UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Canon U.S.A., Inc., and Canon Inc.,

Petitioners

v.

Slingshot Printing LLC,

Patent Owner

Case No. IPR2023-00312

Patent No. 7,484,823

DECLARATION OF STEPHEN F. POND, Ph.D.

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I, Stephen F. Pond, Ph.D. declare as follows:

I. INTRODUCTION

1. I formerly worked for the Xerox Corporation for over 25 years. I now work as a consultant in the area of electronic printing and have done so for the past 24 years. Accordingly, I have extensive experience in electronic printing, including ink jet technology. I have been retained by Canon U.S.A., Inc. and Canon Inc. (collectively, "Canon" or "Petitioners") in connection with the above-captioned Petition for *Inter Partes* Review.

2. I understand that the Petition involves U.S. Patent No. 7,484,823 ("the '823 Patent") (Ex.1001). I have been asked by Canon to offer opinions regarding the '823 Patent, including the patentability of the claims in view of certain prior art. This declaration sets forth my opinions that I have reached to date regarding these matters.

3. In preparing this declaration, I have reviewed the '823 Patent and considered each of the documents cited herein. In reaching my opinions, I have relied upon my experience in the field and also considered the viewpoint of a person having ordinary skill in the art ("PHOSITA") at the time of the earliest claimed priority date of the '823 Patent, *i.e.*, December 2005 As explained below, I am familiar with the level of a PHOSITA regarding the technology at issue as of that time.

4. I am being compensated at my normal rate of $500 per hour in connection with this review. My compensation is not contingent on the outcome of this review or on the substance of my opinions. I further have no financial interest in Canon. I have been informed that the ’823 Patent may currently be assigned to Slingshot Printing LLC (“Slingshot”). I have no financial interest in Slingshot.

II. BACKGROUND AND QUALIFICATIONS

5. A true and correct copy of my *curriculum vitae* is attached as Ex.1002. As set forth in my CV, I have over 49 years of research, product engineering, and consulting experience in the field of electronic printing, including thermal inkjet ink printing technologies. I received a Bachelor’s Degree (Magna Cum Laude) in Physics in 1967 from Dartmouth College, a Master’s Degree in Physics from University of Illinois in 1968, and a Ph.D. in Physics from University of Illinois in 1971. I am a member of the Phi Beta Kappa honor society.

6. I served for 26 years at Xerox Corporation in numerous areas related to electronic printing. From 1972-1979, I served as a scientist at Xerox responsible for experimental studies in toner adhesion, was project leader and principal technical contributor for feasibility studies for a magnetographic electronic duplicator and became a charter technical contributor to Xerox’s continuous inkjet research program. In that last role, I was responsible for early continuous inkjet demonstration, technical strategy, and competitive technology information analysis.

As part of that role, I examined Lexmark printers as they entered the market until my retirement in 1998.

7. During the 1980s, I was a manager at Xerox in the Advanced Marking Development Section, in the Electronic Marking Device Area, and in the Electronic Marking Laboratory, where I was responsible for thermal inkjet research and technology feasibility demonstration.

8. From 1989-1994, I was Chief Engineer in Xerox's Components Development and Manufacturing Unit, where I was responsible for thermal inkjet advanced technology and product development. In that role, I had line management responsibility for approximately 60 engineers and scientists, and I managed inkjet development collaborations with foreign OEM suppliers and a Xerox Japanese subsidiary. My efforts on behalf of the company were recognized in 1991, when I received the Xerox President's Award—the highest individual honor attainable within the organization.

9. From 1994-1998, I was a Principal in Xerox's Ink Jet Business Group, where I was responsible for workgroup and special product concept development. In that role, I managed the initial productization project for Xerox 600 dpi thermal inkjet printhead and ink technology, and I managed the development of a state of the art thermal inkjet printer mechanism.

10. For the past 24 years, I have been an electronic printing and microelectromechanical systems (MEMS) consultant, working with outside investors and corporate managers to evaluate intellectual property for MEMS devices, and inkjet printing.

11. I am a registered patent agent, and I am named an inventor on 51 issued United States Patents. I am also the author of numerous publications in the field of inkjet printing, including the textbook "Inkjet Technology and Product Development Strategies," Torrey Pines Research (2000).

III. MATERIALS REVIEWED

12. In formulating my opinion, I have taken into consideration not only my general knowledge and experience, but also the following:

Exhibit #	***Description***
Ex. 1001	U.S. Patent No. 7,484,823 to Barkley *et al.*
Ex. 1002	[Reserved]
Ex. 1003	File History of U.S. Patent 7,484,823
Ex. 1004	U.S. Patent No. 7,384,113 to Benjamin *et al*. ("Benjamin")
Ex. 1005	U.S. Patent No. 6,612,673 to Giere *et al*. ("Giere673")
Ex. 1006	U.S. Patent No. 7,163,272 to Parish *et al*. ("Parish")
Ex. 1007	U.S. Patent No. 6,565,178 to Giere *et al*. ("Giere178")
Ex. 1008	U.S. Patent No. 6,527,367 to Yabe ("Yabe")
Ex. 1009	U.S. Patent No. 5,808,640 to Bhaskar *et al.* ("Bhaskar")
Ex. 1010	U.S. Patent No. 6,488,363 to Torgerson *et al.* ("Torgerson")

Ex. 1011	U.S. Patent No. 6,082,854 to Axtell *et al.* ("Axtell")
Ex. 1012	Excerpts of Prior Art Dictionaries – Adjacent
Ex. 1013	Oxford English Dictionary, Second Edition (2005)
Ex. 1014	U.S. Patent No. 7,131,714 to Edelen *et al.* ("Edelen")
Ex. 1015	U.S. Patent No. 6,357,863 to Anderson *et al.* ("Anderson")
Ex. 1016	U.S. Patent No. 6,382,773 to Chang *et al.* ("Chang")
Ex. 1017	Daniel A. Kearl & Michael S. Ard, Low-Cost Plain Paper Color Inkjet Printing, Hewlett-Packard J. 43, No. 4, 64 (1992)
Ex.1018	William A. Buskirk et al., Development of a High-Resolution Thermal Inkjet Printhead, Hewlett-Packard J. 39, No. 5, 55 (1988)
Ex. 1019	U.S. Patent No. 7278703 to Benjamin *et al.* ("Benjamin703")
Ex. 1020	Curriculum Vitae of Dr. Stephen Pond
Ex. 1021	[Reserved]
Ex. 1022	[Reserved]
Ex. 1023	[Reserved]
Ex. 1024	[Reserved]
Ex. 1025	[Reserved]
Ex. 1026	[Reserved]
Ex. 1027	*Canon USA, Inc. et al. v. Slingshot Printing LLC*, IPR2023-00313, Paper 2 (PTAB Jan. 21, 2023)

IV. RELEVANT PATENT LAW AND LEGAL STANDARDS

A. Priority Date

13. I have been asked to use December 30, 2005, as the priority date for my analysis and this declaration. I understand that because the application leading to the '823 Patent was filed before March 16, 2013, pre-AIA 35 U.S.C. §§ 102 (novelty) and 103 (obviousness) apply.

B. Obviousness

14. I understand that a determination that a claim is "obvious" is based on underlying factual issues including the content of the prior art and the level of ordinary skill in the art. I understand that for a single reference or a combination of references to render the claimed invention obvious, a PHOSITA must have been able to arrive at the claims by modifying or combining the references.

15. I have further been informed and understand that a claim is unpatentable as **obvious** if the difference between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a PHOSITA.

16. I also have been informed and understand that the combination of familiar elements according to known methods is obvious when it does no more than yield predictable results. However, I further understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. I understand that to

prove a claim would have been obvious, one must demonstrate that a PHOSITA would have been motivated to combine or modify the prior art to achieve the claimed invention, while having a reasonable expectation of success in doing so.

17. I further understand that a claim may be obvious if common sense directs one to combine multiple prior art references or add missing features to reproduce the alleged invention recited in the claims. I also understand that if a PHOSITA could implement a predictable variation, then the claim is likely unpatentable. For the same reason, if a technique has been used to improve one device and a PHOSITA would recognize that it would improve similar devices in the same way, then using the technique is obvious. I further understand that a claim can be obvious if it combines old elements with no change to their respective functions or alters prior art by merely substituting one element for another known in the field to yield a predictable result.

C. Standard of Proof

18. I understand that the standard to prove unpatentability is by a preponderance of the evidence, which means more likely than not.

V. SUMMARY OF OPINIONS

19. Having reviewed the ’823 Patent and the prior art cited above, I have formed the following opinions:

- The combination of Benjamin and Giere673 discloses all of the limitations of claims 1-3, 5-12, 13, and 15-17.
- The combination of Benjamin and Giere673 in view of Parish discloses all of the limitations of claims 4 and 14;
- The combination of Benjamin and Giere178 discloses all of the limitations of claims 1-3, 5-13, and 15-17;
- The combination of Yabe and Giere673 discloses all of the limitations of claims 1-3, 5-13, and 15-17.
- The combination of Yabe and Giere673 in view of Parish discloses all of the limitations of claims 4 and 14.

The reasons for my opinions are discussed in further detail below.

VI. CLAIM CONSTRUCTION

20. I have been advised that the term "ink via" found in independent claims 1 and 11 has not been previously construed in the context of the '823 patent. I understand, however, that an "ink via" as used in the claims of another Slingshot patent (U.S. Patent No. 7,484,823) was construed by Judge Albright in the Western District of Texas during a previously pending litigation asserted by Slingshot against HP Inc. to mean "[a] path to fluidly connect [a] supply of ink to one or more heaters." The '823 Patent and U.S. Patent No. 7,559,629 both share an inventor, David. G.

King, and both were filed in 2005. I agree with this construction and have applied it to my analysis of the prior art below.

21. I have been advised that the term "adjacent" found in independent claims 1 and 11 has not been previously construed in the context of the '823 Patent. As used in the '823 Patent, the term adjacent means "next to and can include," such that a region disposed adjacent each heater array can also include that heater array. This is consistent with the '823 Patent claims and specification describing regions that are next to, and can include, heater arrays. Ex.1001 at 7:45-46 ("pulses are applied to heaters within each region"); *id*. at 7:47-50 ("heaters used in each region"). This construction is also consistent with claims of the related '708 Patent as discussed in Ex.1027 at 7-8. Specifically, claims 1 and 9 of the '708 Patent effectively require that any "region between two adjacent ink vias" be both "adjacent" to and "include" the same two heater arrays. Ex.1027 at 8.

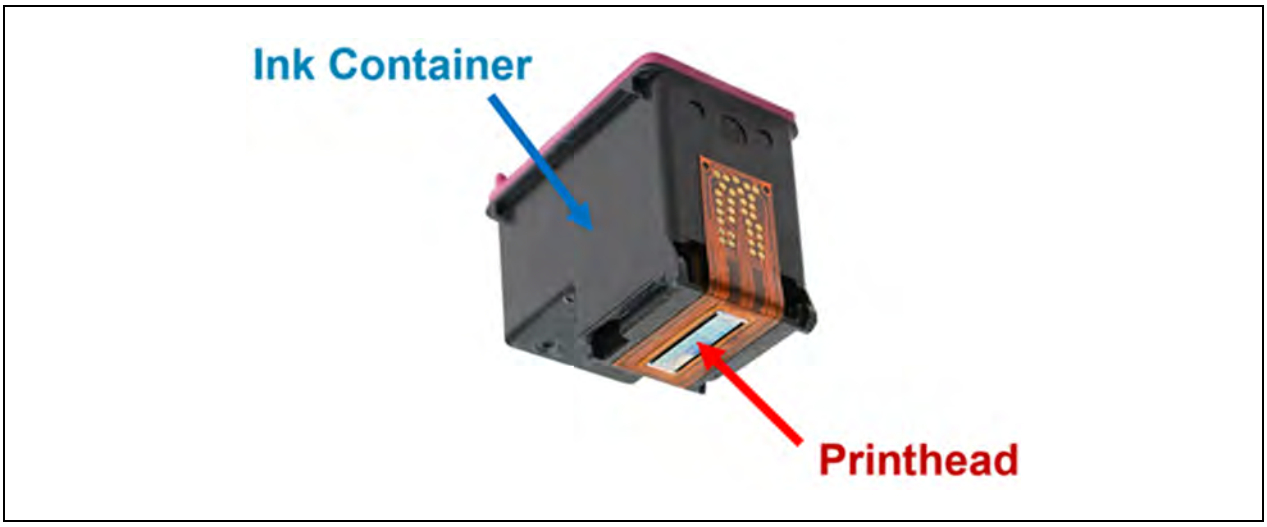
VII. THE RELEVANT TECHNOLOGY

A. Thermal Inkjet Printing

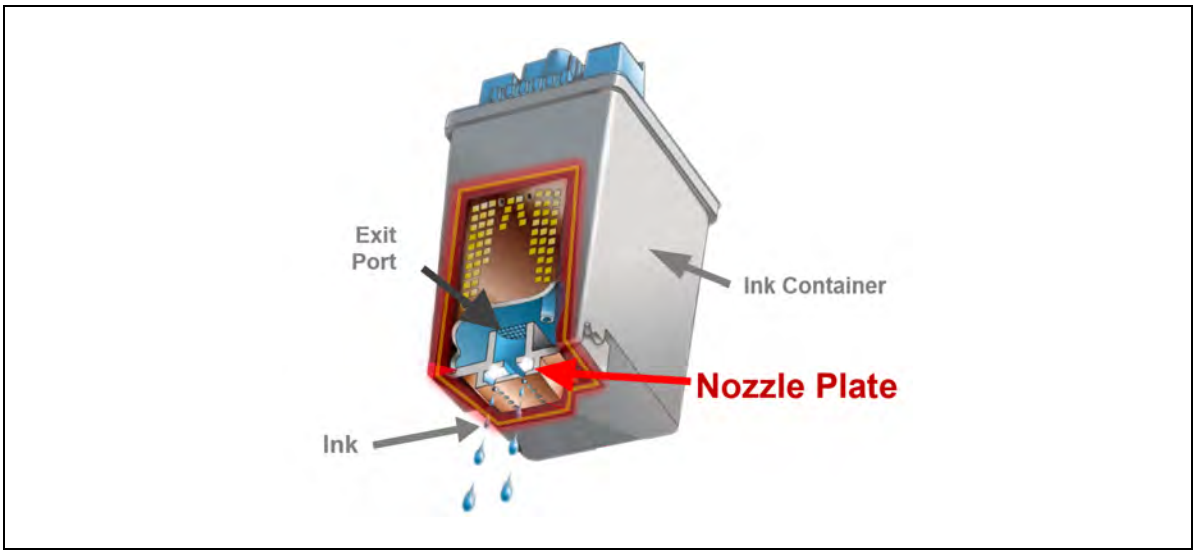
22. Inkjet imaging devices, such as printers, often employ a drop-on-demand inkjet printhead for printing on a printable medium, such as paper. Ink is typically supplied to the printhead from an ink reservoir or ink container via a flow passage. Often, the ink container and printhead form a single unit—referred to as a

print cartridge—and ink flows from an ink container portion to a printhead portion via an internal flow passage during printing.

23. I have annotated in the photograph below of an ink container and printhead of an exemplary Hewlett Packard (HP) drop-on-demand, thermal inkjet printer cartridge:

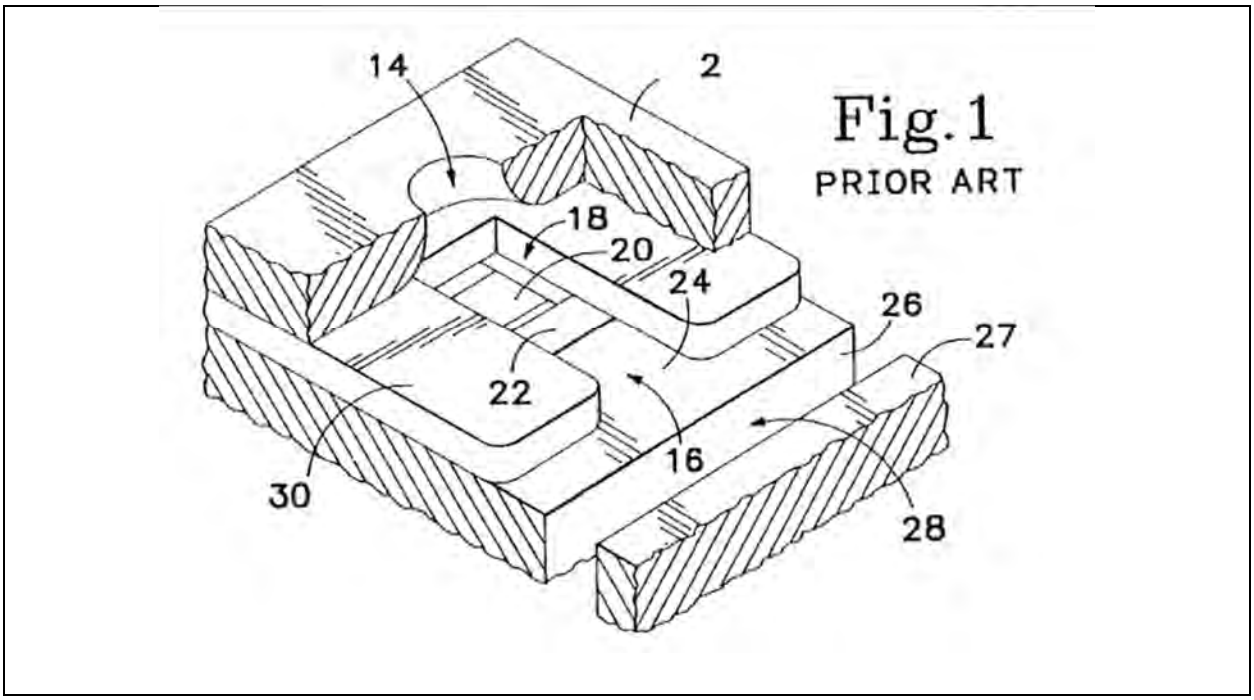


24. The printheads used in thermal inkjet devices include resistors (heaters) that vaporize the ink as it is supplied from the ink container to the nozzle region of the printhead via a fluid exit port. The ink vaporization causes the ejection of micro-droplets of ink through the nozzles in printhead's nozzle plate onto the printable medium.



25. The fundamental inkjet printhead ink ejection structure generally described above was state-of-the-art at least by the mid-1990s (i.e., over a decade before the '823 Patent). For example, U.S. Patent No. 5,808,640 (Ex.1009) ("Bhaskar") describes the fundamental printhead structure illustrated in Figure 1, below. Bhaskar's Figure 1 was labeled "Prior Art" and explains the pathways through which the ink transits through the printhead layers. Ink enters into the printhead from an ink reservoir below the substrate (26) via an ink feed slot (28) (or "ink via") and floods all of the bubble chambers (16) above the heater/resistors (20).

Ex.1009, Fig. 1



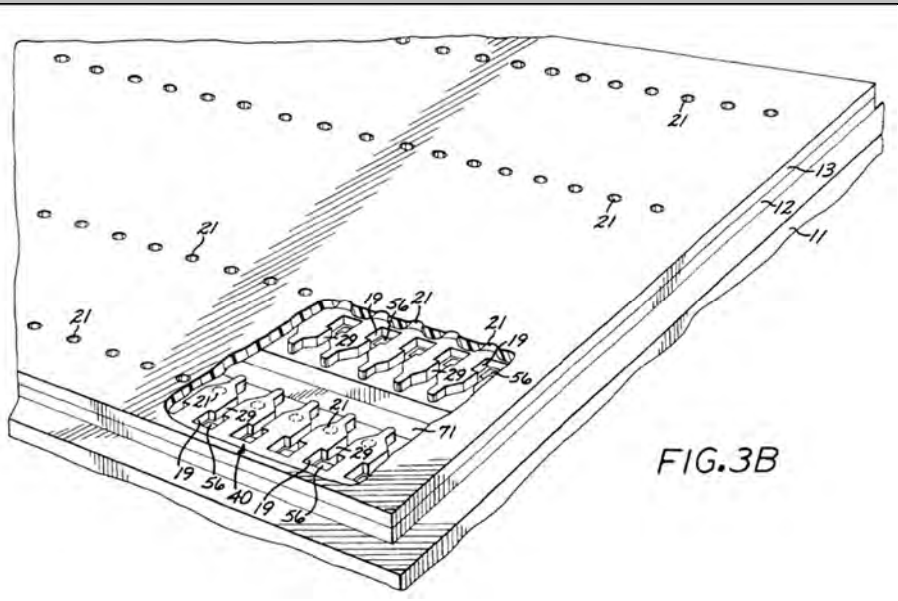
26. With respect to Figure 1 (above), Bhaskar explains ink ejection operations as follows:

> In operation, each firing chamber is charged with ink from ink feed slot 28 through its respective ink feed channel 16. Each firing chamber is fired by an electrical impulse carried over common conductor 22 to the heating resistors 20, which heats, vaporizes, and ejects a portion of the ink from the cell through orifice 14 onto an adjacent print medium (not shown), completing one firing cycle. The firing chamber 18 is then refilled with a fresh charge of ink flowing from ink slot 28 through channel 16.

Ex.1009 at 3:28-36.

27. Inkjet printheads are fabricated upon substrates in the same way as integrated circuits and are thus often called "printhead chips," "printhead die," or "heater chips". With respect to Figure 3B, below, HP's U.S. Patent No. 6,488,363 (Ex.1010) ("Torgerson") describes an inkjet printhead having a fundamental 3-layer anatomy: "ink jet printheads 100A, 100B in which the invention can be employed and which generally includes (a) a thin film substructure or die 11 comprising a substrate such as silicon and having various thin film layers formed thereon, (b) an ink barrier layer 12 disposed on the thin film substructure 11, and (c) an orifice or nozzle plate 13 laminarly attached to the top of the ink barrier 12." Ex.1010 at 2:67-3:6. The substrates are often rectangular in shape. Ex.1010 at 4:16-21 ("thin film substructure 11 can be rectangular…").

Ex.1010, Fig. 3B



28. Torgerson's design and operation is the same fundamental design and operation as Bhaskar's as described above. The ink is boiled by a tiny heater resistor (56) which is attached to the surface of the lower substrate layer. A chamber (19) within the barrier layer (12) provides space for the bubble to form and thereby force a droplet of ink to be expelled through a tiny orifice (21) in the top layer (13). Upon the precise timing commands of sophisticated electronic controllers, the heater/resistors are energized to superheat (boil) the ink, causing a vapor bubble whose pressure discharges an ink droplet through the nozzle hole in the roof of that chamber. The discharge is coordinated with the microsecond timing of hundreds of other drop generators on an inkjet printhead.

29. With reference to Figure 4B, below, Torgerson describes the arrangement of the heater resistors into multiple arrays on the printhead die: "ink drop generators 40 includes a heater resistor 56, the heater resistors are accordingly arranged in **columnar groups or arrays that correspond to the columnar arrays of ink drop generators**." Ex.1010 at 4:36-39. Torgerson further states that "the heater resistor arrays or groups will be referred to by the same reference number 61." *Id.* at 4:39-40.

Ex.1010, Fig. 4B

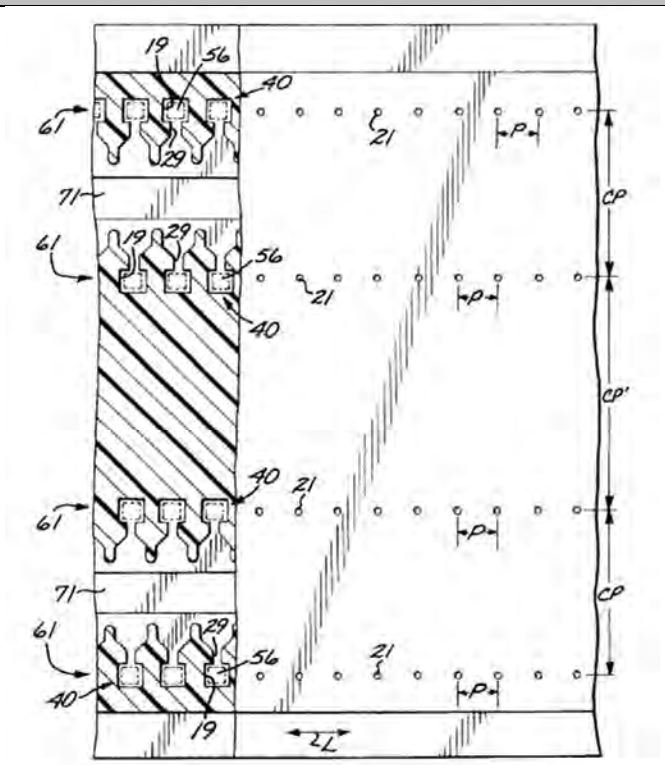


FIG.4B

30. As illustrated in Torgerson's Figures 3B and 4B, above, the printhead includes heater arrays on both sides of an ink feed slot (71). Specifically, Torgerson discloses "**two ink feed slots 71**" that "**respectively feed four columns 61 of ink drop generators respectively located on opposite sides of the two ink feed slots 71**, wherein the ink channels open towards an edge formed by an associated ink feed slot in the thin film substructure." [1] Ex.1010 at 4:61-63. Torgerson states that "[i]n

[1] Emphasis in text and color annotations in figures added throughout unless explicitly indicated otherwise.

this manner, opposite edges of each ink feed slot forms a feed edge and each of the two ink feed slots comprises a dual edge ink feeding slot." Ex.1010 at 4:63-65.

31. Inkjet printheads having dual edge ink feeding slot, i.e., two arrays of heater resistors alongside a single ink supply slot (via), were well known before the '823 Patent. In fact, there several prior art references disclosed to the U.S. Patent Office during prosecution of the '823 Patent showing inkjet printheads having ink vias with heater resistor arrays on either side. For example, Torgerson (discussed above) was disclosed to the Patent Office during prosecution of the '823 Patent. Ex.1001, References Cited.

32. U.S. Patent No. 6,357,863 (Ex.1015) ("Anderson") was also disclosed during prosecution of the '823 Patent. Ex.1001, References Cited. As illustrated below in Figure 2 (below), Anderson discloses chip 16 with ink via 20 where "[o]n either side of the ink via 20 is a column of ink heating resistors 22 formed on the substrate 18." Ex.1015 at 2:61-63.

Ex.1015, Fig. 2

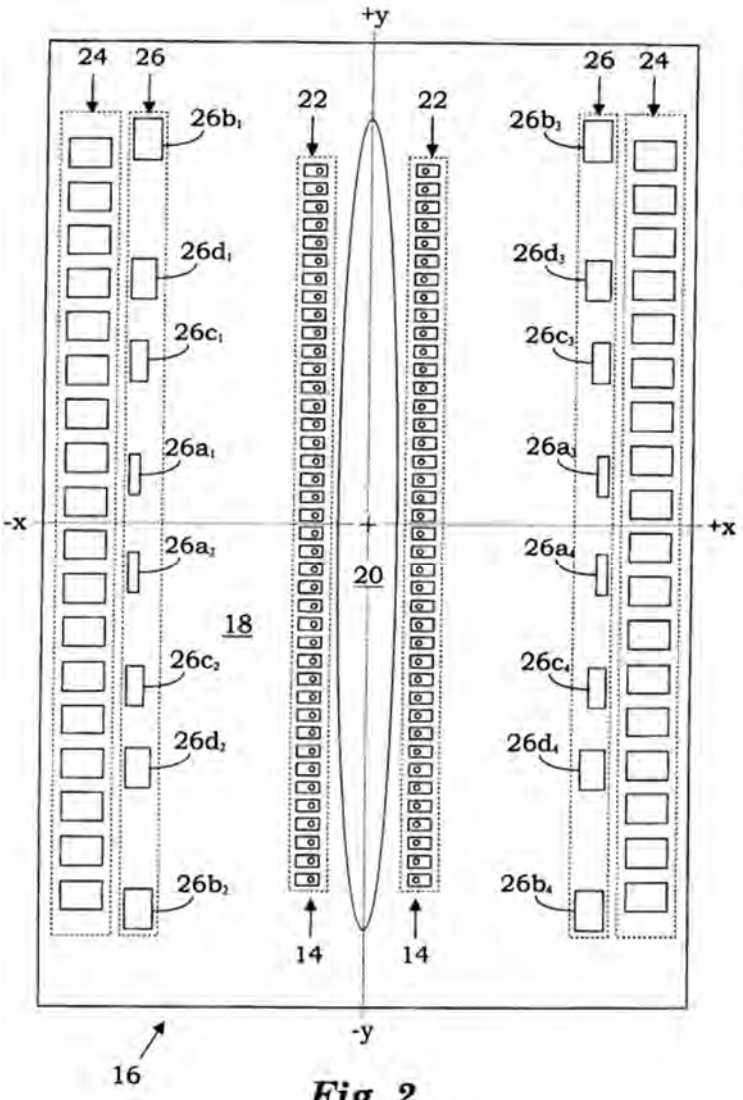


Fig. 2

33. U.S. Patent No. 6,382,773 (Ex.1016) ("Chang") was also disclosed during prosecution of the '823 Patent. Ex.1001, References Cited. As illustrated below in Figure 1 (below), Chang describes ink-jet chip 10 having three ink vias (107) and heating elements (106) on either side.

