation device to any particular type of ink. Furthermore, Nagashima 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.”). Furthermore, Nagashima provides a lengthy discussion on how to operate the ink ejection head for any types of inks. For example, Nagashima provides specific ways to determine the amplitude and frequency of various waveforms to drive the

piezo based on information about the ink, and teaches the use of meniscus vibration waveforms based on the composition of the ink (from an ink ID).

58. In addition to different types of ink, Nagashima teaches that the ink ejection head could be controlled to eject 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 recited by Nagashima include 20 centipoises⁴ and 1.5 times 20 = 30 centipoises, and fall within the “ideal” range of covering ink viscosities described in the Challenged Patents. *See* Nagashima, [0218]; ’806 Patent, 6:44-45 (ideal range is 4-100 centipoises).

59. Finally, the Challenged Patents define 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 products.” And there is little doubt that Nagashima’s inks “cover” because Nagashima explains that the ejection of ink can be done “continuously,” which allows the ejection head to print covering ink. *E.g.*, Nagashima [0086].

60. Although I note that covering inks can be spot printed using an inkjet,

⁴ 1 centipoise (cP) = 1 milliPascal*seconds (mPas).

which is acknowledged by the Challenged Patents' Background Section. '806 Patent, 1:39-41. Likewise, the ejection head of Nagashima uses image data, as well as piezo-electrically driven pressure chambers, for operation, which allows for spot printing covering inks. *E.g.*, Nagashima [0223].

61. Accordingly, Nagashima teaches applying a coating of covering ink.

62. To the extent that it is argued that Nagashima does not teach a covering ink, it was obvious at the time to apply a covering ink using an inkjet printer like Nagashima because it was known at the time that inkjet printers could print covering inks, and covering inks had a viscosity within the range contemplated by Nagashima.

63. It was known at the time that an inkjet could be used to apply a coating of covering ink. For example, when discussing the prior art, the Challenged Patents describe “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). Varnish is used in the Challenged Patents as “synonymous” with “covering ink.” '806 Patent, 3:21-22. 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.

64. Nagashima's image recording device operates in the same way as these prior art inkjet printers. 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]. This passage from Nagashima, and others like it, describe an inkjet printer.

65. Second, the Challenged Patents disclose a broad range of ink types and viscosities. For example, the Challenged Patents state that covering ink, varnish, and viscous product are synonyms. '806 Patent, 3:21-22. The Challenged Patents also state that non-limiting "examples of inks in container 36 are varnish, scratch-off ink, conducting ink, printing ink or adhesive with typical average viscosities in the range of 100 to 1,000 centipoises, but which may have viscosities as low as about ten centipoises." *Id.*, 21-25. The varnish contemplated has a viscosity in the ideal range of 4 to 100 centipoises. *Id.*, 6:45 (using mPa•s). The '806 Patent and '031 Patent disclosure

66. Given that, as discussed above, Nagashima provides in-depth teaching for operating its ink ejection head to eject different ink types over a range of viscosities, including viscosities of covering ink. Inkjet printers were known as capable of coating a covering ink, it would have been obvious to apply a coating of

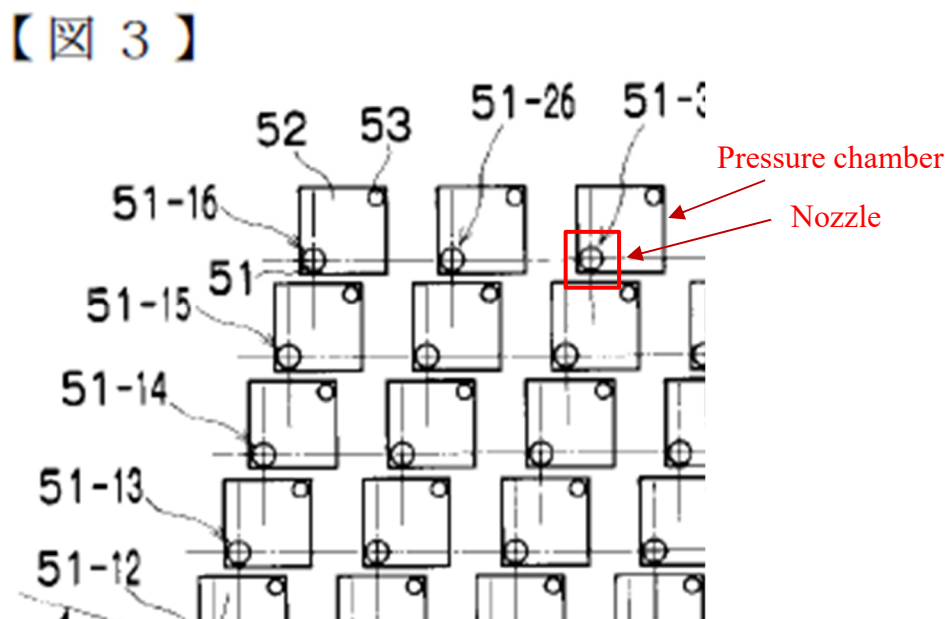
covering ink using the inkjet design of Nagashima. This is particularly true in view of the broad disclosure of covering ink in the '806 Patent.

[COMMON] [an ink jet nozzle arrangement] having a piezoelectric actuator for applying droplets of covering ink to the substrate, the method comprising

Patent	Limitation
'031 Patent	1.P.2
'806 Patent	1.P.2

67. This limitation is common between the '031 Patent and the '806 Patent.

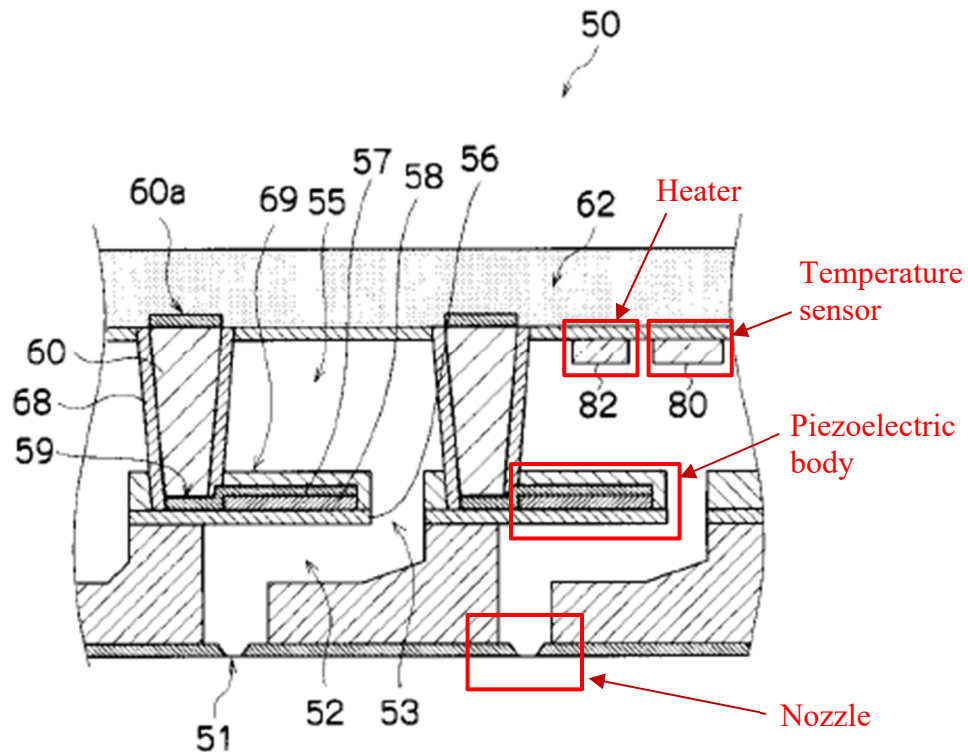
68. Nagashima teaches that the ink ejection head 50 includes a plurality of nozzles 51, which is shown in FIGS. 3 and 15 below:



Nagashima, FIG. 3 (annotated).

69. 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 15】



Nagashima, FIG. 15 (annotated).

70. 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].

71. 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.

[COMMON] controlling by a computer the shapes of the droplets by controlling the shape of an electric waveform applied to the piezoelectric actuator,

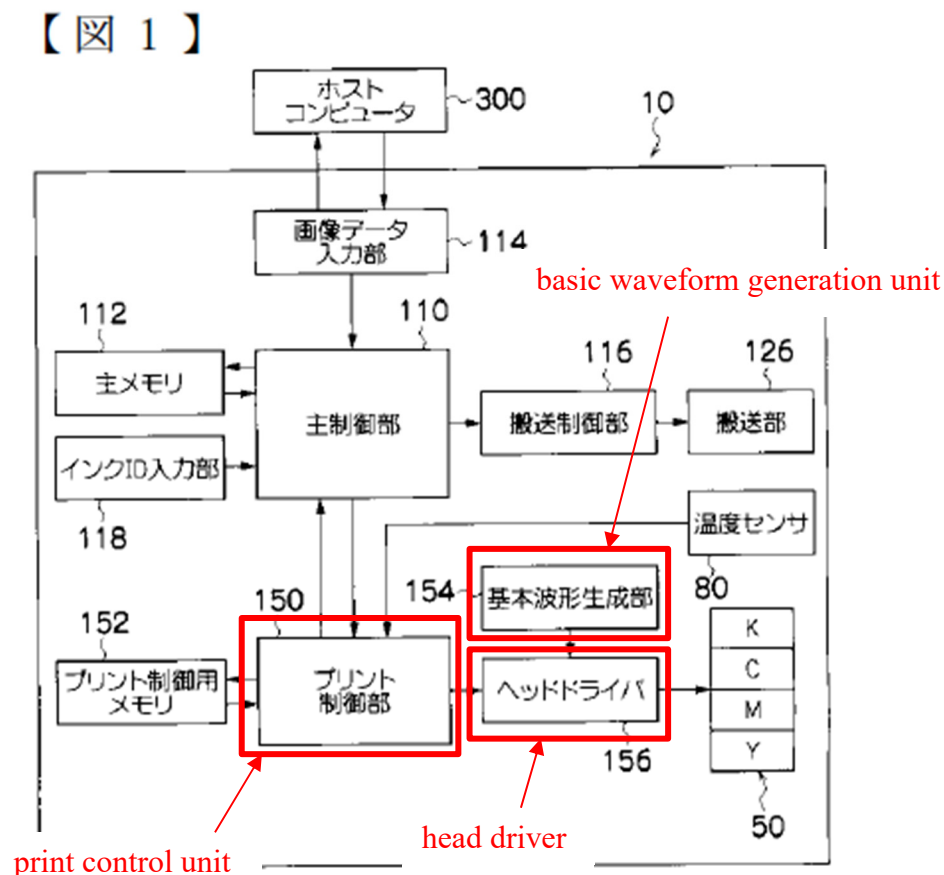
Patent	Limitation
'031 Patent	1.1.1
'806 Patent	1.1.1

72. This limitation is common between the '031 Patent and the '806 Patent.

73. 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 selects and give, to the ink ejection head 50, a necessary drive waveform from among a plurality of types of drive waveforms based on the basic waveform output from the basic waveform generator 154 and the electric signal (selection waveform) that is output from the print controller 152 and instructs selection of the drive waveform.” *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.*

74. FIG. 1 of Nagashima is illustrated below:



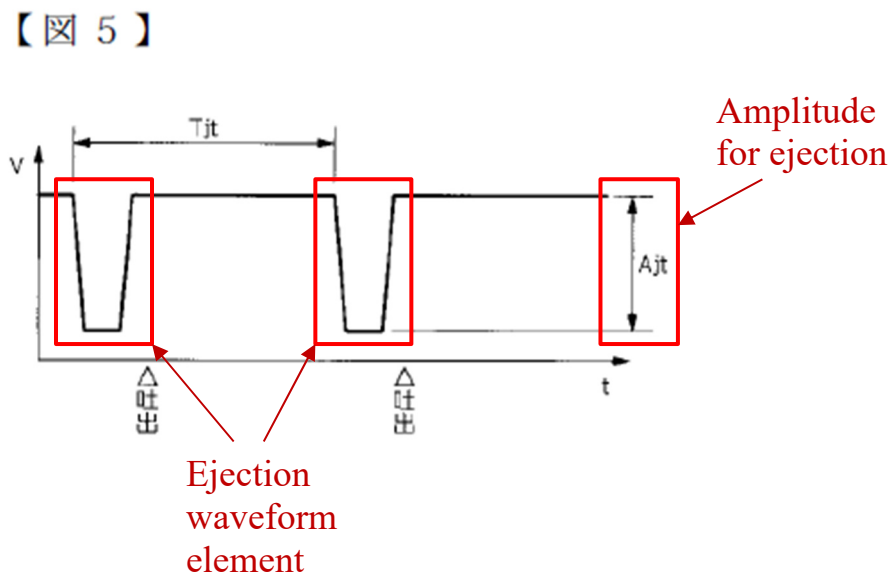
Nagashima, FIG. 1 (labeled with certain features).

75. Nagashima teaches that 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 “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 and 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.*

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

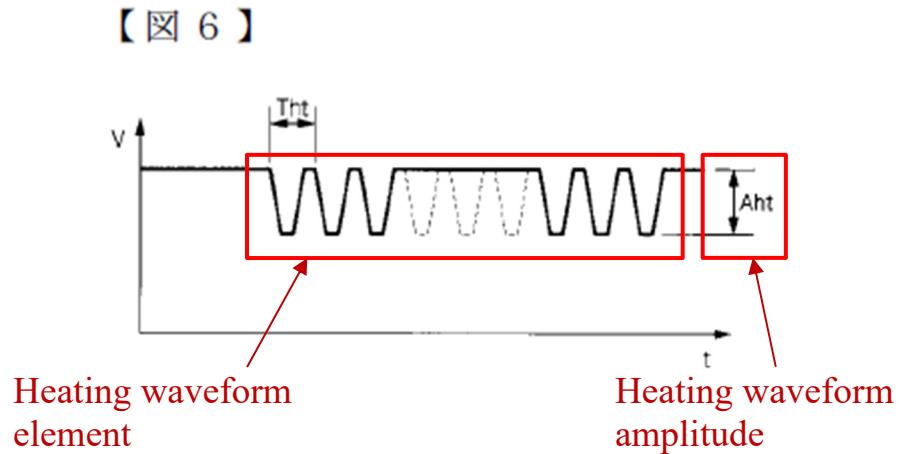
77. The ejection drive waveform is shown in FIG. 5, reproduced below:



Nagashima, FIG. 5 (annotated).

78. FIG. 5 illustrates “the ejection drive waveform in the case of

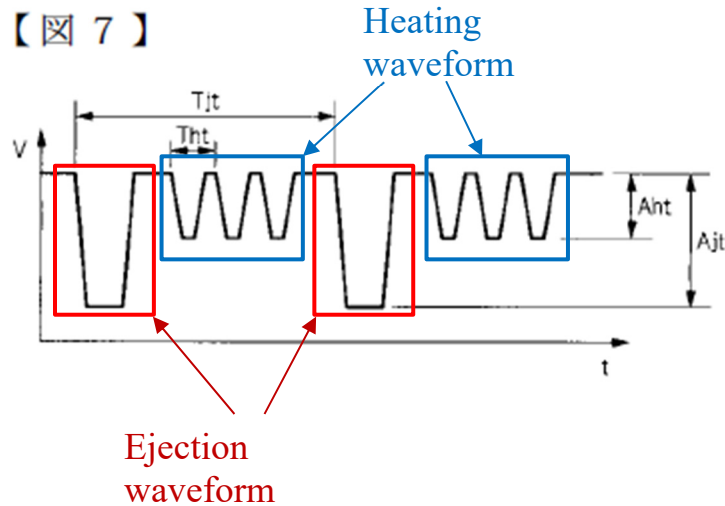
continuously ejecting n droplets (for example, $n = 2$) of ink from the same nozzle e.” Nagashima, [0086]. FIG. 6 shows the heating drive waveform:



Nagashima, FIG. 6 (annotated).

79. 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].

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



Nagashima, FIG. 7 (annotated).

81. 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].

82. Nagashima teaches heating the ink can control the droplet size (and therefore the shape⁵). 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” refers to the ink dot formed on the recording medium. Nagashima, [0059]. But, in describing the dot size, Nagashima is also describing the size of the ejected droplet size, because the

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

size of the droplet ejected by the nozzle dictates the dot size. Nagashima, [0219]-[0220]. In other words, Nagashima teaches controlling the shapes of the droplets by controlling the ink temperature because controlling the ink temperature would change viscosity of the ink and thus the volume of the ink for a given amplitude ejection signal. The referenced temperature control is accomplished, at least in part, 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].

83. The shape of the droplet can be controlled by ejecting a different size droplet, in which case the size and shape of the droplet are controlled by the ejection waveform. The size and shape of the droplet can also be controlled by ejecting multiple droplets of the same (or similar size), which combine in the air. The combination of multiple droplets that merge in air would have a different size and shape based on 1) the size of each droplet ejected and 2) the number of droplets ejected. Both techniques were well known at the time.

84. 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.

85. In addition, or in the alternative, the meniscus tickling waveform mitigates viscosity increases in the ink at the nozzle, and the resulting effect that viscosity increase has on droplet shape. In particular, Nagashima discloses the meniscus vibration 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]. “Compared with the heating drive waveform, the meniscus tickling waveform has a low frequency and a small 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]).

86. 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]. This instability can be because the viscosity increase causes the driving voltage set for ejecting the ink from the nozzle to be incorrect for the desired droplet size. In addition, clogs can form in the nozzle, which can affect droplet stability because the clog can block ejection of ink, especially if the driving voltage remains constant.

87. It was well known at the time that increases in viscosity of the ink due to solvent evaporation could adversely affect ejection of the droplet. *See, e.g.*, 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 because the resulting waveform that is provided

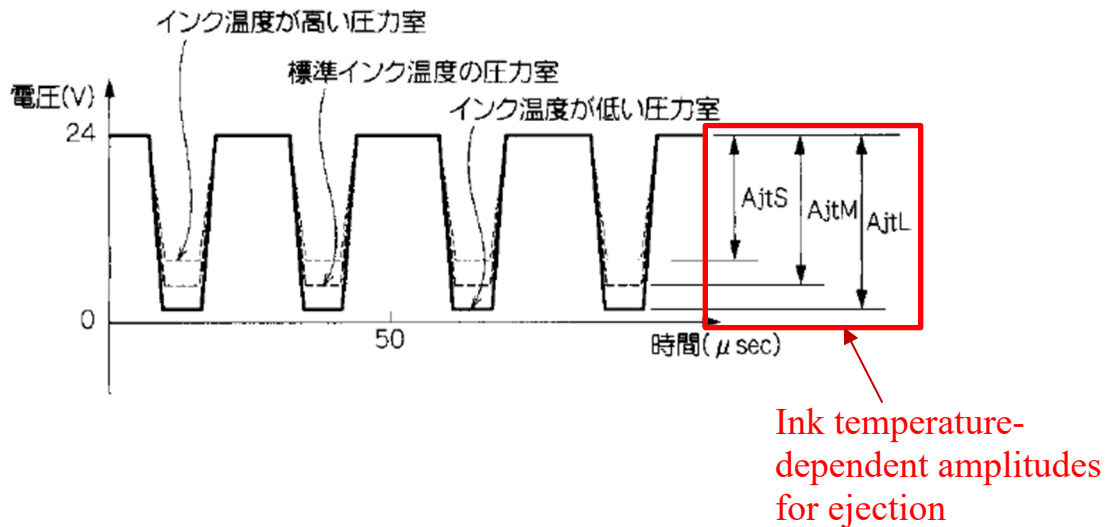
to the piezoelectric body will be shaped by the inclusion or exclusion of certain waveforms and the amplitude and frequencies of the included waveforms.

88. Accordingly, a POSITA would have appreciated that suppressing the increase in viscosity of the ink using a meniscus tickling waveform would have affected the shape of the droplet ejected from the nozzle because an increase in viscosity can create ejection instabilities that impact the droplet ejected from the nozzle.

89. **When considering the '031 Patent**, Nagashima also teaches that the shape of the droplets can be controlled by controlling the amplitude of the ejection drive waveform.

90. Nagashima teaches that the amplitude of the ejection drive waveform is “adjusted according to the ink temperature . . . detected by the temperature sensor 80.” Nagashima [0211]. FIG. 16 illustrates how the amplitude (i.e., shape) of the ejection drive waveform is controlled based on temperature of the ink:

【図 1 6】



Nagashima, FIG. 16 (annotated).

91. As shown in FIG. 16, “the amplitude of the ejection drive waveform is switched for each pressure chamber 52 based on the identified ink temperature for each pressure chamber 52.” Nagashima [0212].

92. Nagashima meets the limitation in the '031 Patent by controlling the amplitude of the ejection drive waveform. As shown in FIG. 16 above, the shape of the ejection drive waveform is different for different amplitudes, which are selected based on the temperature of the ink.

[806::1.1.2] said shape being controlled by selecting at least a number of plateaus of the electric waveform,

93. This limitation is in claim 1 of the '806 Patent, but is not found in

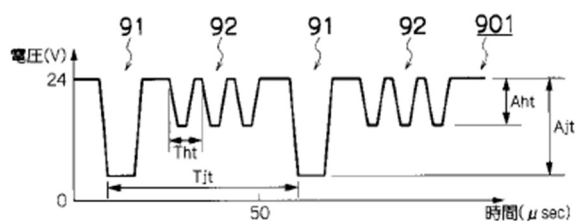
claim 1 of the '031 Patent.

94. It is my understanding that the term “said shape” refers to the shape of the electric waveform, based on the Special Master’s report. SM Claim Constructions at 78.

95. 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:

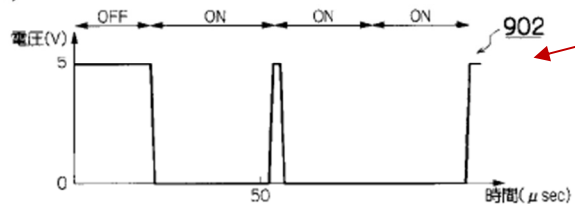
【図 9】

(a)



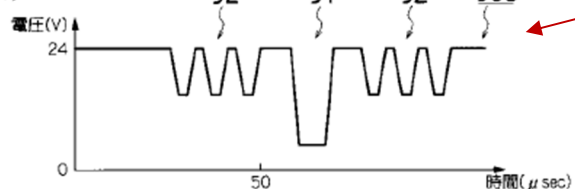
Ejection / heating
drive waveform

(b)



Selection waveform

(c)



Drive waveform,
includes ejection and
heating

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

96. 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].