Ex.1016, Fig. 1

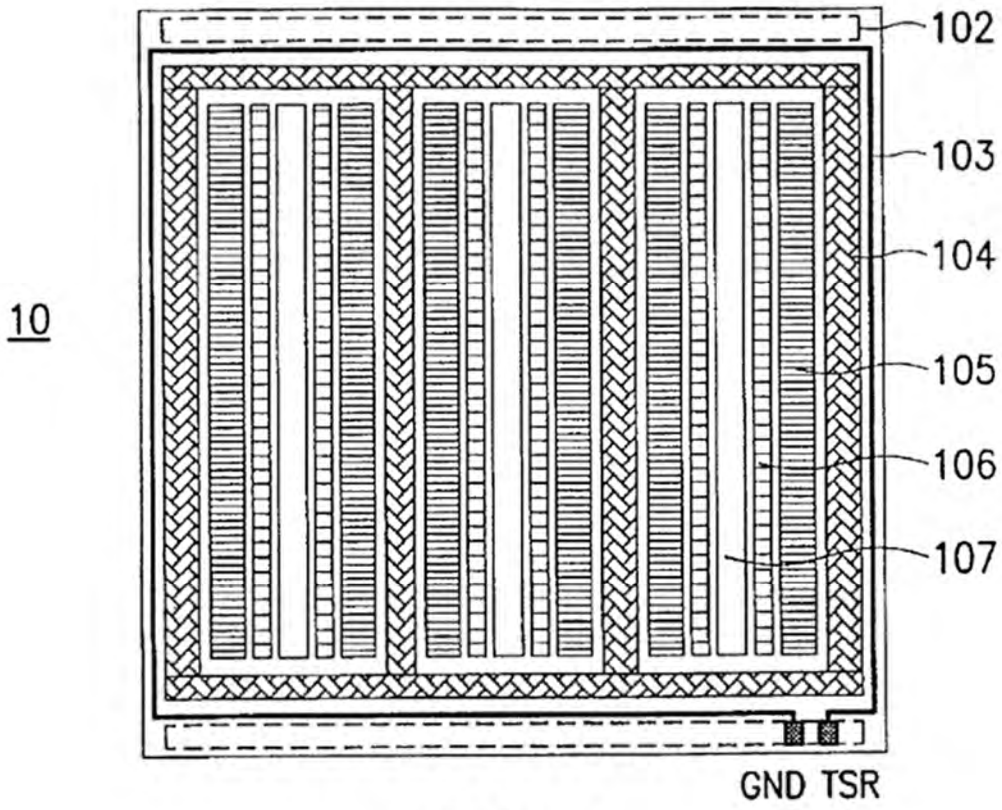


FIG. 1

B. Temperature Considerations for a Thermal Inkjet Printhead

34. A PHOSITA understands that thermal inkjet (TIJ) devices, such as printers, are designed to operate via homogeneous water boiling, i.e., homogeneous water vapor bubble nucleation. This is achieved by driving liquid water molecules (held together by van der Waals forces) *within the ink* into a gaseous (vapor) state by heating a sheath of ink/water molecules atop a heater resistor rapidly to a temperature **above ~270°C**. Once homogeneous boiling nucleates, the ink/water directly above the sheath nucleation area (now itself above ~100°C) will also be

nucleated into changing state. The size of the ink ejection bubble depends on how much ink/water is above 100°C at the time the sheath of ink/water atop the heater resistor surface reaches the homogeneous nucleation temperature of 270-300°C. The larger the bubble, the more ink in the drop generator chamber is displaced both out the nozzle as a dispensed drop and back into the ink supply passageway.

35. A TIJ device is designed to operate optimally at a nominal temperature that is chosen with a *temperature management* strategy in mind.

36. Since passive cooling is the most affordable cooling method, a PHOSITA will choose an elevated temperature as the nominal temperature and use active measures to raise the ink temperature to this nominal temperature if the ambient temperature where the printer is operating is a lower temperature. The printhead temperature can be elevated to the nominal temperature by various means, such as intermittent non-printing energy pulses to the heater resistors, or on-chip, on-printhead assembly, or ink reservoir auxiliary heaters.

37. If the ink temperature is substantially too low, the nucleated bubble may be too small and either no drop, a small drop or a sputtered mist may result. This could produce visible white streaks in the image or color hue shifts as the mix of cyan, yellow, and magenta ink amounts in an image area is wrong. If the ink temperature is substantially too high, then dark streaks or color hue shifts may be visible.

38. If the ink temperature is very high, then bubble volume may be so large that the bubble breaks out through the nozzle, causing air to be ingested into the printhead. The user may have to initiate a printhead maintenance cycle whereby the nozzles are sucked clear of air by a maintenance station vacuum function. Another failure can occur if a hot ink nucleates too early in the drop firing pulse. As soon as the bubble is nucleated, the heater resistor surface can no longer transfer heat to the ink efficiently, causing the heater surface to get much hotter than designed, leading to the "burn out" of the heater resistor and, potentially, the permanent failure of that drop generator.

39. There have been many approaches to ink temperature/printing system management. The implementation is almost always a cost driven decision. Inkjet printers have many different price points. The sophistication, and thereby cost, of the ink system usually tracks the price point. To operate over the widest range of environmental temperatures and heaviest printing (drop firing) loads, a PHOSITA would know to monitor the temperature of the printhead in a manner that adequately represents the temperature of the ink at the drop generator chambers. In the case of a multi-color printhead having multiple columns of drop generator/heater arrays each supplied by different color inks, temperature monitoring should adequately represent each color ink temperature. Ideally it is desired to know the temperature of the ink in contact with each heater resistor surface. Because this is not

economically practicable, the temperature is sensed somewhere else and the ink temperature is inferred by heat flow modelling, but mostly by experimentally derived firmware algorithms.

40. A PHOSITA understands that thermal inkjet printhead devices, for reasons of affordability, are fabricated using microelectronic methods and materials on single crystal silicon substrates. Single crystal silicon is a good thermal conductor having a thermal conductivity in the range of 70 – 75 Watts/meter/deg Kelvin.[2] Because of this good thermal conductivity, the entire silicon substrate quickly becomes in thermal equilibrium with the region on the substrate where heat is being introduced by heater resistors firing ink drops. Therefore, **the silicon substrate is an ideal location for thermal sensors and temperature monitoring**. During product development, the thermal inkjet device is operated while monitoring the proposed temperature sensor(s). Drop size and failure modes such as air ingestion are then noted versus sensor temperature readings.

41. The positions of the temperature sensors depend on the temperature management control design and thermal behavior of the printhead, especially the silicon substrate. If there are regions of the silicon substrate that can differ in temperature sufficiently to require different thermal management actions to ensure

[2] https://analyzing-testing.netzsch.com/en-US/applications/photovoltaics/silicon-wafer-thermophysical-properties.

print quality, or to eliminate failure modes, then multiple temperature sensors are required to supply the information needed to manage those regions differently. A single temperature reading in a region is adequate if it can measure the temperature everywhere in that region within a range of temperatures that has been determined to be controllable by the temperature management system.

42. A PHOSITA would understand that a multi-via thermal inkjet silicon substrate has thermal conduction pathways that are greatly affected by ink via slots because heat travels faster through silicon than it does through the ink or ink supply manifold plastic. By way of background, a PHOSITA would understand the heat flow, H, within the printhead structure by considering the equation for heat flow along a thermal conducting pathway of length L (meters) and cross-sectional area, A (meters^2), having a temperature difference of T2 – T1 (degrees Kelvin), over the path length, L: H = k A (T2 – T1)/L watts.

Francis W. Sears & Mark W. Zemansky, University Physics 371 (3rd ed. 1963).

43. The thermal conductivity, k, has units of watts/meters/degreesK. Heat flow (H) conveys how rapidly heat energy (joules) is conducted from the hotter point, T2, to the cooler point, T1. Thermal conductivity is temperature dependent. Heat energy will flow until thermal equilibrium is reached, defined as the condition wherein the material of the pathway is at the same temperature. The heat flow equation thus conveys that heat flow will be higher (faster) when the pathway area

is larger, the material thermal conductivity is higher, or the pathway length shorter, for a given temperature difference.

44. Single crystal silicon has thermal conductivity of ~ 70 – 75 W/m^{o}K at ~ 50 ^{o}C. Water, the primary constituent of thermal inkjet ink has a thermal conductivity of ~ 0.64 W/m^{o}K at ~ 50 ^{o}C. And a typical printhead ink supply manifold plastic, Delrin (acetal - homopolymer), a has thermal conductivity of ~ 0.23 W/m^{o}K at ~ 23 ^{o}C. Thus, the material in the ink vias, largely water, has thermal conductivity ~ ((70-75)/0.64), i.e., ~ 112 times less than the silicon substrate material. The plastic ink manifold material to which the substrate is sealed, has thermal conductivity ~ ((70-75/0.23), i.e., ~ 315 times less than the silicon substrate material. **The heat introduced by the heater resistors to fire drops will be conducted more rapidly into the adjacent silicon regions that into the ink supply vias or plastic printhead components**.

45. Because of the thermal effects of the very low thermal conductivity ink supply slots, the PHOSITA would be motivated to sense the temperature on any side of a slot that had drop generators. In addition, the PHOSITA would understand that the **high thermal conductivity and large cross-sectional area of the silicon base material between ink vias would cause those regions to rapidly reach an equilibrium temperature,** allowing one sensor in such regions to adequately measure the temperature. This would be especially the case if the sensor were placed

in the middle region portion having full substrate thickness, i.e., away from the ink via edges and any silicon substrate undercutting caused by the through wafer thickness slot-forming method, i.e., ~ 360 microns for a 510 micron thick silicon substrate.

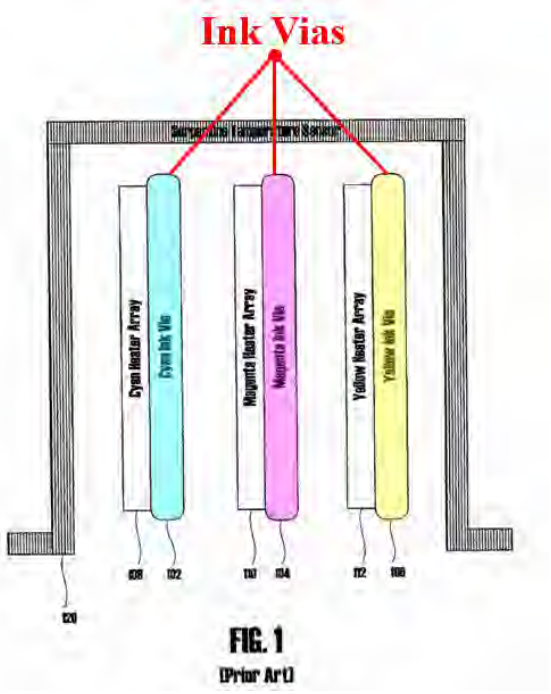
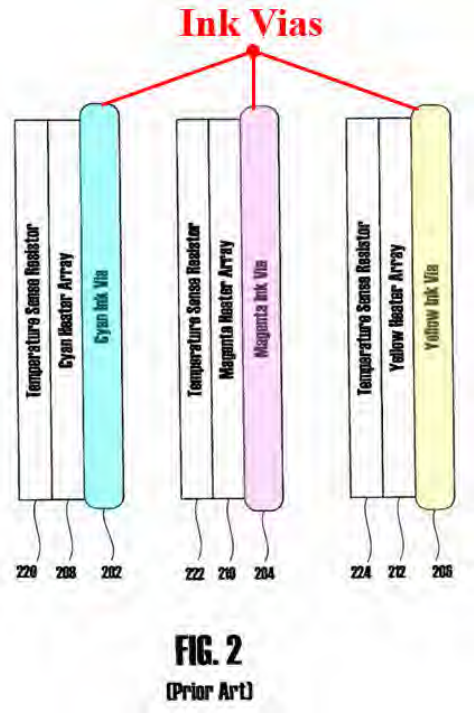
46. A PHOSITA would also realize that it would be advantageous to have a temperature sensor that integrated the temperature over the length of the ink via. The addition of heat to the heater array may be very non-uniform along the drop generator column, depending on the images being printed. Also, the heat flow path all along the ink via in the silicon substrate may be three or more times longer that the inter via distance, thereby increasing the time required for thermal equilibrium to be realized along that direction. A temperature sensor that was affected by temperatures along the via length would thereby quickly provide the printer temperature management system with average temperature data along the via length, that more closely approximates thermal equilibrium for the device. Conductive heat flow in the silicon would, in time, perform a similar averaging function, however, an extended thermal sensor would be **more timely.**

VIII. THE ’823 PATENT

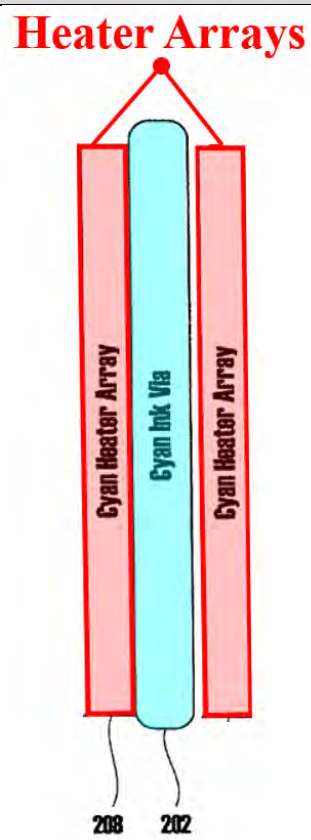
A. The Applicant-Admitted Prior Art

47. According to the ’823 Patent, “a number of printers, copiers, and multi-function products utilize heater chips in their printing heads for discharging ink

drops," which are "supplied through one or more ink vias in the chip." Ex.1001 at 1:21-23. Figures 1 and 2 depict two different prior art heater chips with multiple ink vias, which I have annotated and reproduced below.

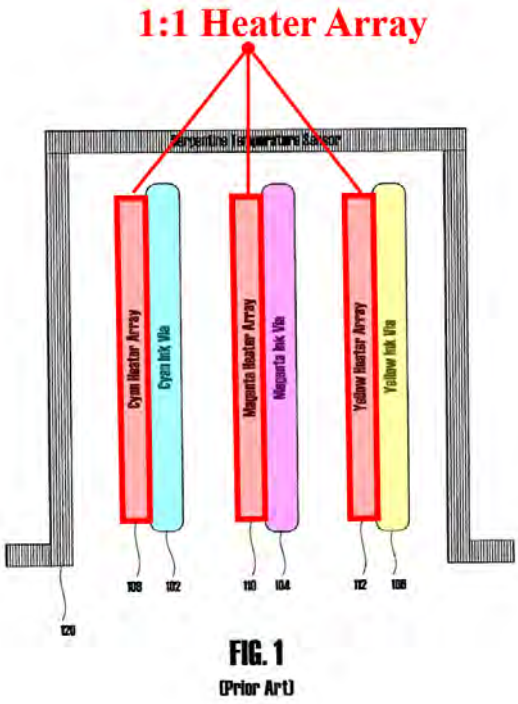
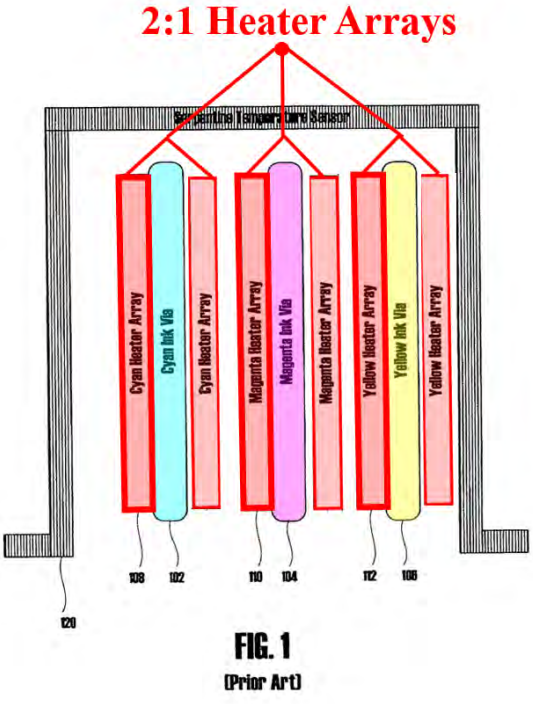
Prior Art: Multi-Via Heater Chip	Prior Art: Multi-Via Heater Chip
	

48. The '823 Patent admits that "heater chips ***typically*** provide only one heater array for each ink via that is disposed along one side of the ink via." Ex.1001 at 1:23-26. Put differently, the '823 Patent concedes that at least some prior art heater chips were known to provide two heater arrays for each ink via, and that each heater array was disposed along one side of the via. By "position[ing] heater arrays on both sides of the ink vias," the 2:1 arrangement "allow[s] the ink vias to provide smaller ink drops in order to achieve higher printing resolutions." Ex.1001 at 1:44-46.

Prior Art 1:1 Arrangement	Prior Art 2:1 Arrangement
	

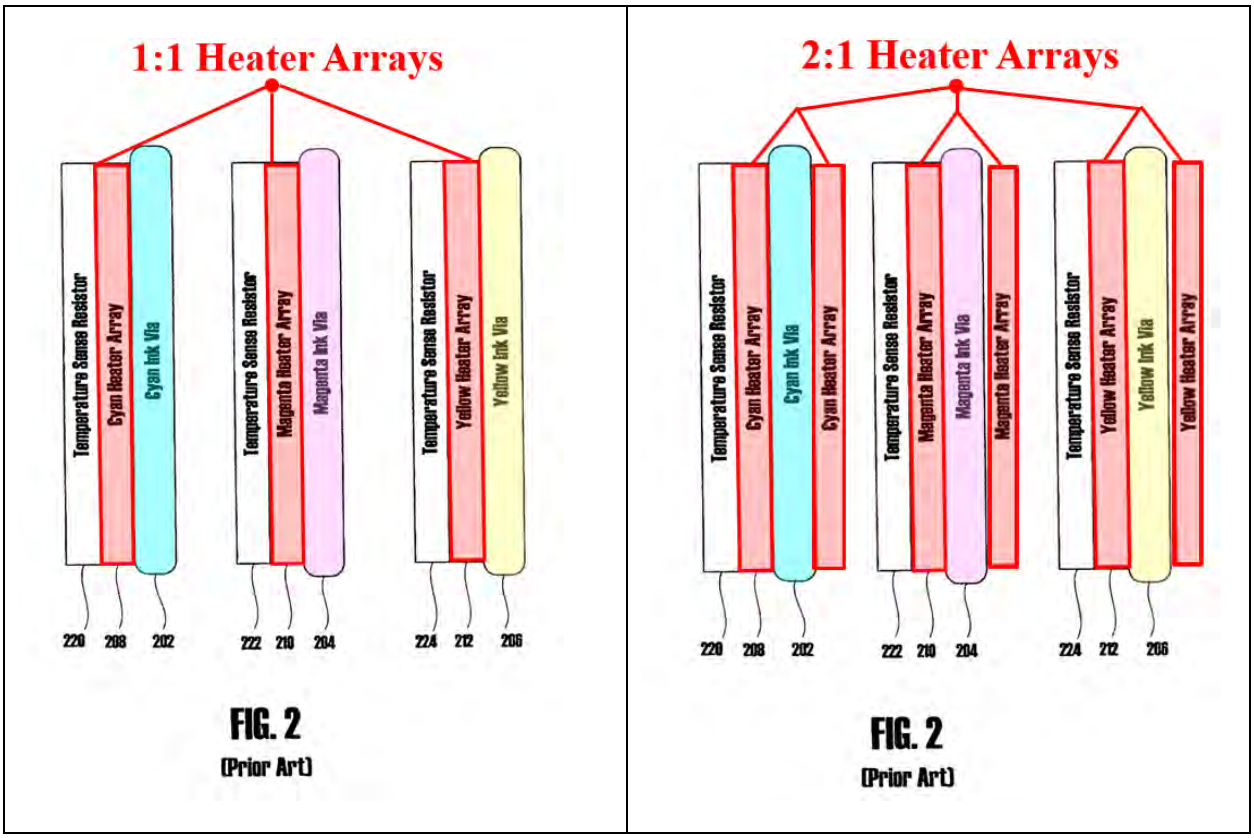
49. To be sure, the '823 Patent teaches that "a traditional heater chip 100 may include three ink vias—a cyan ink via 102, a magenta ink via 104, and a yellow ink via 106," as shown in annotated Figure 1 (reproduced below). Ex.1001 at 1:25-27. "The cyan ink via 102 operates with the cyan heater array 108; the magenta ink via 104 operates with the magenta heater array 110; and the yellow ink via 106 operates with the yellow heater array 112"—*i.e.*, the "typical" one heater per via arrangement used in prior art heater chips. *Id.* at 26-31. Modified Fig. 1 discloses another arrangement often used in prior art heater chips, i.e., the *two* heaters per via

arrangement. *See* Section VII.A above; Ex.1010 at 4:61-63, Figs. 3B, 4; Ex.1015 at 2:61-63, Fig. 2; Ex.1016 at 1:42-50, Fig.1.

Original Fig. 1	Modified Fig. 1
	

50. As yet another example, "FIG. 2 shows a heater chip which includes three ink vias, each connected to a single heater array. The cyan ink via 102 operates with the cyan heater array 108; the magenta ink via 104 operates with the magenta heater array 110; and the yellow ink via 106 operates with the yellow heater array 112." Ex.1001 at 1:27-31. Modified Figure 2 discloses a well-known two heaters per via arrangement used in prior art heater chips.

Original Fig. 2	Modified Fig. 2



51. The ‘823 Patent further recognizes that, “for proper functionality, inkjet heater chips need to monitor and maintain the silicon substrate of the heater chip at an acceptable temperature for printing.” Ex.1001 at 1:48-50. “If the temperature is too low,” for example, the ’823 Patent warns that “the ink drops formed will be smaller and have a lower drop-weight than that required for good image quality.” *Id.* at 1:51-53. And “[a]s the temperature rises,” the ’823 Patent teaches that “the drop-weight of the ink drop will rise. Variations in drop-weight will cause visible hue shifts in the printed image.” *Id.* at 1:54-55. For this reason, the ’823 Patent further concedes that “[a] thermal sense resistor (TSR) is typically used to sense the temperature of the silicon substrate.” Ex.1001 at 1:56-57.

52. Turning back to the heater chip shown in Fig. 1, the ‘823 Patent teaches that the temperature “is measured by way of a metal serpentine temperature sense resistor 120,” which “is routed *around the periphery of the heater chip* and provides an ***average temperature*** of the ***entire die***.” *Id.* at 1:57-62. According to the ’823 Patent, “[t]his average measurement provides no discrimination between individual colors and does not provide any feedback on temperature differences between one area of the heater chip versus another.” *Id.* at 1:62-65. The ’823 Patent criticizes “the metal serpentine temperature sense resistor 120 [because it] lacks the ability to control temperature on a per color or area basis.” *Id.* at 1:65-67.

Fig. 1: Sensing Average Temperature of Entire Die

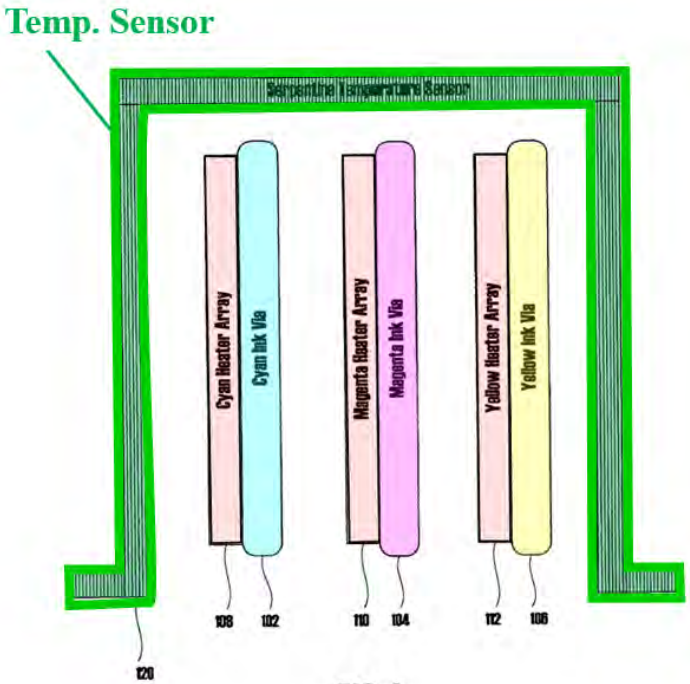


FIG. 1
(Prior Art)

53. Turning next to the heater chip shown in Fig. 2, "[t]hree temperature sense resistors 220, 222, and 224 are placed in close proximity to each of the heater arrays, each situated on the same side of their respective ink vias." Ex.1001 at 2:1-5. Because "[t]he ink vias 202, 204, and 206 act as a thermal barrier between the colors," the prior art heater chips situated "the thermal heater arrays 208, 210, and 212 on only one side of their respective ink vias, ensuring that there is only a small amount of thermal crosstalk between the temperature sense resistors." *Id.* at 2:10-15. According to the '823 Patent, "[t]he heater chip shown in FIG. 2 improves on that of FIG. 1 by providing for temperature sensing on a per color basis." *Id.* at 2:1-2.

54. "Once the temperature within the heater chip is measured" by the prior art heater chips, the '823 Patent teaches that "the temperature can be maintained and regulated at an acceptable temperature for printing," either by "substrate heating elements"—which are "used by traditional heater chips … to heat the silicon substrate to an acceptable temperature"—or by "fire pulses"—which "other heater chips apply to selected heater arrays of a short duration to maintain desired temperature." Ex.1001 at 2:16-22.

Fig. 2: Sensing Temperature on a Per Colour Basis

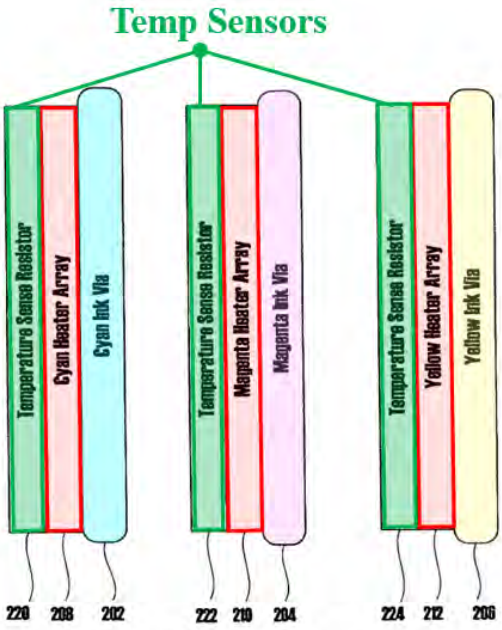


FIG. 2
(Prior Art)

55. Thus, the '823 Patent admits that prior art heater chips placed TSRs in one of two positions: (1) "around the periphery of the heater chip" to sense "an average temperature of the entire die" (as shown in Fig. 1), or (2) "in close proximity to each of the heater arrays" to sense temperature "on a per colour basis." Ex.1001 at 1:59-67.

B. The Purported Novelty of the Claimed Invention

56. The '823 Patent claims that the "prior art do not provide adequate thermal control" where "a heater array is positioned on both sides of an ink vias." *Id.* at 2:35-37. For example:

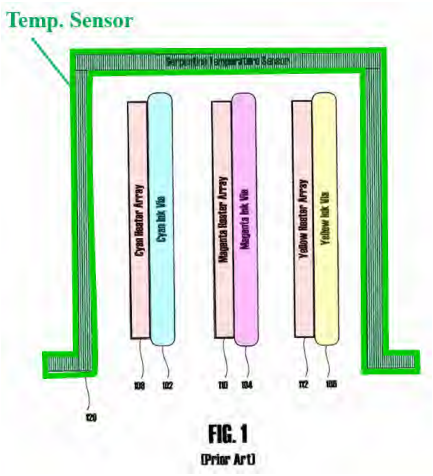


FIG. 1
(Prior Art)

"A serpentine temperature sense resistor 120, as depicted in FIG. 1 is not capable of discriminating between the individual colors of the heater arrays and does not provide any feedback on temperature difference between various areas of the heater chip." Ex.1001, 2:37-41

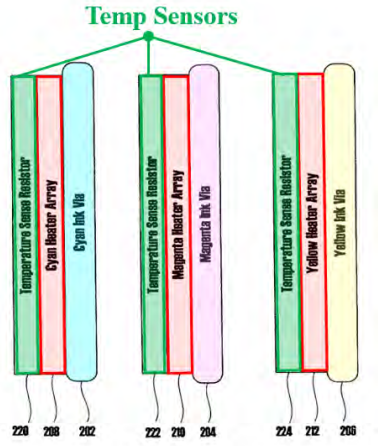


FIG. 2
(Prior Art)

"Further, monitoring and regulating the operating temperature on a per color basis by situating a temperature sense resistor on the same side of each respective ink via, as shown in FIG. 2, is insufficient due to the fact that heater arrays of more than one color now occupy the silicon region between ink vias." Ex.1001, 2:42-46.