97. 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].

98. 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].

99. In addition, or in the alternative, Nagashima teaches selecting the meniscus fine vibration for viscosity suppression. For example, Nagashima discloses that the meniscus vibration is “performed on ink having high volatility” and based on temperature; and does not performed meniscus vibration on ink having low volatility. Nagashima, [0042], [0128]. “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 vibration waveforms to control the shape of the electric waveform applied to the piezo.

100. A POSITA would have known that the shape of the ejected droplet would have been affected by the viscosity of the droplet. For example, for a fixed size nozzle, an increase in viscosity of the ink would decrease the amount of ink that is ejected, assuming the driving signal has not changed. On the other hand, for a fixed size nozzle, a decrease in viscosity of the ink would increase the amount of ink that is ejected, assuming the driving signal has not changed. 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.

In Nagashima, the nozzle size is fixed (not variable) (*see* Nagashima [0219]-[0220] discussing nozzle dot size), so control over the shape of the droplet is based on the control over the driving waveform. And if the viscosity changes, and the waveform does not, the resulting droplet shape and size will also change, accordingly. This change in shape due to an increase in viscosity (which can be caused by solvent evaporation, for example) results in inconsistent ejection and can also lead to ejection errors and failure.

***[806::1.2.1] in response to at least one of the following parameters:
temperature of the covering ink.***

101. Claim 1 of the '806 Patent controls the shape of the electric waveform in response to the temperature of the covering ink. (And '031 Patent claim 1 also controls the shape of the electric waveform in response to the temperature of the covering ink, and is discussed after this section.)

102. 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.

103. 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]. 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* discussion on Common element [1.1.1].

104. 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. The number of plateaus can be selected on a per-wave basis (minimum switching time is one peak or one wave),

which provides high granular control over the heating of the ink. For example, fewer peaks provide less heating.

[806::1.2.2] in response to at least one of the following parameters: composition of the covering ink.

105. This limitation is found in the '806 Patent.

106. 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 vibration “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. This is because the ink volatility is dependent on its composition. 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].

[COMMON] 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.

Patent	Limitation
'031 Patent	1.1.2-1.2
'806 Patent	2

107. The language in Claim 2 of the '806 Patent overlaps with the language of portions of claim 1 of the '031 Patent.

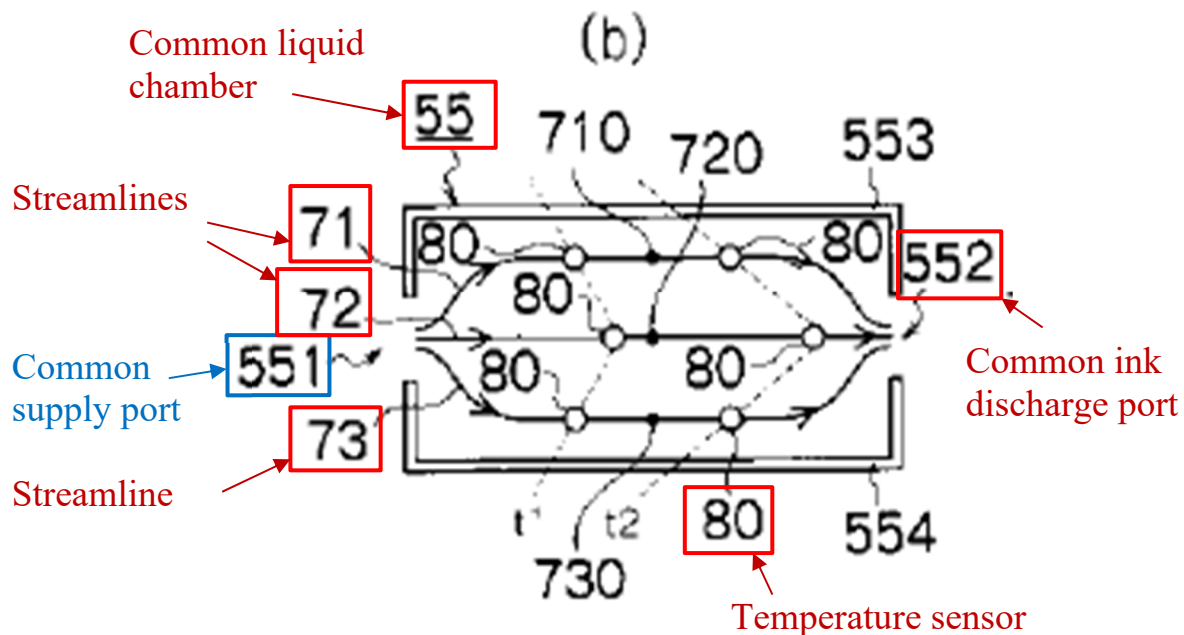
[806::2] For the '806 Patent:

108. 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.

109. 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].

110. 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)⁶ illustrates a “basic arrangement pattern” by way of example:



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

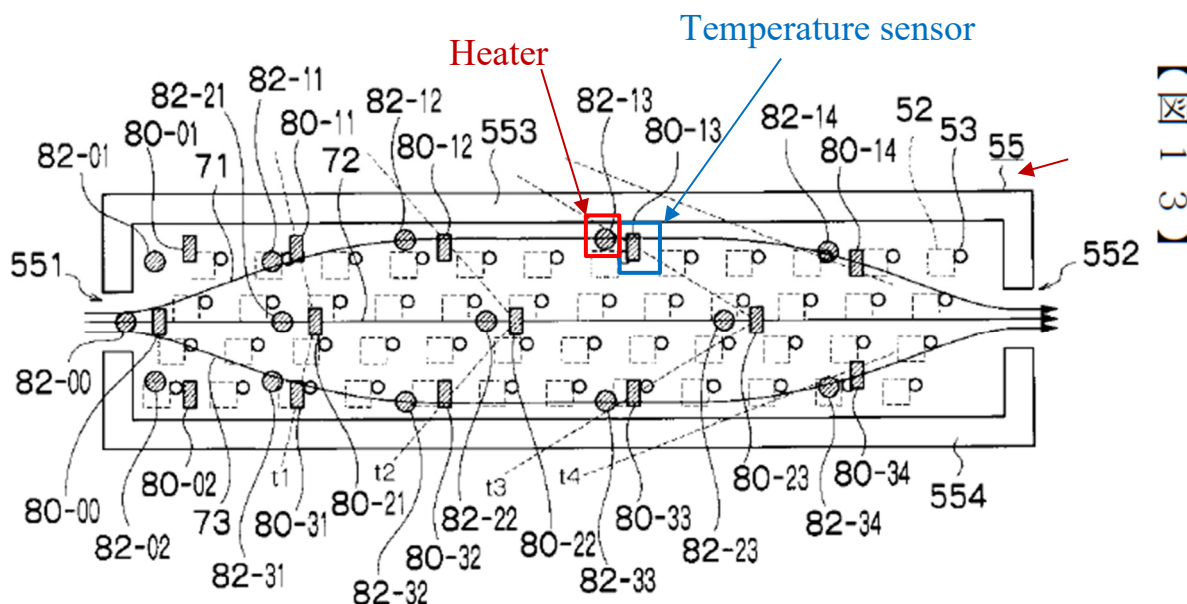
111. In the basic arrangement pattern shown in FIG. 10 (b), “[t]he common liquid chamber 55 includes a common ink supply port 551 through which ink is supplied from the outside of the common liquid chamber 55. . . and to the respective pressure chambers 52.” Nagashima, [0148]. “[T]hree representative flow lines 71, 72, and 73 . . . are indicated by arrows.” *Id.* “Two temperature

⁶ FIG. 10 (b) has overlapping disclosure as FIG. 10 (a). Nagashima, [0146], [0159].

sensors 80 are arranged along each of the plurality of representative flow lines 71, 72, and 73.” Nagashima, [0162].

112. Temperature sensors 80 measure temperature of the ink flowing through the common liquid chamber 55. Nagashima, [0041], [0068]. And as explained for [806::1.2.1], the temperature detected by the temperature sensor 80 is used to switch the heating drive waveform. *See, id.* [0141]-[0142].

113. 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]:

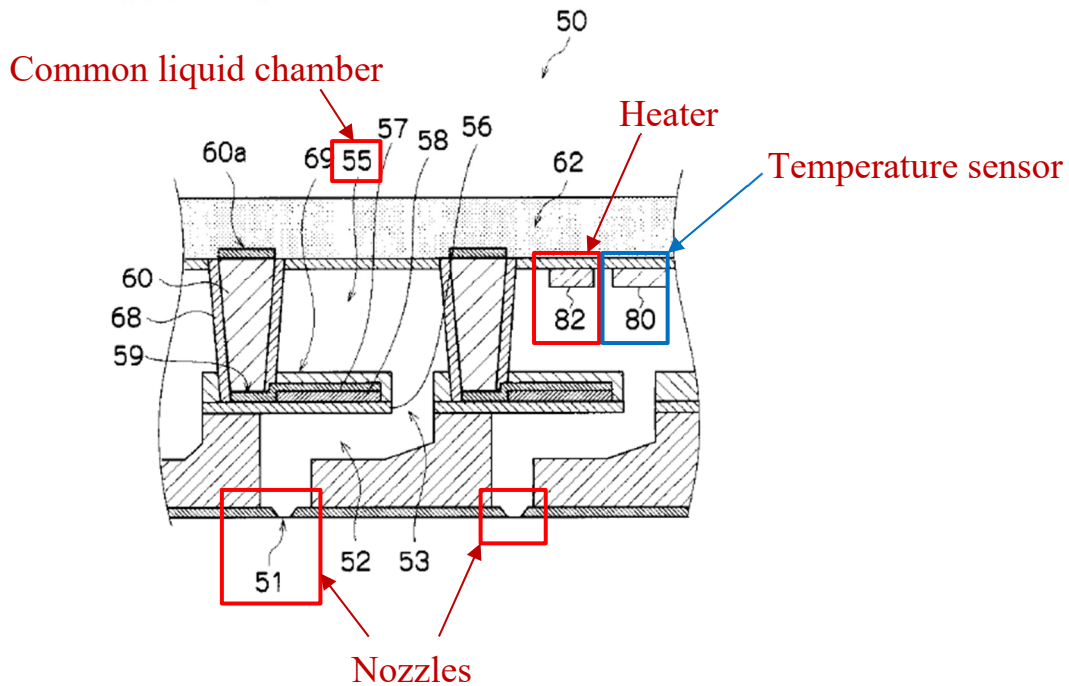


Nagashima, FIG. 13 (annotated).

114. 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.

115. 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 under either construction). The nozzle arrangement of Nagashima (showing the nozzles and the common liquid chamber) is shown in FIG. 15:

【図 15】



Nagashima, FIG. 15 (annotated)

116. 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.

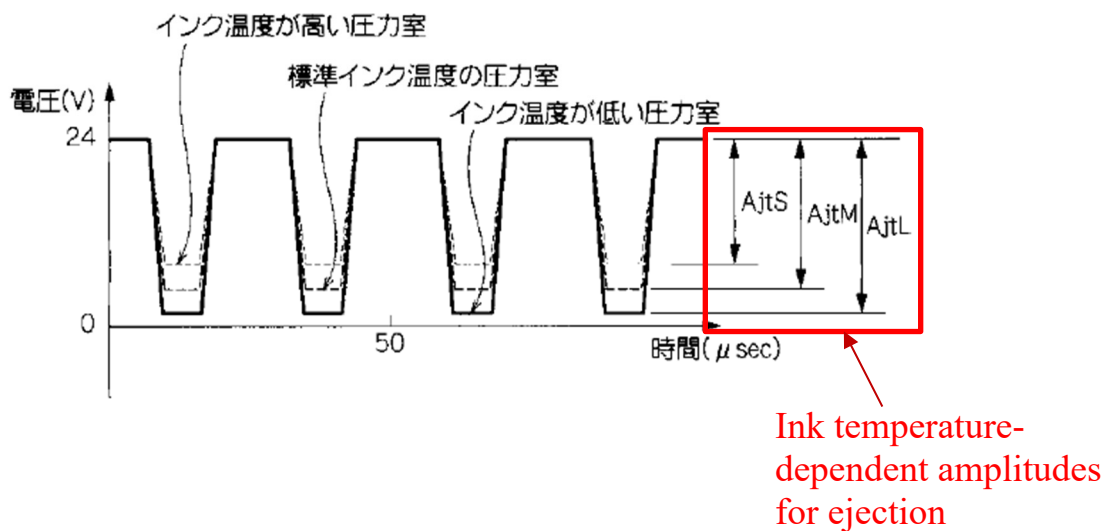
[031::1.1.2] in response to at least one of the viscosity and/or the temperature of the ink,

117. As mentioned in [1.1.1], Nagashima teaches that the shape of the electric waveform is in response to the temperature of the ink. First, Nagashima teaches that the amplitude of the ejection drive waveform is “adjusted according to

the ink temperature . . . detected by the temperature sensor 80.” Nagashima [0211].

FIG. 16 illustrates how the amplitude (i.e., shape) of the ejection drive waveform is controlled based on temperature of the ink:

【 図 1 6 】



Nagashima, FIG. 16 (annotated).

118. As shown in FIG. 16, “the amplitude of the ejection drive waveform is switched for each pressure chamber 52 based on the identified ink temperature for each pressure chamber 52.” Nagashima [0212]. For example, when “ink temperature in the pressure chamber 52 is higher than the predetermined first temperature threshold, the piezoelectric body 58 corresponding to the pressure chamber 52 is given an ejection drive waveform having an amplitude A_{jtS} smaller

than the standard amplitude A_{jtM} .” *Id.* [0213]. Likewise, when “the ink temperature in the pressure chamber 52 is equal to or lower than the second temperature threshold . . . the piezoelectric body 58 corresponding to the pressure chamber 52 has an amplitude A_{jtL} larger than the standard amplitude A_{jtM} .”

119. The shape of the electric waveform is also controlled by the shape of the heating drive waveform amplitude and frequency, which are in response to the temperature of the ink. As described in [1.1.1], the temperature control is accomplished by the heating drive waveform, which can be used to heat the ink in the vicinity of the nozzle (e.g., the pressure chamber). Nagashima [0088].

120. Recall that the “temperature sensor 80 and the print control unit 150 constitute a temperature specifying unit of the image forming apparatus 10.” Nagashima [0069]. Using ink temperature information from temperature sensor 80, the “print control unit 150 specifies the temperatures of the liquids in the plurality of pressure chambers 52, and determines whether the temperature of the ink in each pressure chamber 52 is a temperature to be heated.” Nagashima [0141] & [0068] (temperature sensor 80).

121. “When heating driving is performed, the switching time of the heating driving waveform . . . is switched based on the ink temperature for each pressure chamber 52” so that “lower ink temperature gives a heating drive waveform to the corresponding piezoelectric body 58 for a longer time.” *Id.* [0227]; *see also id.*

[0143] (describing minimum and maximum switching times). Additionally, Nagashima teaches that the heat generation amount, P , of the piezoelectric body is “proportional to the drive frequency f .” *Id.* [0096]. As described above, when heating driving is performed, the heating driving waveform is switched based on the ink temperature for each pressure chamber 52.” *Id.* [0227] (emphasis added). Thus, the frequency (shape) of the heating drive waveform is controlled based on the temperature of the ink.

122. The amplitude of the heating drive waveform is also based on the temperature of the ink. For example, Nagashima teaches that the heat generation amount of the piezoelectric body, P , is proportional to “the square of the applied voltage V of the piezoelectric body.” Nagashima [0096]; *see also id.* [0088] (applied voltage is amplitude of waveform). Thus, the shape (amplitude) of the heating drive waveform is in response to the temperature of the ink.

123. Thus, Nagashima teaches that the shape of the electric waveform is controlled in response to the temperature of the ink.

[031::1.2] 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.

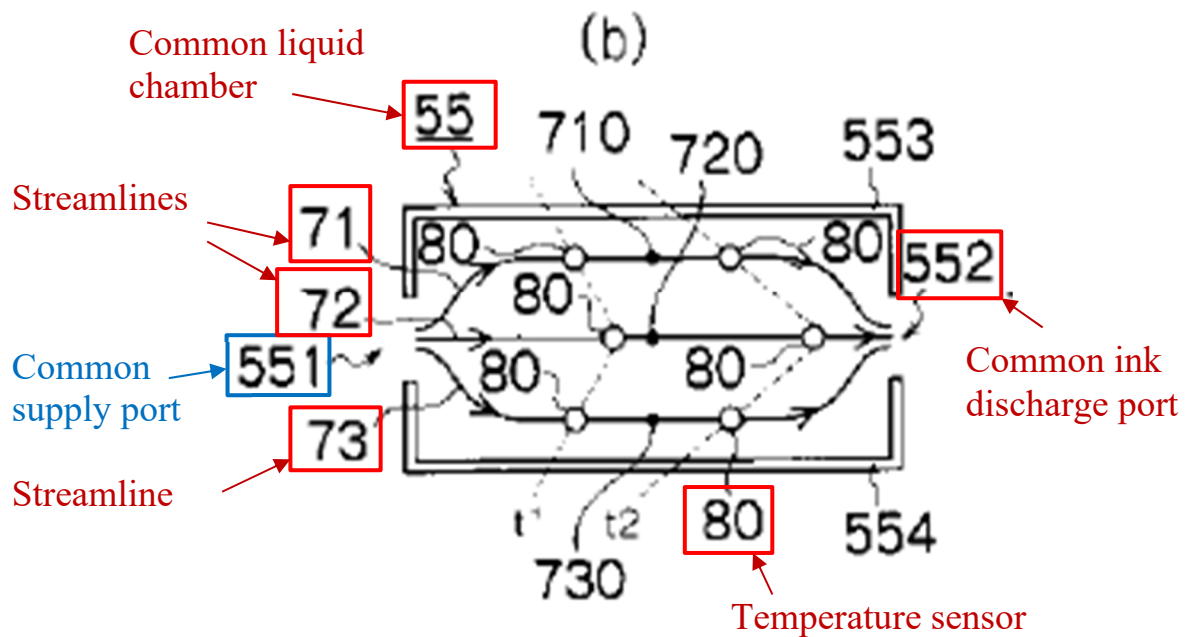
124. Nagashima teaches that the ink temperature is detected as the ink flows from the ink container to the nozzle by at least one detector upstream from a heater included in the nozzle arrangement. *See* [1.1.1]-[1.1.2] of the '031 Patent.

See [2] of the '806 Patent.

125. Nagashima teaches an “ink cartridge . . . containing ink,” (i.e., an ink container). Nagashima [0046]. Nagashima explains that ink is “supplied from the outside of the common liquid chamber 55 to the common liquid chamber 55.” *Id.* [0148]. A POSITA would have known that the ink cartridge is an ink container that supplies ink to the common liquid chamber because such ink cartridges were common place for supplying ink for inkjet printers at the time.

126. Nagashima teaches that ink temperature is detected by the temperature sensor 80.” Nagashima [0211]. Nagashima also 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)⁷ illustrates a “basic arrangement pattern” by way of example:

⁷ FIG. 10 (b) has overlapping disclosure with FIG. 10 (a). *E.g.*, Nagashima [0146], [0159].



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

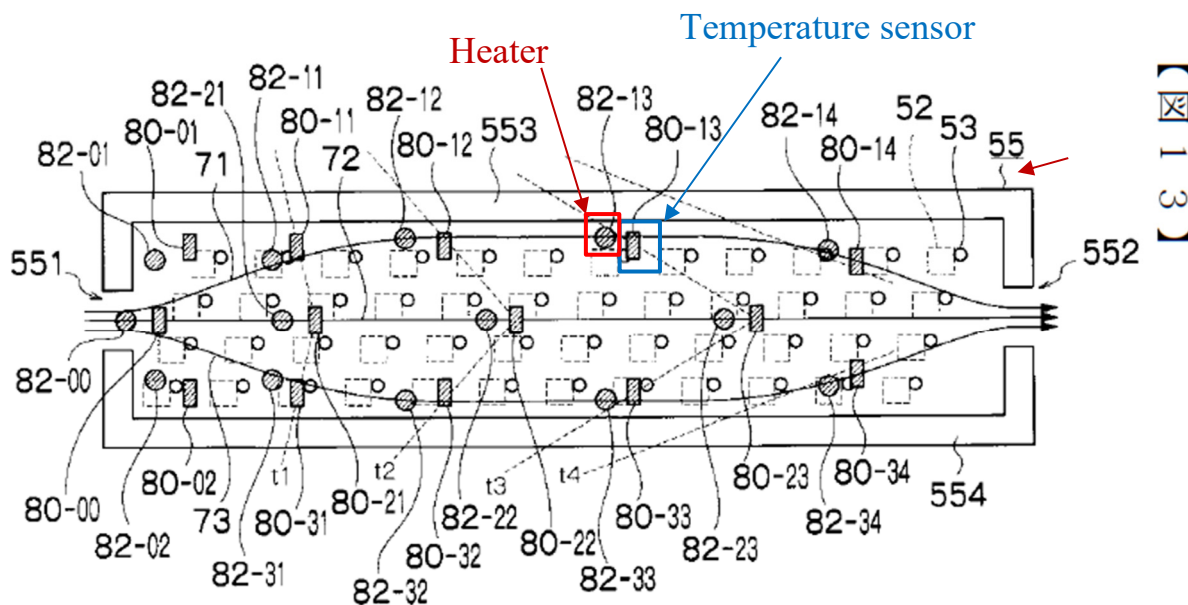
127. In the basic arrangement pattern shown in FIG. 10 (b), the common liquid chamber is “arranged so that ink is supplied from the outside of the common liquid chamber 55 to the common liquid chamber 55 and ink is individually supplied from the common liquid chamber 55 to each pressure chamber 52.”

Nagashima [0148]. “In FIG. 10 (b), as in FIG. 10 (a), three representative stream lines 71, 72, 73 selected in advance from the many stream lines in the common liquid chamber 55 are indicated by arrows.” *Id.* “Two temperature sensors 80 are arranged along each of the plurality of representative stream lines 71, 72, 73.”

Nagashima [0162].

128. Temperature sensors 80 measure temperature of the ink as it flows from the ink supply port to the ink charge port. E.g., Nagashima [0041] (temperature sensor measure ink temperature for adjustment) & As explained by Nagashima, “the temperature distribution information along the representative stream line in the common liquid chamber 55 [is] detected by the temperature sensor 80.” Nagashima, [0068]. And as explain in [806::1.2.1], the temperature detected by the temperature sensor 80 is used to switch the heating drive waveform. *See, e.g., id.* [0141]-[0142].

129. 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]:

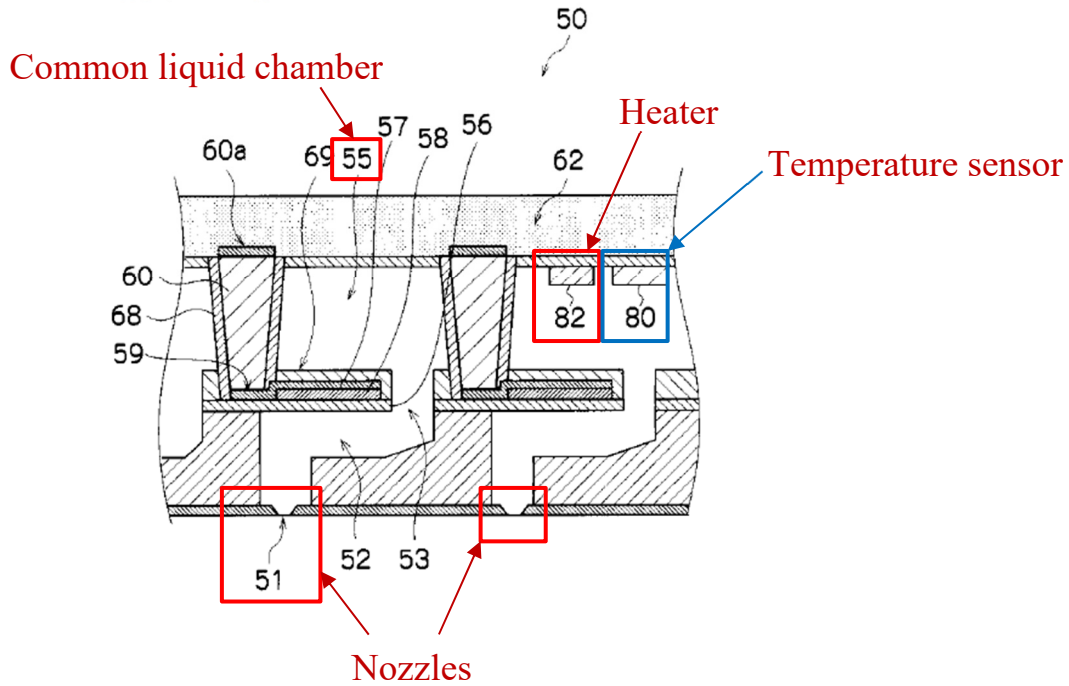


Nagashima, FIG. 13 (annotated).

130. 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). In FIG. 13 shown above, the heating element is upstream of the temperature sensor, which allows the “heating control by the heating element 82” to be “immediately detected by the temperature sensor 80.” *Id.* [0201]. **However**, Nagashima also teaches that, in the alternative, the heating element 82 may be arranged on “the downstream side” of the temperature sensor 80, so that the “desired temperature control can be performed immediately by the heating element 82 . . . based on the temperature detection result by the temperature sensor 80.” Nagashima [0203]. Accordingly, Nagashima teaches that the temperature sensor 80 is upstream of the heater.

131. In Nagashima, the temperature sensor 80 and the heater 82 are in the common liquid chamber 55, which is part of the nozzle arrangement because the common liquid chamber is part of the structure that includes the arrangement of one or more nozzles. As discussed in the Claim Construction section, the term nozzle arrangement is a “structure” that “includes one or more ink jet nozzles.” The nozzle arrangement of Nagashima (showing the nozzles and the common liquid chamber) is shown in FIG. 15:

【図 15】



Nagashima, FIG. 15 (annotated)

132. 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.

[COMMON] Apparatus for applying a coating of covering ink to a substrate, comprising

Patent	Limitation	Corresponding Limitation
'031 Patent	12.P	1.P.1-1.P.2
'806 Patent	9.P	1.P.1-1.P.2

133. This limitation is common between claim 12 of the '031 Patent and

claim 9 of the '806 Patent. This limitation is met by Nagashima as shown by the analysis for the preamble discussed above.

[COMMON] a transport mechanism for causing relative movement between the substrate and an ink jet nozzle arrangement,

Patent	Limitation	Corresponding Limitation
'031 Patent	12.1	1.P.1
'806 Patent	9.1	1.P.1

134. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent. This limitation is met by Nagashima as shown by the analysis for the preamble discussed above.

[COMMON] the ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate;

Patent	Limitation	Corresponding Limitation
'031 Patent	12.2	1.P.1-1.P.2
'806 Patent	9.2	1.P.1-1.P.2

135. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent. This limitation is met by Nagashima as shown by the analysis for the preamble discussed above.

[COMMON] a computer controlling a heater included in the nozzle arrangement heating the covering ink

Patent	Limitation	Corresponding Limitation
'031 Patent	12.3	1.1.1, 1.2
'806 Patent	9.3	1.1.1, 1.2.1, 2

136. This limitation is common between claim 12 of the '031 Patent and

claim 9 of the '806 Patent.

137. See [1.1.1]-[1.2]. The computer here is the print control unit 150. The print control unit 150 can control the heater 82 that is in the common liquid chamber. Nagashima [0205]. Nagashima explains that 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” in combination. *Id.* [0197], [0205].

138. 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].

[COMMON] and an electric source for applying an electric waveform to the piezoelectric actuator, said waveform controlling the shapes of the droplets,

Patent	Limitation	Corresponding Limitation
'031 Patent	12.4.1	1.1.1, 1.2
'806 Patent	9.4.1	1.1.1, 1.2.1, 2

139. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent.

140. The electric source is the basic generating unit 154 and the head driver 156 described in Nagashima.

141. 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).

[806::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,

142. See [806::1.1.1]. A print control unit 150 is a command device.

Nagashima, [0038], [0085].

[806::9.5.1] in response to at least one of the following parameters: temperature of the covering ink

143. See [806::1.2.1].

[806::9.5.2] in response to at least one of the following parameters: composition of the covering ink

144. See [806::1.2.2].

[031::12.4.2] said electric waveform having a shape determined by at least one of the viscosity and/or the temperature of the covering ink,

See [031::1.1.1]-[031::1.1.2], [806::1.2.1, 2].

[031::12.5] the apparatus 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 droplets as the ink flows from the ink container to the nozzle.

See [031::1.2], [806::2].

X. OBVIOUSNESS IN VIEW OF NAGASHIMA WITH RICOH

Obviousness by Nagashima and Ricoh	
Patent	Claims

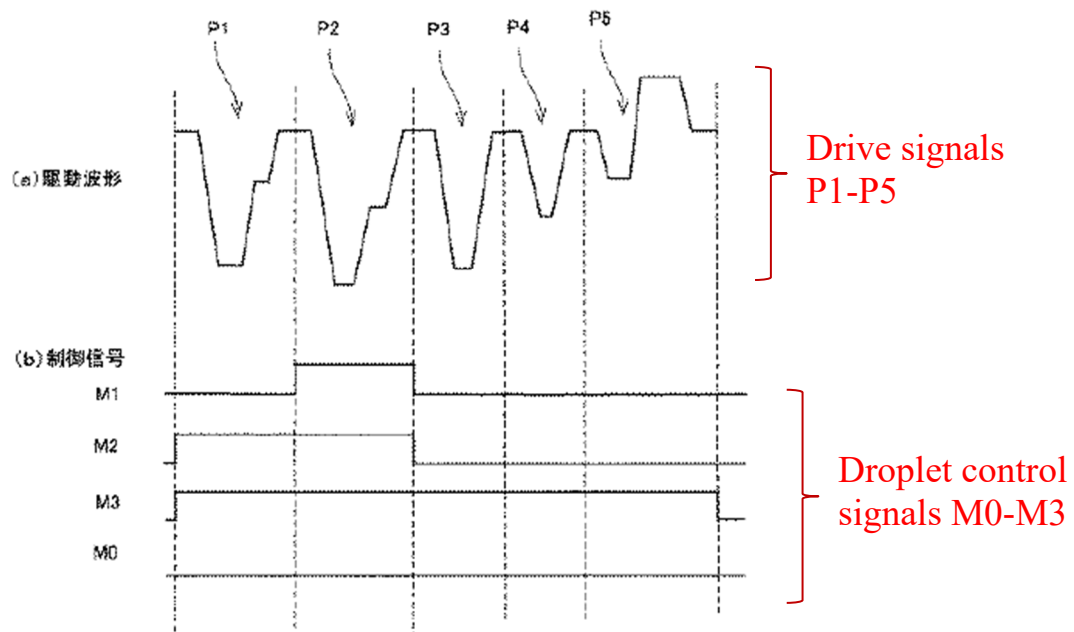
'031 Patent	7 & 18
'806 Patent	2 & 12

A. Overview of Ricoh

145. 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].

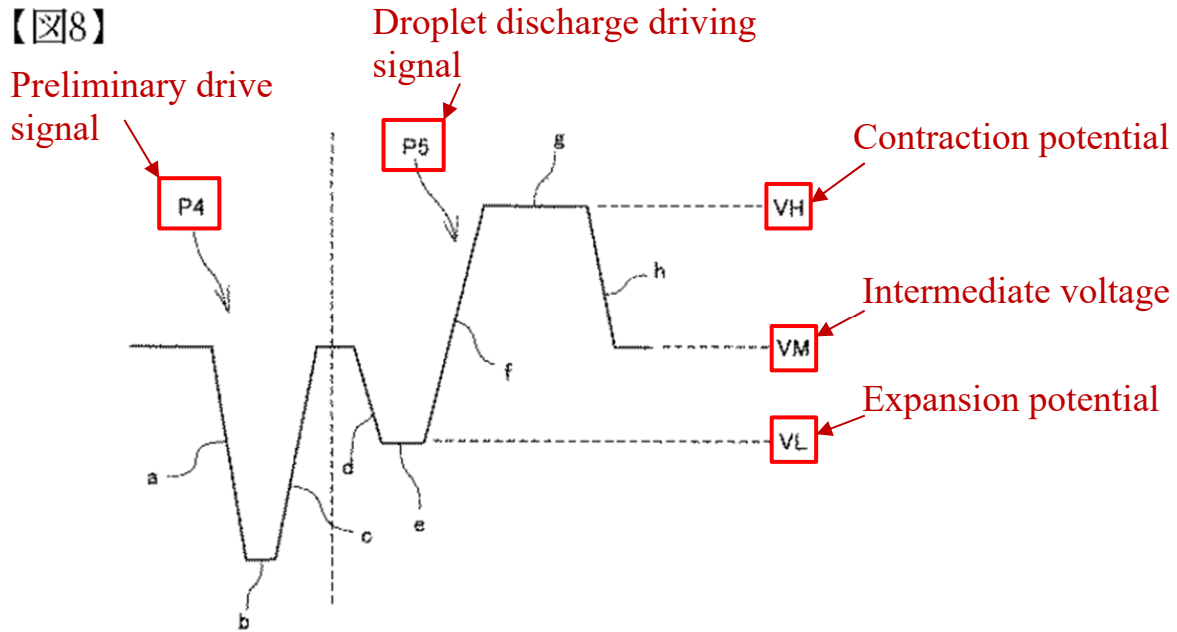
146. Ricoh FIG. 7 illustrates a drive signal waveform for driving the piezo:

【図7】



Ricoh, FIG. 7 (annotated).

147. 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).

148. 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].

149. 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.*

150. 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].

151. 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 “to 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].

B. Combination of Nagashima and Ricoh

152. 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.

C. Reasons to Combine Nagashima and Ricoh

153. 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. 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. P4 is already similar to the waveform elements contemplated by Nagashima (and Nagashima discusses having control over the amplitude of the waveforms and the piezo, Nagashima, FIG. 16 discussion). And P5 provides ink ejection stability that Nagashima identifies as a concern. *E.g.*, Nagashima [0099].

154. High-frequency ejection facilitates faster coating speeds and/or thicker coating layers. 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 because the preliminary drive signal resembles the signals discussed in Nagashima already.

155. In addition, or in the alternative, a POSITA would have been motivated to include waveform elements, such as those described in Ricoh, 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]. 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 as a result “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, teaches that vibration frequency in the pressure chamber affects discharge stability. *See* Nagashima, [0087]. A POSITA would have been motivated to improve 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.

156. A POSITA would have had a reasonable expectation of success in using the waveform signals of Ricoh with Nagashima. Ricoh’s waveform elements offered well-known and predictable solutions for performing stable high-frequency ink ejection. 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 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 for at least the following reasons. 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. The piezoelectric body of Nagashima includes a piezo that "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].

157. 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. *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, because both Nagashima and Ricoh teach the pushing and pulling of the meniscus using waveform to expand and contract the pressure chamber. Thus a POSITA would have had a reasonable expectation of success using the waveforms of Ricoh with the design of Nagashima.

D. Analysis

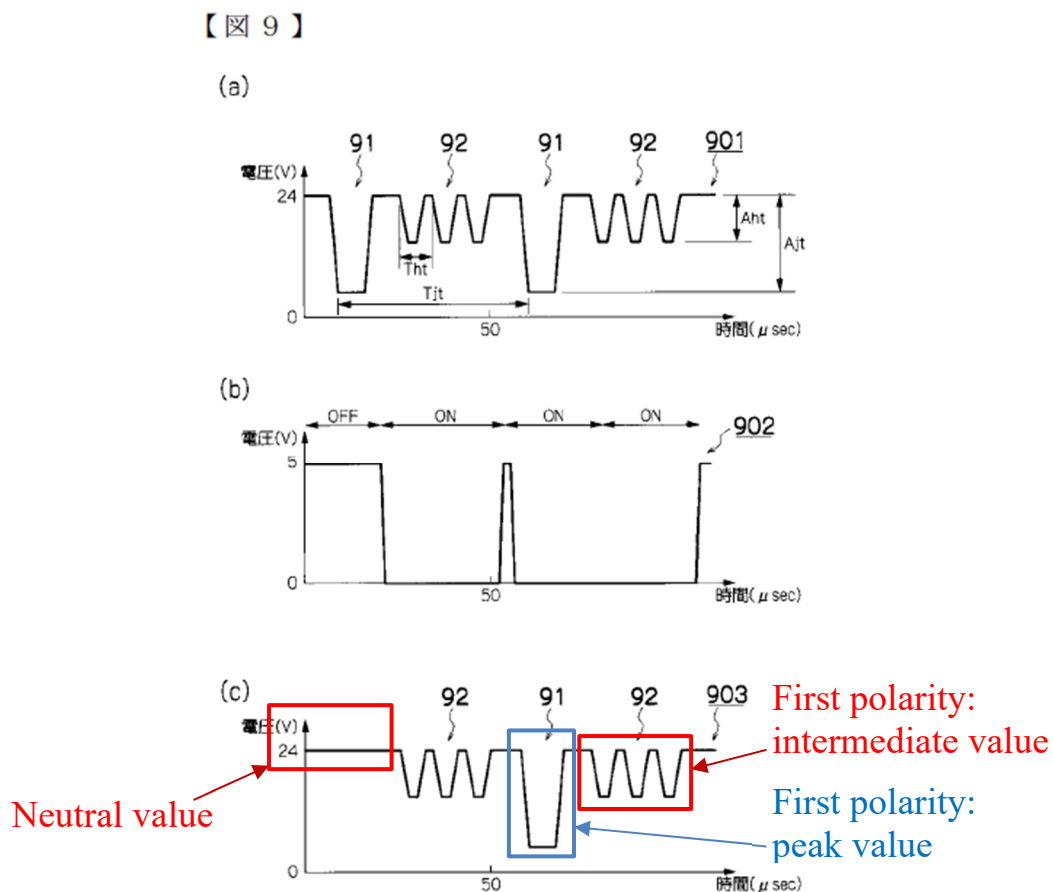
[COMMON] The method of claim 1 wherein the waveform has . . .

Patent	Limitation
'031 Patent	7.P & 18.P
'806 Patent	4.P & 12.P

158. This limitation is common between claims 7 and 18 of the '031 Patent and claims 4 and 12 of the '806 Patent.

159. Nagashima discloses the elements of claim 1. (See independent claims.)

160. 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:



Nagashima, FIG. 9 (annotated).

161. Note that the ejection drive amplitude A_{jt} (peak value) is greater than

the heating drive amplitude Aht (intermediate amplitude). Nagashima, [0122].

[COMMON] (a) neutral value associated with the nozzle arrangement being at rest,

Patent	Limitation
'031 Patent	7.1 & 18.1
'806 Patent	4.1 & 12.1

162. 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.

163. 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).

164. Furthermore, FIG. 9 shows that the ejection driving waveform amplitude Ajt and the heating driving waveform amplitude Aht have values relative to the 24V reference voltage. Nagashima, FIG. 9, [0122]. When the amplitudes Ajt and Aht 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, which is part of the nozzle arrangement, so the neutral

value is associated with the nozzle arrangement at rest.

[COMMON] (b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value,

Patent	Limitation
'031 Patent	7.2.1 & 18.2.1
'806 Patent	4.2.1 & 12.2.1

165. 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.*

166. 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. Thus, Nagashima’s ejection driving waveform causes the nozzle arrangement to have a volume greater than the neutral value.

[COMMON] 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.

Patent	Limitation
'031 Patent	7.2.2 & 18.2.2
'806 Patent	4.2.2 & 12.2.2

167. 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.

168. 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 because Nagashima defines a cycle T_{ht} smaller than the minimum ejection period T_{ht} . Nagashim [0122]. 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.

169. 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.

170. In addition or in the alternative, 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 increase the heat of the ink, 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.

171. In addition, or in the alternative, Nagashima teaches a meniscus vibration waveform that has an intermediate value between the peak value and the neutral value. As mentioned before, the meniscus vibration 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 vibration should not eject ink, so the frequency is set according to the viscosity dependent equation recited above. Accordingly, the meniscus vibration waveform has a frequency (i.e., duration) that is dependent on the viscosity.

[COMMON] each peak value causing a droplet to be expelled from the nozzle arrangement,

Patent	Limitation
'031 Patent	7.2.3 & 18.2.3
'806 Patent	4.2.3 & 12.2.3

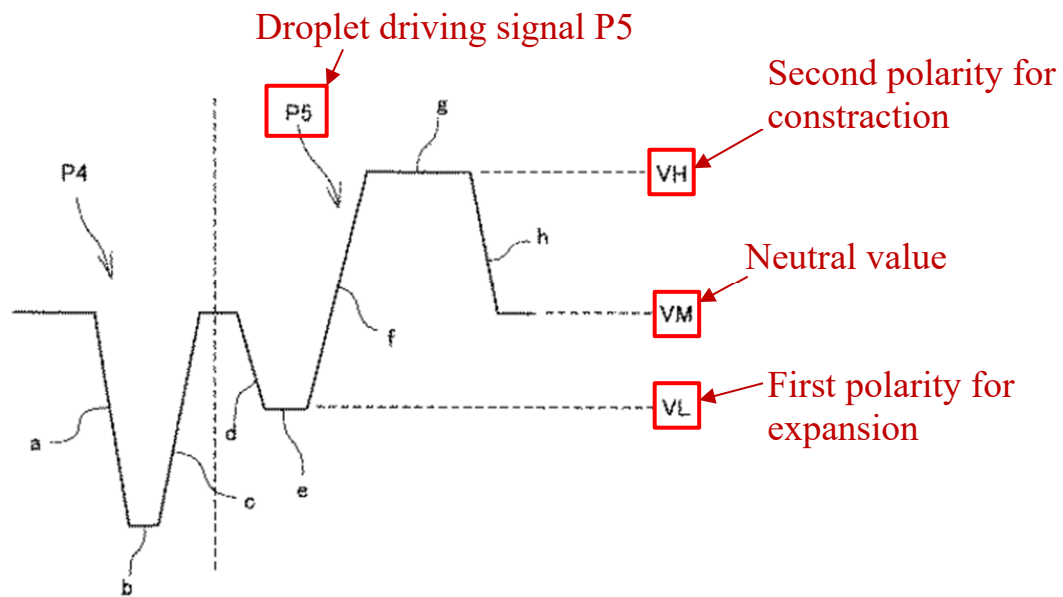
172. See the discussion above pertaining to the preamble of claim 7 (7.P) etc., and the discussion about the first polarity (7.2.1 etc.), showing that the peak values A_{jt} ejects ink. Noteworthy is that Nagashima refers to the A_{jt} (peak value) as part of the “ejection drive waveform,” which causes a droplet ejection from the nozzle, because is greater than the heating drive waveform amplitude A_{ht} (intermediate plateau value). Nagashima, [0122].

[COMMON] (c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value

Patent	Limitation
'031 Patent	7.3 & 18.3
'806 Patent	4.3 & 12.3

173. 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).

174. 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).

175. 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].