Ex.1001 at 2:37-43; *Id.* at 2:43-48

57. "Without accurate temperature readings," the '823 Patent states that the "method of providing fire pulses to regulate thermal conditions on a per color basis would also be subject to error." *Id.* at 2:48-50. For this reason, the '823 Patent purports to solve "a need in the industry for heater chips that can provide for monitoring and regulating the various regions of a heater chip at a desired

temperature when heater arrays are placed on both sides of the ink vias." *Id.* at 2:50-54.

58. "Rather than try to sense temperature on a per color basis with TSRs in close proximity to heaters," the '823 Patent arranges TSRs to "sense[] temperature by silicon region." *Id.* at 6:1-5. To do so, the '823 Patent disposes "various thermal regions [*blue*] separated by insulating ink vias on the heater chip." *Id.* at 2:42-45. Within each region, the '823 Patent positions "[a] temperature sensing element [] in each of the thermal regions," each of which "is operable to measure the temperature of the silicon substrate in a corresponding thermal region." *Id.* at 2:43-45.

Ex1004, Fig. 5

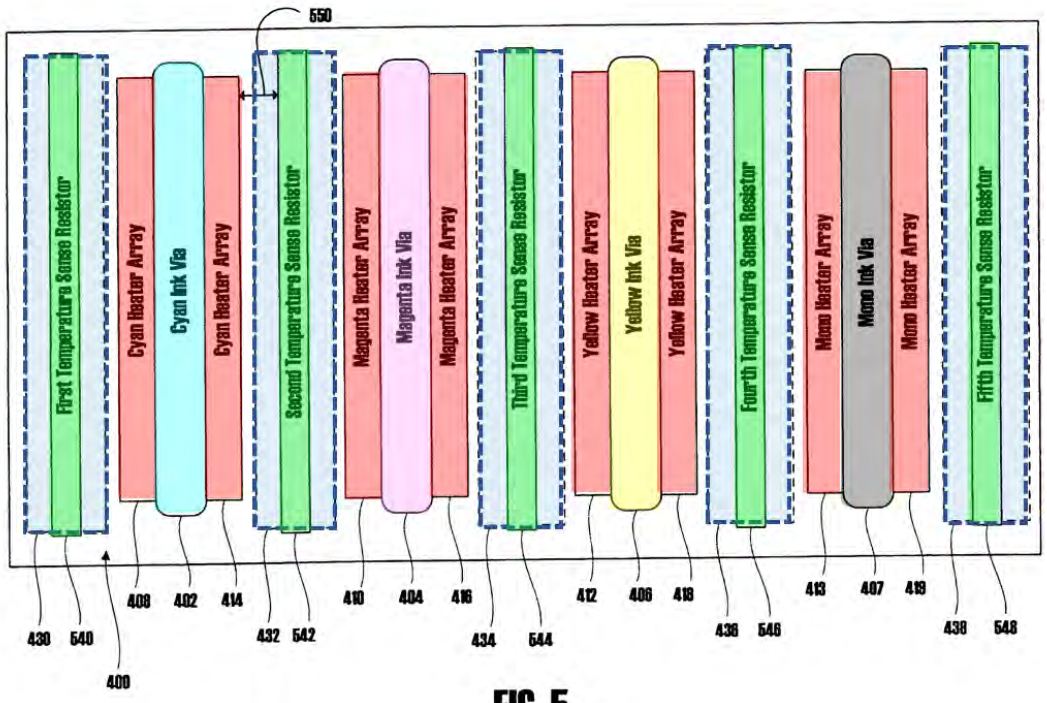


FIG. 5

59. While the ‘823 Patent teaches placing the TSRs “well away from the heater arrays [] at a distance [] of several hundred microns, rather than in close proximity to the heater arrays,” it also makes clear that “the TSRs [] need not be centered within their respective thermal regions, but rather, they can be positioned at any point within their respective thermal regions.” Ex.1001 at 6:61-7:10. By positioning the TSRs within each region, the ‘823 Patent teaches that “each thermal region can be regulated at its optimal operating temperature.” *Id.* at 8:29-30

IX. THE PRIOR ART

A. Summary of the Prior Art

60. I have been advised that U.S. Patent No. 7,384,113 to Benjamin *et al.* (“Benjamin”; Ex.1004) is pre-AIA 35 U.S.C. § 102(e) prior art to the ’823 Patent. Benjamin was filed on April 19, 2004, which is more than 20 months prior to the filing date of the ’823 Patent, *i.e.*, December 30, 2005. *Compare* Ex.1004 with Ex.1001.

61. I have been advised that U.S. Patent No. 6,612,673 to Giere *et al.* (“Giere673”; Ex.1005) is pre-AIA 35 U.S.C. § 102(b) prior art to the ’823 Patent. Giere673 was filed on April 29, 2002, which is more than 3 years prior to the filing date of the ‘823 Patent, i.e., December 30, 2005. *Compare* Ex.1005 *with* Ex.1001.

62. I have been advised that U.S. Patent No. 7,163,272 to Parish *et. al.* (“Parish”; Ex.1006) is pre-AIA 35 U.S.C. § 102(e) prior art to the ’823 Patent.

Parish was filed on June 10, 2004, which is more than 18 months prior to the filing date of the ’823 Patent, *i.e.*, December 30, 2005. *Compare* Ex.1006 *with* Ex.1001.

63. I have been advised that U.S. Patent No. 6,565,178 to Giere *et. al.* (“Giere178”; Ex.1007) is pre-AIA 35 U.S.C. § 102(b) and (e) prior art to the ’823 Patent. Giere178 was filed on October 29, 2001 which is more than 4 years prior to the filing date of the ’823 Patent, *i.e.*, December 30, 2005. *Compare* Ex.1007 *with* Ex.1001.

64. I have been advised that U.S. Patent No. 6,527,367 to Yabe *et. al.* (“Yabe”; Ex.1008) is pre-AIA 35 U.S.C. § 102(b) prior art to the ’823 Patent. Yabe was filed on September 4, 2001 which is more than 4 years prior to the filing date of the ’823 Patent, *i.e.*, December 30, 2005. *Compare* Ex.1008 *with* Ex.1001.

B. Brief Description of the Prior Art

1. U.S. Patent No. 7,384,113 to Benjamin et al. (“Benjamin”; Ex.1004)

65. Benjamin is a Hewlett-Packard Development Company, L.P. patent publication directed to a thermal ink jet printhead. *See, e.g.*, Ex.1004. Benjamin was neither cited nor considered by the Patent Office during prosecution of the ’823 Patent.

66. Figure 21 of Benjamin provides “a diagram illustrating an example layout of one embodiment of a printhead die 1700.” Ex.1004 at 64:53-54; *see below id*. at Fig. 21.

Ex.1005, Fig. 21.

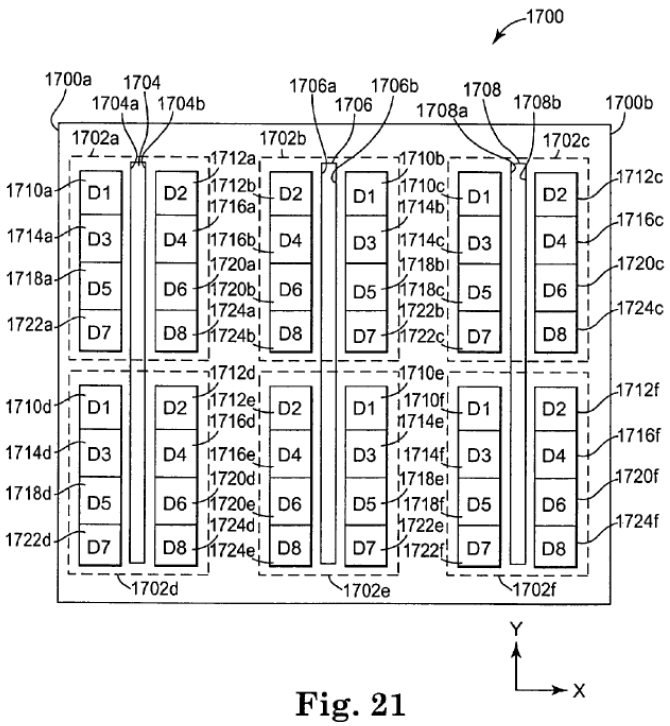


Fig. 21

67. As seen in Figure 21, the "printhead die 1700 includes six fire groups 1702a-1702f disposed along three ink fluid feed sources, here depicted as feed slots 1704, 1706 and 1823." Ex.1004 at 64:54-56. Benjamin further explains that "[t]he fire groups 1702a-1702f are divided into eight data line groups, indicated at D1-D8 and that "[e]ach data line group D1-D8 includes pre-charged firing cells 120 from each of the fire groups 1702a-1702f." Ex.1004 at 65:6-8.

68. Figure 22 of Benjamin provides "another aspect of the example layout of one embodiment of printhead die 1700." Ex.1004 at 69:13-14; *see below id.* at Fig. 22.

Ex.1004, Fig. 22

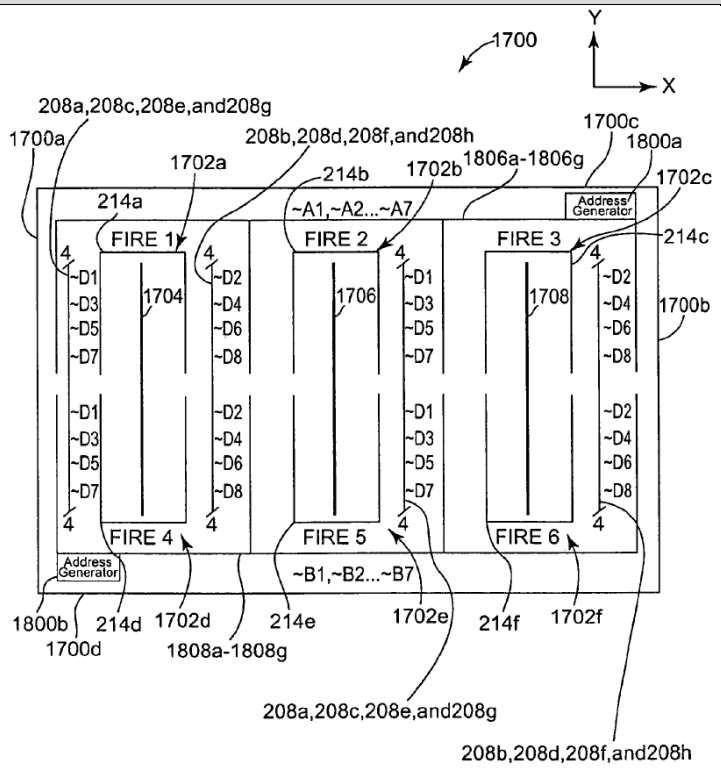


Fig. 22

69. Benjamin explains that as seen in Fig. 22, the "conductive fire lines 214a-214f are located along ink feed slots 1704, 1706 and 1823 to supply energy signals FIRE1, FIRE2 . . . FIRE6 to the fire groups 1702a-1702f, respectively. Ex.1004 at 71:23-26. Benjamin further notes that the "fire lines 214a-214 supply energy to firing resistors 52 in conducting pre-charged firing cells 120 to heat and eject ink from drop generators 60," and "the corresponding fire line 214a-214f is configured to uniformly supply energy to each firing resistor 52 in the fire group 1702a-1702f." Ex.1004 at 71:26-32.

70. Benjamin further explains that "the address signals may be provided from an external source" as opposed to being placed on the printhead die itself. Ex.1004 at 79:23-24. Figures 25A-25B depict "contact areas 2000 of a flex circuit 2002 that may be utilized to couple external circuitry to a printhead die 40." Ex.1004 at 79:29-31; *see below id.* at Figs. 25A and 25B.

Ex.1005, Fig. 25A-25B

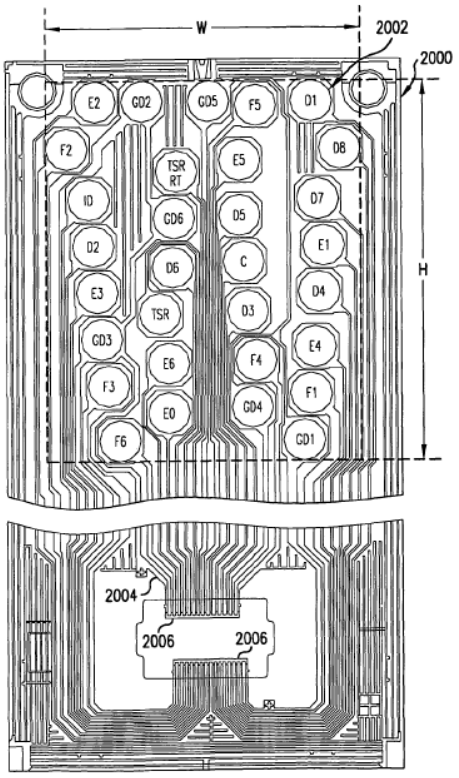


FIG.25A

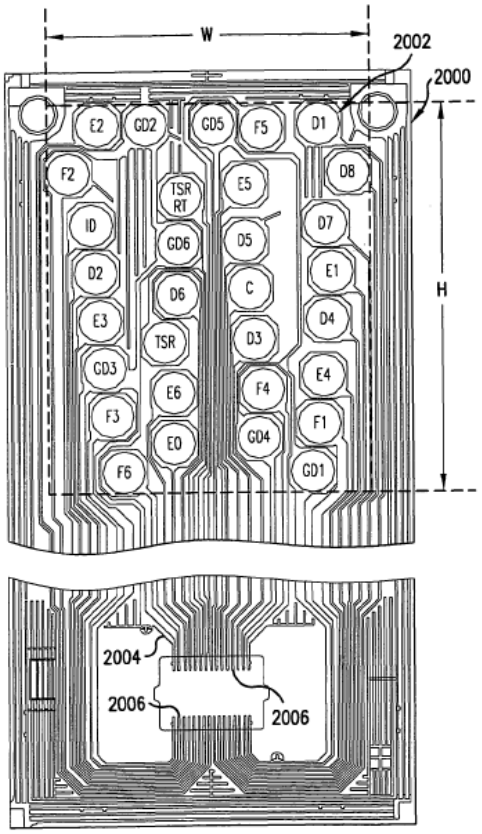


FIG.25B

71. Benjamin explains that Figure 25 shows "[f]ire line contact areas F1-F6 configured to receive energy pulses and to provide the energy signals along fire lines Fire1-Fire6 to the appropriate fire groups, e.g. fire groups 202a-202f and

1702a-1702f." Ex.1004 at 79:50-52. Benjamin further teaches "[t]he contact areas 2000 [i.e., F1-F6] are electrically coupled via conductive paths 2004 to contacts 2006 which provide coupling to the printhead die." Ex.1004 at 79:32-34.

2. U.S. Patent No. 6,612,673 to Giere et al. ("Giere673"; Ex.1005)

72. Giere673 is a Hewlett-Packard Development Company, L.P. patent directed to a system and method for predicting dynamic thermal conditions of an inkjet printing system. Ex.1005 at Title ("System and Method for Predicting Dynamic Thermal Conditions of an Inkjet Printing System"). Giere673 was neither cited nor considered by the Patent Office during prosecution of the '823 Patent.

13. Figure 1 of Giere673 provides a block diagram of an overall printing system incorporating one embodiment of the present invention. Ex.1005 at Fig. 1. The figure shows a temperature control "system 110" [*colored yellow below in Fig. 1*]; for predicting dynamic thermal conditions of the printhead assembly 102. Ex.1005 at 2:50-51.

Ex.1005, Fig. 1

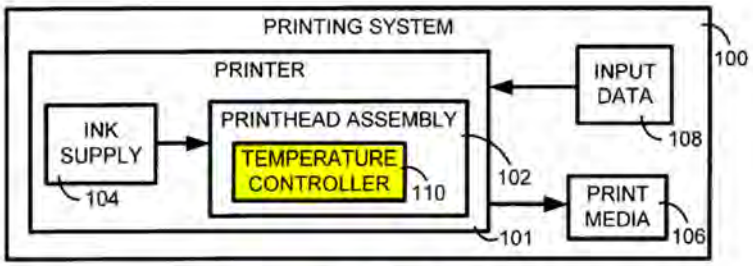


FIG. 1

73. Giere673 further explains that "in general, the temperature controller 110 is coupled to multiple temperature sensors (not shown). The multiple temperature sensors preferably determine, at a given time, a mean or average temperature of the substrate and an actual local temperature profile near designated ink ejection elements." Ex.1005 at 2:60-61.

74. Giere673 further provides "when the sensors detect that the mean temperature of the substrate has dropped below a predefined baseline or threshold temperature, the loop activates the heating elements in an effort to raise the substrate above the baseline temperature before printing.

75. Figure 3 of Giere673 provides "a perspective view of an exemplary cartridge." Ex.1005 at 2:1-2. Giere673 further explains that "the embodiments of the present invention can be incorporated in any printhead and printer configuration." Ex.1005 at 3:49-51.

Ex.1005, Fig. 3

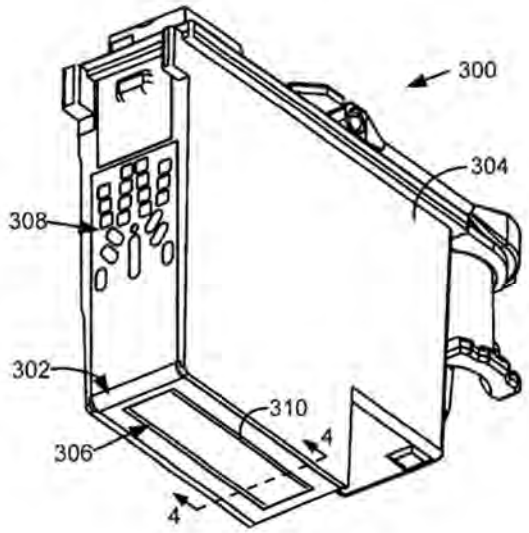
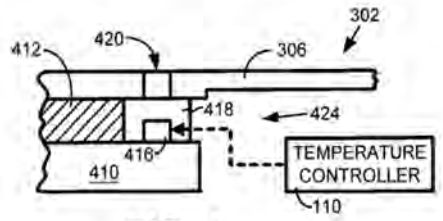
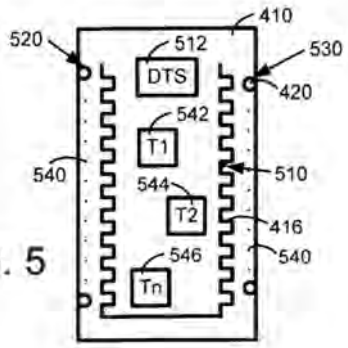


FIG. 3

76. Referring to Figs. 1-4 along of Giere673 along with Fig. 4, the temperature controller 110 of Fig. 1 is coupled to at least one measurement sensor. Ex.1005 at 4:51-52. In one embodiment, there are two measurement sensors, namely, a thermal sense resistor (TSR) 510 and a digital temperature sensor (DTS). Ex.1005 at 4:52-54. One or multiple TSRs 510 can be used to provide an approximation of the mean temperature of the substrate. Ex.1005 at 4:55-56 Preferably it is not located adjacent to any particular heating element and reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510. Ex.1005 at 4:57-61 The TSR 510 therefore reports a temperature that reflects heating element firings that have already occurred. Ex.1005 at 4:60-61.

Ex.1005, Figs. 4-5	
 FIG. 4	 FIG. 5

77. In one embodiment of Giere673, the DTS 512 shown in Fig. 5 is located on the substrate 410 referenced in Fig. 4-5, centrally between the first and second rows 520, 530 of the lower numbered nozzles at the top portion of the substrate referenced in Fig. 5. Ex.1005 at 5:6-9 . The TSR 510 is located along the length of the substrate 410 Fig. 4-5. Ex.1005 at 5:6-7. The TSR 510 in Fig 5 can have two legs that are approximately 680 μm inward from the center of the columns of ink ejection elements 416 and 540 from Figure 4 and 5. Ex.1005 at 5:10-12. .

78. The temperature logic system in Giere673 uses these temperature and printing inputs, as well as some embedded knowledge (such as latencies in the response of the sensors to firing, and conduction paths between different nozzles, e.g., where there are slots separating some nozzles but not others), to generate

printing parameters and then output them in a closed loop system to the actual substrate temperature profile 610. Ex.1005 at 6-46-53.

Ex.1005, Figs. 6A-6B

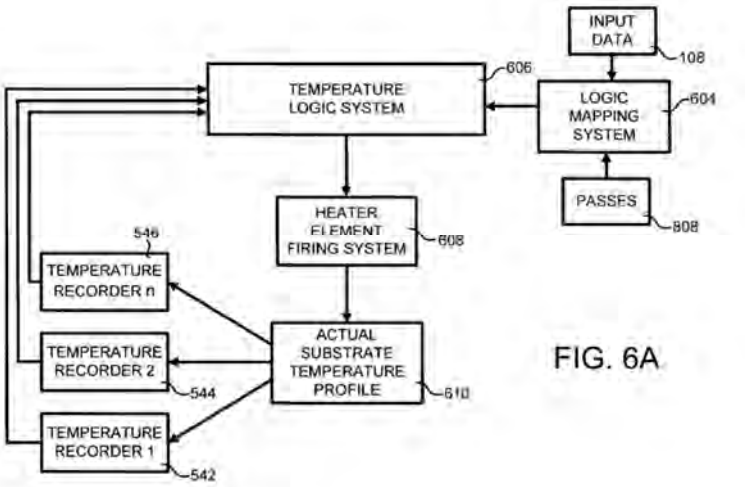


FIG. 6A

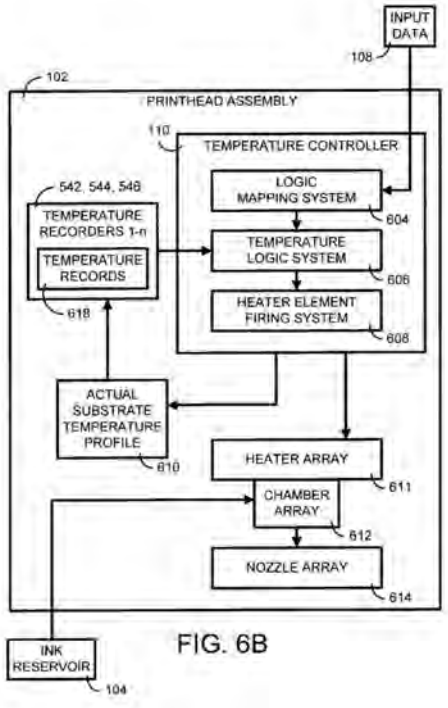


FIG. 6B

79. The temperature logic system in Giere673 also generates firing voltages 814 and activates heater elements that do not eject ink 816. The heat from the heater elements will have to pass through the body of the substrate before reaching the temperature recorders 542, 544, 546. Ex.1005 at 9:25-27. Therefore, there will be a difference in temperature between the recorder and the heater elements. Ex.1005 at 9:27-29. The controller element that calculates latency 810 will allow for this difference. Ex.1005 at 9:29-30.

Ex.1005, Fig. 8

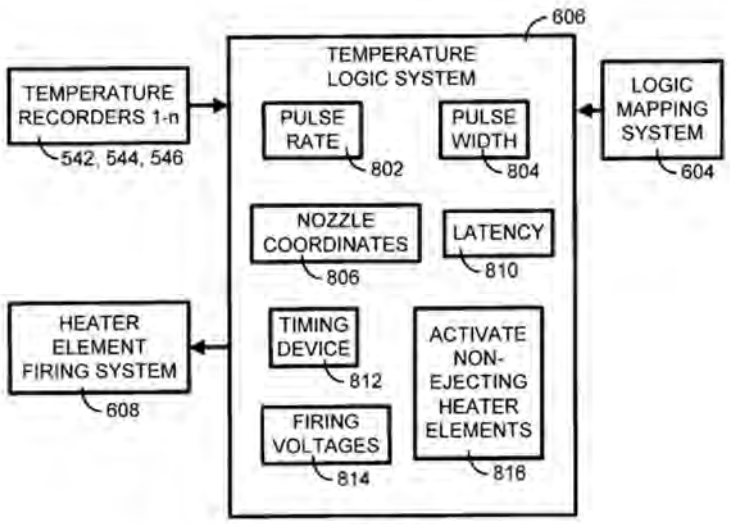


FIG. 8

3. U.S. Patent No. 7,163,272 to Parish et al. ("Parish"; Ex.1006)

80. The assignee listed on the face of Parish is a Lexmark International, Inc. The listed inventors are George K. Parish and Kristi M. Rowe. Parish was not cited or considered by the Patent Office during prosecution of the '823 Patent.

81. Parish is directed to temperature controls for inkjet printheads using temperature sensors. *See* Ex.1006 at Abstract.

82. Parish discloses that "[i]nkjet print heads typically require a well-controlled substrate temperature to maintain a consistent ink viscosity and jetting performance." To meet this requirement, Parish discloses that "[c]urrently, inkjet print heads include a temperature sense resistor (TSR) integrated into a chip to monitor the substrate temperature" and "a printer control unit periodically monitors the TSR(s) to determine the substrate temperature." Ex.1006 at 1:9-18. Then, "the control unit turns heating elements on and off, accordingly, to maintain the proper substrate temperature for optimum jetting performance." Ex.1006 at 1:19-21.

83. Parish discloses that in the present invention, "**one or more temperature sense elements can be positioned with respect to the inkjet print head such that the temperature sense element(s) can provide accurate temperature readings** while not interfering with ink flow or while providing reduced interference with ink flow." Ex.1006 at 1:33-39.

84. Parish, like the ’823 Patent, discloses a printhead chip having an ink via with heater arrays on either side. For example, with respect to Figure 3 (below), Parish discloses that “[a] portion of the inkjet print head 10, particularly the substrate (e.g., chip) 16, [includes]…heating **elements 32** are arranged into a **first heating array 50** [*red*] and a **second heating array 52** [*red*].” Ex.1006 at 4:61-65; Ex.1006 at 4:40-41 (“heating elements 32 can include any element capable of converting electrical energy into heat, such as a transducer or resistor.”). Parish further states that “**the array of actuators substantially parallel [to] the longitudinal extent of the ink via 68 [*magenta*] on either sides 71, 73 thereof**….” Ex.1006 at 6:9-11.

Ex.1006, Fig. 3

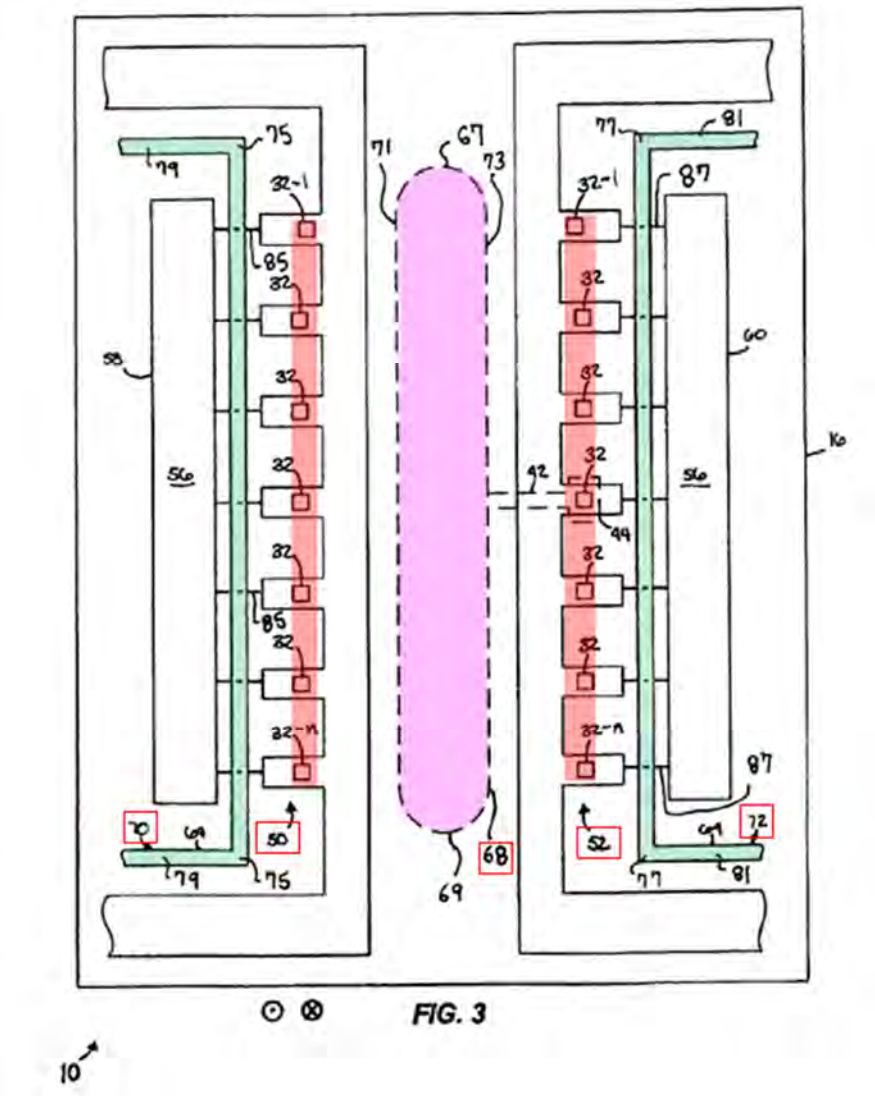


FIG. 3

85. Parish further discloses that printhead chip 16 includes temperature sense resistors (TSRs). Ex.1006 at 5:30-34 ("chip 16 further includes at least one temperature sense element positioned to sense a temperature of a location on the print head 10….the temperature sense element is or comprises a temperature sense resistor (TSR) 64."). With respect to Figure 3 (above), Parish discloses that "TSR's

70, 72 [*green*] have a longitudinal extent that is substantially parallel along and to an entire length of arrays 50, 52, [*red*] respectively, such as between individual heating elements 32-1 and 32-n." Ex.1006 at 6:5-8. As such, "each TSR is able to sense local heating per an entire array and not just a portion thereof." Ex.1006 at 6:16-18.

86. Parish further explains that the TSR 64 can include a polysilicon material or another material responsive to temperature. *See e.g.,* Ex.1006 at 5:34-35. For example, "TSR can include a N-type source drain (NSD) material, a N-well layer material...or another suitable material." *See e.g.,* Ex.1006 at 5:35-38.

87. Finally, Parish discloses that its TSR "senses the temperature of the chip 16, one or more of the heating elements 32, the ink chamber 44, or other location of the print head 10 and provides this information to the printer controller 30 or another circuit." Ex.1006 at 5:43-47. Like the '823 Patent, Parish recognizes that the ink via in the printhead chip "acts as a thermal insulator between each array 50, 52". Ex.1006 at 6:18-19; Compare with Ex.1006 at 5:64-67 ("The ink vias 402, 404, 406, 407, on the other hand, act as thermal insulators between the thermal regions 430, 432, 434, 436, 438.")]. To address that problem, Parish incorporates heater arrays [50, 52, *red*] and TSRs [70, 72, *green*] on both sides of the ink via [68, *magenta*].

4. U.S. Patent No. 6,565,178 to Giere et al. ("Giere178"; Ex.1007)

88. The assignee listed on the face of Giere178 is Hewlett-Packard Development Company, L.P. The listed inventors are Matthew D. Giere, Satya Prakash, and Michael J. Barbour. Giere178 was not cited or considered by the Patent Office during prosecution of the '823 Patent.

89. Giere178 is directed to a temperature management system for an inkjet printhead. Giere178 discloses heater chips with multiple ink vias and a heater array disposed on both sides of each ink via, and more specifically, to sensing the heater chip substrate in regions disposed on each side of the ink vias.

90. Giere178 describes the structure and operation of a typical inkjet printhead:

> The **typical inkjet printhead** (i.e., a silicon substrate having a plurality of thin film layers, structures built on the substrate, and connections to the substrate) uses liquid ink (i.e., dissolved colorants or pigments dispersed in a solvent). It has an array of precisely formed orifices or nozzles attached to a printhead substrate that incorporates an array of ink ejection chambers which receive liquid ink from the ink reservoir. Each chamber is located opposite the nozzle so ink can collect between it and the nozzle. The ejection of ink droplets is typically done under the control of a microprocessor, the signals of which are conveyed by electrical traces to the ink ejection element. The ink ejection element includes a firing resistor. When electric printing pulses are supplied to the firing resistor, a small portion of the ink next to it vaporizes and ejects a drop of ink from the printhead.

Ex.1007 at 2:59-3:6.

91. Giere178 further explains that an increase in printhead temperature caused by firing nozzles at high frequency can result in a degradation in print quality:

> **The rate at which signals are supplied to resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead**. **For a printhead where there is no attempt made to stabilize the temperature of the substrate, the temperature of the substrate can change substantially during use of the printhead depending upon changes in the firing frequency of the nozzles over time**. Localized heating of the substrate can occur from firing nozzles at a greater frequency in a particular region of the printhead. The localized heating effect can more readily occur for larger size printheads than smaller size printheads because of the larger thermal resistance across the substrate of the larger size printheads as compared to smaller size printheads. **If at least some compensation is not made for these temperature changes, a perceptible degradation in print quality can result**.

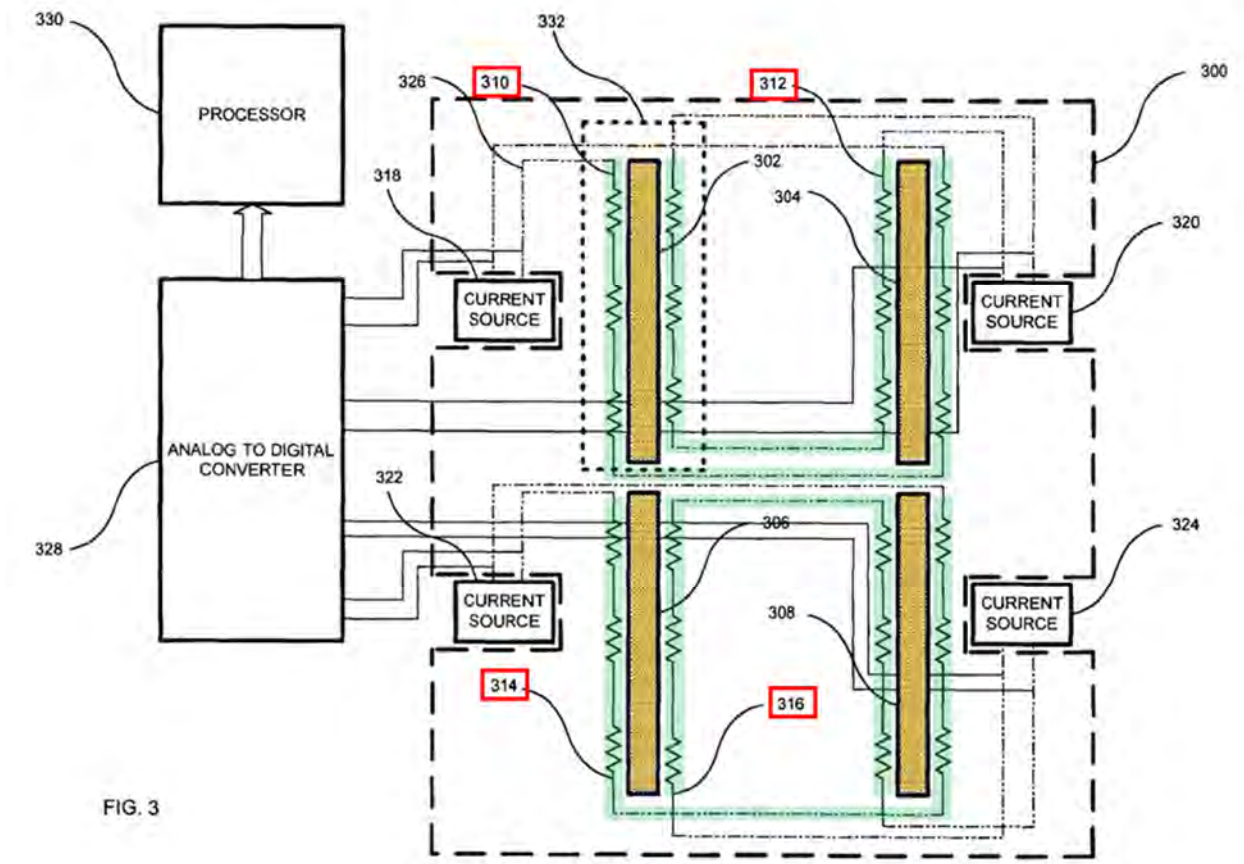
Ex.1005 at 5:36-51.

92. Specifically, Giere178 explains that "the mass of ejected ink drops increases as the temperature of the structure surrounding the ink ejection chamber increases." Ex.1007 at 5:23-25. As a result of the excessive quantity of ink applied per drop print quality can degrade with undesirable shifts in hue, chroma, and the luminance of regions, as well as reduction in the sharpness of the edges when the image is formed onto paper. Ex.1007 at 5:62-6:3. Giere178 discloses a "temperature management system" to control these undesirable effects that temperature can have on print quality.

93. Figure 3 of Giere178 provides a "high level schematic diagram of an embodiment of the temperature measurement system implemented upon an

embodiment of a printhead." Ex.1007 at 8:41-43. Giere178 further discloses that the "printhead is formed upon substrate 300." Ex.1007 at 8:43-44.

Ex.1007, Fig. 3



94. Giere178 discloses that "substrate 300 includes the structures of a typical printhead such as, **ink feed slots, ink ejection chambers, firing resistors**, etc.." Ex.1007 at 8:45-47. Giere178 also discloses "regions 302, 304, 306, and 308 each include an **array of nozzles and associated firing resistors for ejecting ink**." Ex.1007 at 8:47-49.

95. Giere178 uses four temperature sense resistors (e.g., resistive elements 310, 312, 314, and 316) (*green* in Fig. 3 above) located on the substrate 300 to "**assume the temperature of the local region of substrate 300 on which they are placed**." Ex.1007 at 8:53-54. Giere178 discloses that by using these resistive elements "a measurement of the temperature change of regions of substrate 300 can be determined." Ex.1007 at 9:46-48. Giere178 further discloses that using its "temperature compensation system" the temperature of the substrate can be "controlled substantially at a desired temperature" using various methods, such as adjusting the pulse width of the drive signals supplied to the firing resistors or controlling resistive heating elements thermally coupled to the substrate to maintain the substrate at a desired temperature. Ex.1007 at 9:50-64.

5. U.S. Patent No. 6,527,367 to Yabe et al. ("Yabe"; Ex.1008)

96. The assignee listed on the face of Yabe is Canon Kabushiki Kaisha. The sole listed inventor is Kenji Yabe. Yabe was neither cited nor considered by the Patent Office during prosecution of the '823 Patent.

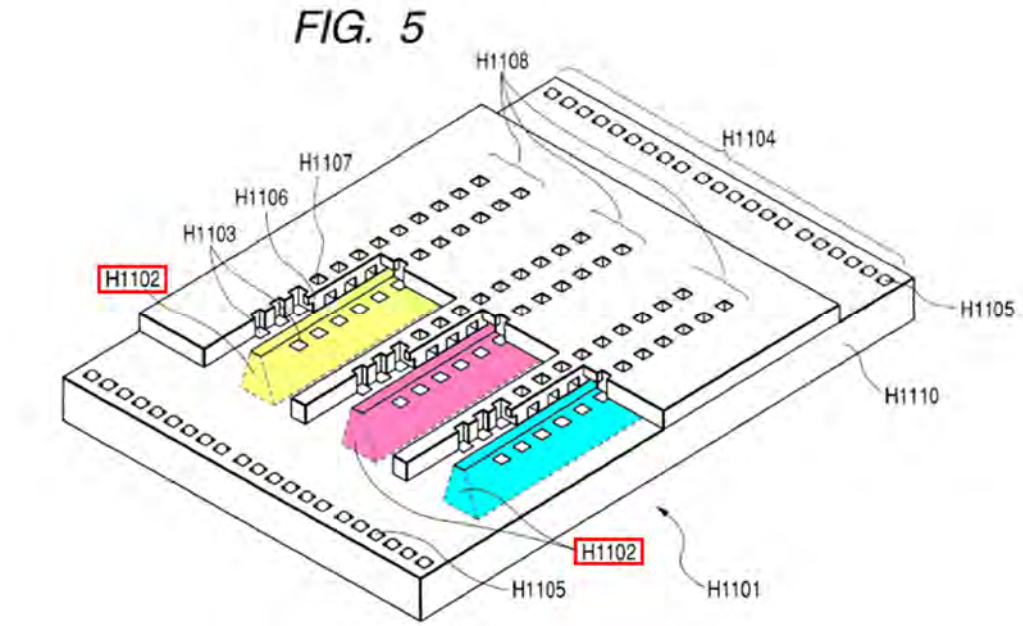
97. Yabe is generally directed to heater chips with multiple ink vias and a heater array disposed on both sides of each ink via, and more specifically, to sensing the temperature of regions of the heater chip adjacent the ink vias and heater arrays.

98. Yabe discloses that inkjet printheads having higher image quality and faster printing capability are desired. Ex.1008 at 2:23-26 ("the performance required

for the ink jet recording head at present should be such as to record in the image quality in precision higher still at recording speed faster still."). To achieve higher image quality, Yabe states that "it is required to discharge finer ink droplets under well-conditioned control." Ex.1008 at 2:23-26. To achieve faster print speeds, Yabe states that "it is required to increase the number of heaters for use of ink discharges." Ex.1008 at 2:31-33.

99. Thus, according to Yabe, to attain more precise images at faster recording speeds, "it is considered effective to **adopt the structure of the so-called side shooter type** where ink droplets are discharged in the direction perpendicular to the heater board which is the base plate having heat generating resistive elements for use of ink discharges formed therefor." Ex.1008 at 2:34-40. The "side shooter type" printhead, as illustrated in Yabe's Figure 5 (below), uses a recording element base plate (H1101) having a **plurality of ink vias** (H1102) (*yellow, magenta, cyan*) wherein "the ink supply into the head is made from the reverse side of each heat generating resistive element of the heater board by way of the **through opening that penetrates the heater board [i.e., ink vias]**." Ex.1008 at 2:41-43; *see also id.* at 3:16-18 ("in the mode of the side shooter recording head, a plurality of ink supply ports provided for the heater board…").

Ex.1008, Fig. 12



100. Yabe further states that by using ink vias wherein ink is supplied from the reverse side of the substrate the printhead can be more compact because "it becomes unnecessary to make the distance between the discharge ports and a recording medium larger owing to the presence of a member for supplying ink to the head." Ex.1008 at 2:43-47.

101. Yabe emphasizes that using a ***plurality*** of ink supply vias (ports) (versus a single ink supply port) on a single printhead chip can be used to form images with high precision and speed. Ex.1008 at 5:19-23. ("With the side shooter type recording head structured as described above, it is compatible to form images in high precision and to attain a high printing speed… Conceivably, **therefore, a**

plurality of ink supply ports are provided for one heater board."). Moreover, bidirectional printing with an even color application is achievable using a plurality of ink supply ports on a printhead. Ex.1008 at 5:24-27. ("**[t]hen, for example, it becomes possible to implement the bidirectional printing without color unevenness by arranging plural ink supply ports for one and the same color ink in the head scanning direction**.")

102. In fact, Yabe explains that there is a tendency to increase not only ink supply ports but also the number of ink drops and heaters on a printhead to meet the industry necessity for higher precision of recorded images at higher recording speed. Ex.1008 at 3:35-39. ("As described above, there is a tendency that **the discharge ports, the number of heaters arranged for one heater board, and the number of ink supply ports are increased to cope with the necessity of higher precision of recorded images at higher recording speed for an ink jet recording head**.").

103. Yabe also discloses that using more heaters, and therefore, more nozzles (i.e., discharge ports) is useful for discharging different color inks from a printhead. Ex.1008 at 2:50-54 ("for the recording head of side shooter type, a **plurality of discharge ports** can be arranged on the plane with the advantages in forming a structure in which ink droplets of plural colors should be discharged.").

104. As such, Yabe's "invention aims at the provision of an ink jet recording head of the so-called side shooter type where heater lines and ink supply ports for

use of plural colors are arranged for one heater board, which has attained the higher preciseness of the quality of recorded images at higher recording speed in a smaller size of the head itself, by arranging the layout of diode sensors and sub-heaters appropriately." Ex.1008 at 3:55-62.

105. Additionally, Yabe recognized the importance of accurately monitoring certain regions of the heater chip substrate where the plurality of ink vias act as insulators for heat transfer through the heater chip substrate material. Ex.1008 at 3:17-27. ("it is found that in the mode of the side shooter recording head, a plurality of **ink supply ports provided for the heater board demonstrate the heat insulating characteristic against the heater board material**, and that this condition is the factor that should be taken into consideration when dealing with the problems described above…In other words, depending on the layout of the diode sensors and sub-heaters, the **heat radiating action and the heat conduction of the heater board are deteriorated by the presence of the plural ink supply ports** that shows the heat insulating characteristics.").

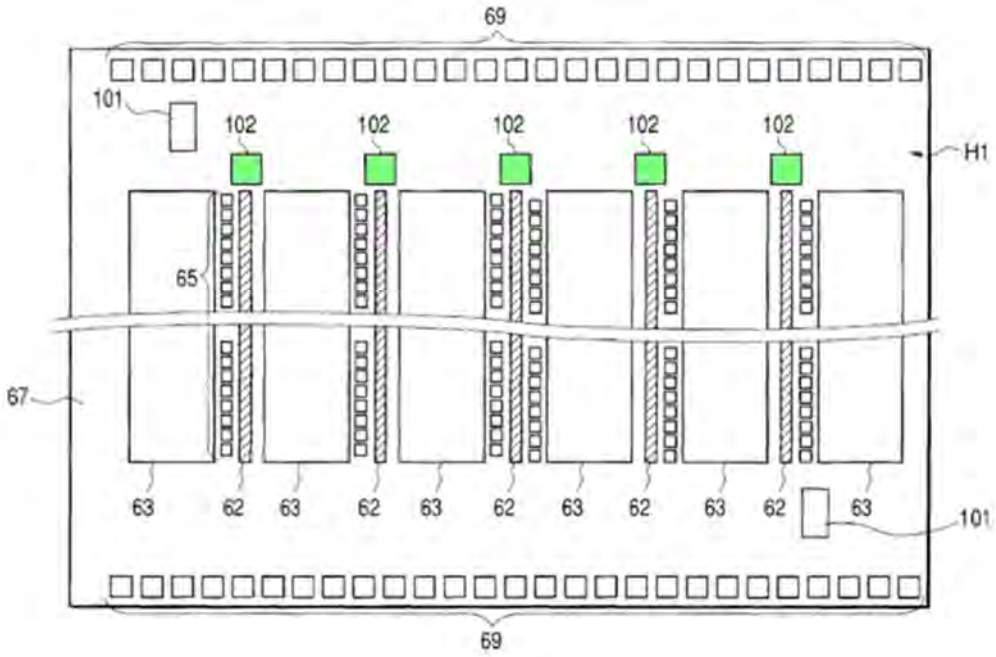
106. To address this issue, Yabe discloses a means for efficiently measuring and controlling the temperature of the heater board of a printhead having plural ink vias with associated heater arrays on either side so as to maintain high quality printing. Ex.1008 at 3:55-62 ("the present invention aims at the provision of an ink jet recording head of the so-called side shooter type where **heater lines and ink**

supply ports for use of plural colors are arranged for one heater board, which has attained the higher preciseness of the quality of recorded images at higher recording speed in a smaller size of the head itself, by arranging the layout of diode sensors and sub-heaters appropriately."); *see also id.* at 3:45-54 ("it is necessary to prevent the 'initial discharge performance' from being deteriorated and the color tone of recorded images from becoming unstable" and, as such, "there should be **provided means for measuring the temperature of the heater board more efficiently** in accordance with the temperature characteristics obtainable by temperature detecting means, **as well as means for controlling the temperature of the heater board efficiently** in accordance with such measurement information.").

107. For example, Yabe's Figure 12 shows a plurality of "temperature detecting means 102 [green]" that are diode sensors used to detect heat at discrete locations on the heater board.

Ex.1008, Fig. 12

FIG. 12



X. PERSON HAVING ORDINARY SKILL IN THE ART

108. I was also asked to provide an opinion regarding the skill level of a PHOSITA of the '823 Patent during the period leading up to December 30, 2005. I considered several factors, including the types of problems encountered in the art, the solutions to those problems, the pace of innovation in the field, the sophistication of the technology, and the education level of active workers in the field.

109. In my opinion, a PHOSITA at the time of the alleged invention of the '823 Patent would have been a person holding a Bachelor's or Master's level college degree in Mechanical Engineering, Materials Science, Physics, Electrical

Engineering, or a related field, and two years of training or experience in the design of inkjet printheads or semiconductor circuit layout.

110. At all relevant times, I have had a level of skill as great as a PHOSITA. I am able to provide insight into the understanding of one of ordinary skill in this art at all relevant times by virtue of my education, training, and experience. All of my opinions expressed herein are as viewed through the eyes of a PHOSITA before the alleged priority date.

XI. GROUND 1: BENJAMIN IN VIEW OF GIERE673 RENDERS OBVIOUS CLAIMS 1-3, 5-13, and 15-17

111. In my opinion, the Benjamin-Giere673 combination discloses all of the limitations of claims 1-3, 5-13, and 15-17 of the ’823 Patent.

A. Claim 1

1. 1[P] “A chip for use with a printing device”

112. I have been informed by counsel that a preamble is generally not limiting unless it is necessary to give life, meaning, and vitality to the claim. I understand that the preamble here is not limiting because it merely states the intended use of the purported invention and is not a limitation of the independent claim.

113. To the extent the preamble is determined to be limiting, it is my opinion that Benjamin discloses “a chip for use with a printing device.”

114. Benjamin discloses a "an inkjet printing system 20"—*e.g.*, an inkjet printer or other printing device—that comprises, among other things, (i) an "inkjet printhead assembly 22" (*yellow in Figure 1 below*) with at least "one printhead or **printhead die 40**" (*magenta*) that "causes characters, symbols, and/or other graphics or images to be printed upon [a] print medium 36" (*orange*) "such as paper," (ii) an "ink supply assembly 24" that supplies liquid ink from an ink reservoir (*cyan*) to the printheads 40 on the printhead assembly, and (iii) an "electronic controller" (*green*) that controls the printhead die 40 and "defines a pattern of ejected ink drops that form characters, symbols, and/or other graphics or images on print medium 36." Ex.1004 at 3:32-33.

Ex.1004, Fig. 1

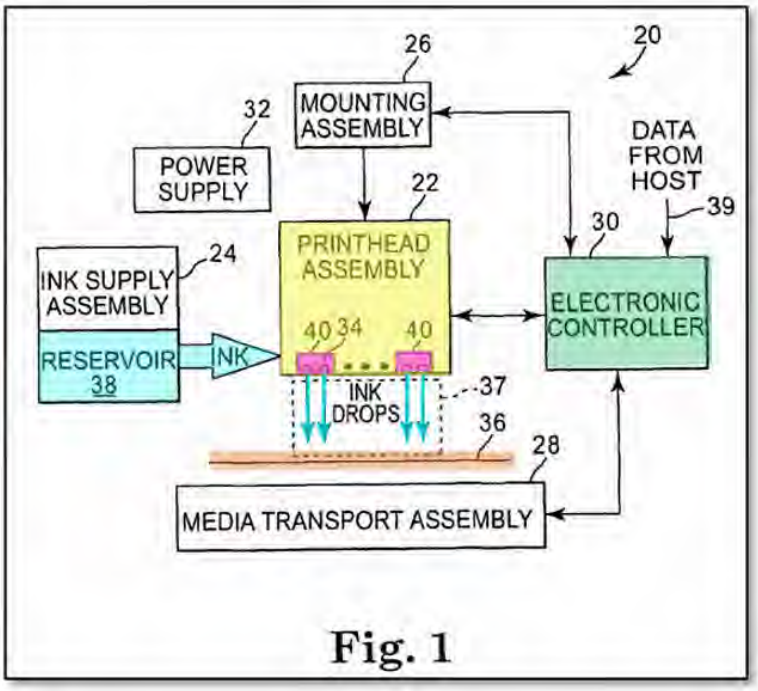
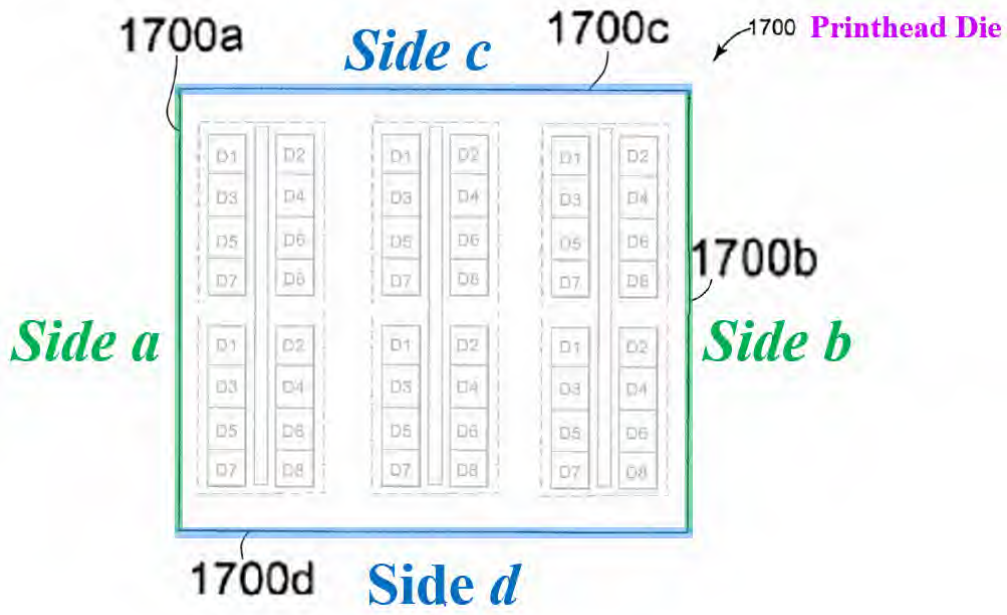


Fig. 1

115. Turning first to the printhead, Benjamin teaches that the printhead die has a left and right edge (e.g., side 1700a and 1700b, *green below*) and top and bottom edge (side 1700c and 1700d, *blue*), each of which converges with another edge to form a distinct corner of the printhead die 1700. Ex.1004 at 69:67-70:3 (describing printhead die has having four corners bound by two of its four sides, such as a first "corner bounded by printhead die sides 1700b and 1700c," and a second "corner bounded by printhead die sides 1700a and 1700d.").

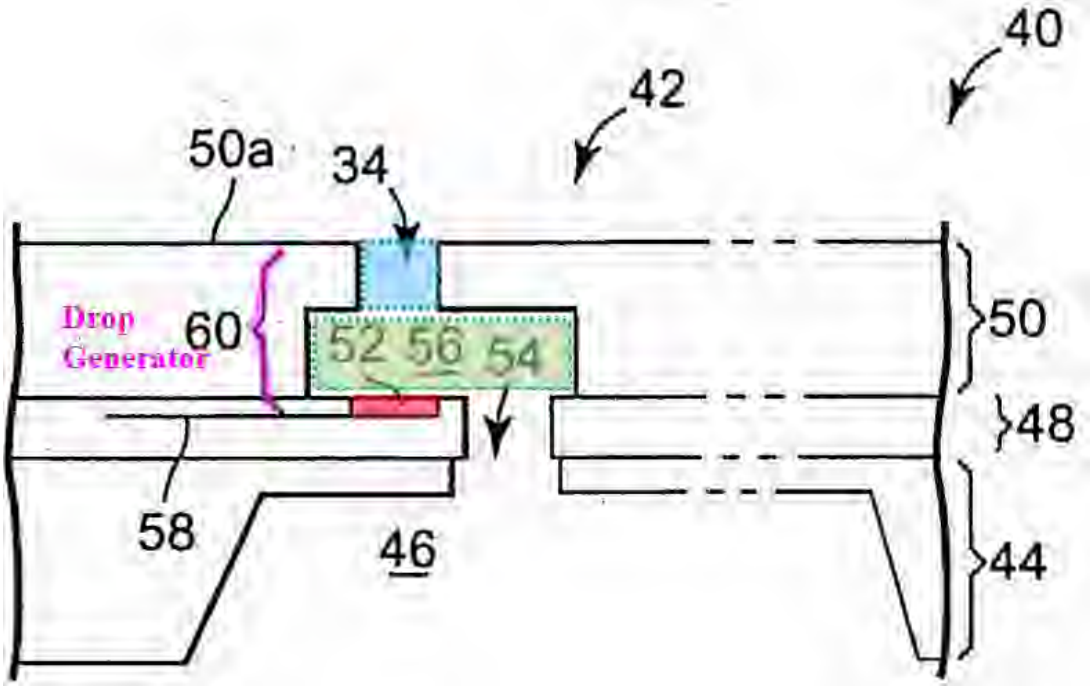
Ex.1004, Fig. 21 (simplified)



116. Consistent with a "typical thermal inkjet printing system," Benjamin teaches that the printhead die "eject[s] ink drops through nozzles [34, *purple*] by rapidly heating small volumes of ink located in vaporization chambers [56]" which "causes the ink to vaporize and be ejected through the nozzles." Ex.1004 at 1:32-

38. Referring to Figure 2 below, Benjamin teaches that "the ink is heated with small electric heaters, such as thin film resistors referred to herein as **firing resistors** [52, *red*]," which together with the vaporization chamber 56 [*outlined in green]* and nozzle opening 34 [*blue*] collectively form a drop generator 60 [*annotated in purple*]. Ex.1004 at 6:8-10. "The firing resistors 52 of drop generators 60 are energized in a controlled sequence to eject fluid from vaporization chambers 56 and through nozzles 34 to print an image on print medium 36." Ex.1004 at 6:3-5; *see below id.* at Figs. 2 and 3.