XI. OBVIOUSNESS IN VIEW OF TAKATSUKA WITH CHANG

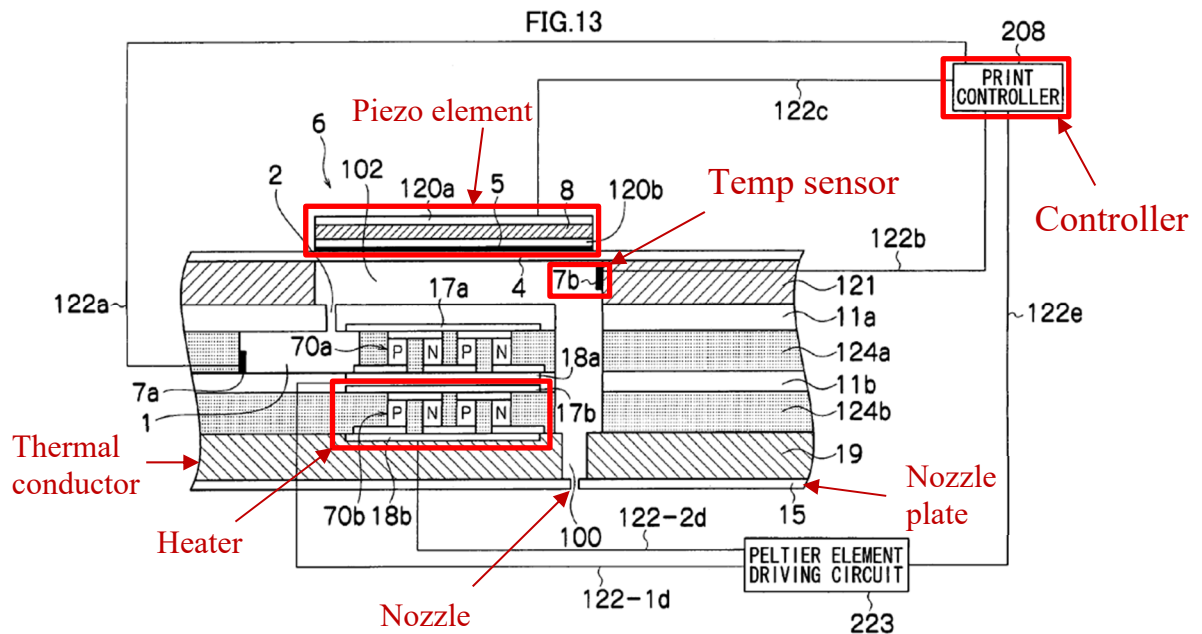
Obviousness by Takatsuka and Chang	
Patent	Claims
'031 Patent	1, 7, 12, & 18
'806 Patent	1, 2, 4, 9, 10, & 12

A. Overview of Takatsuka

176. 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.

177. Takatsuka describes using a piezo actuator to eject 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. 13⁸ below:



Takatsuka, FIG. 13 (annotated).

178. The piezo element 6 can generate a pressure inside pressure chamber 102 to eject an ink droplet when actuated by an applied voltage by a print controller. *See* Takatsuka, 11:38, 11:46-51. In addition, “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, in such a manner that air bubbles inside the pressure chamber 102 are broken up and the air is caused to become dissolved

⁸ “Parts which are the same as those in the first embodiment are labeled with the same reference numerals as FIG. 6.” 17:28-30. “In the inkjet head according to the present embodiment, the controller 208 is able to implement similar control to the ejection control of the first embodiment” *Id.*, 61-63.

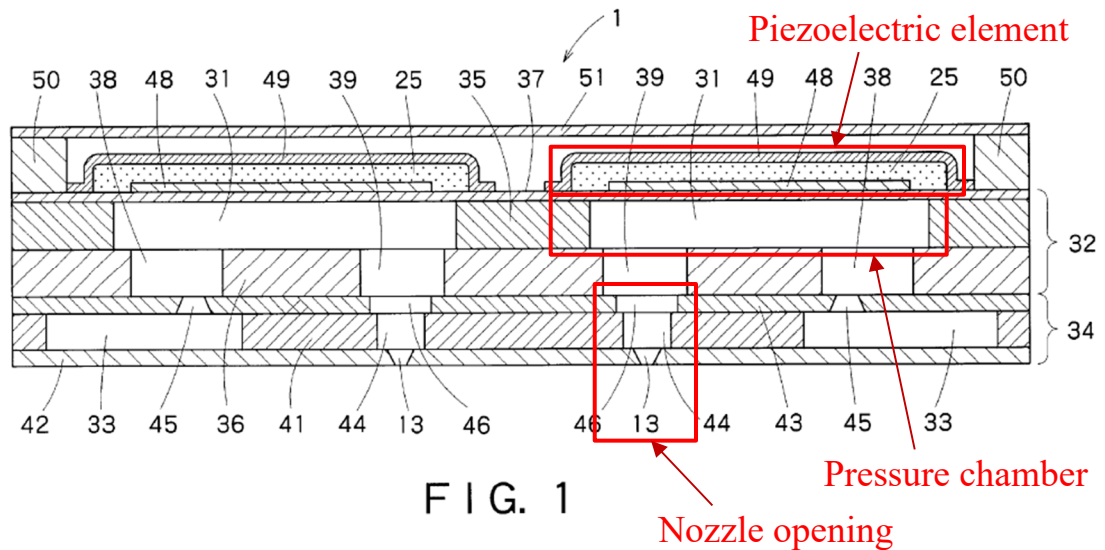
inside the ink.” *Id.*, 20:52-57.

B. Overview of Chang

179. Chang is directed to 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 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.

180. Additionally, Chang provides a minute vibration pulse 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, 12:9-25. 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, 11:60-64 (emphasis added), 9:38-45 (describing connection element and waveform element), 11:54-65 (a portion of connection element not used for minute vibration pulse).

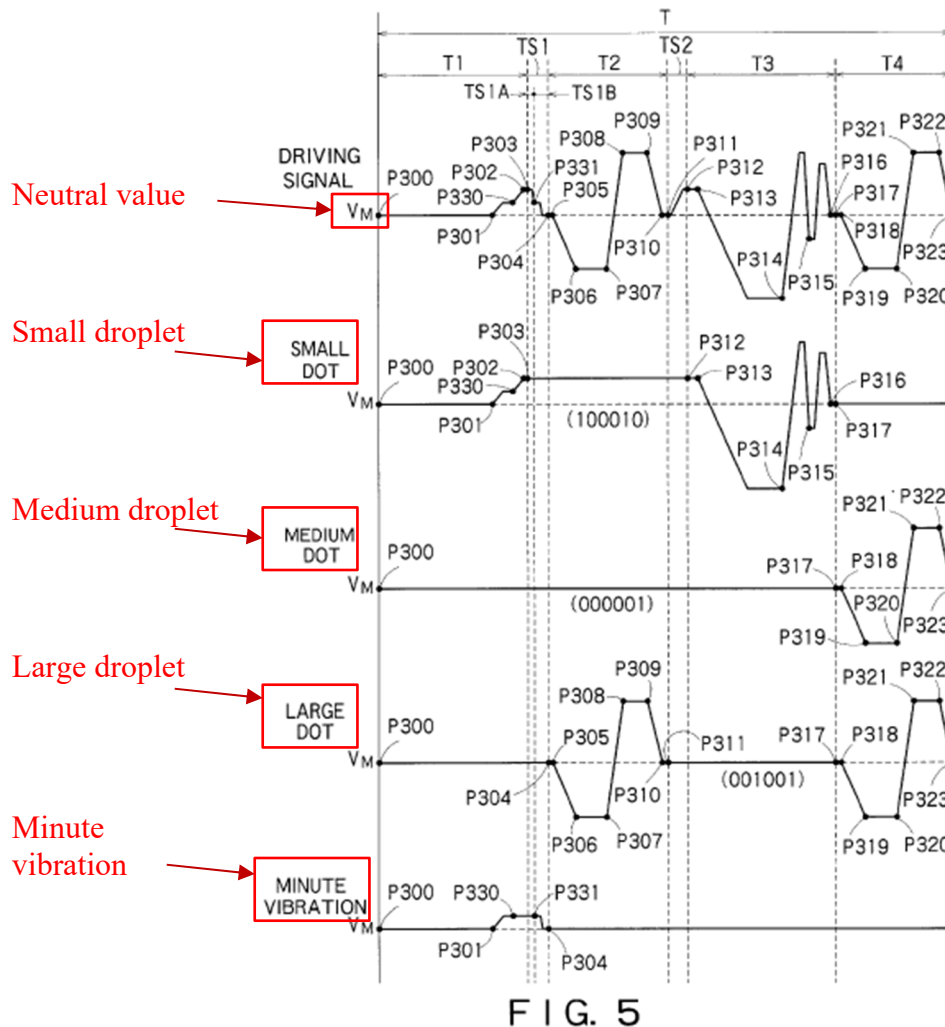
181. FIG. 1 of Chang illustrates an example structure of a recording head of an ink jet recorder, Chang, 5:43-45:



Chang, FIG. 1 (annotated).

182. Chang FIG. 1 illustrates a “recording head 1 has an actuator unit 32 in which a plurality of pressure chambers are formed, a flow path unit 34 in which nozzle openings 13 and common link chambers 33 are formed, and the piezo-electric vibrators 25.” Chang, 5:49-52. “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.*, 5:56-59. “Ink drops (liquid drops) are ejected from the nozzle openings 13 due to changes in the ink pressure in the pressure chambers 31.” *Id.*, 5:59-61.

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



Chang, FIG. 5 (annotated).

184. The waveforms 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.

185. FIG. 5 also illustrates a minute vibration pulse for non-ejection of ink. 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.

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.

C. Combination of Takatsuka and Chang

186. 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, Takatsuka’s controller uses an electrical waveform, such as those described in Chang, to perform ink ejection and non-ejection functions.

D. Reasons to Combine Takatsuka and Chang

187. 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.

188. 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.* That Takatsuka does not identify the specifics of the ejection and non-ejection waveforms, but assumes that a POSITA reading the patent would understand how to accomplish this, is further evidence that adjusting the amplitude and duration of the waveforms to achieve ejection and non-ejection were well within the skill of a POSITA, for one reason, because doing so was common place at the time. Thus, a POSITA would have found it obvious to implement Chang's waveforms to drive Takatsuka's piezo as an example of an electrical waveform for driving the piezo of an inkjet having both ejection and non-ejection forms.

189. In addition, or in the alternative, a POSITA would have motivated to implement the waveforms in Chang, because they offer other features useful in driving Takatsuka's inkjet printer. For example, Chang's electrical waveforms are configured to produce ink droplets of different shapes and sizes (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 droplets (4 pL), medium droplets (8 pL), and large droplets (20 pL). 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.

190. In addition, or in the alternative, 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. 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, as evidenced by other references described here. 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 number of droplets). Also Schneider provides a disclosure showing that the thickness of the layer is based on the size of the droplets. 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.

191. In addition, or in the alternative, 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 to achieve stable ejections during high-frequency ejections, and to facilitate consistent ejection between high- and low-frequency ejections.

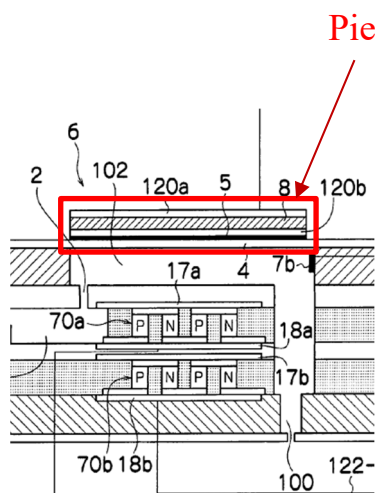
192. Chang's waveform incorporates "minute vibration" non-ejection waveforms that drive the piezo to mitigate this increase in viscosity of the ink at the meniscus, and a POSITA would have been motivated to incorporate Chang's waveform with "minute vibration" to mitigate an increase in viscosity from, 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.

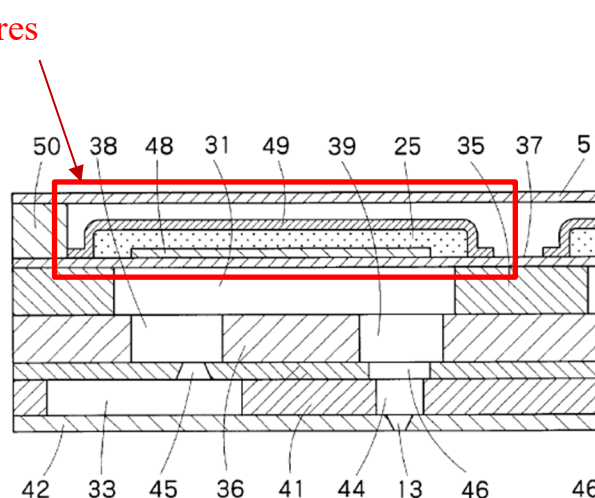
193. For at least these reasons, it would have been obvious to a POSITA to drive the inkjet piezo structure of Takatsuka with waveforms for ejection and non-ejection operations, such as those described by Chang. A POSITA would have had a reasonable expectation of success using the waveforms of Chang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

194. 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)

195. 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 piezoelectric that uses deflection mode, as well as a piezoelectric 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.

196. 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. This is because Takatsuka is silent on the specific waveforms to use, but does intend on controlling the amount of ink ejected. Takatsuka, 10:64-67 (describing that the print controller controls the amount of ink ejected). And, Chang provides the waveforms that are compatible with Takatsuka and can provide the intended result. In addition, Chang's waveform provide other benefits, such as vibration of the meniscus for inks of different viscosities, to prevent increases in viscosity due to solvent evaporation.

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.

E. Analysis

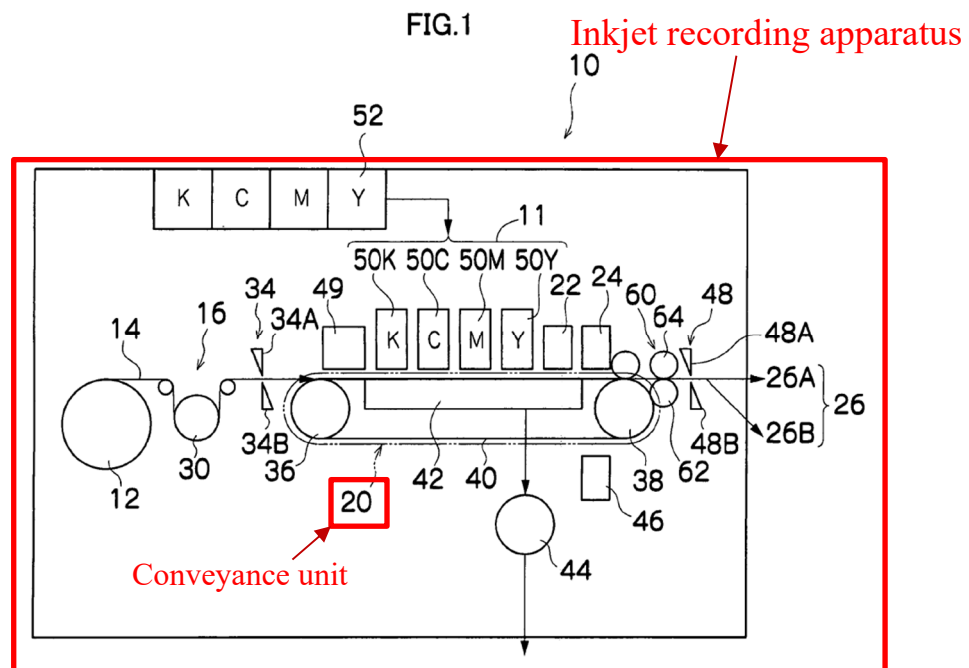
[COMMON] A method of applying a coating of covering ink to a substrate moving relative to an ink jet nozzle arrangement . . .

Patent	Limitation
'031 Patent	1.P.1
'806 Patent	1.P.1

198. This limitation is common between the '031 Patent and the '806 Patent.

199. 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:

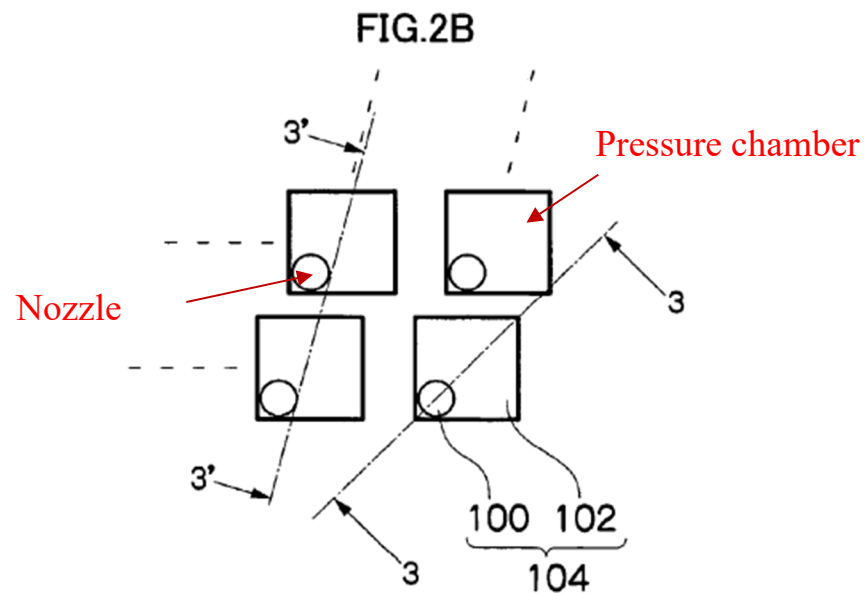


Takatsuka, FIG. 1 (annotated).

200. Takatsuka’s design includes a conveyance unit for moving paper relative to the inkjet nozzles. For example, the inkjet recording apparatus of Takatsuka includes “a suction belt conveyance unit 20 disposed facing the nozzle

face (ink-droplet ejection face) of the print unit 11, for conveying the recording paper 14 while keeping the recording paper 14 flat.” Takatsuka, 5:24-27. “The suction belt conveyance unit 20 has a configuration in which an endless belt 40 is set around rollers 36 and 38 so that the portion of the endless belt 40 facing at least the nozzle face of the print unit 11.” *Id.*, 6:5-9.

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

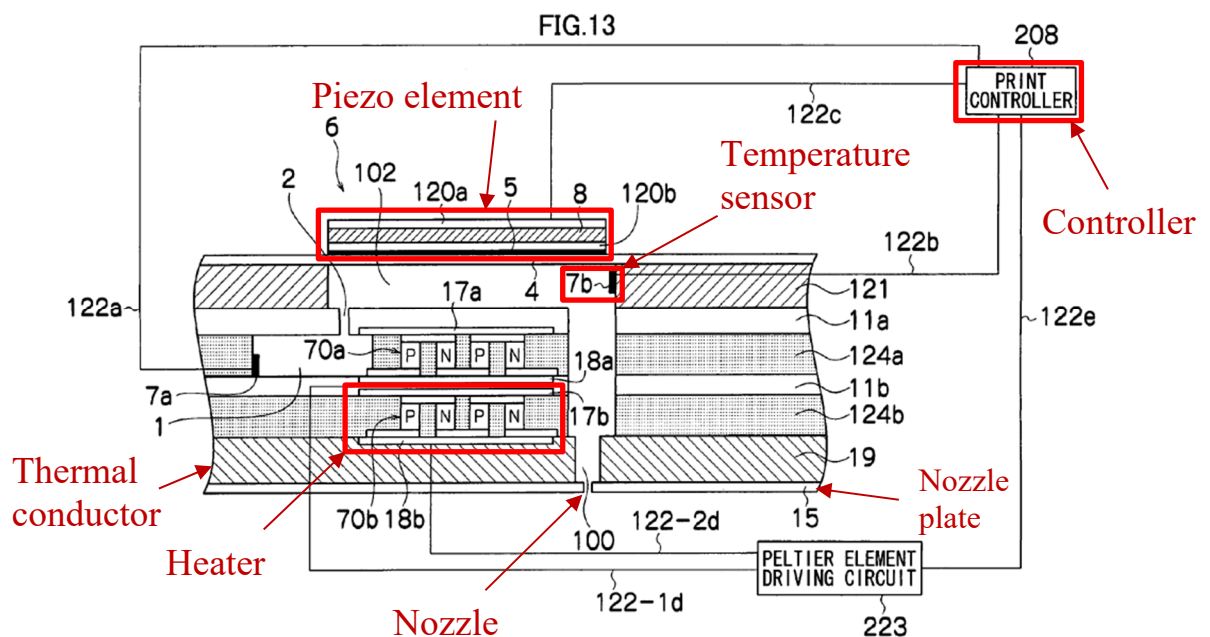


Takatsuka, FIG. 2B (annotated).

202. As shown in FIG. 2B, the inkjet head “has a structure in which a plurality of ink chamber units 104 including nozzles 100 for ejecting ink droplets and pressure chambers 102 connecting to the nozzles 100 are disposed in the form

of a staggered matrix.” Takatsuka, 8:20-24. Takatsuka notes that “the structure of the nozzle arrangement is not particularly limited to the examples shown in the drawings.” Takatsuka, 9:20-22.

203. The “ink ejection head” is the claimed nozzle arrangement under both constructions, because it is a structure that includes an arrangement of one or more ink jet nozzles. Takatsuka, 8:19-25 (plurality of nozzles for ejecting ink droplets); *see also, id.*, 1:64-67 (ink ejection head has a plurality of nozzles), FIGS. 2A-C, 3, 6, 13. FIG. 13 of Takatsuka illustrates a “general schematic drawing of an inkjet head.” Takatsuka, 17:26:



Takatsuka, FIG. 13 (annotated).

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

205. Takatsuka discloses coating a covering ink. For example, Takatsuka teaches that the droplet ejecting steps can be used “for coating a processing liquid, a functional liquid, or another type of liquid other than ink, onto a medium.”

Takatsuka 21:15-17. 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.

206. 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 mPa•s to 3000 mPa•s 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” and “typical average viscosities in the range of 100 to 1,000 centipoises.” '806 Patent, 4:21-24 (typical) & 6:44-45 (ideal).

207. Finally, the Challenged Patents broadly defines the term “covering ink” as synonymous with “viscous product.” '806 Patent, 3:21-22. Given that Takatsuka discusses example viscosities when discussing inks, such example inks expressly disclosed by Takatsuka are “viscous product” as contemplated by the

claims of the '806 Patent, since inks were liquids and exhibited viscosity.