Ex.1004, Fig. 2



117. Because the term "die" is another name for a chip,[3] it is my opinion that a PHOSITA would have understood that the printhead die 40 used in Benjamin's printing system 20 is synonymous with the term "chip for use with a printing device." To be sure, the '823 Patent admits that "[a] number of printers, copiers, and multi-function products utilize **heater chips in their printheads** for discharging ink drops from one or more ink vias. The ink is supplied through one or more ink vias in the chip. These heater chips typically provide only one heater array for each ink via that is disposed along one side of the ink via." Ex.1001 at 1:21-26. In other words, the '823 Patent explains that conventional prior art printers included a chip located on the printhead and contained ink vias and heaters located next to the ink vias.

118. Accordingly, it is my opinion that Benjamin discloses "a chip [e.g., printhead die 1700] for use with a printing device [e.g., inkjet printing system such as an inkjet printer]."

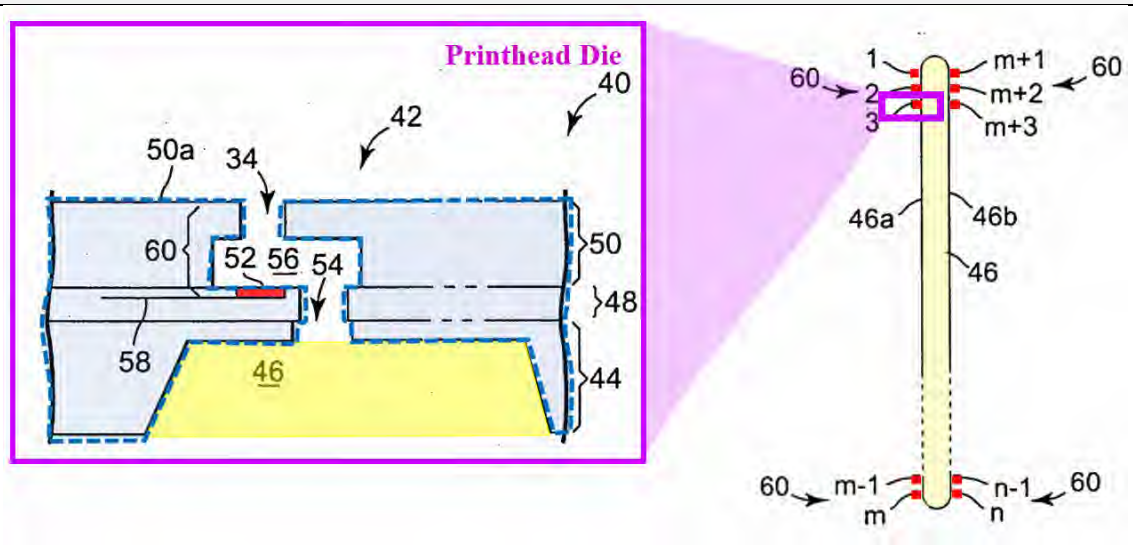
2. 1[A] "a first heater array positioned substantially adjacent a first via"

119. Claim 1 of the '823 Patent recites "a first heater array positioned substantially adjacent a first via." In my opinion, Benjamin discloses this element.

[3] *See* https://en.wikipedia.org/wiki/Die_(integrated_circuit).

120. Benjamin's printhead die 40 includes "an **array of printing or fluid ejecting elements 52**" [*red*] that are "formed on a substrate 44" [*blue below*] with an "ink feed slot 46 [*yellow*] formed therein." Ex.1004 at 4:57-61; *see below id.* at Fig. 2. According to Benjamin, "ink feed slot 46 provides a supply of liquid ink to printing elements 42" through, for example, "corresponding individual ink feed holes feeding corresponding vaporization chambers and multiple shorter ink feed trenches that each feed corresponding groups of fluid ejecting elements." Ex.1004 at 4:61-5:1.

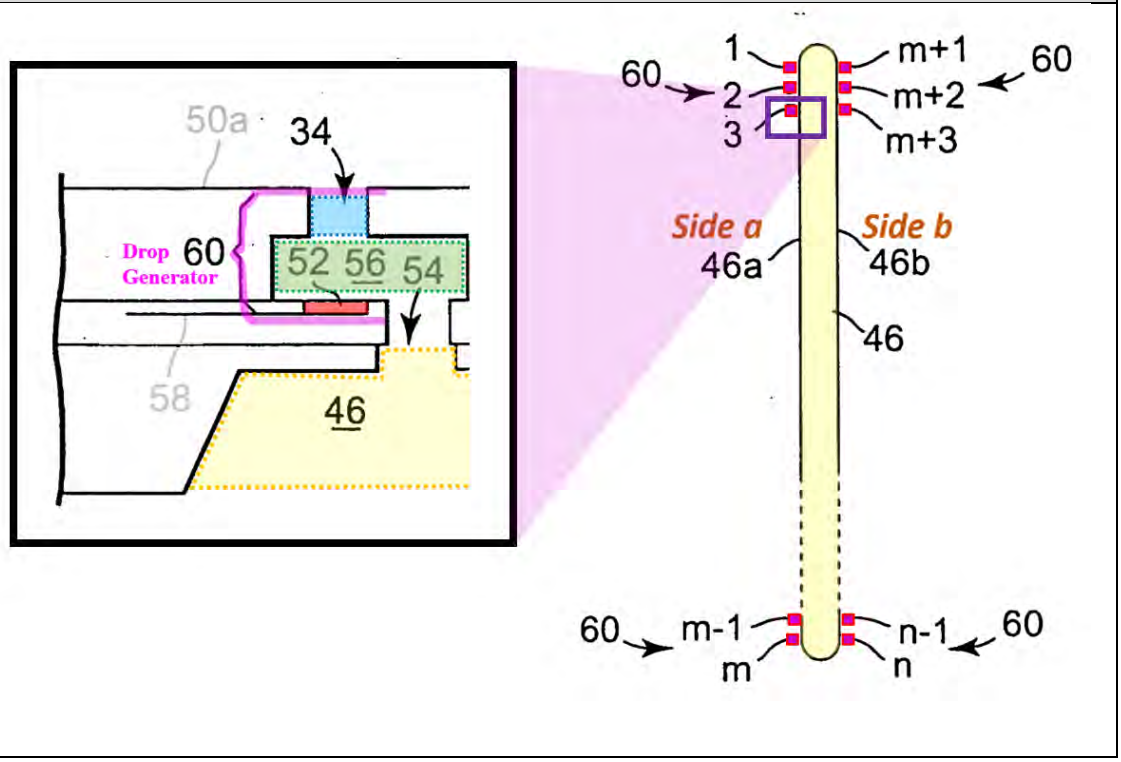
Ex.1004, Figs. 2 and 3



121. Benjamin's printhead includes one or more **ink feed slots 46**— each of which is fluidically coupled to a column of drop generators 60 [*purple*] disposed adjacent to each of its longitudinal sides. Ex.1004, 5:53-54. "A drop generator 60 [*purple*] as referred to herein includes firing resistor 52 [*red*], nozzle chamber or

vaporization chamber 56 [*green*] and nozzle opening 34 [*blue*].” Ex.1004, 5:11-14. “During printing, ink flows from ink feed slot 46 [*yellow in Figure 2 below*] to vaporization chamber 56 **via ink feed channel 54**],” and “nozzle opening 34 [*blue*] is operatively associated with firing resistor 52 such that droplets of ink within vaporization chamber 56 are ejected through nozzle opening 34 (e.g., substantially normal to the plane of firing resistor 52) and toward print medium 36 upon energizing of firing resistors 52.” Ex.1004, 5:3-30.

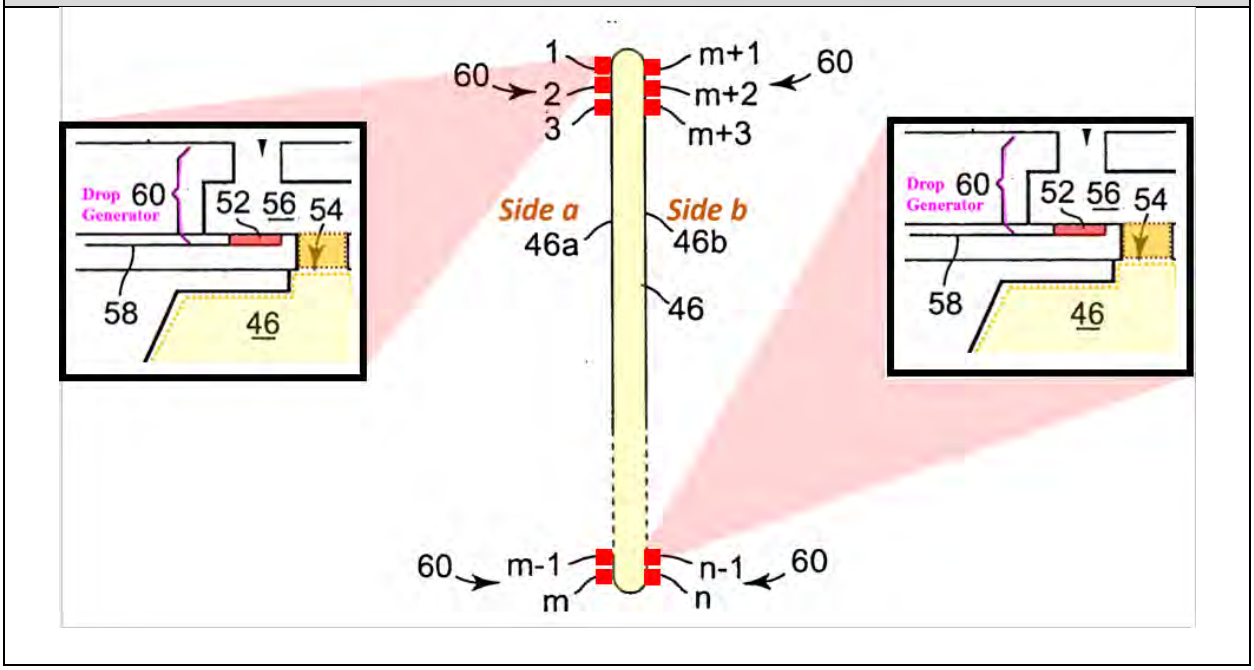
Ex.1004, Fig. 2



122. Moreover, as illustrated above and below, Benjamin discloses that “[a] firing resistor 52 [*red*] is positioned within vaporization chamber 56 and leads 58 electrically couple firing resistor 52 to circuitry controlling the application of

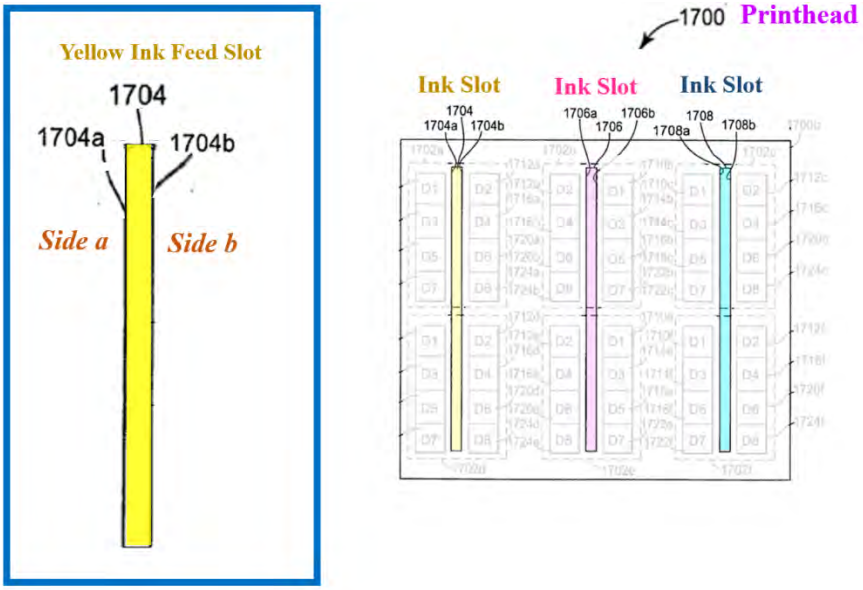
electrical current through selected firing resistors." Ex.1004 at 5:8-14. "During printing, ink flows from ink feed slot 46 to vaporization chamber 56 via ink feed channel 54," and thereafter "[n]ozzle opening 34 is operatively associated with firing resistor 52 such that droplets of ink within vaporization chamber 56 are ejected through nozzle opening 34 (e.g., substantially normal to the plane of firing resistor 52) and toward print medium 36 upon energizing of firing resistor 52." Ex.1004 at 5:15-21

Ex.1004, Fig. 2



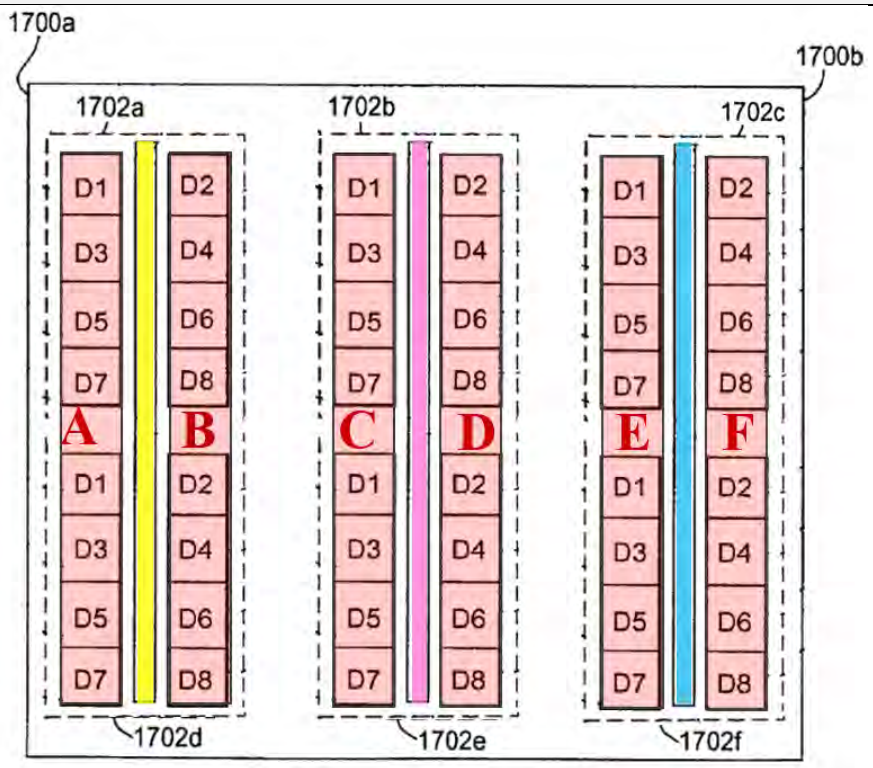
123. Figure 21 of Benjamin provides "a diagram illustrating an example layout of one embodiment of a printhead die 1700." Ex.1004 at 63:20-21. "In this embodiment, ink feed slot 1704 supplies yellow colored ink, ink feed slot 1706 supplies magenta colored ink and ink feed slot 1708 supplies cyan colored ink."

Ex.1005 at 63:20-21. According to Benjamin, each ink feed slot has two longitudinal sides—longitudinal side "a" (purple) and longitudinal side "b" (*orange*)—that extend along the y-direction of the printhead die 1700—*viz.*, "ink feed slot 1704 includes opposing sides 1704 a and 1704 b that extend along the y-direction of printhead die 1700," Ex.1004 at 65:34-36; "ink feed slot 1706 includes opposing sides 1706 a and 1706 b that extend along the y-direction of printhead die 1700," Ex.1004 at 66:37-39; and "ink feed slot 1708 includes opposing sides 1708 a and 1708 b that extend along the y-direction of printhead die 1700," Ex.1004 at 67:37-39. "The ink feed slots 1704, 1706 and 1708 are located **parallel to one another** and each ink feed slot 1704, 1706 and 1708 includes a length that extends along the y-direction of printhead die 1700." Ex.1004 at 64:63.

Ex.1004, Fig. 21


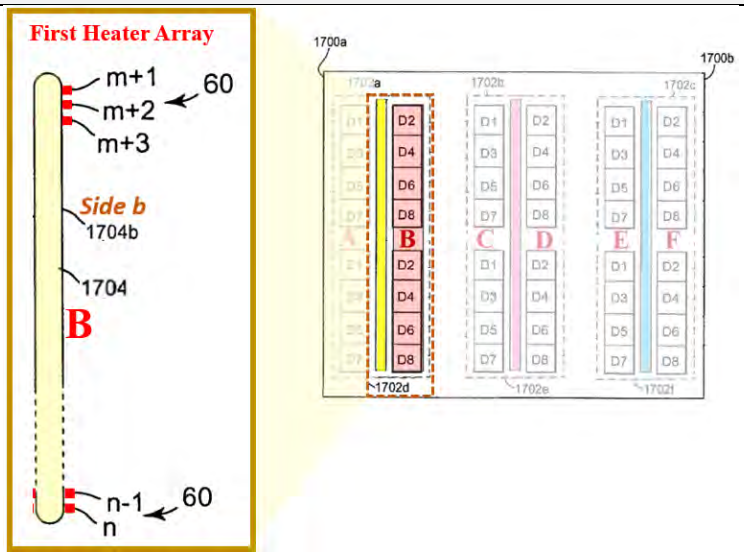
124. Benjamin's "printhead die 1700 includes six fire groups 1702a-1702f ***disposed along*** [the] three ink fluid feed sources, here depicted as feed slots 1704 [yellow], 1706 [magenta] and 1708 [cyan]." Ex.1004, 63:21-24; *id.* at 64:66-65:1 Benjamin further explains that "[t]he fire groups 1702a-1702f are divided into eight data line groups, indicated at D1-D8 and that "[e]ach data line group D1-D8 includes **pre-charged firing cells 120** from each of the fire groups 1702a-1702f." Ex.1005, 63:39-42.

Ex.1004, Fig. 21 (simplified)



125. Looking at Heater Array B, for example, Benjamin's Printhead 1700 includes an array of firing resistors 52 (Heater Array B, *red*) formed from the ink drop generators 60 disposed on side 1704 b of the yellow ink feed slot 1704.

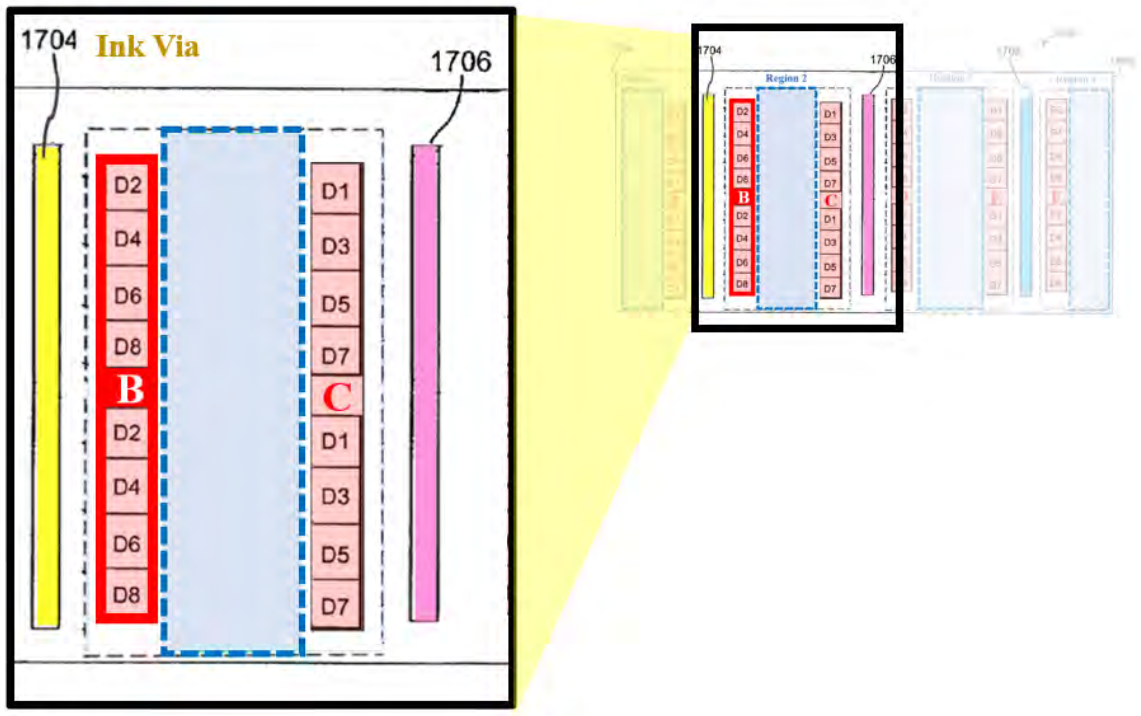
Ex.1004, Figs. 3 and 21



126. To be sure, Benjamin teaches that "Fire group one (FG1) ***1702 a*** is disposed along one half of the length of ink feed slot 1704," and "[t]he drop generators 60 in FG1 1702 *a* are disposed along each of the opposing sides 1704 a and 1704 b of ink feed slot 1704," and "[F]ire group four (FG4) 1702 d is disposed along the other half of the length of ink feed slot 1704," and that "[t]he drop generators 60 in FG4 1702 d are disposed along opposing sides 1704 a and 1704 b of ink feed slot 1704." Ex.1004 at 65:33-66:7; Ex.1004 at 66:36-67:8 (stating the same for ink feed slot 1706); Ex.1004 at 67:36-68:7 (stating the same for ink feed slot 1708).

127. Moreover, Benjamin teaches that Heater Array B is disposed next to the yellow ink feed slot 1704, and therefore, is substantially adjacent the Yellow Ink Via.

Ex.1004, Fig. 21(simplified)



128. Accordingly, it is my opinion that Benjamin discloses "a first heater array [e.g., Heater Array B] positioned substantially adjacent a first via [e.g., positioned next to the Yellow Ink Via]."

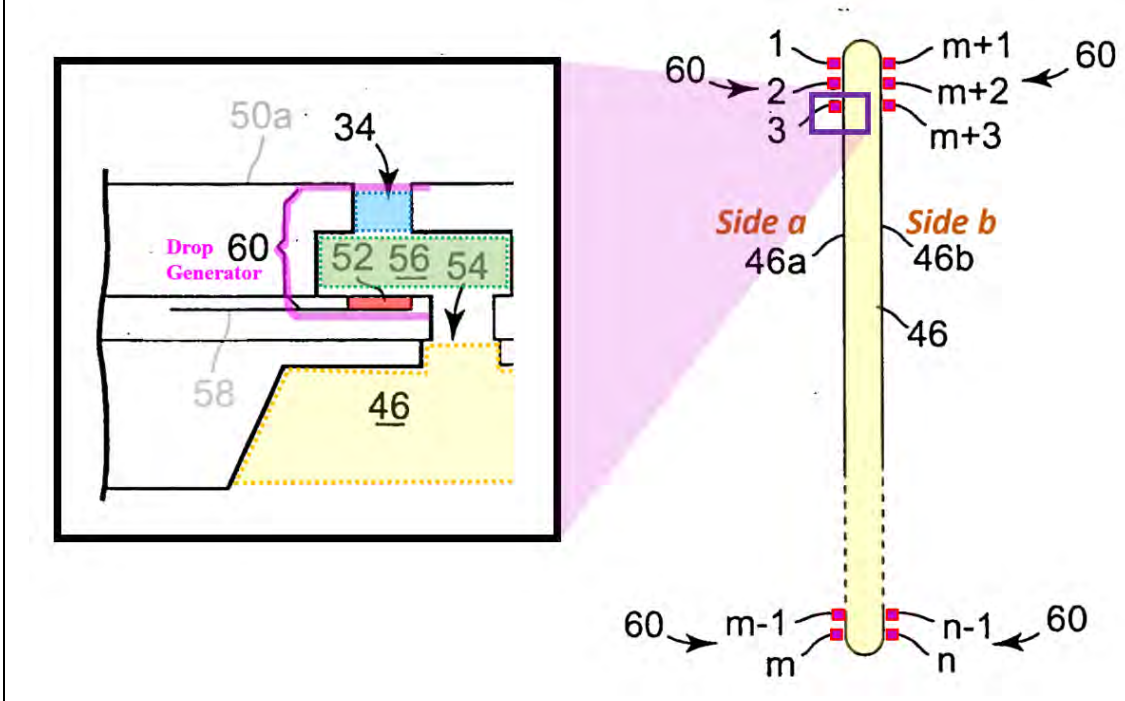
3. 1[B] "a second heater array positioned substantially adjacent a second via"

129. Claim 1 of the '823 Patent recites "a second heater array positioned substantially adjacent a second via." In my opinion, Benjamin discloses this limitation.

130. As I explain above for 1[A], incorporated here, Benjamin's printhead includes one or more ink feed slots 46— each of which is fluidically coupled to a

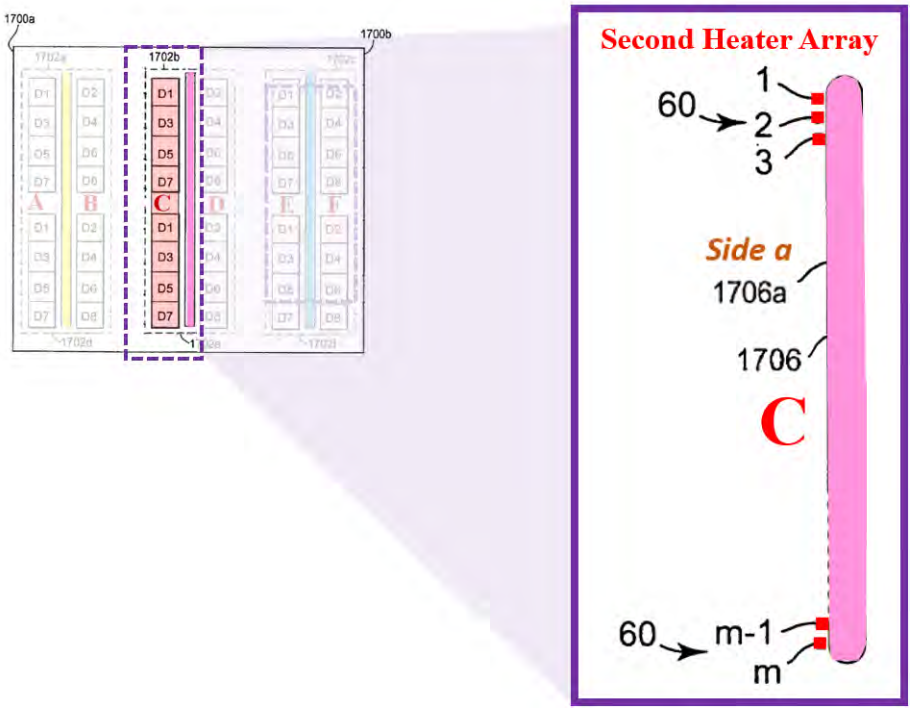
column of drop generators 60 [*purple*] disposed adjacent to each of its longitudinal sides. Ex.1004, 5:53-54. "A drop generator 60 [*purple*] as referred to herein includes firing resistor 52 [*red*], nozzle chamber or vaporization chamber 56 [*green*] and nozzle opening 34 [*blue*]." Ex.1004, 5:11-14. "During printing, ink flows from ink feed slot 46 [*yellow in Figure 2 below*] to vaporization chamber 56 **via ink feed channel 54**]," and "nozzle opening 34 [*blue*] is operatively associated with firing resistor 52 such that droplets of ink within vaporization chamber 56 are ejected through nozzle opening 34 (e.g., substantially normal to the plane of firing resistor 52) and toward print medium 36 upon energizing of firing resistors 52." Ex.1004, 5:3-30.

Ex.1004, Fig. 2



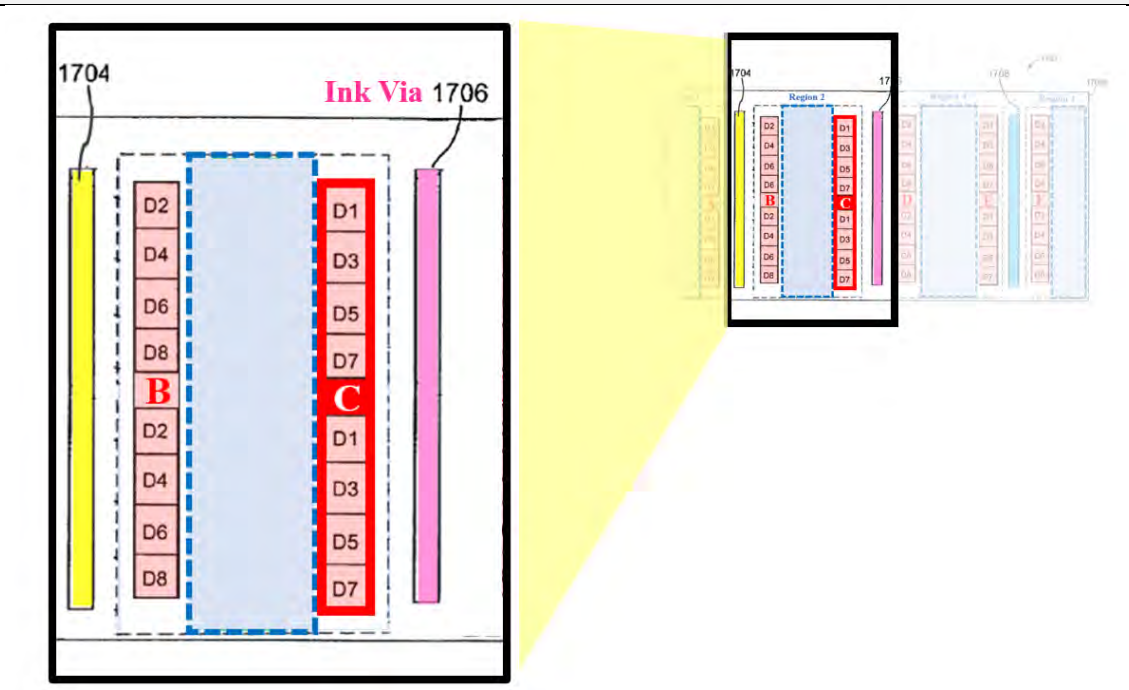
131. For example, Benjamin's Printhead 1700 includes an array of firing resistors 52 [e.g., Heater Array C] formed by the ink drop generators 60 disposed on side 1706 a of the magenta ink feed slot 1706. Ex.1004 at 66:36-67:8

Ex.1004, Figs. 3 and 21



132. Heater Array C is disposed next to the magenta ink feed slot 1706, and therefore, substantially adjacent the Magenta Ink Via.

Ex.1004, Figs.3,21



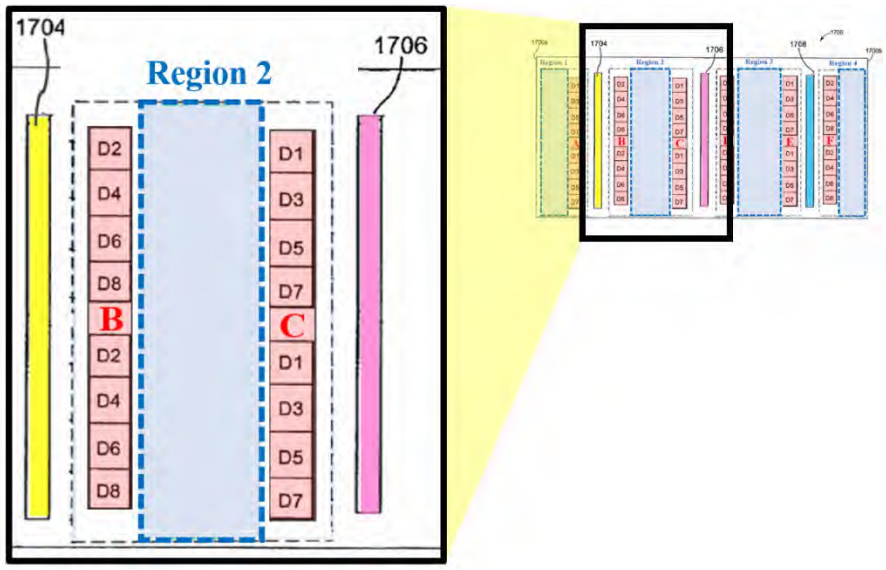
133. Accordingly, it is my opinion that Benjamin discloses "a second heater array [e.g., Heater Array C] positioned substantially adjacent a second via [e.g., positioned next to the Magenta Ink Via.]"

4. 1[C] "a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array"

134. Claim 1 of the '823 Patent further recites "a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array." In my opinion, Benjamin discloses this element.

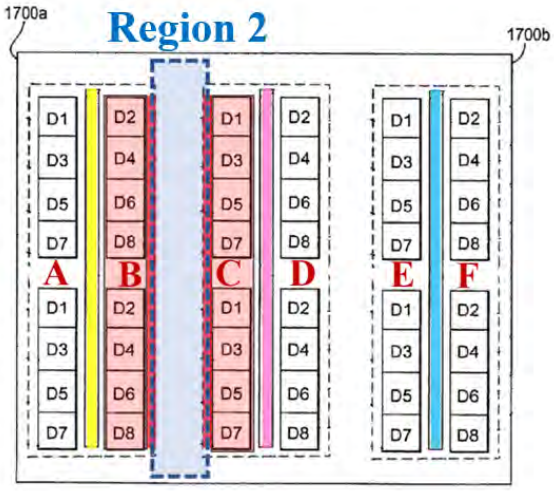
135. Referring to the printhead die 1700 shown in Figure 21, Benjamin discloses a first region on the printhead die 1700 [*e.g.*, Region 2 *blue below*) positioned between the first heater array [e.g., Heater Array B] and the Second Heater Array [*e.g.*, Heater Array C]. Ex.1004, Fig. 21.

Ex.1004, Fig. 21 (simplified)



136. Region 2 of Benjamin's Printhead Die 1700 is also substantially adjacent to the first heater array because it is next to, and even shares a border with, the first and second array of firing resistors 52 [e.g., Heater Arrays B and C, *shared borders outlined red*].

Ex.1004, Fig. 21 (simplified)



137. Accordingly, it is my opinion that Benjamin discloses "a region [e.g., Region 2] positioned between the first heater array and the second heater array and also positioned substantially adjacent to the first heater array and the second heater array [e.g., positioned between and next to Heater Arrays B and C]."

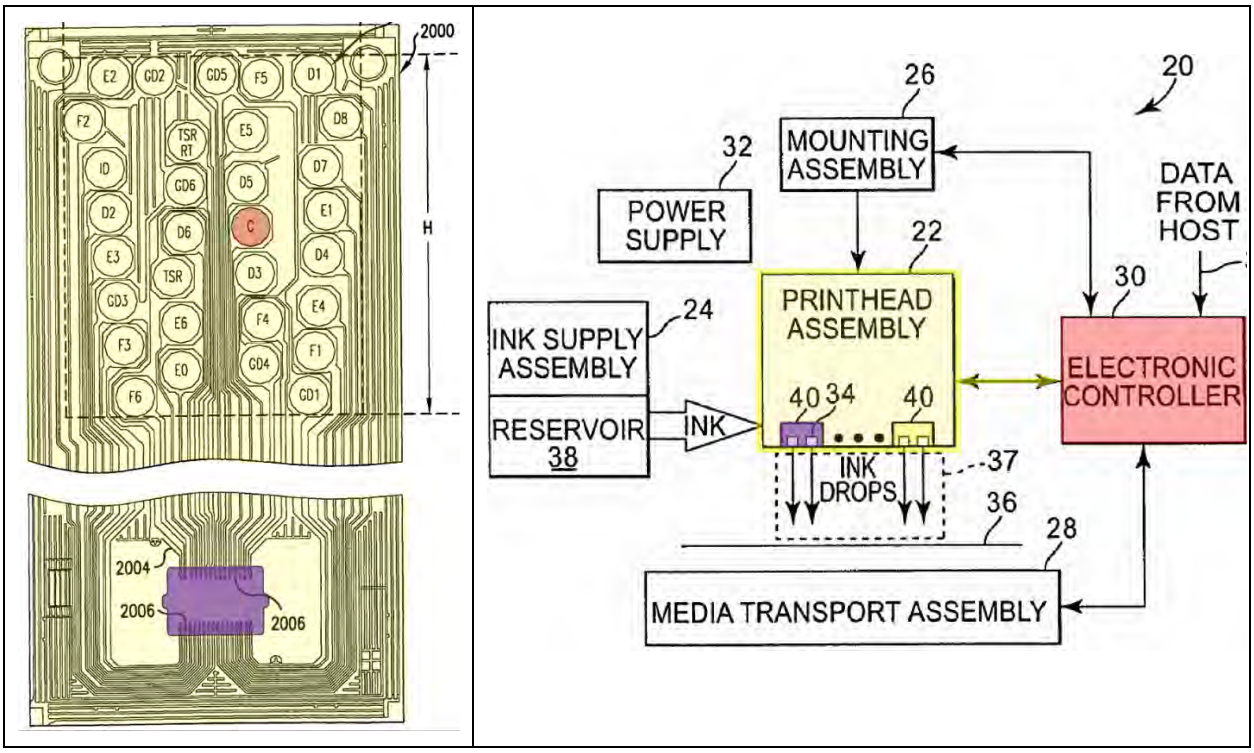
5. 1[D] "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region"

138. Claim 1 of the '823 Patent further recites "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region." In my opinion, Benjamin in view of Giere673 (the Benjamin-Giere673 combination) discloses this limitation

139. Benjamin's printing system determines the temperature of a printhead die using temperature sense resistors on the die. Ex.1004 at 79:60-67. *First*, Benjamin describes the means to electrically couple the printer and printhead

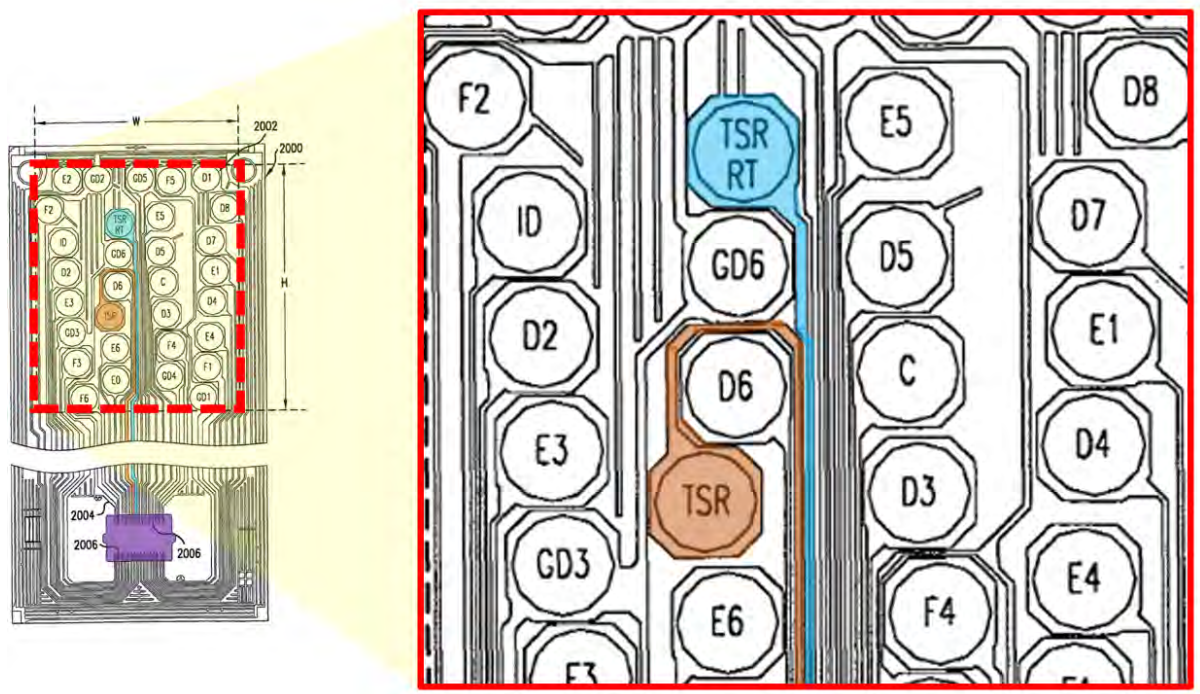
assembly to the printhead die. Referring to the flex circuit shown in Figures 25A and 25B, Benjamin teaches "electrically couple[ing] via conductive paths 2004" the "contact areas 2000 of a flex circuit 2002" to "contacts 2006," which provide coupling to the printhead die." Ex.1004 at 79:32-34.. Once electrically coupled to the contact areas of the flex circuit (yellow below), Benjamin teaches that the printhead die (*purple*) may "receive [different] signals from an external source," including, for example, "[c]ontact area C [which] is configured to receive a signal for controlling the internal operation of the printhead die, *e.g*. the CSYNC signal" from electronic controller 30," (*red*). Ex.1004 at 79:57-59; *compare* Ex.1004, Fig. 25B *with* Fig. 1; *see also, e.g.*, Ex.1004 at 79:46-48 ("[C]ontact areas D1-D8 are configured to receive data signals which provide print data representative of an image to be printed"), Ex.1004 at 79:50-52 ("Fire line contact areas F1-F6 configured to receive energy pulses" that "provide energy signals along fire lines Fire1-Fire6 to the appropriate fire groups.").

Ex.1004, Fig. 25B	**Ex.1004, Fig. 1**



140. Benjamin further teaches that "[t]emperature sense resistor contact area TSR (*brown below*) allows a printer coupled to an ink jet cartridge to determine a **temperature of the printhead die**, based upon a measurement of the resistor. A temperature sense resistor return contact area TSR-RT (*teal*) provides a return path for signals provided at temperature sense resistor contact area TSR." Ex.1004 at 79:60-65.

Ex.1004, Fig. 25B



141. Although Figures 25A and 25B do not depict the actual temperature sensor (just the **contact areas TSR and TSR TW** associated with the actual temperature **sense resistor** on the printhead die), a PHOSITA would understand that the temperature sense resistor (TSR) is incorporated into the printhead die based on Benjamin's disclosure that "the resistor" determines "the temperature ***of the printhead die***." In my opinion, a PHOSITA would know that contact fingers 2006 of the flex circuit are provided to be thermosonically bonded to bondpads on the silicon configured to receive, from the TSR on the printhead die, a temperature sense resistance (TSR) value indicative of the temperature of the printhead die.

142. To be sure, Benjamin teaches that the flex circuit also includes an "identification bit contact area ID [that] is coupled to identification circuitry on printhead die that allows a printer to determine the operating parameters of the printhead die and print cartridge," such as the temperature of the printhead die. Ex.1004, 80:1-4. To show how the identification circuitry "utiliz[es] a temperature sense resistor" on the printhead die, Benjamin incorporates by reference "co-owned patent application serial no. [Ser. No. 11/849,078; issued as U.S. Patent No. 7,278,703 (Ex.1019; Benjamin703)]," entitled "Fluid Ejection Device With **Identification Cells**,"[4] Ex.1004, 71:44-50, which teaches electrically coupling the "identification bit contact area ID" referenced by Benjamin to "identification cells" configured to store and provide "identification information indicating a thermal sense resistance value as determined at a selected temperature, such as 32 degrees centigrade." Ex.1019 at 18:19-28. Like Benjamin, Benjamin 703 states that the "printhead includes a thermal sense **resistor** (TSR) that is read to provide a TSR value," which then "is compared to the thermal sense resistance value stored in the identification cells to determine the temperature of the printhead." Ex.1019 at 18:25-

[4] Benjamin contains a typographical error of omission because it abruptly ends the sentence without actually providing the serial number of the co-owned application. However, it is quite clear that Benjamin intended to incorporate-by-reference Benjamin 703, which was filed on the same day, shares the same specification as Benjamin, and concerns the "identification circuitry" referenced by Benjamin in the subsequent sentence.

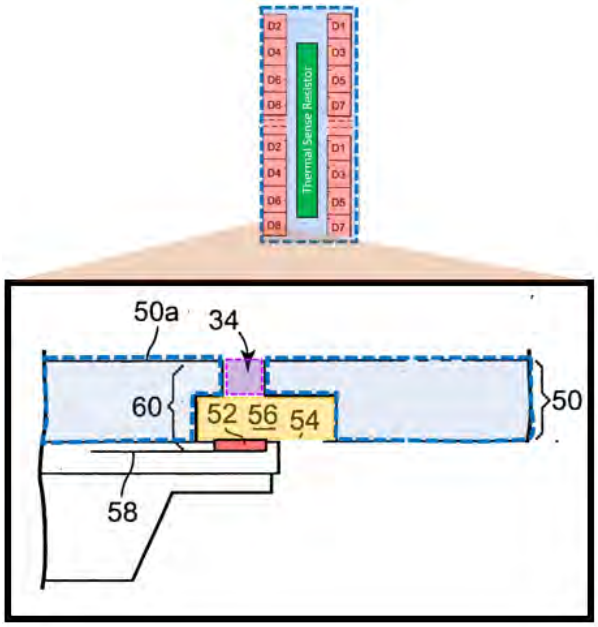
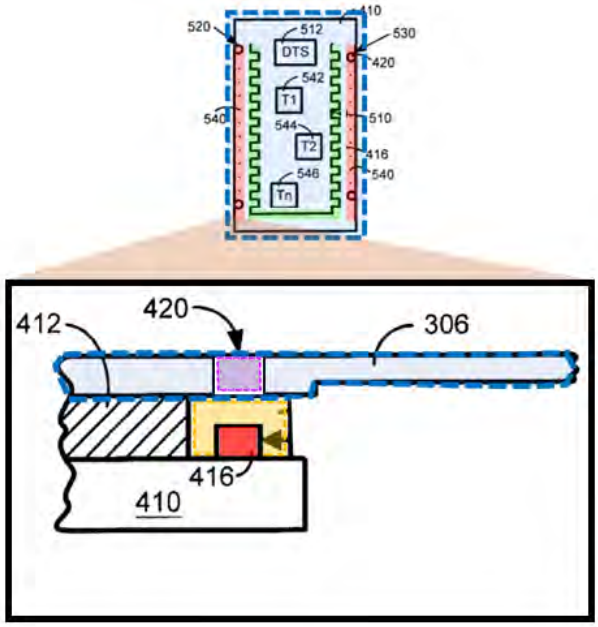
28. Put differently, upon electrically coupling the "temperature sense resistor **contact area** TSR" on the flex circuit to the actual "temperature sense **resistor** (TSR) on the printhead die via "identification circuity on the printhead die," Benjamin's printhead die using "TSR information to optimize print quality" by (1) reading the thermal sense resistor (TSR) on the printhead die to "provide a TSR value," (2) comparing the value obtained from the TSR "to the to the thermal sense resistance value stored in the identification cells to determine the temperature of the printhead," and (3) regulating the printhead's temperature "to optimize printing quality." Ex.1004, 79:60-66; Benjamin 703, at 18:19-28.

143. Although Benjamin does not say *where* on the printhead die the TSR should be disposed, Giere673 does and provides an optimal location for a TSR on Benjamin's printhead die. Moreover, as I explain below, there was plenty of motivation to combine Benjamin and Giere673, which any PHOSITA would have recognized.

144. As an initial mater, Benjamin and Giere673 both qualify as analogous art to the claimed invention at least because they are both in the same field of endeavor as the '823 patent—namely, regulating operational temperature of a printhead die. At the very least, both Benjamin and Giere673 are both reasonably pertinent to maintaining the optimal temperature of a multi-via heater chip allegedly solved by the inventors of the '823 patent.

145. As another point, it is my opinion that ample motivation existed to combine Benjamin with Giere673 for several reasons.

146. *First*, because Benjamin fails to specify where the TSR should be disposed to optimize print quality, it is my opinion that a PHOSITA would have looked beyond Benjamin and considered Giere673. Benjamin and Giere673 both share to the same assignee—*viz.*, Hewlett-Packard Development Company L.P. (Ex.1004, 1; Ex.1005, 1)—and both involve the same field of endeavour— *viz.*—regulating operational temperature of a printhead die for a printing device—and similar printing devices within that field. Referring to the illustration below, the printhead dies of Benjamin and Giere673 both include at least two adjacent ink channels (*not shown*) for feeding ink into a chamber (*yellow below*) and at least two adjacent heater arrays (*red*) for vaporizing the ink within each channel and ejecting drops of the vaporized ink through a nozzle (*purple*) onto a print media, such as paper.

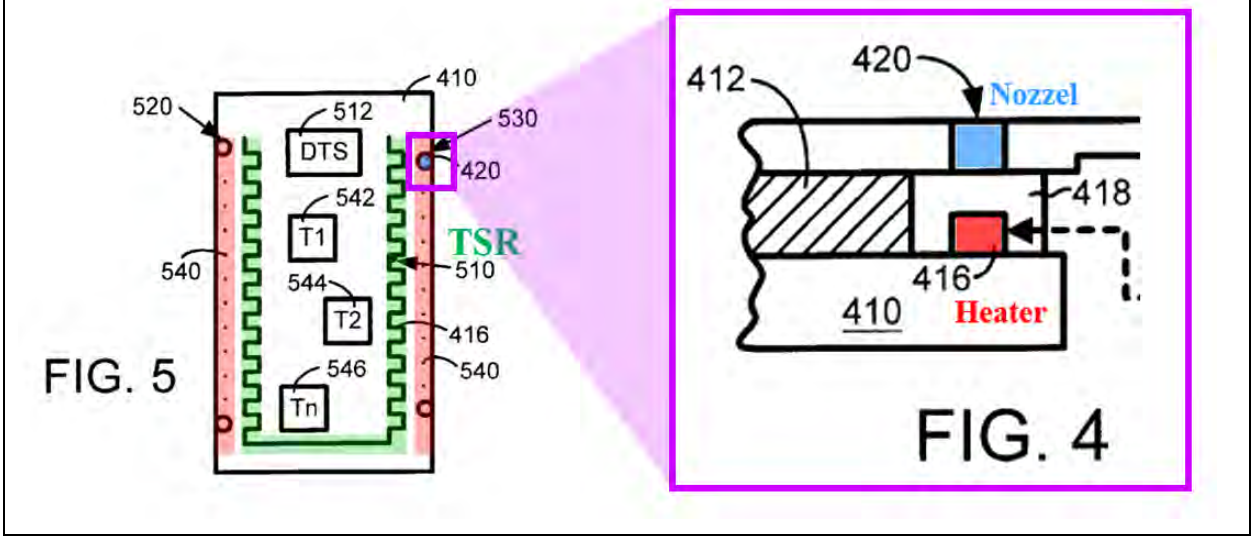
Printhead Region of Benjamin (Ex.1004)	Printhead Region of Giere673 (Ex.1005)
	

147. Moreover, as set forth in greater detail below in Section XI.A.9, Benjamin and Giere673 both address similar problems in their shared field— *viz.*, reduced print quality caused by the printhead die operating outside its optimal temperature —and both provide a similar solution to that problem— *viz.*, disposing a temperature sense resistor (TSR, *green*) on the printhead for determining the mean temperature of the printhead and using a controller to maintain the printhead at its optimal temperature by, for example, lengthening and shortening the firing pulses sent to the heater arrays.

148. Like Benjamin, Giere673 uses "**[o]ne** or multiple TSRs 510 [to] provide an approximation of the ***mean temperature*** of the substrate [410]." Ex.1005

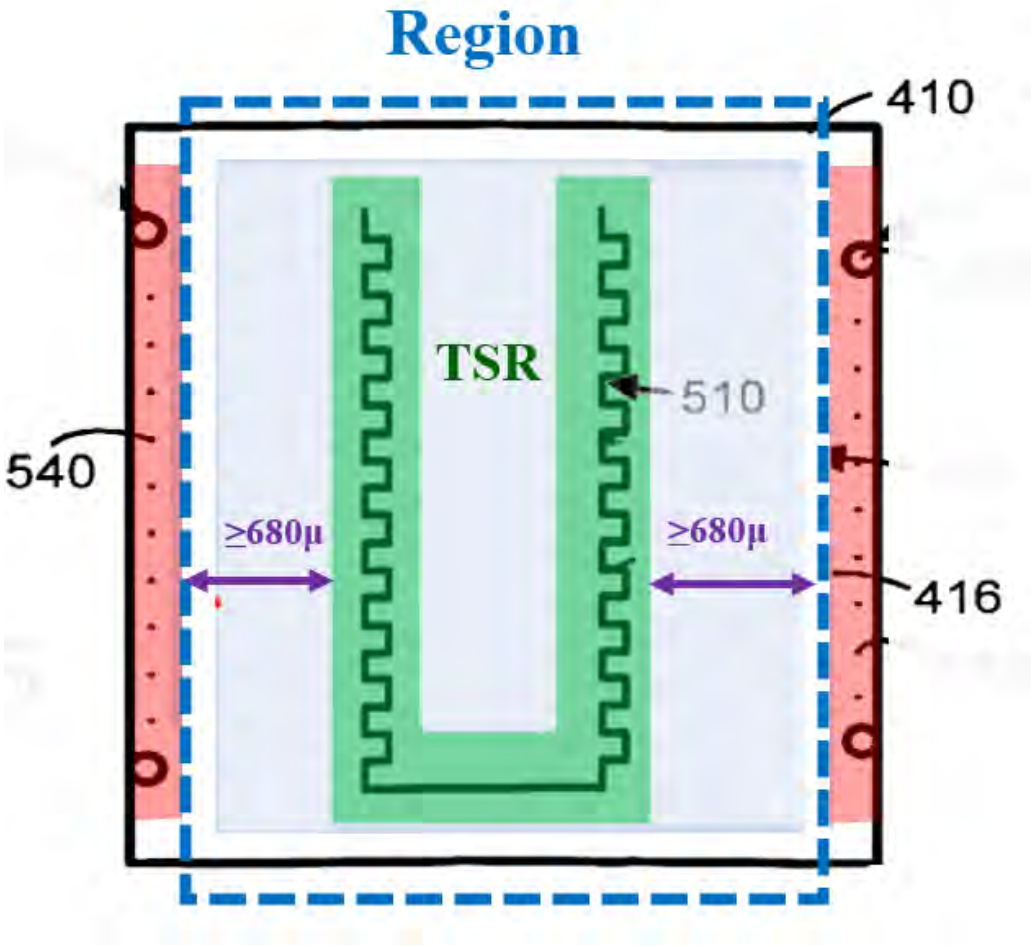
at 4:55-56. And just like Benjamin, Giere673 optimizes the print quality of the inkjet printer based upon the temperature value provided by the TSR. But unlike Benjamin, Giere673 explicitly discloses *where* on the printhead the TSR should be located for providing a sufficiently accurate temperature value to meaningfully improve print quality (e.g., approximately 680 µm inboard from the center of the columns of ink ejection elements and along their length). Not only does Giere673 teach positioning a single temperature sensor—i.e., "temperature sensor resistor (TSR) 510 [*green below*]—between two heater arrays [*red*], but also that the TSR 510 "preferably is not located adjacent to any ***particular*** heating elements" so that the obtained TSR value "reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005, 2:50, 4:51-56. To be sure, Giere673 teaches that "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are approximately 680 µm inboard from the center of the columns of ink ejection elements 416," [*red in Figs. 4 and 5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12.

Ex.1005, Figs. 4 and 5



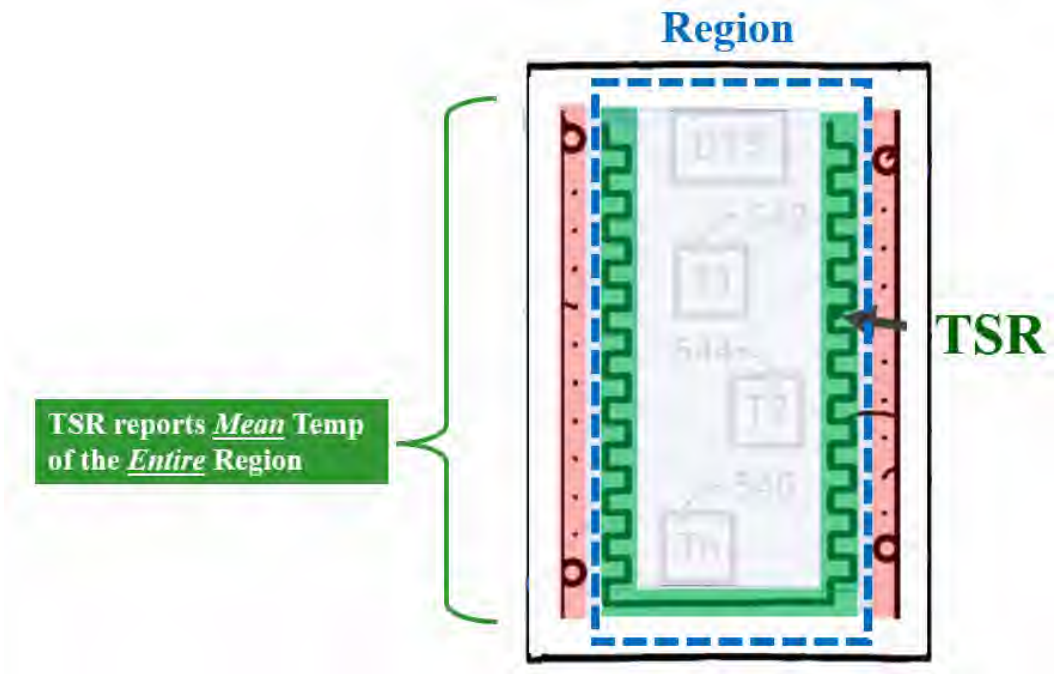
149. Second, Giere673 itself expressly motivates the combinmation. Giere673 teaches disposing a single temperature sense resistor (TSR) [*i.e.*, serpentine TSR 510, *green below*] in a region on the printhead die [region of the substrate 410, *blue*] adjacent two heater arrays [columns of ink ejection elements 416 and 516, *red*], and positioning that TSR equidistant from the two heater arrays but no less than "approximately 680 µm inboard from the center of the [heater arrays]."