208. To the extent it is argued that Takatsuka does not disclose coating a covering ink, a POSITA would have found it obvious to apply Takatsuka to coat a covering ink. As noted above, 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 encompass 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. For example, Applicant Admitted Prior Art 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). Also, Dainippon describes an inkjet printer for coating a varnish onto a substrate. Dainippon, 10:28-32 (inkjet sprays varnish same way as ink) & 10:39-40-41 (droplet spraying using piezoelectric elements); *see also* Schneider, Abstract, 3:21-30 (describing advantages of using inkjet for coating), 4:40-48 (inkjet for coating varnish), FIG. 8-9 (showing varying amount of coating by inkjet). Given that Takatsuka describes applying a “coating a processing liquid, functional liquid, or other type of liquid other than ink,” a POSITA would have found it obvious to apply a coating of covering ink having the same viscosities using the inkjet design of Takatsuka. Takatsuka, 21:15-16.

209. A POSITA therefore, would have also found the use of a covering ink

in Takatsuka to be obvious.

210. For at least these reasons, Takatsuka teaches element [1.P.1].

[COMMON] [an ink jet nozzle arrangement] having a piezoelectric actuator for applying droplets of covering ink to the substrate, the method comprising

Patent	Limitation
'031 Patent	1.P.2
'806 Patent	1.P.2

211. This limitation is common between both the '031 Patent and the '806 Patent.

212. In Takatsuka, a “piezo element 6 is formed by a lower electrode layer 120b bonded via a bonding layer 5 to a vibration plate 4 that forms a portion of the pressure chamber 102, a piezo thin plate 8, and an upper electrode layer 120a.”

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.

[COMMON] controlling by a computer the shapes of the droplets by controlling the shape of an electric waveform applied to the piezoelectric actuator,

Patent	Limitation
'031 Patent	1.1.1
'806 Patent	1.1.1

213. This limitation is common between the '031 Patent and the '806

214. Takatsuka teaches a system control unit 200 (computer) that includes a print controller 208 that controls the piezoelectric actuator 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 based on image data. Takatsuka, 10:64-67. Takatsuka describes that the print controller 208 controls the piezo element 6, as shown in FIG. 13:



106

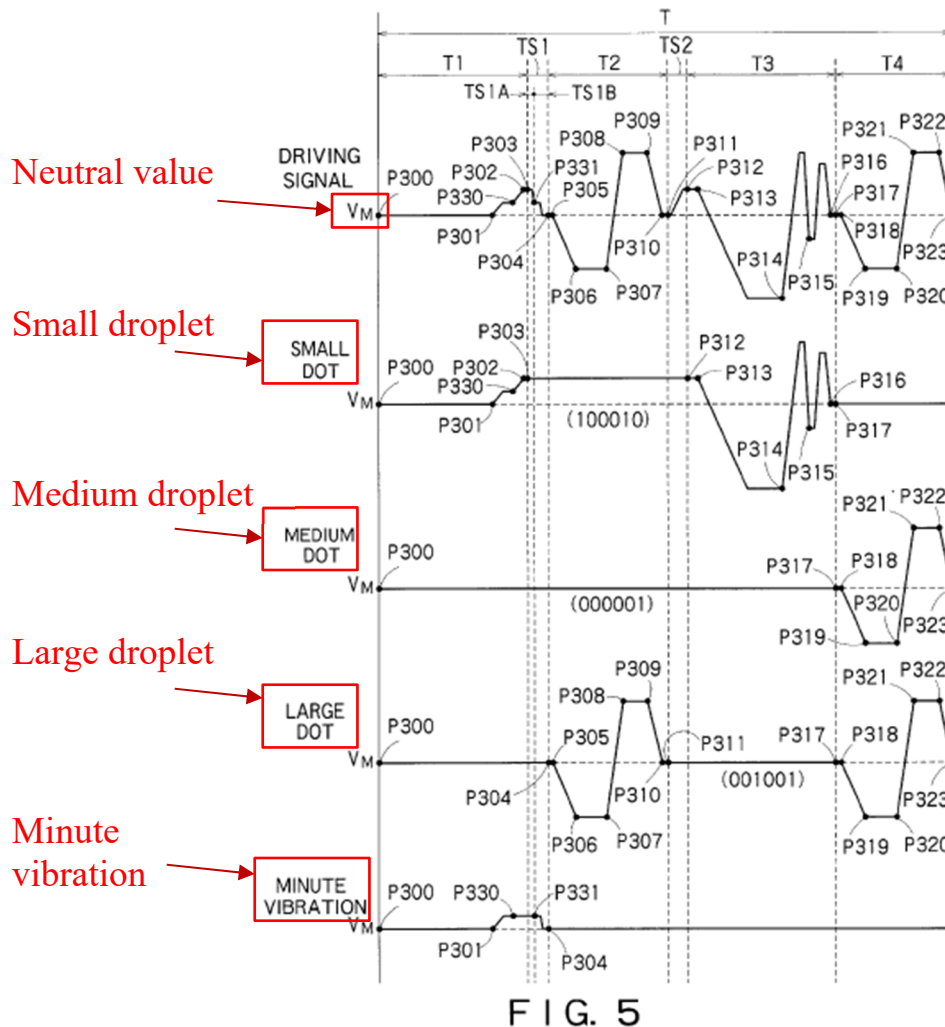
vibration plate of the piezo element 6 is caused to bend due to a unimorph effect, and hence a pressure is generated inside the pressure chamber 102 and an ink droplet is ejected from the nozzle 100.” Takatsuka, 11:46-51.

216. 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 because the amplitude and/or frequency of a non-ejection waveform would be different so as to prevent ejection or misting from the nozzles.

217. In addition, Takatsuka discloses that the print controller 208 controls the “amount of ink ejected” through the head driver 222 based on image data. A POSITA would have found it obvious to control the amount of ink ejected (i.e., the shape of the droplet) using waveform signal applied to the piezo, as is described in Chang because Takatsuka and Chang describe similar piezo structures. Also Takatsuka teaches controlling an amount of ink ejected via the head driver 222, which uses a piezo, and Chang teaches how to drive the piezo using a waveform to control the amount of ink ejected. For example, recall that the Applicant Admitted

Prior Art states that “the size and 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. Likewise, according to Chang, the prior art at the time taught that based on “it is necessary to connect driving pulses in correspondence to the number of the kinds of ink volumes to be ejected.” Chang, 2:5-7. Thus, it was known at the time, as evidenced by Chang, that the shape of the droplet could be controlled by selecting an appropriate waveform. Such knowledge in the prior art is evidenced by, for example, Chang, described below.

218. 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:



Chang, FIG. 5 (annotated).

219. Chang discloses that the different shapes of the electrical waveform applied to the piezo are 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 because the shape of the droplet correlates to its volume.

220. 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.

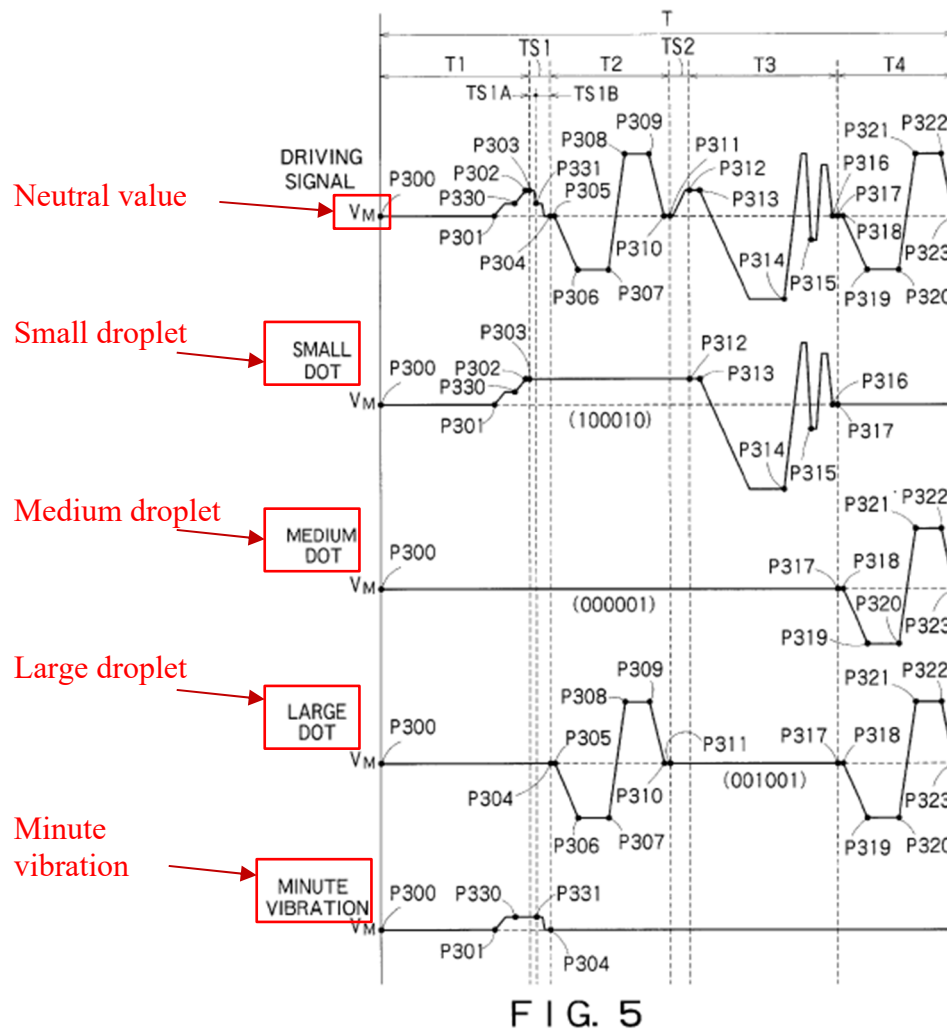
221. It would have been obvious to a POSITA to use the waveforms of Chang to drive the piezo actuator of Takatsuka to control the droplet size of the ink for at least the reasons described above. Accordingly, the combination of Takatsuka and Chang renders this limitation obvious.

[806::1.1.2] said shape being controlled by selecting at least a number of plateaus of the electric waveform,

222. This limitation is in claim 1 of the ’806 Patent, but is not found in claim 1 of the ’031 Patent.

223. 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).

224. The waveforms 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.

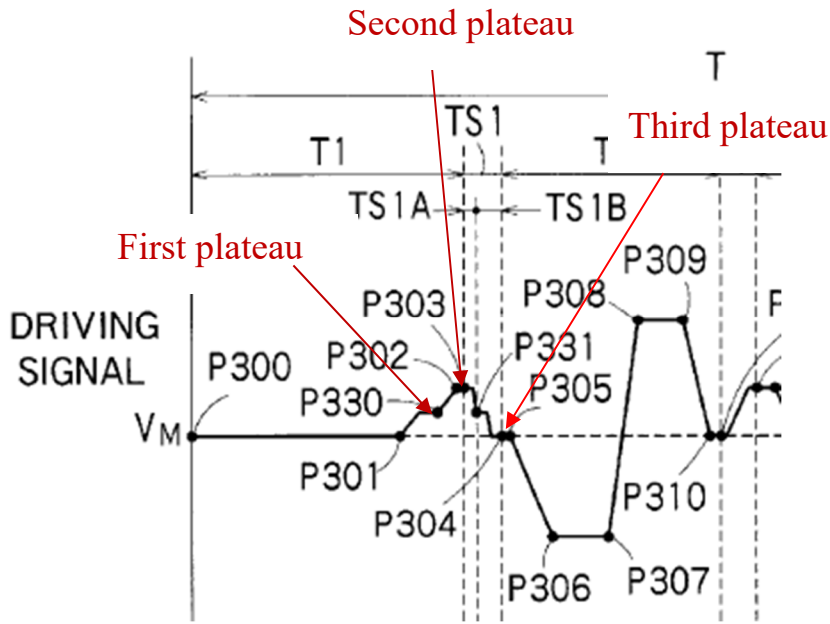
Medium dots are “formed from medium ink drops of about 8 pL in volume.” *Id.*, 9:6-7. Small dots are “formed from small ink drops of about 4 pL in volume.” *Id.*, 9:8-9.

225. In Chang, to generate a small dot driving pulse the pulse generation means “selects the first waveform element and the third waveform element and connects the selected waveform elements.” Chang, 10:7-14. To generate a medium dot driving pulse, the pulse generation means 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 dot driving pulse, “the pulse generation means selects the second waveform element and the fourth waveform element.” *Id.*, 10:20-29.

226. 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 minute vibration waveform is generated based on the viscosity of the ink. Chang 12:4-6 (connection element) & 11:66-12:3.

227. As shown in FIG. 5, the “step-shaped part (P330 included) is formed in the contraction waveform element (P301 to P302) constituting a preparatory part of a small dot driving pulse and the step-shaped part (P331 included) is formed in the first connection element (P303 to P304) following the contraction waveform element (P301 to P302).” Chang, 12:9-15. In this way, “a wave height of a minute

vibration pulse can be set at two level selectively for the sake of these step-shaped parts.” *Id.*, 12:15-17. FIG. 5 is reproduced below to show a view of the step-shaped minute vibration waveform:

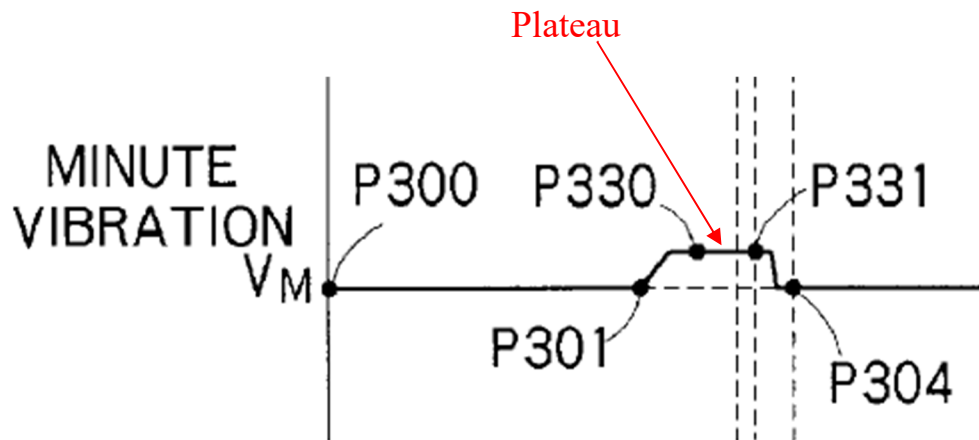


Chang, FIG. 5 (partial, annotated).

228. 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.

229. The minute vibration pulse of lower wave 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 wave height

pulse is shown in FIG. 5 shown below:



Chang, FIG. 5 (partial, annotated).

230. The close-in view of FIG. 5 immediately above shows the minute vibration pulse having the same voltage level at the waveform element and a connection element. Specifically, 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 of relatively low wave height; 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). By using the same voltage level at the waveform element and the connection element, the low height pulse does not include the additional step-shaped part (i.e., plateau) that the high-wave height

minute vibration pulse has.

231. “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.

232. A POSITA would have known that the shape of the ejected droplet would have been affected by the viscosity of the droplet. For example, for a fixed size nozzle, an increase in viscosity of the ink would decrease the amount of ink that is ejected, assuming the driving signal has not changed. On the other hand, for a fixed size nozzle, a decrease in viscosity of the ink would increase the amount of ink that is ejected, assuming the driving signal has not changed. 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.

233. It would have been obvious to a POSITA to select a number of waveform elements of Chang to drive the piezo actuator of Takatsuka to control the droplet size of the ink for at least the reasons described above. Accordingly, the combination of Takatsuka and Chang renders this limitation obvious.

[806::1.2] in response to at least one of the following parameters: viscosity of the ink.

234. 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.

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

[COMMON] 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.

Patent	Limitation
'031 Patent	1.1.2-1.2
'806 Patent	2

236. The language in Claim 2 of the '806 Patent overlaps with the language of portions of claim 1 of the '031 Patent.

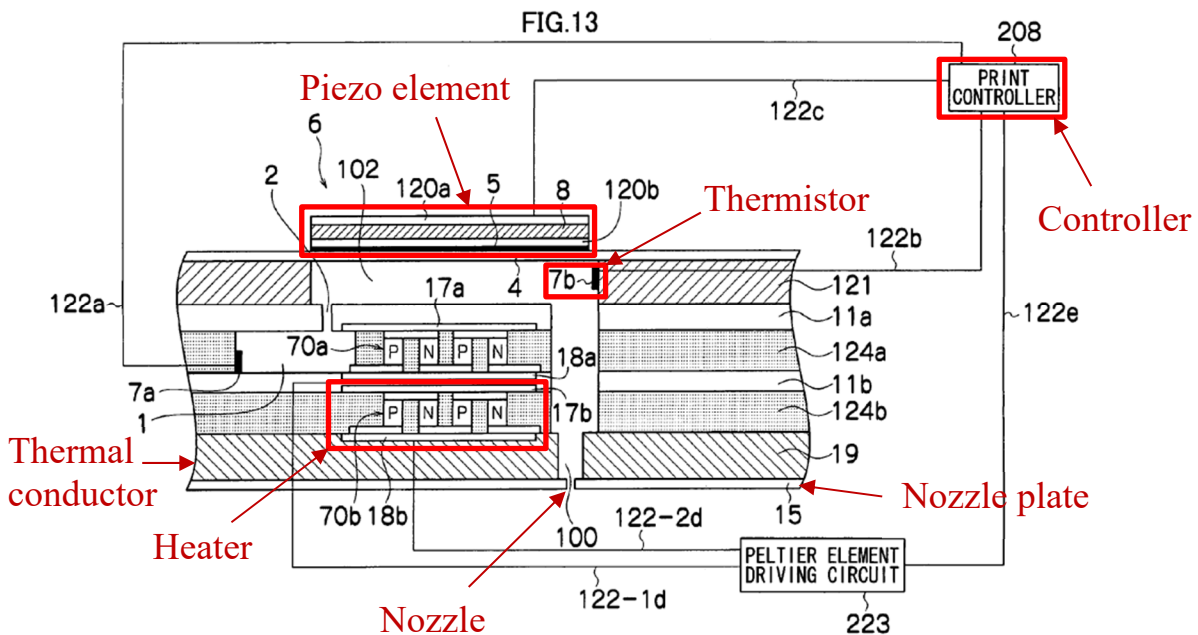
[806::2] For the '806 Patent:

237. 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.

238. 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.

239. 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 because it was well known that temperature affected viscosity, as acknowledged by Takatsuka. Takatsuka, FIG. 7 (discussion of temperature and viscosity curve).

240. 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 15:⁹



Takatsuka, FIG. 13 (annotated).

241. 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

⁹ “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.

the inside” of the pressure chamber would measure temperature of the ink inside the pressure chamber because the ink would have contacted the thermistor 7b during operation because ink would flow into the pressure chamber. Thus, the thermistor 7b is a detector.

242. 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.

243. Accordingly the combination teaches claim 2.

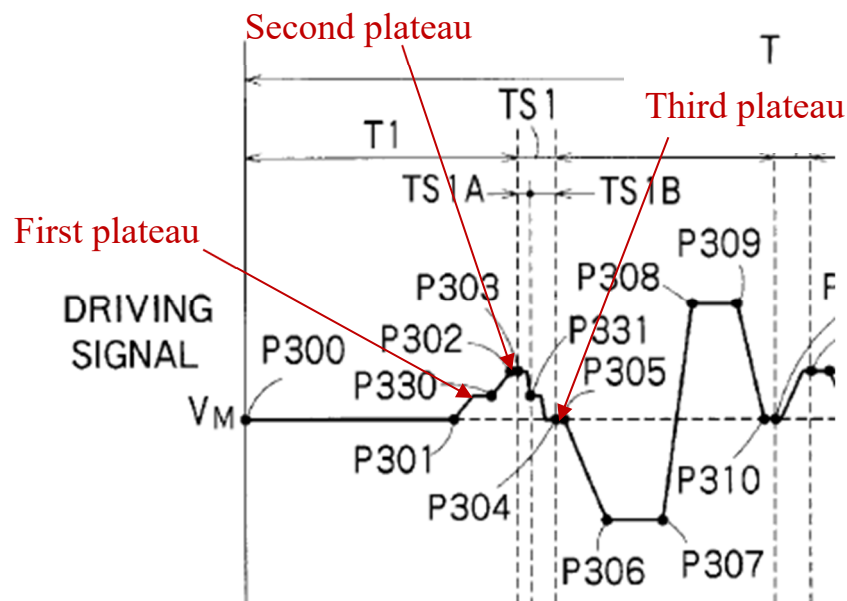
[031::1.1.2-1.2] For the '031 Patent:

[031::1.1.2] in response to at least one of the viscosity and/or the temperature of the ink,

244. 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 minute vibration waveform is generated based on the viscosity of the ink. Chang 12:4-6 (connection element) & 11:66-12:3.

245. As shown in FIG. 5, the “step-shaped part (P330 included) is formed in the contraction waveform element (P301 to P302) constituting a preparatory part

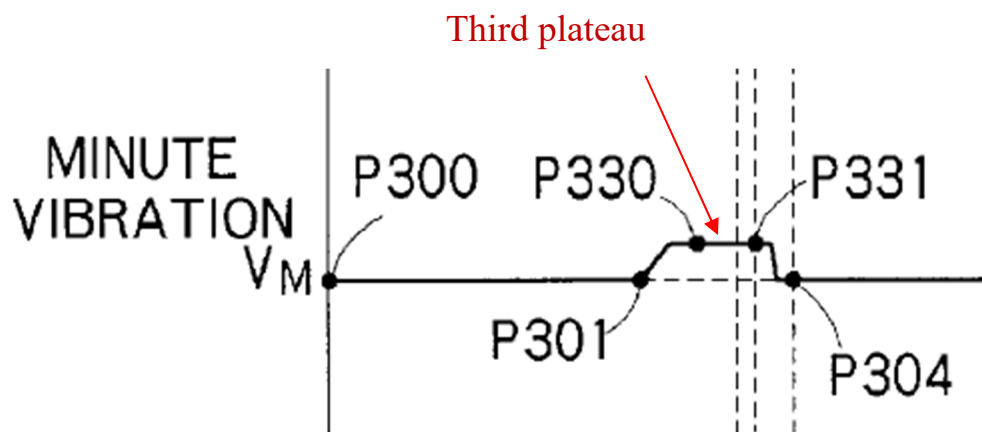
of a small dot driving pulse and the step-shaped part (P331 included) is formed in the first connection element (P303 to P304) following the contraction waveform element (P301 to P302).” Chang, 12:9-15. In this way, “a wave height of a minute vibration pulse can be set at two level selectively for the sake of these step-shaped parts.” *Id.*, 12:15-17. FIG. 5 is reproduced below to show a view of the step-shaped minute vibration waveform:



Chang, FIG. 5 (partial, annotated).