Ex.1005, Fig. 5



150. By positioning the TSR 510 in the centre of the region, Giere673 teaches that the TSR value obtained by TSR 510 "reflects heating elements firing that have already occurred," which "more accurately reflects the ***mean temperature*** of the substrate 410," as illustrated below. Ex.1005 at 4:57-59.

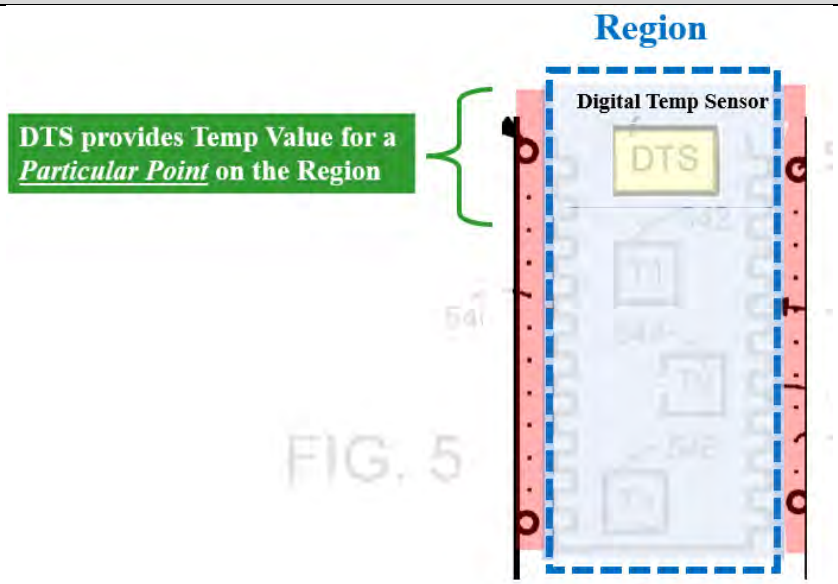
Ex.1005, Fig. 5



151. Conversely, Giere673 positions an optional "a point sensor"—*i.e.*, Digital Temperature Sensor (DTS) 512 (yellow)—"at the top of the substate" without expressing any similar preference on location because, unlike the TSR, the DTS 510 "reflects the temperature ***at that point***, it does not give an accurate temperature for other heating elements on the substrate." *Id.*, 4:67-5:2. In my opinion, a PHOSITA would not position a TSR in the same location as Giere673's DTS 510 (top of the region) because Benjamin's system "determine[s] a temperature of the ***printhead die*** based upon a measurement of the **resistor**"—not the temperature of a ***particular point on that die*** based on the measurement of a **digital**

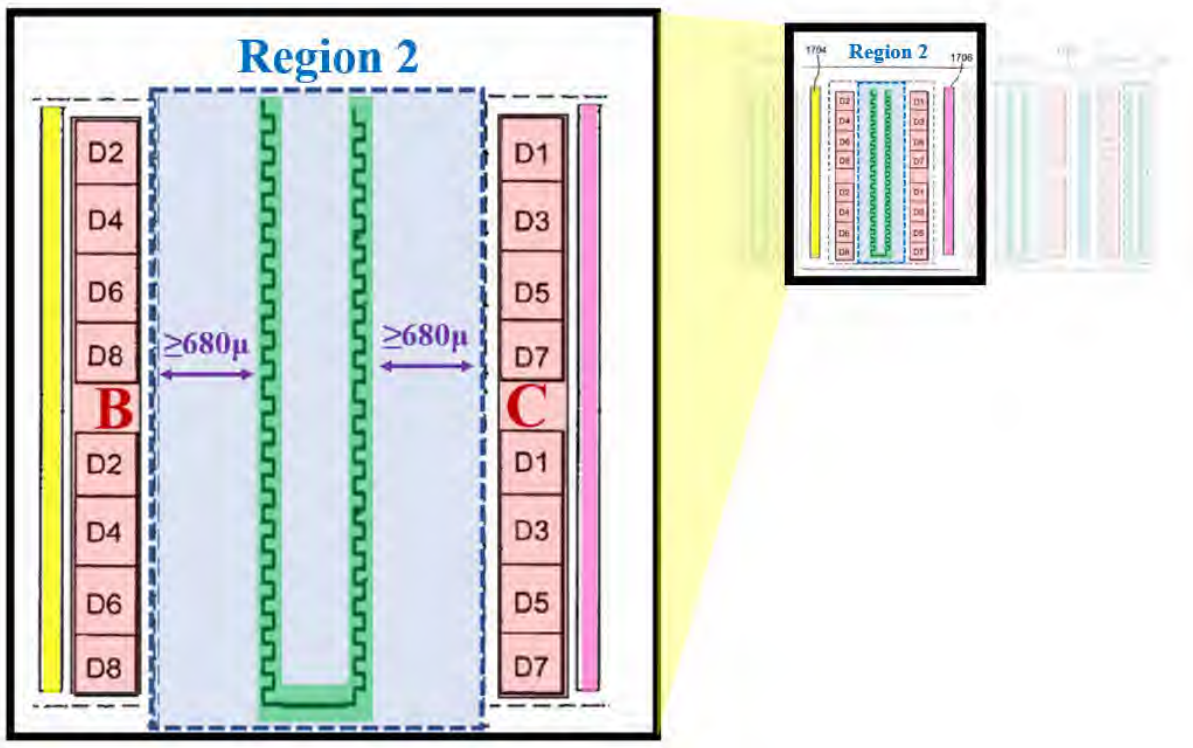
sensor—and positioning the TSR near the top of the region would not provide a value reflecting an accurate temperature for the other heating elements in that region.

Ex.1005, Fig. 5



152. Given the structural similarities between Benjamin and Giere673's printhead dies, a PHOSITA would have applied Giere673's teachings to Benjamin by (1) disposing a single TSR within a region of Benjamin's printhead formed between two adjacent heater arrays [*e.g.*, Region 2, *blue below*], and (2) positioning the TSR equidistant from both heater array within the region but no less than approximately 680 µm inboard from the center of the heater arrays, as shown below, to ensure that the temperature value provided by the TSR reflects the mean temperature of the region. Ex.1005 at 4:57-59.

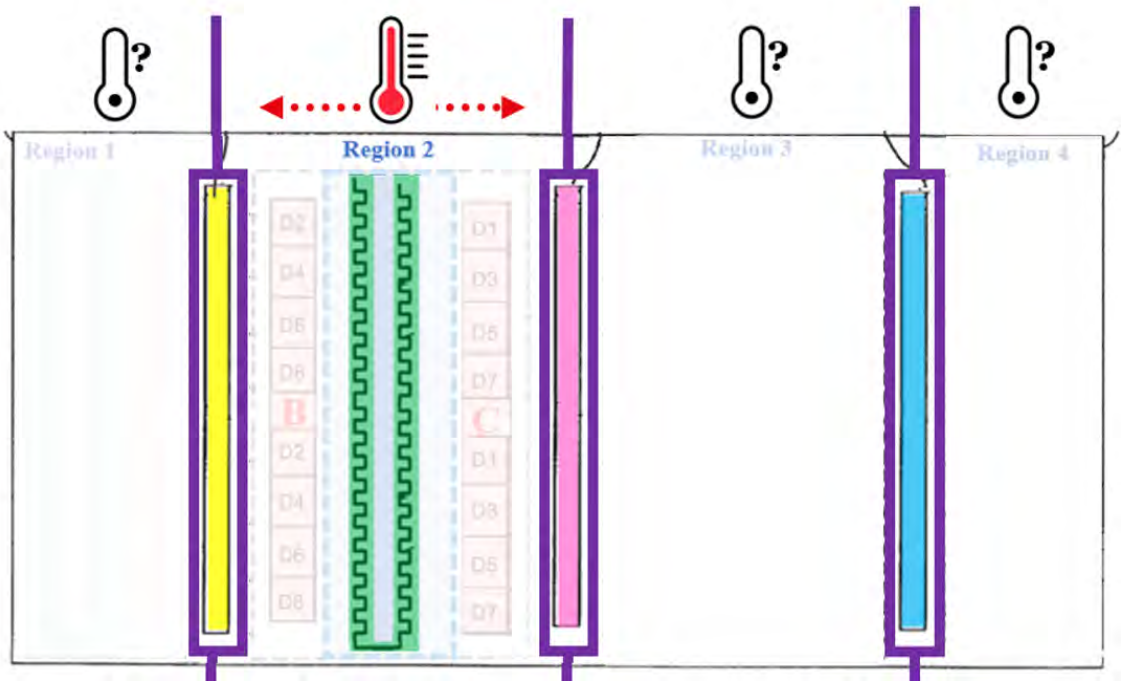
Ex.1004, Fig. 21 (Simplified)



153. However, a PHOSITA would have known that placing the TSR within Region 2 *alone* would not be an ideal location to accurately report the mean temperature of the ***entire printhead die***, which Giere673 attributes to meaningfully regulating operational temperature, because the two ink vias adjacent to the TSR [*e.g.*, ink feed slot 1704, *yellow below*, and ink feed slot 1706, *magenta*, for Region 2, *blue*] act as thermal insulators between other regions of Benjamin's printhead [Regions 1, 3, and 4], making the temperature value read by the TSR reflective of the temperature of Region 2, but not the mean temperature of the entire printhead. Ex.1001 at 5:52-55; Ex.1008 (Yabe) at 3:16-21 ("it is found that in the mode of the side shooter recording head, a plurality of ink supply ports provided for the heater

board demonstrate the heat insulating characteristic against the heater board material…").

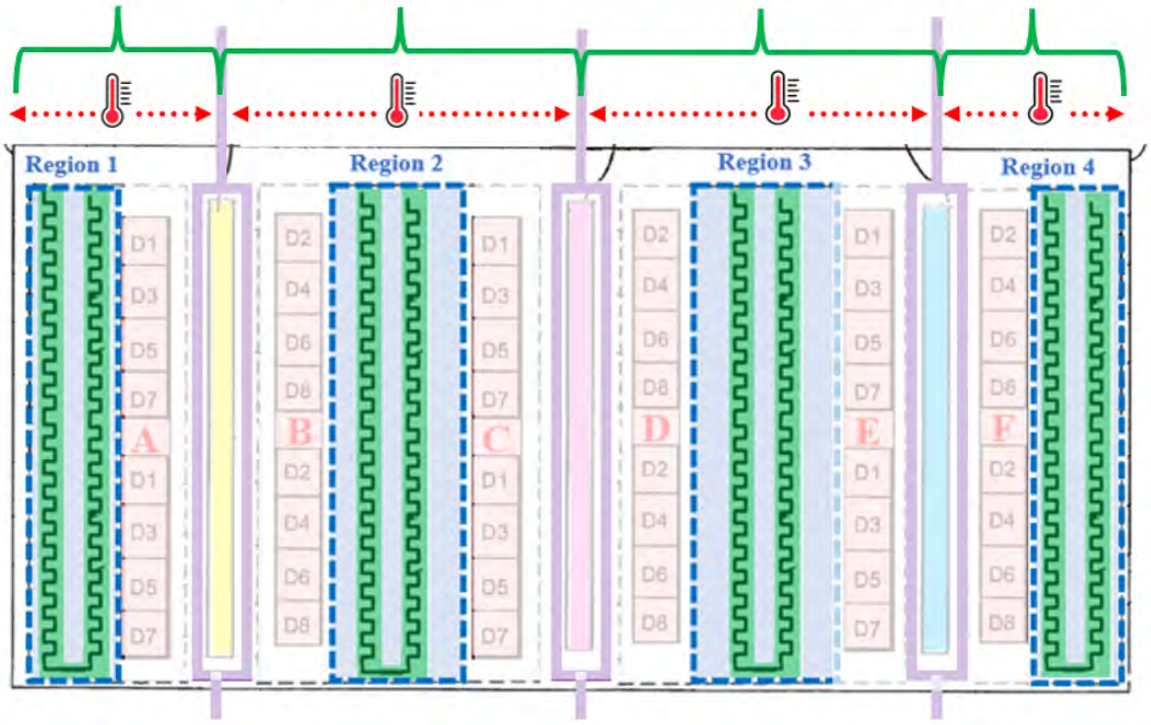
Ex.1004, Fig.21



154. To regulate the operational temperature of Benjamin's printhead die and optimize the printing quality of the inkjet printing device, it is my opinion that a PHOSITA would have further configured Benjamin to determine a mean temperature of the ***entire printhead*** by disposing a single TSR within each of the remaining regions [e.g., Region 1, 3, and 4, blue below] so that the temperature value

collectively provided by the TSRs within Regions 1-4 reflect the mean temperature of Benjamin's printhead die, as illustrated below.

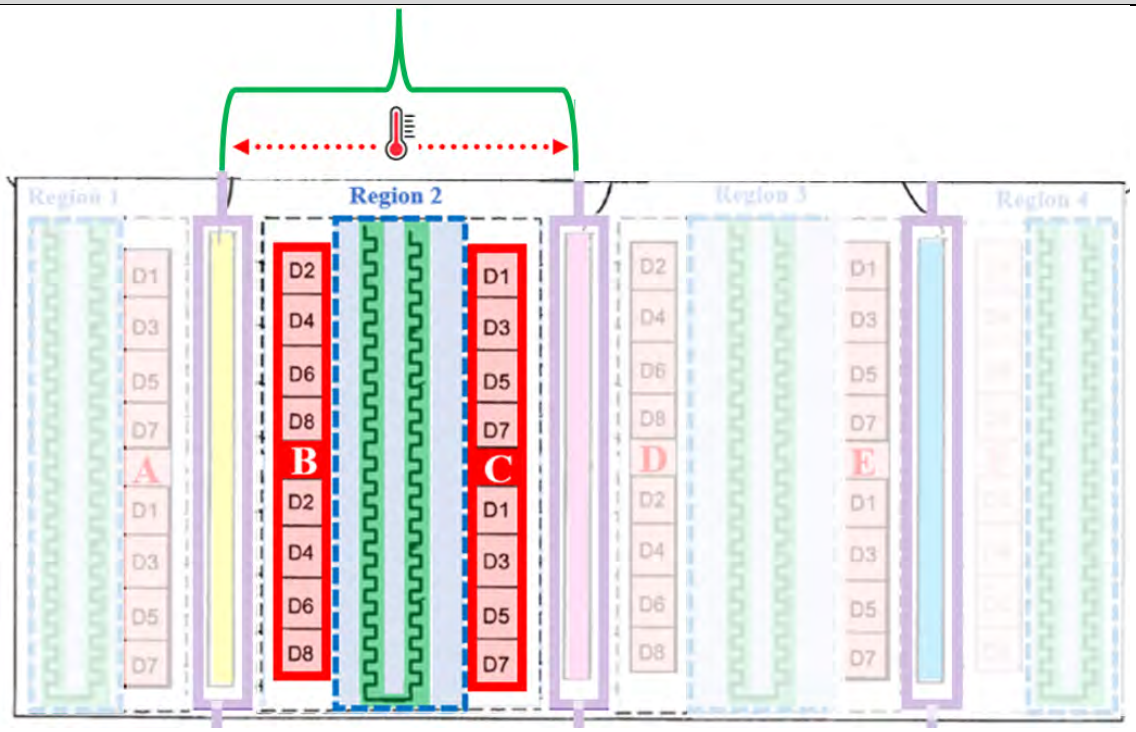
Benjamin-Giere673



155. Because the ink vias act as thermal insulators between the four different regions of Printhead Die 1700, it is further my opinion that a PHOSITA would further understand that the temperature values provided by TSR would not accurately represent the temperature of the entire printhead die, but rather only the temperature of the substrate between the two adjacent ink vias. Conversely, a PHOSITA would know that the temperature sensed by each TSR represents the

temperature of its region because the region is positioned between, not outside, the two adjacent ink vias.

Benjamin-Giere673



156. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses "a temperature sensing element [e.g., TSR] operable to sense a temperature of the region [e.g., Region 2], the temperature being representative of the region."

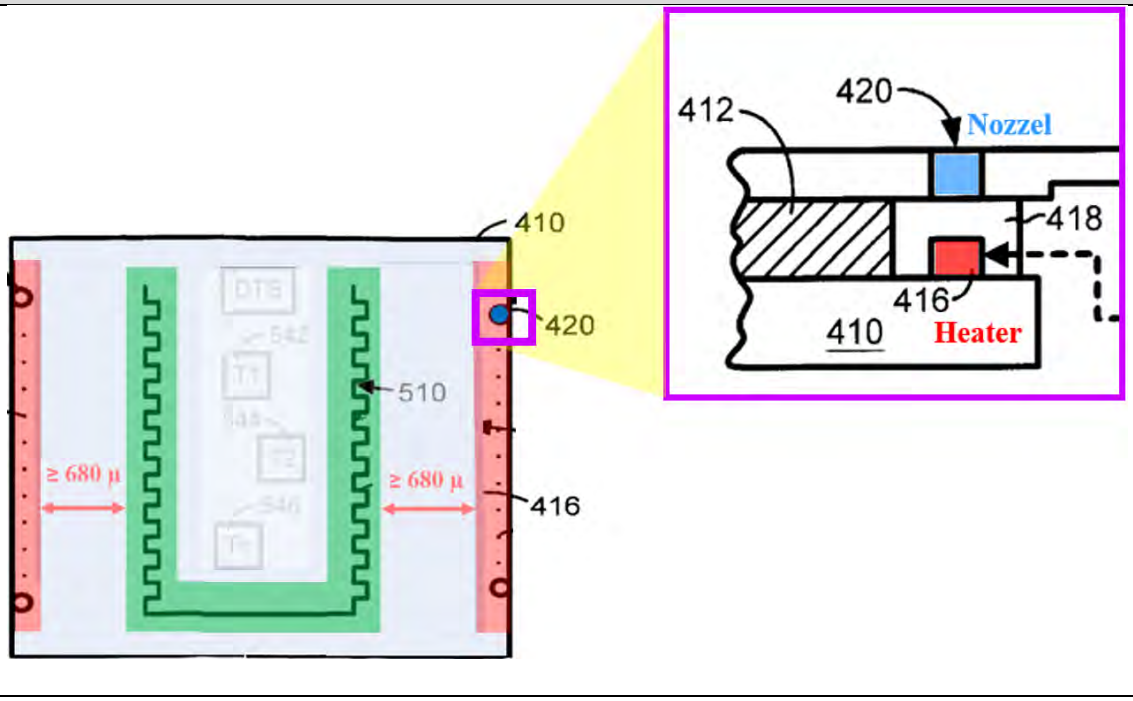
6. 1[E] "wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array"

157. Claim 1 of the '823 Patent further recites "wherein the temperature sensing element is substantially centrally disposed with respect to the region and

substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array." Ex. 1001, 6:65-7:10 (stating that "the first TSR 440 is centered between the left edge of the heater chip 400 and the cyan ink via" and "the fifth TSR 448 is centered between the right edge of the heater chip 400 and the mono ink via," while "[t]he remaining TSRs 542, 544, 546 are centered between heater arrays from adjacent ink vias corresponding to different colors," but recognizing that "[i]t will be understood by those skilled in the art that the TSRs … need not be centered within their respective thermal regions …, but rather, they can be positioned at any point within their respective thermal regions."). In my opinion, the Benjamin-Giere673 combination discloses this limitation.

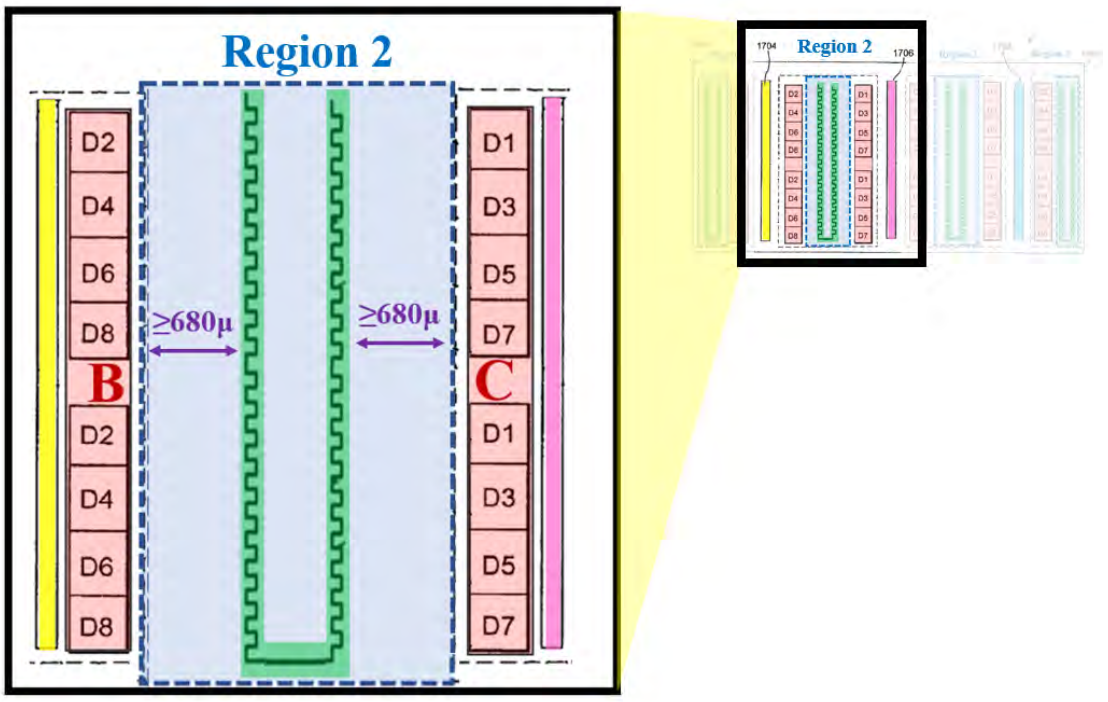
158. As shown in Figures 4 and 5 below, Giere673 teaches that "[t]he TSR 510 [*green in Fig. 5*] is located along the length of the substrate 410" at a predetermined distance "approximately 680 μm inboard from the center of the columns of ink ejection elements 416" [*red in Figs. 4 and 5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:10-12.

Ex.1004, Figs. 4 (right) and 5 (left)



159. Moreover, it is my opinion that a PHOSITA familiar with Giere673 would have been motivated to dispose a single TSR [*e.g.*, TSR 510, *green below*] within each region of Benjamin's printhead die [*e.g.*, Regions 1-4, *blue*] and position each TSR equidistant from the two heater arrays adjacent the region [e.g., heater arrays B and C in Region 2, *red*] and not less than "approximately 680 µm inboard from the center of the [heater arrays]" so that, *individually*, each TSR provides a temperature value reflective of the temperature of its region, including the heater arrays adjacent those regions, *and collectively*, the values provided by the TSRs reflect the mean temperature of the entire printhead die.

Ex.1004 and Ex.1005, (The Benjamin-Giere673 Combination)



160. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses that the "temperature sensing element [e.g., TSR] is substantially centrally disposed with respect to the region [e.g., disposed equidistant from Heater Arrays B and C] and substantially adjacent to both the first heater array and second heater array [e.g., disposed next to Heater Arrays B and C], and further extends substantially the length of the first heater array and second heater array [e.g., TSR extends the length of the chip, which is greater than (but no less than equal to) the length of the Heater Arrays B and C]."

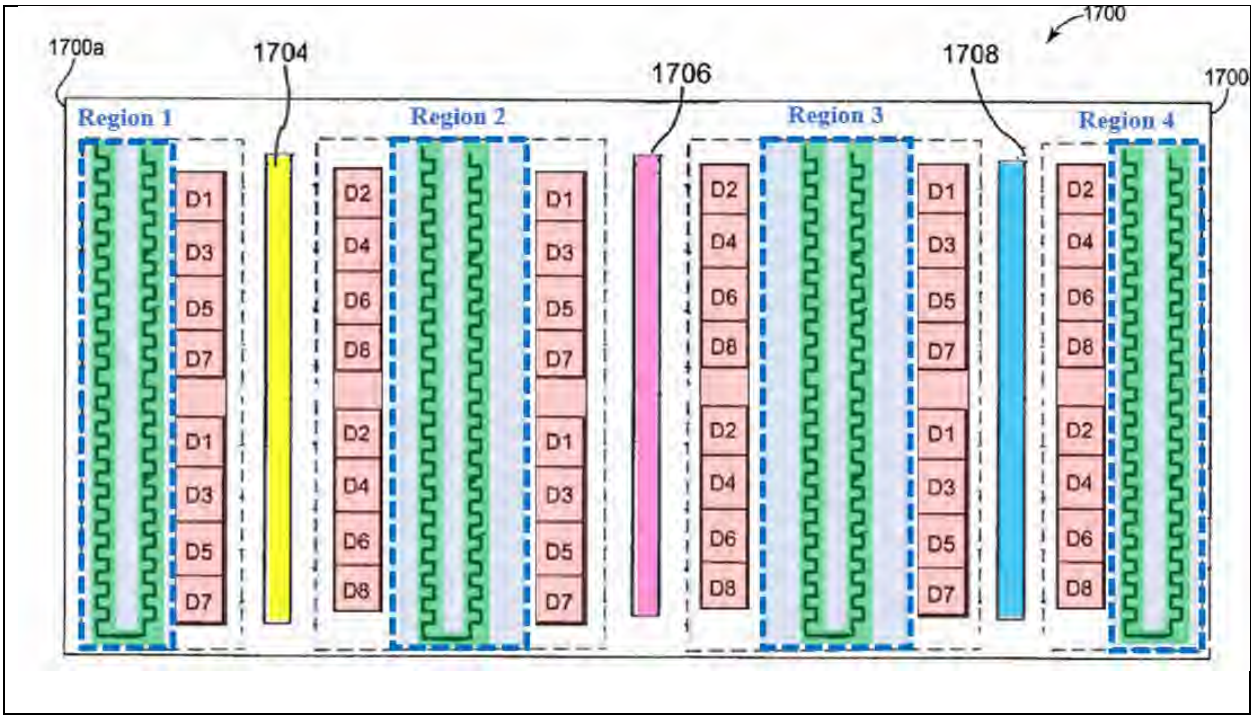
7. 1[F] "wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing

element, and wherein the received heating regulates the temperature of the region"

161. Claim 1 of the '823 Patent further recites "wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region." In my opinion, the Benjamin-Giere673 combination discloses this limitation.

162. For the reasons discussed above in 1[D]-[E] and set forth below in Section XI.P., it is my opinion that a PHOSITA familiar with Giere673 would have been motivated to dispose a single TSR [*e.g.*, TSR 510, *green below*] within each region of Benjamin's printhead die [*e.g.*, Regions 1-4, *blue*] and position each TSR equidistant from the two heater arrays with the region [e.g., heater arrays B and C in Region 2, *red*] and not less than "approximately 680 μm inboard from the center of the [heater arrays]" so that, *individually*, each TSR provides a temperature value reflective of the temperature of its region, including the heater arrays within those regions, *and collectively*, the values provided by the TSRs reflect the mean temperature of the entire printhead die.