246. 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.

247. The minute vibration pulse of lower wave 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 wave height pulse is shown in FIG. 5 shown below:



Chang, FIG. 5 (partial).

248. The close-in view of FIG. 5 immediately above shows the minute vibration pulse having the **same voltage level** at the waveform element and a connection element. Specifically, 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 of relatively low wave height; 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). By using the same voltage level at the waveform element and the connection element, the low height pulse does not include the additional step-shaped part (i.e., plateau) that the high-wave height minute vibration pulse has.

249. 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.

“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.

250. A POSITA would have known that the shape of the ejected droplet would have been affected by the viscosity of the droplet. As discussed above, a higher viscosity ink driven by a constant amplitude waveform through a fixed nozzle size would have a different shape than the same ink ejected through the same nozzle using the same voltage. 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.*

251. It would have been obvious to a POSITA to select a number of waveform elements of Chang to drive the piezo actuator of Takatsuka to control the droplet size of the ink for at least the reasons described above. Accordingly,

the combination of Takatsuka and Chang renders this limitation obvious.

[031::1.2] 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.

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

253. 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 (estimate) 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. *E.g.*, 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.

254. Further, Chang already contemplates altering the waveform dynamically. *See, e.g.*, 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 because it was known that as viscosity increases, a higher amplitude driving voltage was used to compensate.

255. 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 15:¹⁰

¹⁰ “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.

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.

258. Accordingly the combination teaches claim 1.

[COMMON] Apparatus for applying a coating of covering ink to a substrate, comprising

Patent	Limitation	Corresponding Limitation
'031 Patent	12.P	1.P.1-1.P.2
'806 Patent	9.P	1.P.1-1.P.2

259. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent. This limitation is met by the analysis for the preamble discussed above.

[COMMON] a transport mechanism for causing relative movement between the substrate and an ink jet nozzle arrangement,

Patent	Limitation	Corresponding Limitation
'031 Patent	12.1	1.P.1
'806 Patent	9.1	1.P.1

260. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent. This limitation is met by the analysis for the preamble discussed above.

[COMMON] the ink jet nozzle arrangement having a piezoelectric actuator for applying droplets of covering ink to the substrate;

Patent	Limitation	Corresponding Limitation
'031 Patent	12.2	1.P.1-1.P.2

'806 Patent	9.2	1.P.1-1.P.2
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261. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent. This limitation is met by the analysis for the preamble discussed above.

[COMMON] a computer controlling a heater included in the nozzle arrangement heating the covering ink

Patent	Limitation	Corresponding Limitation
'031 Patent	12.3	1.1.1, 1.2
'806 Patent	9.3	1.1.1, 1.2.1, 2

262. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent.

263. In Takatsuka, the controller 208 controls the Peltier element 70b. *E.g.*, 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.* A POSITA would have known that heating the nozzle plate would have heated the ink in the vicinity of the nozzle because of thermal effects.

[COMMON] and an electric source for applying an electric waveform to the piezoelectric actuator, said waveform controlling the shapes of the droplets,

Patent	Limitation	Corresponding Limitation
'031 Patent	12.4.1	1.1.1, 1.2
'806 Patent	9.4.1	1.1.1, 1.2.1, 2

264. This limitation is common between claim 12 of the '031 Patent and claim 9 of the '806 Patent.

265. Takatsuka's print controller 208 with the head driver 222 is the electric source. The head driver 222 provides electrical signals to the nozzles based on information it receives from the print controller 208.

[806::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,

266. See [806::1.1.2]. Print controller 208 selects the number of waveform plateaus using selection waveform.

[806::9.5.1] in response to at least one of the following parameters: temperature of the covering ink

267. See [806::1.2.1].

[806::9.5.2] in response to at least one of the following parameters: composition of the covering ink

268. See [806::1.2.2].

[031::12.4.2] said electric waveform having a shape determined by at least one of the viscosity and/or the temperature of the covering ink,

269. See [031::1.1.1]-[031::1.1.2].

[031::12.5] the apparatus 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 droplets as the ink flows from the ink container to the nozzle.

270. See [031::1.2].

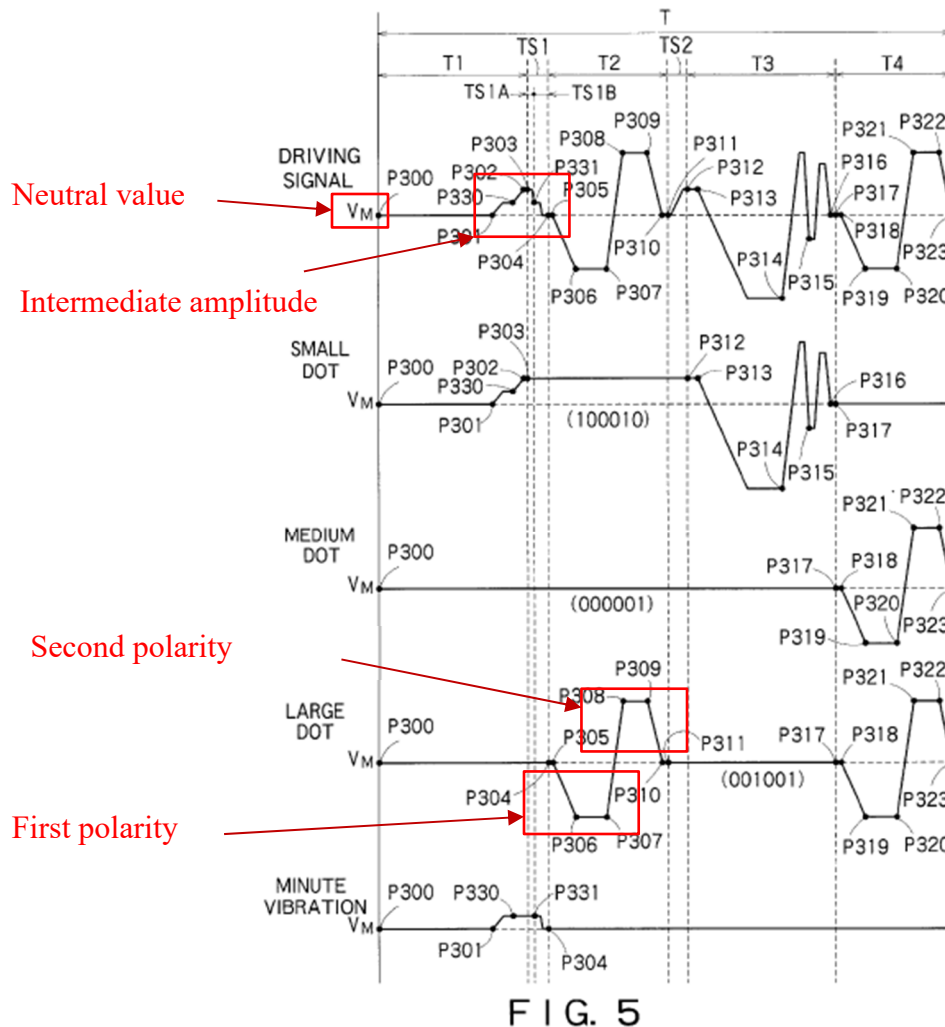
[COMMON]¹¹ The method of claim 1 wherein the waveform has . . .

Patent	Limitation
'031 Patent	7.P & 18.P
'806 Patent	4.P & 12.P

271. This limitation is common between claims 7 and 18 of the '031 Patent and claims 4 and 12 of the '806 Patent.

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

¹¹ For ease and clarity, Claim 4 is presented out of order than what is recited in the Challenged Patents.



Chang, FIG. 5 (annotated).

273. 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.

274. 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.

[COMMON] (a) neutral value associated with the nozzle arrangement being at rest,

Patent	Limitation
'031 Patent	7.1 & 18.1
'806 Patent	4.1 & 12.1

275. Chang teaches 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.

[COMMON] (b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value,

Patent	Limitation
'031 Patent	7.2.1 & 18.2.1
'806 Patent	4.2.1 & 12.2.1

276. 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).

277. 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 piezoelectric 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.

[COMMON] 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.

Patent	Limitation
'031 Patent	7.2.2 & 18.2.2

278. 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.

279. 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.

280. 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.

281. 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.*

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

[COMMON] each peak value causing a droplet to be expelled from the nozzle arrangement,

Patent	Limitation
'031 Patent	7.2.3 & 18.2.3
'806 Patent	4.2.3 & 12.2.3

283. 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.

284. 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 piezoelectric vibrator can be inverted, and the positive and negative of voltage with respect to a boundary voltage can be interchanged. Chang, 14:19-30.

[COMMON] (c) a second polarity relative to the neutral value for causing the nozzle arrangement to have a volume less than the neutral value

Patent	Limitation
'031 Patent	7.3 & 18.3
'806 Patent	4.3 & 12.3

285. 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.

286. 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 piezoelectric vibrator can be inverted, and the positive and negative of voltage with respect to a boundary voltage can be interchanged. Chang, 14:4-30.

XII. OBVIOUSNESS IN VIEW OF DAINIPPON AND CHANG

Obviousness by Dainippon and Chang	
Patent	Claims
'806 Patent	1 and 4

A. Overview of Dainippon

287. 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.

B. Combination of Dainippon and Chang

288. 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.

C. Reasons to Combine

289. A POSITA would have been motivated to use Chang’s waveforms to drive the piezoelectric elements of Dainippon to control the quantity (droplet size) sprayed from the nozzles because doing so would facilitate control over the thickness of the varnish. 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.

290. 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, given that the Challenged Patents describes the 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).

D. Analysis

[1.P.1] A method of applying a coating of covering ink to a substrate moving relative to an ink jet nozzle arrangement . . .

291. Dainippon teaches a coating material applying apparatus that includes a guide board 53 for stabilizing transport of the printing paper S and a droplet spray nozzle head 50. Dainippon, 9:58-61. The printing paper S 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.

292. The Dainippon 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” is a structure with an arrangement of droplet spray

nozzles, so it is a nozzle arrangement. *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.* 25-32.

[1.P.2] [an ink jet nozzle arrangement] having a piezoelectric actuator for applying droplets of covering ink to the substrate, the method comprising

293. 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 S” 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 because that is how inkjet printers ejected ink.

[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,

294. In connection with 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.” Dainippon, 10:25-31. Dainippon is silent on the energizing signal used to drive the different spraying mode using piezoelectric elements. Although a POSITA would have known that a piezoelectric element was driven by an electric waveform for ejecting ink droplets with a desired shape and size.

295. In the combination, Chang teaches an electric waveform for controlling the size (i.e., shape) of the droplet.

[1.1.2] said shape being controlled by selecting at least a number of plateaus of the electric waveform,

296. In the combination, Chang teaches controlling the size (i.e., shape) of the droplet by selecting a number of plateaus of the electric waveform.

[1.2] in response to at least one of the following parameters: desired thickness of the layer.

297. 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

energization of the resistors in 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.

298. The Dainippon sections above are described in connection with the thermal printer. However, these steps would apply to the inkjet printer using the piezoelectric mode, as well, because the piezoelectric mode could control the droplet shape the same way the thermal printer did. Thus, the process and results described above apply equally well to the inkjet printer using the piezoelectric mode.

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

299. See XI . . . [4.P].

[4.1] (a) neutral value associated with the nozzle arrangement being at rest,

300. See XI . . . [4.1].

[4.2.1] (b) a first polarity relative to the neutral value for causing the nozzle arrangement to have a volume greater than the neutral value, and

301. See XI . . . [4.2.1].

[4.2.2] 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.

302. See XI . . . [4.2.2].

[4.2.3] each peak value causing a droplet to be expelled from the nozzle arrangement,

303. See XI . . . [4.2.3].

[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;

304. See XI . . . [4.3].

XIII. CONCLUSION

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code.

Dated: May 19, 2023

By:

A handwritten signature in black ink, appearing to read 'C. F. Reinholtz', with a long horizontal line extending to the right.

Charles F. Reinholtz

APPENDIX A

Charles F. Reinholtz

Business Address

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Education

Doctor of Philosophy, University of Florida, Mechanical Engineering, 1983
Master of Engineering, University of Florida, 1980
Bachelor of Science, University of Florida, 1976

Full-time Industrial Experience

1978, Burroughs Corporation, Orlando, Florida, Design Engineer, Non-impact Printing Group
1989-1996 Milliken and Company, Spartanburg, South Carolina, summer employment and consulting involving textile equipment design

Academic Employment Experience

Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Assistant Professor, September 1983 to August 1988, Tenure Granted
Associate Professor, August 1988 to August 1993
Professor, August 1993 to 2007
W. S. White Chair for Innovation in Engineering Education, Aug. 1996 to Aug. 1999
Assistant Department Head and ABET Review Chair, 1996-2002
Alumni Distinguished Professor, 2002-2007
Embry-Riddle Aeronautical University, Daytona Beach, Florida
Professor and Chair, Department of Mechanical Engineering, 2007-2017
Professor, Department of Mechanical Engineering, 2017-2022
Emeritus Professor and Chair, 2022-

Membership in Professional Organizations and Honor Societies

<u>Society</u>	<u>Membership Grade</u>
ASME	Fellow
SAE	Member
American Nuclear Society	Member 1995-1997
Tau Beta Pi	Member
Pi Tau Sigma	Member
Sigma Xi	Member
Epsilon Lambda Chi	Member
ASEE	Member, 1984-1987, 1998-99
AUVSI	Member

Professional Honors and Awards

Benton Engineering Council Service Key, University of Florida, 1976-1977.
Procter and Gamble Best Paper Award, 9th Applied Mechanisms Conference, October 1985.
Presidential Young Investigator Award, 1987-1992, National Science Foundation
Certificate of Teaching Excellence, Virginia Polytechnic Institute and State University, 1987-88, 1997-98 and 2001-02.

ASME Outstanding Faculty Advisor Award, 1989-1990 and 1991-92
 Procter and Gamble Best Paper Award of Merit, 2nd National Applied Mechanisms and Robotics Conference, November 1991.
 George Wood Best Applied Mechanism Design Paper Award, 2nd National Applied Mechanisms and Robotics Conference, November 1991.
 Wine Award for Excellence in Teaching, Virginia Polytechnic Institute and State University, 1992.
 Virginia Tech Academy of Teaching Excellence, Inducted 1992
 Procter and Gamble Best Paper Award of Merit, 22nd ASME Mechanisms Conference, Scottsdale, Arizona, September 1992
 ASME National Faculty Advisor Award, 1995.
 Applied Mechanism Conference "Beyond the Call of Duty" Award for prodigious contributions to mechanism science, 1995.
 W. S. White Chair for Innovation in Engineering Education, Aug. 1996 to Aug. 1998
 Dean's Award for Excellence in Teaching, Virginia Tech College of Engineering, 1998
 South-Pointing Chariot Award, 1999 Applied Mechanisms and Robotics Conference, for lifetime contributions to the mechanism's community
 Ingersoll-Rand Faculty Award for Outstanding Contributions to the Mechanical Engineering Department, 2000
 National Instruments Award for Best Application of Measurement and Automation for the Development of a Tele-Operated CASE CX-160 Excavator Using FieldPoint, National Instruments Week 2002, Austin Texas, Aug 12-15, 2002.
 Virginia Tech Alumni Distinguished Professor, 2002-
 Outstanding Faculty Member Award selected and awarded by the students in Mechanical Engineering, April 2003.
 Fellow, American Society of Mechanical Engineers, 2003
 Alumni Teaching Award, Virginia Polytechnic Institute and State University, 2004
 National Instruments Virtual Instrumentation Applications Best Control Paper Award, Developing a Fully Autonomous Vehicle for Virginia Tech's Entry in the DARPA Grand Challenge," National Instruments NI Week 2006, Austin Texas.
 ASME Distinguished Service Award, 2005
 College of Engineering Certificate of Teaching Excellence, 2006-2007
 Volusia Manufacture's Association "Friend of Industry" Award, 2013

Funded Research

1. "Design Optimization of Spatial Mechanisms Subject to Real-World Constraints," National Science Foundation Grant MEA-8404313, June 15, 1984 through November 30, 1986, \$47,979, 100% Responsibility.
2. "Presidential Young Investigator Award: Interactive Spatial Mechanism Synthesis," National Science Foundation, Grant No. DMC 8657828, June 15, 1987 through January 31, 1993, \$312,000, 100% Responsibility.
3. "High-Speed Bearing Research," supported by the Industrial Drives Division of Inland Motor Corporation, Jan. 1, 1987 through Dec. 31, 1987, \$15,000, 100% Responsibility.
4. "Analysis of Warhead Structures," Department of the Navy, July 24, 1987 to November 15, 1987, \$99,348, Project Director with J. B. Kosmatka, R. H. Fries, A. L. Wicks, and L. D. Mitchell, Responsible for \$19,535.
5. "Analysis of Warhead Structures, Year 2," Department of the Navy, October 30, 1987 to March 31, 1988, \$174,000, Project Director with J. B. Kosmatka, R. H. Fries, A. L. Wicks, and L. D. Mitchell, Responsible for \$12,908.
6. "Hull Joint Model Test," Georgia Institute of Technology, May 16, 1988 to Aug. 16, 1988, \$10,141, Principal Investigator with R. H. Fries, Responsible for \$5,071.

7. "Design of Variable-Geometry Truss Manipulators," Virginia Center for Innovative Technology (CIT), 10/1/88 to 9/31/89, \$30,000, 100% Responsibility.
8. "Active Structures for Space Applications," 1/1/89 to 12/31/90, \$200,000, Principal Investigator with H. H. Robertshaw, Responsible for \$80,000.
9. "Computer-Aided Design of Fully-Wiped, Co-rotating Extruder Screws," Windward International and CIT, January 1, 1989 through December 31, 1989, \$44,029, Principal Investigator with Sanjay Dhande, Responsible for \$22,015.
10. "Construction of a NASP Mock-up," NASA Langley Research Center, February 1, 1989 to July 15, 1989, \$51,692, Principal Investigator with W. F. O'Brien, A. L. Wicks, and J. Marchman.
11. "Design of Advanced Manipulators for Steam Generator Maintenance," Babcock & Wilcox Co., November 1, 1989 to August 15, 1990, \$20,000, Principal Investigator with Sanjay Dhande, Responsible for \$15,000.
12. "Calibration, Control and Menu Design for an Advanced Steam-Generator Maintenance Manipulator," Babcock and Wilcox Co., February 1, 1991 through January 31, 1992, \$41,408, Principal Investigator with Sanjay Dhande, Responsible for \$31,056.
13. "Calibration, Control and Menu Design for an Advanced Steam-Generator Maintenance Manipulator," Virginia Center for Innovative Technology, February 1, 1991 through January 31, 1992, \$29,663, Principal Investigator with Sanjay Dhande, Responsible for \$22,247.
14. "Computer-Aided Design and Manufacture of Extruder Screw Elements," Windward International and CIT, July 1, 1990 through June 30, 1991, \$30,984, Principal Investigator with Sanjay Dhande, Responsible for \$15,492.
15. "Design of a Cellulose Acetate Preconditioning Heat Exchanger," Tennessee Eastman Co., October 1990 through July 1991, \$25,560, Principal Investigator with D. J. Nelson, Responsible for \$9,876.
16. "Continued Steam Generator Manipulator Support Based on Kinematic Control and Investigation of Vision Based Approach," Babcock and Wilcox Co., October 1, 1991 through September 31, 1992, \$40,000, Principal Investigator with A. L. Abbott, Responsible for \$32,000.
17. "Cellulose Acetate Packaging Study," Tennessee Eastman Co., October 1991 through July 1992, \$51,120, Principal Investigator with D. J. Nelson, Responsible for \$19,752.
18. "Continued Steam Generator Manipulator Support Based on Kinematic Control and Investigation of Vision Based Approach," Virginia CIT, January 1, 1992 through December 31, 1992, \$35,570, Principal Investigator with A. L. Abbott, Responsible for \$28,456.
19. "Preliminary Design of a Medical Waste Processing Machine," Virginia Center for Innovative Technology, June 1, 1992 through August 31, 1992, \$14,386, 100% Responsibility.
20. "Preliminary Design of a Medical Waste Processing Machine," Bioconversions Technologies, May 1, 1992 through January 31, 1993, \$16,377, 100% Responsibility.
21. "Conceptual Design of an Advanced Reactor Vessel Inspection Manipulator," B&W Nuclear Services Company, March 1, 1992 through February 28, 1993, \$30,000, 100% Responsibility.
22. "Engineering Development of a Medical Waste Processing Machine," Bioconversions Technologies, Aug. 15, 1992 to May 15, 1994, Principal Investigator with A. A. Kornhauser, \$93,088, responsible for \$46,544.
23. "Engineering Development of a Medical Waste Processing Machine," CIT, Aug. 15, 1992 to Aug. 14, 1993, Principal Investigator with A. A. Kornhauser, \$90,988, responsible for \$45,494.
24. "Enhancing the Capability and Performance of Nuclear Service Robots with Kinematic Analysis and Computer Vision," B&W Nuclear Services Co., Dec.1, 1992 to Nov. 30, 1993, with A. L. Abbott, \$50,000, responsible for \$40,000.

25. "Design of a Reactor Vessel Inspection Manipulator," B&W Nuclear Services, June 16, 1992 through June 15, 1993, \$100,146, 100% responsibility.
26. "Design of an Automated Needle/Armature Tray Loader," Siemens Automotive, Sept. 1, 1993 to Aug. 31, 1994, \$24,925, 100% Responsibility.
27. "Enhancing the Design and Performance of Nuclear Service Robots with Flexure Analysis, Computer Vision, and Optimization Techniques," B&W Nuclear Technologies, Dec.1, 1993 to Nov. 30, 1994, with A. L. Abbott, \$40,000, responsible for \$30,000.
28. "Enhancing the Design and Performance of Nuclear Service Robots with Flexure Analysis, Computer Vision, and Optimization Techniques," Center for Innovative Technology, Feb. 1, 1994 to Jan. 31, 1995, with A. L. Abbott, \$47,023, responsible for \$35,000.
29. "Design Studies for Nautilus," Nautilus, Inc, Jan.1, 1994 to Oct. 15, 1994, \$7,723, 100% responsibility.
30. "Design Studies for Nautilus," Center for Innovative Technology, Jan.1, 1994 to Dec. 31, 1994, \$13,795, 100% Responsibility.
31. "Rod Formation Dynamics," R. J. Reynolds Co., Jan. 1, 1994 to Dec. 31, 1994, with D. J. Nelson, 116,557, 50% Responsibility.
32. "A Short-term Proposal to Develop Cam-Design Software for Cadkey, Inc.," June 16, 1994 to Sept 15, 1994, \$9,981, 100% Responsibility.
33. "Design of an Automated Injector Body Tray Loader," Siemens Automotive, Sept. 1, 1994 to Aug. 31, 1995, \$20,744, 100% Responsibility.
34. "Design Studies for Nautilus," Nautilus, Inc, Dec 1, 1994 to Nov. 30, 1995, \$23,731, 100% Responsibility.
35. "Design Studies for Nautilus," Center for Innovative Technology, Dec.1, 1994 to Dec. 31, 1995, \$25,924, 100% Responsibility.
36. "Preliminary design and Equipment Selection for a Mulch-Making Machine," Fred Whitaker Co., June 1, 1995 to Dec. 31, 1995, \$10,920, %100 Responsibility.
37. "Improving the Kinematic Control of Robots with Computer Vision," NSF, July 15, 1995 to June 30, 1996, \$22,026, %100 Responsibility.
38. "Proposal to Increase Funding in Siemens Valve-Body Loader Project," Siemens Automotive, \$7,018, 100% Responsibility.
39. "Preliminary Design and Equipment Selection for a Mulch-Making Machine," CIT, June 1, 1995 to August 31, 1995, \$8,185, %100 Responsibility.
40. "Design of a Personal Smith Machine," Nautilus, Inc, July 1, 1995 to Oct. 31, 1995, \$12,273, 100% Responsibility.
41. "Development of Advanced Control Strategies for Variable Geometry Truss Manipulators," Batelle-Pacific Northwest Laboratory, Jan. 1, 1995 to June 31, 1995, \$10,000, with R. J. Salerno, 10% Responsibility.
42. "Curriculum Renewal in Mechanical Engineering at Virginia Tech," NSF SUCCEED, Sept. 15, 1995 to Dec. 15, 1995, with Paul Tidwell, \$4,500 (NSF), \$4,677 (Cost Sharing), 50% Responsibility.
43. "Development of a Parallel Architecture Robotic Wrist," Triad Investors, Jan. 1, 1996 to May 31, 1997, \$51,707, 100% Responsibility.
44. "Development of Advanced Control Algorithms for Variable Geometry Truss Manipulators," Batelle-Pacific Northwest Laboratory, Jan. 1, 1996 to June 31, 1996, \$10,000, 100% Responsibility.

45. "Curriculum Renewal in Mechanical Engineering at Virginia Tech – Year 5," NSF SUCCEED, June 16, 1996 to June 15, 1997, \$10,000 (NSF), \$10,000 (Cost Sharing), 100% Responsibility.
46. "Technology Assessment for a Robotic Vacuum Cleaner," Servus Robots Incorporated, Sept.1, 1998 to Feb. 28, 1999 with John Bay, Bob Sturges, and Mike Deisenroth, \$8,333, 25% Responsibility.
47. "Technology Assessment for a Robotic Vacuum Cleaner," Virginia CIT, Oct.1, 1998 to March 31, 1999 with John Bay, Bob Sturges, and Mike Deisenroth, \$25,000, 25% Responsibility.
48. "MBC Guidance Project," Long-Airdox Company, August 1998 to July 1999, P.I.: R.H. Sturges, Co-P.I.'s: M. P. Deisenroth, C.F. Reinholtz. \$100,000.
49. "MBC Guidance Project," Virginia Center for Innovative Technology (matching), August 1998 to July 1999, P.I.: R.H. Sturges, Co-P.I.'s: M. P. Deisenroth, C.F. Reinholtz. \$100,000.
50. "Vertical Integration of Mechatronics at Virginia Tech," NSF SUCCEED, Aug 1999 to July 2002, P.I.: W. R. Saunders, Co-P.I.'s: J. S. Bay, D. J. Leo, C.F. Reinholtz, \$18,000/year for three years.
51. Development of a Remote-Controlled CASE CX-160 Excavator, Naval Surface Warfare Center, Dahlgren G-64 Division, February 2003 to September 2003, Co-PI with A. L. Wicks, \$17,000
52. Investigation of Adaptive Structures for Morphing Aircraft, NASA Langley Research Center, \$65,078, July 1,2002 to June 30, 2003, 25% (with H. Robertshaw and D. Inman).
53. Increased Scope for Delivery Orders 0019, Remote Control Excavator, Naval Surface Warfare Center, with Al Wicks, PI, \$21,223.
54. Develop the Joint Unmanned Systems Experimentation and Research (JOUSTER) Site, U.S Army RDECOM STTC, Orlando, FL, June 10, 2004 to June 9, 2007, \$12,200,000, C. Reinholtz, PI (55% Responsibility), A. Wicks, Co-PI (43% Responsibility), Carstensen Co-PI (2% Responsibility).
55. Virginia First Lego League 2004 Pilot High School Robotics Program, NASA Langley Research Center, Education Grant NNL04AA65G, \$20,000, July 9, 2004 to July 8, 2005, 100% Responsibility
56. Virginia First Lego League NIA Outreach Program, National Institute of Aerospace, Grant No. VT-03-1, \$8,000, February 1, 2005 to August 31, 2005, 100% Responsibility.
57. Heterogeneous Teams Of Autonomous Vehicles: Advanced Sensing And Control, Office of Naval Research, Dennis W. Hong, Naira V. Hovakimyan, Marty E. Johnson, Charles F. Reinholtz, Daniel J. Stilwell, A. L. Wicks, Craig A. Woolsey, Christopher L. Wyatt, 07/01/05 – 6/30/06, Total Funding: \$1,050,000, C. F. Reinholtz share: \$52,752.
58. Coordinated Sensing and Control for Surveillance and Tracking by Heterogeneous Autonomous Vehicle Teams, Daniel J. Stilwell, Christopher L. Wyatt, Craig A. Woolsey, Naira V. Hovakimyan, A. L. Wicks, Andy Kurdila, Charles Reinholtz and Michael Roan, Office of Naval Research 5/15/06 – 9/14/07, \$1,417,500, Reinholtz share: \$184,275.
59. Development Of An Autonomous Vehicle For The DARPA Urban Challenge, with Al Wicks and Dennis Hong, the Defense Advanced Research Projects Agency, 10/1/06 to 12/31/07, \$999,274.
60. Development of a Drive-by-Wire Commercial Vehicle, General Dynamics Robotics Systems (GDRS), \$54,256, 1-11-07 to 6-30-07.
61. Navigation And Autonomous Control For Nemesis, Applied Research Associates, Inc. (ARA), \$61,513, 7-1-06 to 6-30-07
62. Dynamic Model of CAT 777-797 Haul Trucks for Autonomous Operation, Caterpillar,

\$74,303, 7-1-06 to 6-30-07

63. Boeing Digitally Manufactured UAV Project, \$22,740, The Boeing Company, 10-15-2010 to 12-31-2010.
64. Reconnaissance and Autonomy for Small Robots – Canine (RASR-K9), Robotic Research, \$17,951.50, 1-1-2011 to 4-30-2012
65. Proposal to Develop an Autonomous Maritime System to Compete in the International Maritime Robotics Competition, AUVSI and the Office of Naval Research, \$30,000, 10-1-13 to 12-31-14.
66. Robotic Tool Kit (RTK) Logistics Automation, (OTA) #W15QKN-14-9-1002, U.S. Army TARDEC via Great Lakes Systems & Technology LLC, \$75,000, August 2018 through September 2019, with Patrick Currier and Eric Coyle.
67. Continued Development of Robotic Tool Kit (RTK) Logistics Automation and RTK Training, (OTA) #W15QKN-14-9-1002, U.S. Army GVSC via Great Lakes Systems & Technology LLC, \$100,000, November 2019 through November 2020, with Patrick Currier and Eric Coyle.

Refereed Papers in Major Technical Journals

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66. Lee, H. Y., Fallon, J. B., Cordle, W. H., and Reinholtz, C. F., "Inverse Kinematic Analysis of a Mobile Underwater Inspection Robot," Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-085.
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68. Shooter, S. B., Reinholtz, C. F. and Dhande, S. G., "On the Kinematic Design of Manipulators for Limited Access Workspaces (LAWS)," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 485-491.
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70. Padmanabhan, B., Tidwell, Salerno, R. J. and Reinholtz, C. F., "VGT-Based Gimbals: Practical Construction and General Theory," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 47, September 1992, pp. 437-443.
71. Arun, V., Padmanabhan, B., Kolady, K., and Reinholtz, C. F., "Determination of the workspace of the 3-DOF Double-Octahedral Variable-Geometry Truss Manipulator," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 493-500.
72. Tidwell, P. H., Glass, S. W., Hildebrand, J. J., Reinholtz, C. F., and Shooter, S. B., "COBRA - Design and Development of a Manipulator for Nuclear Steam Generator Maintenance," Proceedings of the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio, (Winner of Proctor and Gamble Best Paper Award and Winner of The George Wood Best Applied Paper Award).
73. Stulce, J. R., and Reinholtz, C. F., "Observations on Caterpillar Locomotion and Their Application to a Crawling Robot," Proceedings of the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio.
74. Stulce, J. R., W. D. Burgos, S. G. Dhande, and C. F. Reinholtz, "Conceptual Design of a Multibody Passive-Legged Crawling Vehicle," Proceedings of the 1990 ASME Mechanisms Conference, DE-Vol. 26, Cams, Gears Robot and Mechanism Design, Sept. 16-19, 1990, pp. 199-205.
75. Arun, V., and C. F. Reinholtz, L. T. Watson, "Enumeration and Analysis of Variable Geometry Truss Manipulators," Proceedings of the 1990 ASME Mechanisms Conference, DE-Vol. 26, Cams, Gears Robot and Mechanism Design, Chicago, IL, Sept. 16-19, 1990, pp. 93-98.
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77. Tidwell, P. H., C. F. Reinholtz, H. H. Robertshaw, C. G. Horner, "Kinematic Analysis of Generalized Adaptive Trusses," First Joint US/Japan Conference on Adaptive Structures, Maui, Hawaii, November 13-15, 1990.

78. Padmanabhan, B., and C. F. Reinholtz, "Design of Robotic Manipulators Using Variable-Geometry Trusses as Joints," paper 89 AMR-8C-7, Proceedings of the First National Applied Mechanisms and Robotics Conference, Vol. II, 1989.
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80. Williams, R. L., II, C. F. Reinholtz, "Forward Dynamic Analysis and Power Requirement Comparison of Parallel Robotic Mechanisms," ASME paper No. 88078, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988. (Also accepted for publication in the ASME Journal of Mechanisms, Transmissions and Automation in Design, 1989.)
81. Williams, R. L., II, C. F. Reinholtz, "Closed-Form Workspace Determination and Optimization for Parallel Robotic Mechanisms," ASME paper No. 88079, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988.
82. Robertshaw, H. H., and C. F. Reinholtz, "Variable Geometry Trusses," Proceedings of the US Army Research Office Workshop on Smart Materials, Structures and Mathematical Issues, Sept. 15-16, 1988.
83. Salerno, R. J., C. F. Reinholtz, and H. H. Robertshaw, "Shape Control of High Degree of Freedom Variable Geometry Trusses," presented at the NASA Workshop on Controls/Structures Integration, Williamsburg, VA, July 11-13, 1988.
84. Williams, R. L., II, C. F. Reinholtz, "Closed-Loop Planar Manipulators: Part I - Forward and Inverse Kinematics; Part 2 - Workspace Optimization," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
85. Rogers, C. A., H. H. Mabie, and C. F. Reinholtz, "Numerical Determination of Accuracy Points Using Chebyshev Polynomials for Displacement and Velocity Synthesis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
86. Mabie, H. H., C. F. Reinholtz, and C. A. Rogers, "Determination of Hob Offsets to Maximize the Ratio of Recess to Approach Action and Balance Tooth Strengths for Nonstandard Spur Gears by Limit Analysis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
87. Mabie, H. H., C. F. Reinholtz, and C. A. Rogers, "Determination of Pinion Cutter Offsets to Maximize Recess to Approach Action or to Equalize Tooth Strengths of Nonstandard Spur Gears with Backlash," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
88. Reinholtz, C. F., and D. Gokhale, "Design and Analysis of Variable Geometry Truss Robots," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
89. Reinholtz, C. F., V. Arun, and R. L. Williams, "A Reassessment of the Tasks of Kinematic Synthesis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
90. Arun, V., and C. F. Reinholtz, "Design of the RCCC Spatial Mechanism," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.

91. Klatt, M. A., and C. F. Reinholtz, "Mechanism Optimization Using Zero-Order Methods and Penalty Functions: A Comparison of Incremented Versus Nonincremented Penalty Parameter," DE-VOL. 10-1, Advances in Design Automation, Vol. 1, Proceedings of the 1987 Design Automation Conference, Boston, MA, Sept. 27-30, 1987, pp. 205-213.
92. Rogers, C. A., R. E. Cobb, and C. F. Reinholtz, "Incorporating Computer Programming Projects Into the Mechanical Engineering Curriculum," Proceedings of the Fifth National Conference on University Programs in Computer-Aided Engineering, Design, and Manufacturing (UPCAEDM '87), pp. 176-180.
93. Williams, II, R. L., C. F. Reinholtz, and A. Myklebust, "Complete Function-Generation Synthesis and Design of RSSR Spatial Mechanisms," ASME Paper 86-DET-151, presented at the 19th ASME Mechanisms Conference, Columbus, Ohio, October 1986.
94. Reinholtz, C. F., "Integrating Computers into Kinematics Courses at VPI&SU," Proceedings of the Fourth National Conference on University Programs in Computer-Aided Engineering, Design and Manufacture, August 1986, pp. 127-130.
95. Mabie, H. H., C. F. Reinholtz, D. Puzio, and G. M. Irwin, "Optimum Design of Spur Gear Teeth Cut with a Hob," Proceedings of the Ninth Applied Mechanisms Conference, Kansas City, MO, 1985, Vol. 2, Session VIII.B, Paper VI.
96. Keil, M. J., A. Myklebust, and C. F. Reinholtz, "Prediction of Link Interference in Planar Mechanisms," Proceedings of the Ninth Applied Mechanisms Conference, Kansas City, MO, 1985, Vol. 1, Session III.B, Paper V, (Winner of Proctor and Gamble Best Paper Award).
97. Myklebust, A., C. F. Reinholtz, W. H. Francis, and M. J. Keil, "Design of a Radar Guidance Mechanism Using MECSYN-ANIMEC," ASME Paper 84-DET-139, presented at the 18th ASME Mechanisms Conference, Cambridge, Massachusetts, October 10, 1984.
98. Sandor, G. N., A. G. Erdman, E. Raghavacharyulu, and C. F. Reinholtz, "On the Equivalence of Higher and Lower Pair Planar Mechanisms," Proceedings of the Sixth World Congress of the International Federation for the Theory of Machines and Mechanisms, New Delhi, India, 1983.
99. Sandor, G. N., D. Kohli, X. Zhuang, and C. F. Reinholtz, "Synthesis of a Five-Link Spatial Motion Generator," ASME paper 82-DET-130, 1982.
100. Sandor, G. N., D. Kohli, A. Ghosal, and C. F. Reinholtz, "Closed-Form Analytic Synthesis of a Five-Link Spatial Motion Generator," Proceedings of the Seventh Applied Mechanisms Conference, Kansas City, MO, 1981, pp. XXVI-1 to XXVI-7

Patents

1. "Spatial, Parallel-Architecture, Robotic Carpal Wrist," U. S. Patent 5,699,695, Inventors: Canfield, S. L., Reinholtz, C. F., Salerno, R. J., and Ganino, Anthony J., Assignee: Virginia Tech Intellectual Properties, Inc., Awarded December 23, 1997.
2. "Snubber Profile," U. S. Patent 4,998,942, Inventor: Reinholtz, Charles F. Assignee: Milliken Research Corporation, Spartanburg, S.C., Awarded March 12, 1991.

Invited Presentations at National Meetings

1. "Test Drive an Autonomous Vehicle: Experiences from the 2007 DARPA Urban Challenge," Presentation to USAA, 19 January 2009, San Antonio, TX
2. "Challenges and Opportunities Offered by the DARPA Grand Challenge," Invited Presentation and Panel Discussion at the 2004 AIAA Unmanned Aerial Vehicle Conference, Chicago, IL, September 2004.

3. "Product Safety and Product Liability," Invited Lecture at the 2001 ASME World Congress, New York, NY, Nov.13, 2001
4. "Life after Tenure" Invited Speaker and Panelist at the ASEE Annual Conference and Exposition, Charlotte NC, June 20-23, 1999.
5. "Reduced Complexity Robotics," Invited presentation at the 1998 ASME Design Technical Conferences, 25th Biennial Mechanisms Conference, Atlanta, GA, September 1998.
6. "Trends and Opportunities in Mechanisms Research," Plenary Panel Session Speaker at the 4th National Applied Mechanisms and Robotics Conference, Cincinnati, Ohio, December 10-14, 1995.
7. "Trends and Opportunities in Robotics," Opening Plenary Session Lecture at the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
8. "Observations on Robotics and Mechanisms Research," Opening Plenary Panel Session Speaker at the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio, November 3-6, 1991.

University Service

Invited Speaker at the following University Events and Alumni Association Chapter Meetings:

June 23, 2005, Research Triangle Park Alumni Chapter, Raleigh, NC
 March 18, 2004, Greensboro, NC Triad Alumni Chapter
 March 31, 2004, Atlanta Alumni Chapter
 November 1, 2004, Committee of 100 - Hotel Roanoke
 November 21, 2004, Class of 1968, Donaldson Brown

Advisor to the following Embry Riddle Autonomous Vehicle Teams:

Unmanned Aerial Systems Competition, 2007-Present
 International Aerial Robotics Competition, 2007-Present
 Intelligent Ground Vehicle Competition, 2007-Present
 RoboBoat, 2007-Present
 RoboSub, 2007-Present
 Maritime RobotX Competition, 2013-Present
 EcoCAR (CAVs Advisor), 2016-Present

Member, College Promotion and Tenure Committee 2018-21

Fulbright Scholarship Advisory Committee 2005

Advisor to the Virginia Tech Autonomous Aerial Vehicle Competition Team, 2004-

Advisor to the Virginia Tech DARPA Grand Challenge Team, 2003-

Virginia FIRST Lego League Coordinator, 2002-

Advisor to the Virginia Tech Intelligent Ground Vehicle Competition Team, 1995-

Advisor to Entering Honors Students 2003-

Horton Honors Scholarship Selection Committee 2003-

Member, University Strategic Planning Committee, 2001

Chair, Virginia Tech Academy of Teaching Excellence 2000-2001

Vice Chair, Virginia Tech Academy of Teaching Excellence 1999-2000

Member, University Promotion and Tenure Committee 2000-2001

Member, College Promotion and Tenure Committee 2000-2001

Chair, Mechanical Engineering Curriculum Committee 1997-2002

Chair, Mechanical Engineering ABET Review, 1998-2002

Member, College of Engineering Curriculum Committee 1997-2002

Member, 1st Year Special Curriculum Review Committee 1997

Member, Engineering Dean Search Committee, 1993-4

Chairman, Mechanical Engineering Honors and Awards and Publicity Committee, 1993-99

Member, Mechanical Engineering Honors and Awards and Publicity Committee, 1993-99

Chairman, College Wine Teaching Award Committee, 1992-95
 Chairman, University Wine Teaching Award Committee, 1995-96
 Member, Mechanical Engineering Department Head Search Committee, 1992-93
 Member, Mechanical Engineering Curriculum Committee, 1984-87, 1992-2004
 Member, Mechanical Engineering Tenure and Promotion Committee, 1989-2004
 Member, Mechanical Engineering Graduate Committee, 1987-89
 Member, Mechanical Engineering Recruiting Committee, 1992-93
 Member, Sigma Xi High School Teaching Award Committee 1987-88, Chairman 1989
 Member, College of Engineering Commencement Committee, 1988-
 Faculty Advisor to the Virginia Tech Student Section of ANS, 1993-
 Faculty Advisor to the Virginia Tech Student Section of ASME, 1988-
 Faculty Advisor to the Virginia Tech Chapter of Tau Beta Pi, 1984-88
 Host for the Virginia Tech Academic Challenge, 1991

Professional Service

<u>Society</u>	<u>Positions Held</u>
ASME	Secretary of the Virginia Section 1987-92 Chairman of the National Student Mechanism Competition 1987-88 Chairman of the Joint Regional Conference 1989 and 2000 Virginia Tech Student Section Advisor, 1988-2007 Member of the ASME Mechanisms Committee, 1990-1993 Associate Technical Editor, <i>ASME Journal of Mechanical Design</i> , 1991-93 Paper Review Chairman, 22nd ASME Mechanisms Conference, Sept. 1992 Conference Arrangements Chairman, 23rd ASME Mechanisms Conference, Sept. 1994 Member, ASME National Design Contest Committee, 1996-2002 Virginia Section Newsletter Editor, 1994-2000 Region IV Senior Representative to the National Student Sections Committee, 1995-2000
Sigma Xi	High School Teaching Award Committee, Member 1987-88, Chair 1989
ANS	Student Section Advisor, Virginia Tech, 1993-95
NAE	Invited review Board member, National Academies' National Research Council (NRC) Army Research Laboratory Technical Assessment Board (ARLTAB), May 2004

Graduate Advising

Master's Degree Students Completed				
	Degree	Name	Completion Date	Title
1	MS	Robert L Williams, II	8/85	Synthesis and Design of the RSSR Spatial Mechanism for Function Generation
2	MS	Arun Veeraraghavan	3/86	Computer Aided Design of the RCCC Spatial Mechanism
3	MS	Michael A. Klatt	10/86	Design Optimization of Planar Mechanisms
4	MS	Kevin K. Moyers	11/87	A Microcomputer-Based Data Acquisition System for Diagnostic Monitoring of High-Speed Electric Motors
5	MS	Christodoulos S. Demetriou	12/87	A PC Implemented Kinematic Synthesis System for Planar Mechanisms
6	MS	Dipen P. Gokhale	12/87	Kinematic Analysis and Animation of a Variable-Geometry Truss Robot
7	MS	William R. Seith	5/88	Design of a Flying Cutter
8	MS	George M. Clessas	5/88	Direct Calculation of Cable Tension in a Store Separation Program Which Models the Launch of an Aerial Tow Target
9	MS	Mark W. Biegler	8/88	Determination of Stress Concentration Factors Using Experimental Methods
10	MS	Nandan Joshi	2/88	Mobility Analysis of Variable-Geometry Trusses
11	MS	Vasant Marathe	12/88	Design of a Hot Melt Book Binding Machine
12	MS	Babu Padmanabhan	12/88	Design of a Robotic Manipulator Using Variable-Geometry Trusses as Joints
13	MS	Robert J. Salerno	6/89	Shape Control of High Degree-of-Freedom Variable-Geometry Truss Manipulators
14	MS	Ravinder S. Voruganti	8/90	Symbolic and Computational Conjugate Geometry for Design and Manufacturing Applications
15	MS	Steven B. Shooter	12/90	Conceptual Manipulator Design for Limited Access Workspaces
16	MS	Paul Mele	5/91	Mechanical Design of a Stewart Platform-Based Crawling Vehicle
17	M.S.	William K. Carpenter	12/92	Design of Medical Waste Treatment Systems Employing Bioremediation
18	MS	Allen Maples	5/93	Design of a Robust Acoustic Positioning System for an Underwater Nuclear Reactor Vessel Inspection Robot
19	MS	William Cordle	5/93	Numerical Inverse Kinematics for a Six Degree-of-Freedom Manipulator
20	MS	Glenn Melnyk	6/93	Mechanisms for Automated Toolhead Changing in Nuclear Steam Generator Robotics
21	MS	Steve Payne	5/94	A CAD-Interactive Software Package for the Synthesis of Planar Disk Cams
22	MS	Anil K. Garg	8/94	Design, Installation and Testing of a Bioremediation-Based System for Treating Regulated Medical Waste
23	MS	Todd Denkins	12/94	Design Methodology to reduce the Number of Actuators in Complex Mechanisms

24	MS	Joseph Calkins	12/94	Real-Time Compensation of Static Deflections in Robotic Manipulators
25	MS	Randy Soper	8/95	Synthesis of Planar Four-Link Mechanisms for Force Generation
26	MS	Keith Garguilo	8/95	Design and Testing of a Nonlinear Mechanical Advantage Demonstration Mechanism
27	MS	Ganino, A. J.	5/96	Mechanical Design of the Carpal Wrist: A Parallel-Actuated, Singularity-Free Robotic Wrist
28	MS	Larkin, Susan	6/96	Wheeled Autonomous Mobile Robots for use in Harsh Environments: A Survey of Recent Publications
29	MS	Iskandar, Kurnia	6/96	Computer Assisted Synthesis of Wrapping Cam Mechanisms
30	MS	Riutort, Kevin	7/96	Applied Design and Implementation of Straight-Line Mechanisms
31	MS	Saccoccio, Greg	8/96	Error Modeling of the Carpal Wrist
32	MS	Scardina, Mike	10/96	Optimal Synthesis of Force-Generating Planar Four-Link Mechanisms
33	MS	Palmer, Matthew	12/96	Kinematics of Beam-Flexure Four-Bar Linkages with Applications in a Compound Bow
34	MS	Coombs, Dana	2/97	Design of User-Weight-Based Exercise Machines
35	MS	Doyle, Matthew	12/97	The Foundation for CADSPAM
36	MS	Hayes, Thomas J.	12/97	The Creative Entrepreneurs Organization
37	MS	Adler, Alex	5/98	Testing and Understanding Screwdriver Bit Wear
38	MS	Haynie, C. Dean	8/98	Mechanical Design and Navigation Strategies for a Zero-Turn-Radius Autonomous Vehicle
39	MS	Holland, Michael	12/98	Assembly Optimization for Double-Row Ball Bearings
40	MS	Abbott, Michael	6/00	Dynamics and Control of the Biplanar Bicycle
41	MS	Conner, David	8/00	Sensor Fusion, Navigation, and Control of Autonomous Vehicles
42	MS	Jillcha Wakjira	1/01	Design of a SMA Heat Engine
43	MS	Carr, Angela	5/01	Position Control Comparison of Equilibrated and Mass Counterweight Systems
44	MS	Kedrowski, Philip	5/01	Development and Implementation of a Self-Building Global Map for Autonomous Navigation
45	MS	Blackett, Ricardo	5/01	Optimization of Multi-Degree-of-Freedom Force Generating Mechanisms
46	MS	Matthew Thompson	7/01	Design of a Cyclic Sliding, Dynamically Loaded Wear Testing Device for the Evaluation of Total Knee Replacement Materials
47	MS	Rundgren, Brian	12/01	Design and Optimization of Force Generation Linkages to Include Dynamic Effects
48	MS	Schiller, Ean	9/02	Heat Engine Driven by Shape Memory Alloys: Prototyping and Design

49	MS	Gopinath, Sudir	12/02	Using Color and Shape Analysis for Boundary Line Extraction in Autonomous Vehicle Applications
50	MS	Whittier, Will	12/02	Kinematic Analysis of Tensegrity Structures
51	MS	Terwelp, Chris	5/03	Remote Control of Hydraulic Equipment for Unexploded Ordnance Remediation
52	MS	Henshaw, Graham	5/03	Single-Session Design: Design Methodology in Compressed Timeframes Derived from the Robot Rivals Television Series
53	MS	Corey, Chris	12/03	Epicyclic Gear Train Solution Techniques with Application to Tandem Bicycling
54	MS	Fleming, Michael	12/03	Teleoperated Control of Hydraulic Equipment for Hazardous Material Handling
55	MS	Stubbs, Matthew	12/03	Kinematic Design and Analysis of a Morphing Wing
56	MS	Bacha, Andrew	5/05	Line Detection and Lane Following for an Autonomous Robot
57	MS	Frentzel, John	5/05	A Wireless Instrumented Payload for Testing Unmanned Vehicles
58	MS	Naik, Ankur	12/05	Arc Path Collision Avoidance Algorithm for Autonomous Ground Vehicles
59	MS	Barnett, Shane	12/05	Development of a Tow Capacity Test Device for Small Unmanned Vehicles
60	MS	Cooper, Jared	12/05	Modeling of a Small-Scale Remote Controllable Helicopter for Simulation and Control Development
61	MS	Baity, Sean	5/06	Development of a Next-generation Experimental Robotic Vehicle (NERV) that Supports Intelligent and Autonomous Systems Research
62	MS	Leedy, Brett	5/06	Two Minds for One Vehicle: A Case Study in Deliberative and Reactive Navigation
63	MS	Gombar, Brett	5/06	Design and Evaluation of a Mobile Instrumentation Platform for Unmanned Vehicle Testing
64	MS	Putney, Joseph	5/06	Reactive Navigation of an Autonomous Ground Vehicle Using Dynamic Expanding Zones
65	MS	Willis, Christopher Ryan	5/06	A Kinematic Analysis and Design of a Continuously Variable Transmission
66	MS	James Hayward Bittorf	6/06	Mechanical Device to Assist the Landing of Unmanned Aerial Vehicles
67	MS	Ramirez, Rachael	8/06	Computer Vision Based Analysis of Broccoli for Application in a Selective Autonomous Harvester
68	MS	Grant Edward Gothing	7/07	Development of the “Discretized Dynamic Expanding Zones with Memory” Autonomous Mobility Algorithm for the Nemesis Tracked Vehicle Platform
69	MS	David Burns Van Covern	7/07	Collaborative Target Localization and Inspection Using a Heterogeneous Team of Autonomous Vehicles
70	MS	Thomas James Alberi	4/08	A Proposed Standardized Testing Procedure for Autonomous Ground Vehicles

71	MS	Patrick Norman Currier	4/08	Development of an Automotive Ground Vehicle Platform for Autonomous Urban Operations
72	MS	Jesse Lee Farmer	2/08	Kinematic Analysis of a Two Body Articulated Robotic Vehicle
73	MS	Chris Hockley	12/10	Development of an Autonomous Monocopter
74	MS	Katrina Corley	4/11	Supervisory Autonomous Control of Homogeneous Teams of Unmanned Ground Vehicles: Application to The Multi-Autonomous Ground-Robotic International Challenge
75	MS	Robert Andrew Lister	5/11	Classification of Marine Vessels in a Littoral Environment Using a Novel Training Database
76	MS	Kevin Rigby	8/11	Localization of Aircraft Using Wide-Baseline Stereopsis
77	MS	Lafe Zabowski	8/11	A Low Cost, Computer Vision Based, Target Tracking Hexapod
78	MS	Christine Dailey	5/12	A Novel Resistance Exercise Machine for Use in a Lower Body Negative Pressure Box to Counteract the Effects of Weightlessness

Ph.D. Students Completed				
1	PhD	Robert L. Williams II	5/88	Planar Robotic Mechanisms: Analysis and Configuration Comparison
2	PhD	Arun Veeraraghavan	9/90	The Solution of Variable-Geometry Truss Problems Using New Homotopy Continuation Methods
3	PhD	Shahriar Tavakkoli	6/91	Shape Design Using Intrinsic Geometry
4	PhD	Babu Padmanabhan	12/92	A Study of Isostatic Framework with Application to Manipulator Design
5	PhD	Robert J. Salerno	12/93	Positional Control Strategies for a Modular, Long-Reach, Truss-Type Manipulator
6	PhD	Paul Tidwell	8/95	Wrapping Cam Mechanisms
7	PhD	J. Barry Fallon	8/95	Improving the Kinematic Control of Robots by Estimating the End-Effector Pose Directly with Computer Vision
8	PhD	Steven B. Shooter	12/95	Information Modeling in Mechanical Design: With Application to Cam Mechanism Design
9	PhD	Ravi S. Voruganti	12/95	Robot System Characterization: Error Modeling, Identification, Analysis and Calibration
10	PhD	Canfield, Steve	5/98	Development of the Carpal Wrist
11	PhD	Stulce, John	1/02	Conceptual Design of a Multibody Passive-Legged Crawling Vehicle
12	PhD	Calkins, Joseph	8/02	Quantifying Coordinate Uncertainty Fields in Coupled Spatial Measurement Systems
13	PhD	Snorri Gudmundsson	12/16	A Biomimetic, Energy-Harvesting, Obstacle-Avoiding, Path-Planning Algorithm for UAVs

APPENDIX B

Charles F. Reinholtz, Ph.D.

Deposition and Court Testimony, 2018 - Present

Year	Counsel	Opposing Counsel	Case Information (Client Shown in Boldface)	Plaintiff/ Defendant	Deposition/ Court Appearance
2018	Calfee, Halter & Griswold LLP	Quinn Emanuel Urquhart & Sullivan, LLP	Lincoln Electric Company , et al. Plaintiffs, v. Harbor Freight Tools USA Inc., Defendants, Case No. 1:17-CV-02329	Plaintiff	Deposition, February 22, 2018, Cleveland, OH
2018	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Sterne, Kessler, Goldstein & Fox, P.L.L.C.	Caterpillar v. Wirtgen GmbH, et. al., In the Matter of Certain Road Construction Machines and Components Thereof, ITC Investigation No. 337-TA-1088	Complainant	Deposition, May 10, 2018, Washington, DC
2018	Fish & Richardson P.C	Quinn Emanuel Urquhart & Sullivan, LLP	Sanofi-Aventis U.S. LLC et al, Plaintiffs, v. Merck Sharp & Dohme Corp., Defendant., 1:16-cv-00812	Plaintiff	Deposition, April 13, 2018, New York, NY
2018	Fish & Richardson P.C	Quinn Emanuel Urquhart & Sullivan, LLP	Sanofi-Aventis U.S. LLC et al, Plaintiffs, v. Merck Sharp & Dohme Corp., Defendant., 1:16-cv-00812	Plaintiff	Court Testimony, U. S. District Court, District of Delaware, May 29-31, 2018, Wilmington, DE
2018	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Caterpillar v. Wirtgen GmbH, et. al., In the Matter of Certain Road Construction Machines and Components Thereof, ITC Investigation No. 337-TA-1088	Complainant	Deposition, July 24, 2018, Washington, DC
2018	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Caterpillar v. Wirtgen GmbH, et. al., In the Matter of Certain Road Construction Machines and Components Thereof, ITC Investigation No. 337-TA-1088	Complainant	ITC Court Testimony, September 25 and 26, 2018, Washington, DC, ALJ: Dee Lord

2018	Weil, Gotshal & Manges LLP	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis , Plaintiffs v. Mylan GmbH, Biocon Ltd., Defendant, C.A. No. 17-cv-09105-SRC-CLW	Plaintiff	Deposition, October 30, 2018, Washington, DC
2019	Weil, Gotshal & Manges LLP	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis , Plaintiffs v. Mylan GmbH, Biocon Ltd., Defendant, C.A. No. 17-cv-09105-SRC-CLW	Plaintiff	Markman Hearing Court Testimony, April 12, 2019, Newark, New Jersey
2019	Step toe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, et. al., In the Matter of Certain Unmanned Aerial Vehicles and Components Thereof, ITC Investigation No. 337-TA-1133	Complainant	Deposition, July 19 and 12, 2019, Washington, DC
2019	Weil, Gotshal & Manges LLP	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis , Plaintiffs v. Mylan GmbH, Biocon Ltd., Defendant, C.A. No. 17-cv-09105-SRC-CLW	Plaintiff	Deposition, October 15, 2019, Washington, DC
2019	Step toe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, et. al., In the Matter of Certain Unmanned Aerial Vehicles and Components Thereof, ITC Investigation No. 337-TA-1133	Complainant	ITC Court Testimony, Oct 21 to 23, 2019, Washington, DC ALJ: Charles Bullock
2019	Kirkland & Ellis, LLP	Gibson Dunn and Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	iRobot Corp. v. SharkNinja, Civil Action No. 1:19-cv-12125	Plaintiff	Deposition, October 28, 2019, Washington, DC
2019	Step toe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, Inter Partes Review, Case IPR2019-00249 and Case IPR2019-00250, Patent 7,979,174 B2	Patent Owner	Deposition, October 31, 2019, Chicago, IL
2019	Step toe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, Inter Partes Review, Case PGR2019-00016, Patent 10,044,013B2, PGR 2019-00014, Patent 9,979,000, Case IPR2019-00343, Patent 9,260,184 B2	Patent Owner	Deposition, November 15, 2019, Orlando, FL
2019	Weil, Gotshal & Manges	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis v. Mylan GmbH, Biocon Ltd., Defendant,	Plaintiff	Court Testimony, December 2-4, 2019, Newark, NJ

	LLP		C.A. No. 17-cv-09105-SRC-CLW		
2019	Fish & Richardson P.C	Pepper Hamilton LLP	2019, Floodbreak, LLC , Plaintiff, v. Art Metal Industries, LLC, et al., Defendants, No. 3:18-cv-503, United States District Court District of Connecticut, 2019.	Plaintiff	Deposition, December 13, 2019, Bridgeport, CT
2020	Stephoe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, Inter Partes Review, Case IPR2019-00846, Patent 9,260,184 B2	Patent Owner	Live Video Deposition, April 3, 2020, New Smyrna Beach, FL
2020	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Caterpillar v. Wirtgen GmbH, et. al., Modification Proceeding in the Matter of Certain Road Construction Machines and Components Thereof, ITC Investigation No. 337-TA-1088	Complainant	Live Video Deposition, May 12, 2020, New Smyrna Beach, FL
2020	Stephoe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, Inter Partes Review, Case IPR2019-00846, Patent 9,260,184 B2	Patent Owner	Live Video Deposition, June 16, 2020, New Smyrna Beach, FL
2020	Fish & Richardson P.C	Davis & Kuelthau, s.c.	Wash World Inc., Plaintiff, v. Belanger Inc., et al. , Defendants, Case No.: 19-Cv-1562, United States District Court Eastern District of Wisconsin	Patent Owner	Deposition, December 3, 2020, (appearing by videoconference from Eugene, OR)
2020	Fish & Richardson P.C	Troutman Pepper Hamilton Sanders LLP	Floodbreak, LLC , Plaintiff v. A rt Metal Industries, LLC, et al., Defendants, No. 3:18-cv-503, United States District Court District of Connecticut.	Patent Owner	Court Testimony, December 9 & 10, Bridgeport, CT (appearing by videoconference from Florence, OR)
2020	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Willkie Farr & Gallagher LLP	Civil Action No. 5:19-cv-6021	Defendant	Deposition, December 21, 2020, (appearing by videoconference from Moab, UT)

2021	Faegre Drinker Biddle & Reath LLP	RuyakCherian LLP	Team Worldwide Corporation, Plaintiff, v. Academy, Ltd. D/B/A Academy ports + Outdoors, et al. , Defendants, Lead Case No. 2:19-cv-00092-JRG-RSP	Defendant	Deposition, January 5 & 6, 2021, (appearing by videoconference from Colorado Springs, CO)
2021	Durie Tangri LLP	Kramer Levin Naftalis & Frankel LLP	Midwest Athletics and Sports Alliance, LLC v. Xerox Corporation (represented by Durie Tangri LLP) v Case No. 6:19-CV-06036-EAW-MJP.	Defendant	Deposition, September 20, 2021 (appearing by videoconference from New Smyrna Beach, FL)
2021	Kirkland & Ellis, LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	iRobot Corp. v. SharkNinja, In The Matter of Certain Robotic Floor Cleaning Devices And Components Thereof, ITC Investigation No. 337-TA-1252	Complainant	Deposition, October 6, 2021 (appearing by videoconference from New Smyrna Beach, FL)
2021	Fish & Richardson P.C	Latham & Watkins LLP and Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	AbbVie Inc. and AbbVie Biotechnology Ltd, Plaintiff, v Alvotech Hf. , Civil Action No. 1:21-cv-2258, United States District Court for the Northern District of Illinois Eastern Division.	Defendant	Deposition, December 6, 2021, (appearing by videoconference from Boulder, CO)
2022	Kirkland & Ellis, LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	iRobot Corp. v. SharkNinja, In The Matter of Certain Robotic Floor Cleaning Devices And Components Thereof, ITC Investigation No. 337-TA-1252	Complainant	ITC Court Testimony, January 6, 7 and 12 (appearing by videoconference from the offices of Kirkland & Ellis, Washington, DC), ALJ: MaryJoan McNamara
2022	Faegre Drinker Biddle & Reath LLP	Crowell & Moring	Wonderland Nurserygoods Co., Ltd., Plaintiff, v. Baby Trend, Inc. , Denny Tsai and Betty Tsai, Defendants, Case No. 5:14-cv-01153-JWH-SPx	Defendant	Deposition, April 12, 2022, Daytona Beach, FL
2022	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Willkie Farr & Gallagher LLP	Provisur Technologies, Inc., Plaintiff, v. Weber, Inc., Textor, Inc., et. al. , United States District Court, Western District of Missouri, St. Joseph Division, Case No. 5:19-CV-06021.	Defendant	Deposition, May 5, 2023, Washington, DC

2022	Fish & Richardson P.C	Davis & Kuelthau, s.c.	Wash World Inc., Plaintiff, v. Belanger Inc., et al. , Defendants, Case No.: 19-Cv-1562, United States District Court Eastern District of Wisconsin	Patent Owner and Defendant	Court Testimony, August 2 & 3, United States District Court Eastern District of Wisconsin, Green Bay, WI
2022	Faegre Drinker Biddle & Reath LLP	Crowell & Moring	Graco Children's Products Inc. and Wonderland Nurserygoods Co., Ltd. v. Baby Trend, Inc. et. al. , "In the Matter of Certain Playards and Strollers," ITC Investigation No. 337-TA-1288	Defendant	Deposition, September 27-28, 2022, Indianapolis, Indiana
2022	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Willkie Farr & Gallagher LLP	Provisur Technologies, Inc., Plaintiff, v. Weber, Inc., Textor, Inc., et. al. , United States District Court, Western District of Missouri, St. Joseph Division, Case No. 5:19-CV-06021.	Defendant	Court Testimony, October 25 & 26, United States District Court, Western District of Missouri, Kansas City
2022	Faegre Drinker Biddle & Reath LLP	Crowell & Moring	Graco Children's Products Inc. and Wonderland Nurserygoods Co., Ltd. v. Baby Trend, Inc. et. al. , "In the Matter of Certain Playards and Strollers," ITC Investigation No. 337-TA-1288	Respondent	ITC Court Testimony, Washington, DC, December 13-15, 2022, ALJ: Bryan F. Moore
2023	Fish and Richardson	K&L Gates LLP	Kidde v. First Alert & BRK, USDC WDTX (CA No. 6:22-00566) Civil Action No. 6:22-cv-411-ADA	Plaintiff	Deposition Testimony, Atlanta, GA, January 4, 2023
2023	Fish and Richardson	Husch Blackwell LLP	MGI Digital Technology S.A v Duplo U.S.A. , Case No. 8:22-cv-00979-DOC-KES, District Court for the Central District of California	Defendant	Deposition, March 7, 2023 (appearing by videoconference from New Smyrna Beach, FL)