The Benjamin-Giere673 Combination



163. "To control[] the temperature of the substrate and the temperature of each ejection chamber or nozzle chamber," Giere673 discloses that "temperature sensors … determine, at a given time, a mean or ***average temperature of the substrate*** and an ***actual local temperature profile near designated ink ejection elements***." Ex.1005 at 2:57-62. Thereafter, "the input data 108" supplied by the temperature sensors is used "to predict thermal conditions of particular ejection chambers for selectively firing the associated heating elements." Ex.1004, 3:1-6

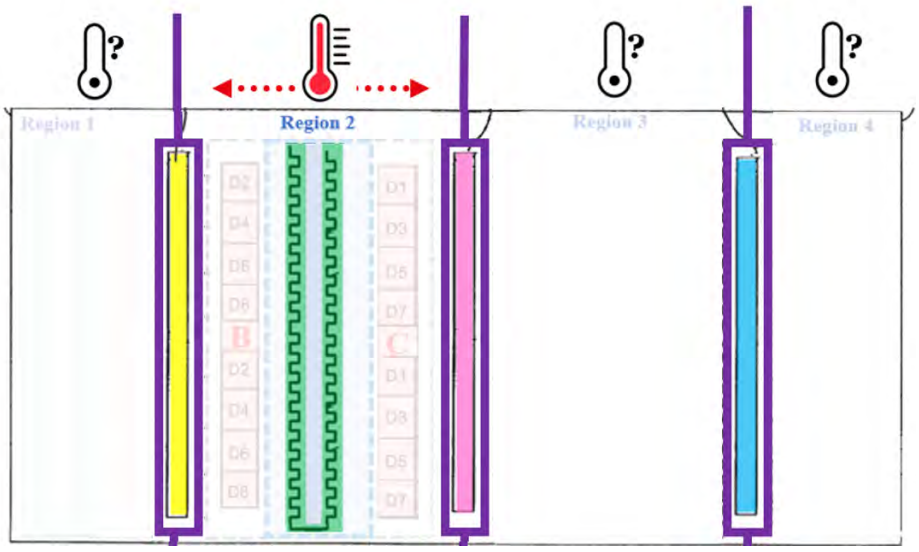
164. Based upon the temperature sensed by the TSR, Giere673 teaches that the heater arrays receive heating "so that the **temperature of the heater array** [], and therefore the temperature of the ink in the chamber array [], are maintained at an **optimum temperature for the formation of ink droplets**." Ex. 1004, 7:41-45;

9:8-19. For example, Giere673 teaches that the "[t]he temperature logic system [] **generates firing Voltages 814** and **activates heater elements** that do not eject ink 816." *Id.*

165. Because the ink vias act as thermal insulators between the four different regions of Printhead Die 1700, it is my opinion that a PHOSITA would further understand that the temperature values provided by TSR would not accurately represent the temperature of the entire printhead die, but rather only the temperature of the substrate between the two adjacent ink vias.

The Benjamin-Giere673 Combination

Ink Vias Form a Thermal Barrier Between Each Region

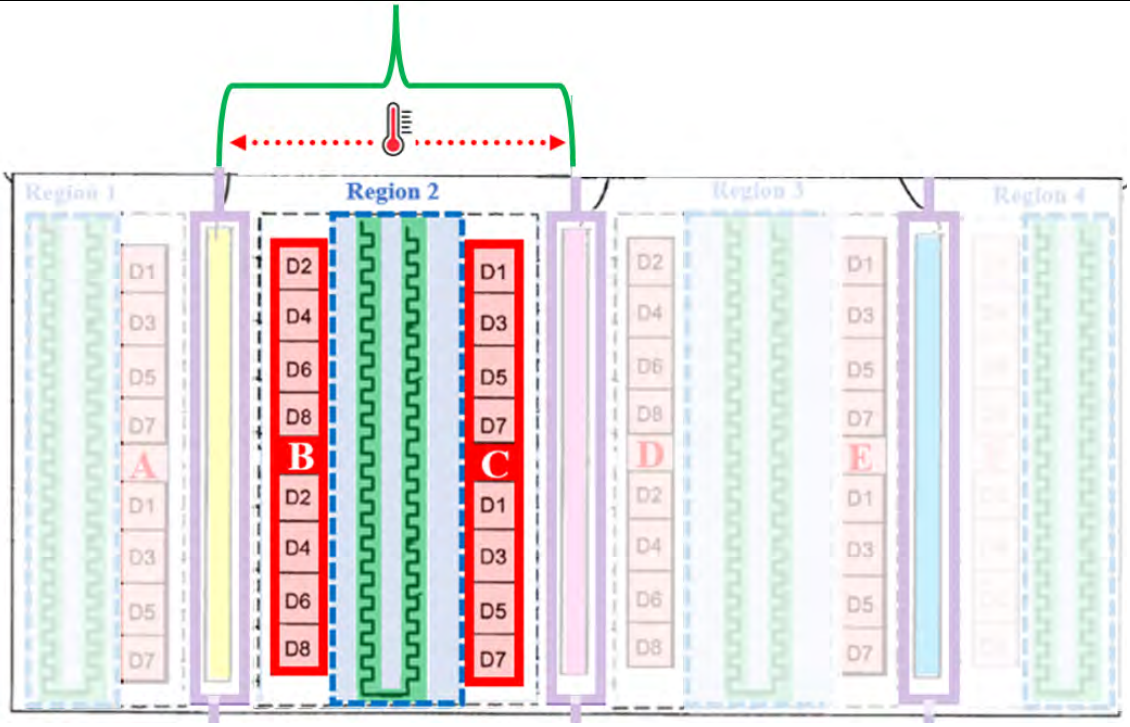


166. Conversely, it is my opinion that a PHOSITA would know that the temperature sensed by the TSR with each region would necessarily represent the

temperature of the two heater arrays adjacent to that region but positioned between the two adjacent ink vias.

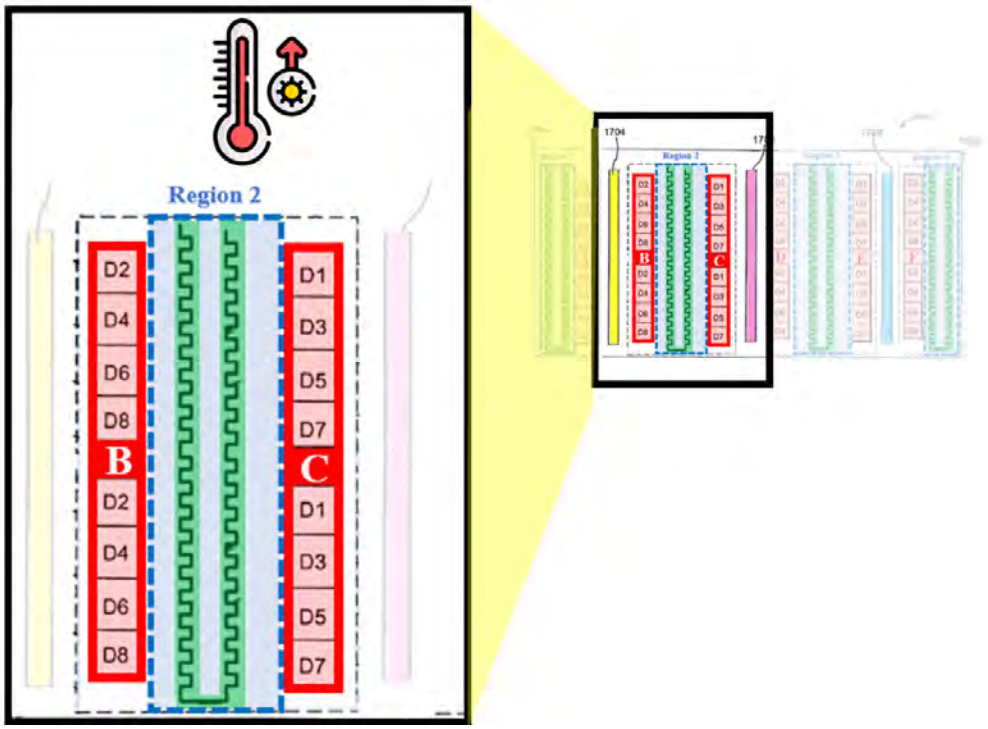
167. Looking at Region 2, for example, a PHOSITA would know that the TSR within that region accurately reports the temperature of Heater Arrays B and C because they are positioned between, not outside, the yellow and magenta ink vias.

The Benjamin-Giere673 Combination



168. Based upon the temperature of the region sensed by the TSR and provided to the temperature controller 100, Giere673 teaches that the heater arrays receive heating "so that the **temperature of the heater array** [], and therefore the temperature of the ink in the chamber array [], are maintained at an **optimum**

temperature for the formation of ink droplets." Ex. 1004, 7:41-45; 9:8-19. For example, Giere673 teaches that "[t]he temperature logic system [] **generates firing Voltages 814** and **activates heater elements** that do not eject ink 816.").

Benjamin-Giere673


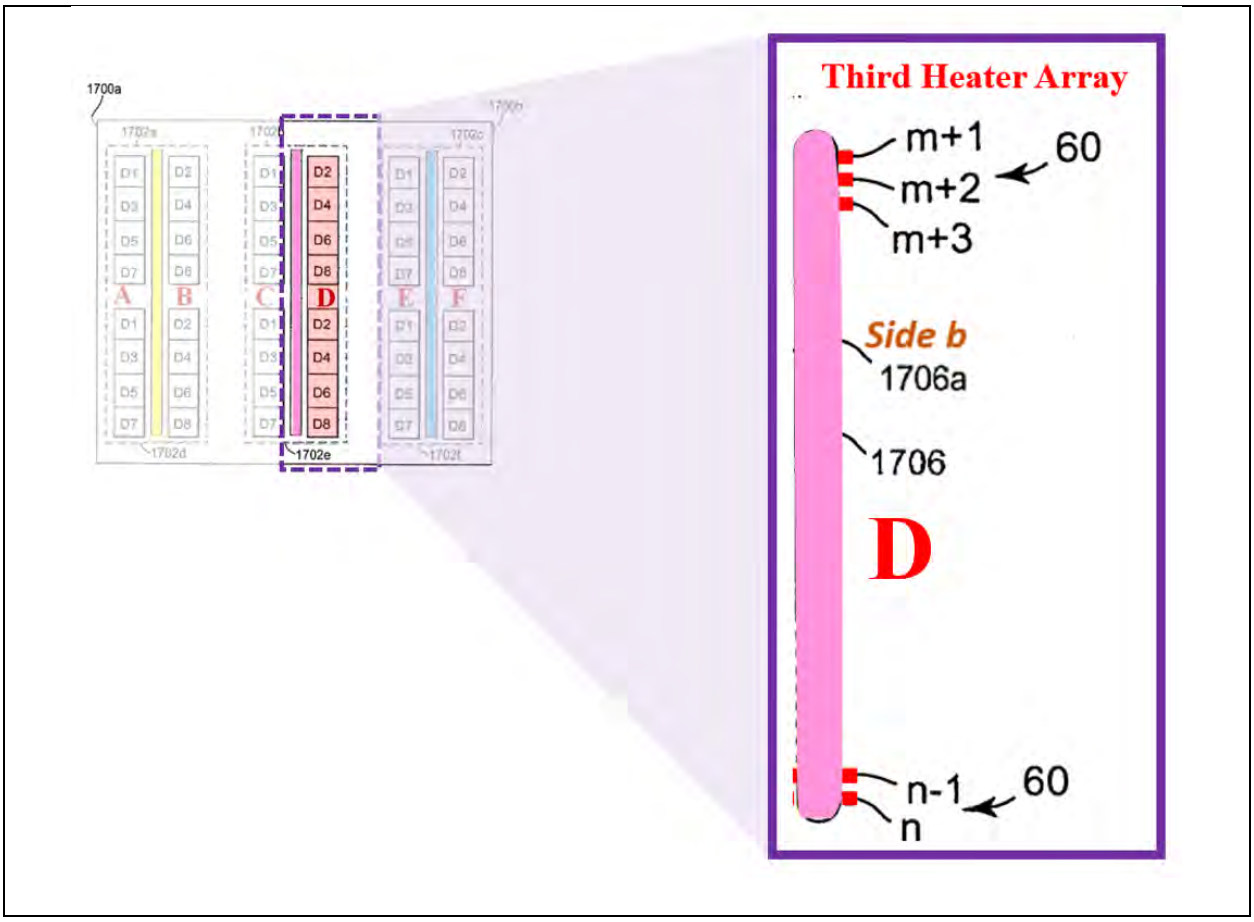
169. Accordingly, it is my opinion that Benjamin-Giere673 discloses "wherein the first heater array [e.g., Heater Array B] and the second heater array [e.g., Heater Array C] are operable to receive heating responsive to the temperature of the region [e.g., Region 2] sensed by the temperature sensing element [e.g., TSR], and wherein the received heating regulates the temperature of the region [e.g., generate firing voltages and activates heater elements]."

8. 1[G] "a third heater array[,] positioned substantially adjacent the second via"

170. Claim 1 of the '823 Patent further recites "a third heater array[,] positioned substantially adjacent the second via." In my opinion, the Benjamin-Giere673 combination discloses this limitation.

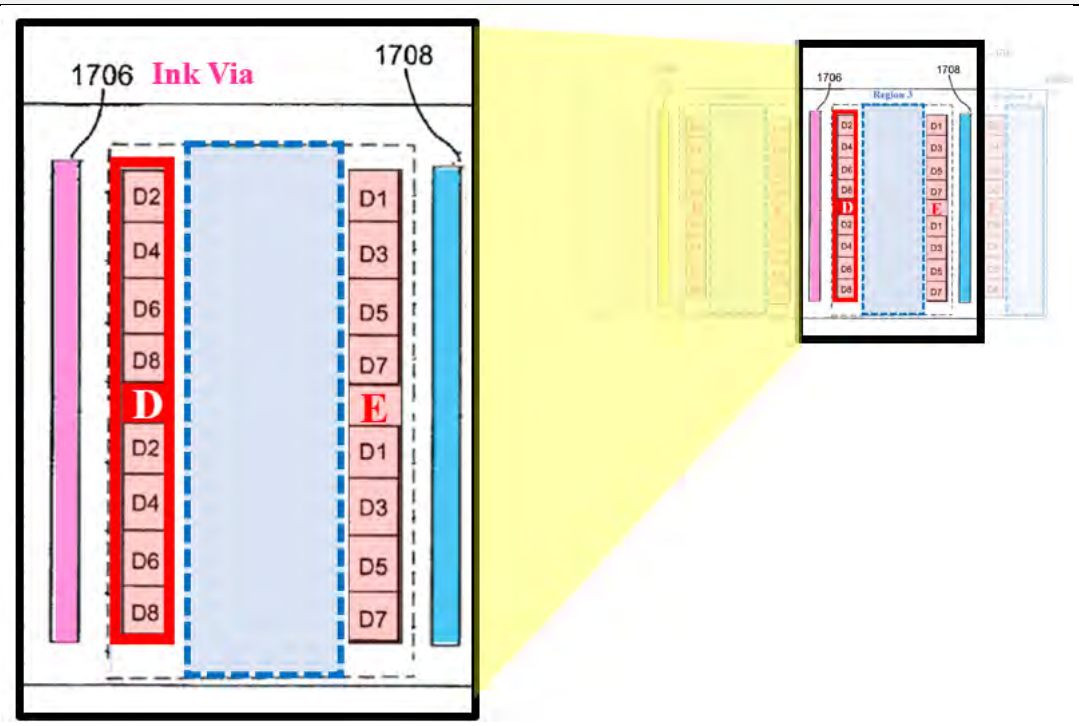
171. The printhead die 1700 includes a third array of firing resistors 52 (*e.g.*, Heater Array D) from the drop generators 60 associated with side 1706*b* of the magenta ink feed slot 1706—*e.g.*, "[t]he drop generators 60 in FG2 1702*b* [and in FG4 1702*e*] are disposed along each of the opposing sides 1706 *a* and 1706 *b* of ink feed slot 1706." Ex.1004 at 66:36-67:8.

Ex.1004, Fig. 21 (simplified)



172. Heater Array D is disposed next to the magenta ink feed slot 1706, and therefore, substantially adjacent the Magenta Ink Via.

Ex.1004, Figs. 3, 21



173. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses "a third heater array[,] [e.g., Heater Array D] positioned substantially adjacent a second via [e.g., Magenta Ink Via]."

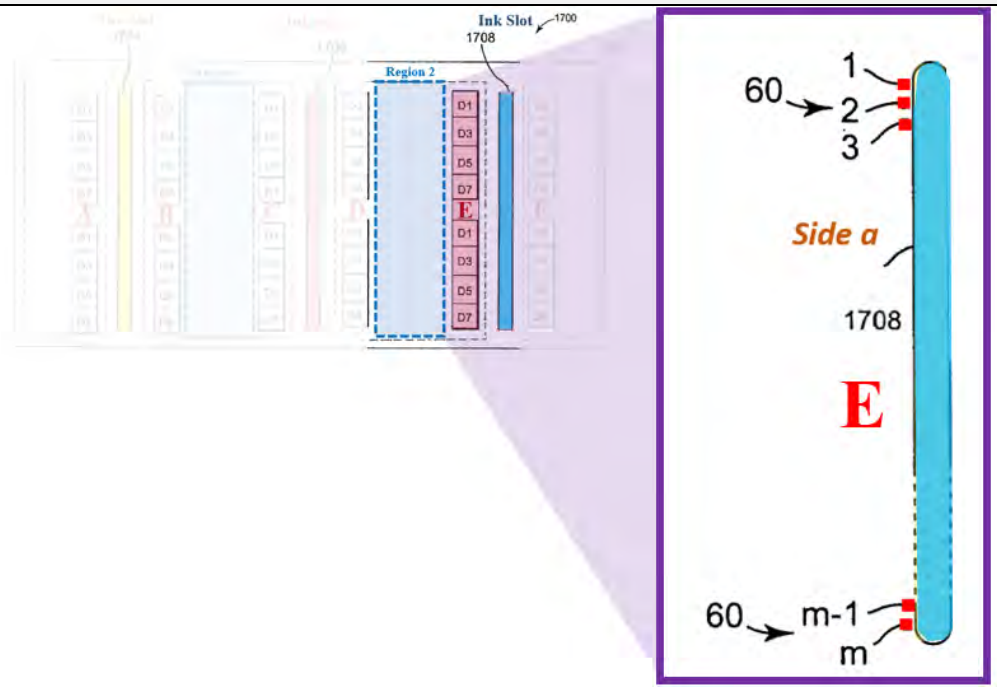
9. 1[H] "a fourth heater array, positioned substantially adjacent a third via"

174. Claim 1 of the '823 Patent further recites "a fourth heater array, positioned substantially adjacent a third via." In my opinion, the Benjamin-Giere673 combination discloses this limitation.

175. The printhead die 1700 includes a fourth array of firing resistors 52 (*e.g.*, Heater Array E) from the drop generators 60 associated with side 1708*a* of the

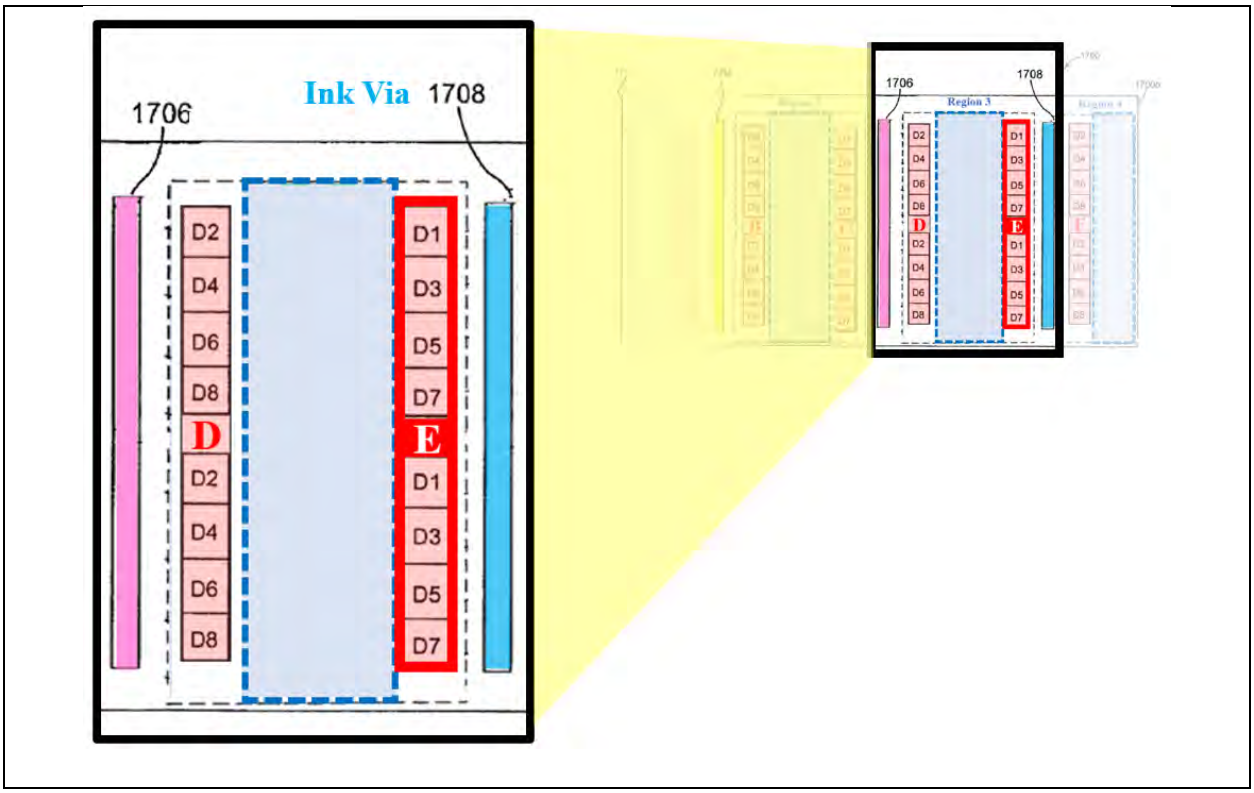
cyan ink feed slot 1708—*e.g.*, "[t]he drop generators 60 in FG3 1702*c* [and in FG6 1702*f*] are disposed along each of the opposing sides 1708 *a* and 1708 *b* of ink feed slot 1708." Ex.1004 at 66:36-67:8.

Ex.1004, Fig.3,21(simplified)



176. Heater Array E is disposed next to the cyan ink feed slot 1708, and therefore, substantially adjacent the Cyan Ink Via.

Ex.1004, Fig.21(simplified)



177. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses "a fourth heater array, [e.g., Heater Array E] positioned substantially adjacent a third via" [*e.g.*, Cyan Ink Via].

10. 1[I] "a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array"

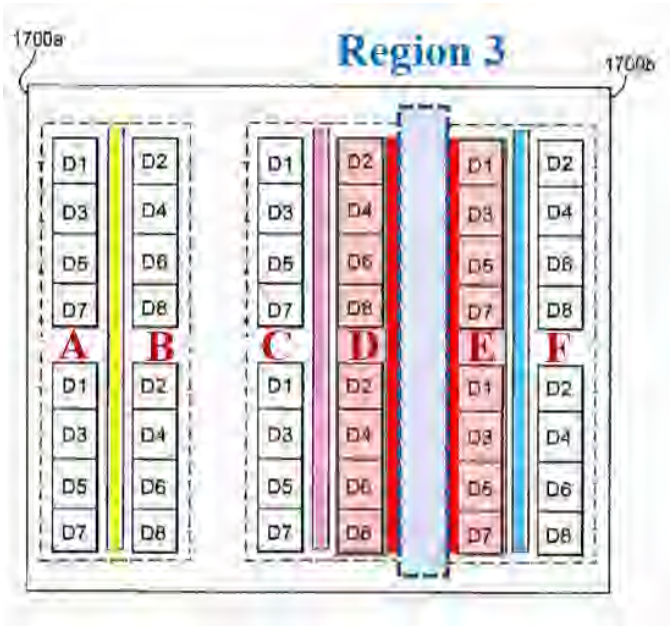
178. Claim 1 of the '823 Patent further recites "a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array." In my opinion, the Benjamin-Giere673 combination discloses this limitation.

179. The Printhead die 1700 includes a second region [*e.g.*, Region 3, *blue below*] positioned between Heater Array D and Heater Array E (*red*).

Ex.1004, Fig.21 (simplified)


180. Region 3 of Printhead Die 1700 is also positioned immediately next to, and shares a border with, both Heater Array D and E, and therefore, is substantially immediately adjacent each heater array.

Ex.1004, Fig.21



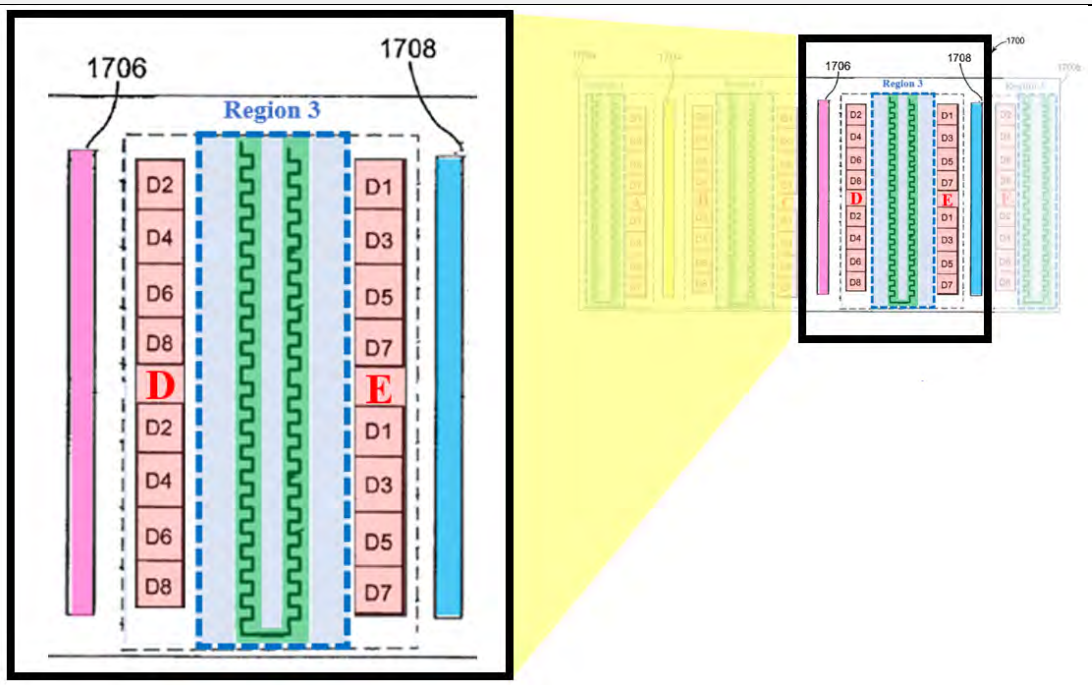
181. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses "a second region [e.g., Region 3], positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array [e.g., positioned between and immediately next to and sharing a border with Heater Arrays D and E]."

11. 1[J] "a second temperature sensing element operable to sense the temperature of the second region"

182. Claim 1 of the '823 Patent further recites "a second temperature sensing element operable to sense the temperature of the second region." As I explained in greater detail above for Limitations 1[d], the printhead die resulting from the Benjamin-Giere673 combination includes a single temperature sense resistor [e.g., TSR, *green below*] within each of the thermal regions on the printhead die [e.g., Regions 1-4, *blue*], including the thermal region between the Heater Array D and

Heater Array E [*e.g.*, Region 3], which the TSR senses to provide a temperature value for the second region.

Ex.1004 and Ex.1005, (The Benjamin-Giere673 Combination)



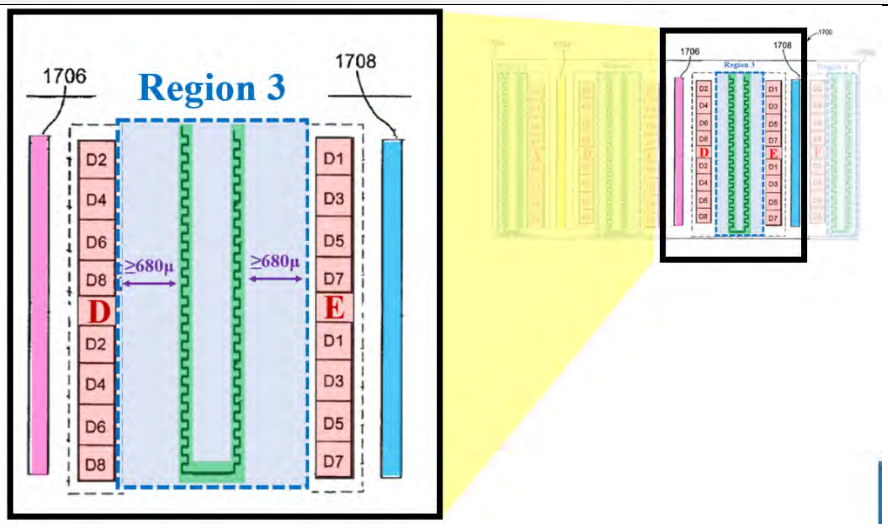
183. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses "a second temperature sensing element [*e.g.*, TSR] operable to sense the temperature of the second region. [e.g., Region 3]."

12. 1[K] "wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array"

184. Claim 1 of the '823 Patent further recites "wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array." As

I explained in greater detail above for Claim 1[d] and 1[e], the printhead die resulting from the Benjamin-Giere673 combination positions each TSR equidistant from the two adjacent heater arrays but no less than "approximately 680 µm inboard from the center of the [heater arrays]" so that, *individually*, each TSR provides a temperature value reflective of the temperature of its region, including the heater arrays adjacent those regions, *and collectively*, the values provided by the TSRs reflect the mean temperature of the entire printhead die.

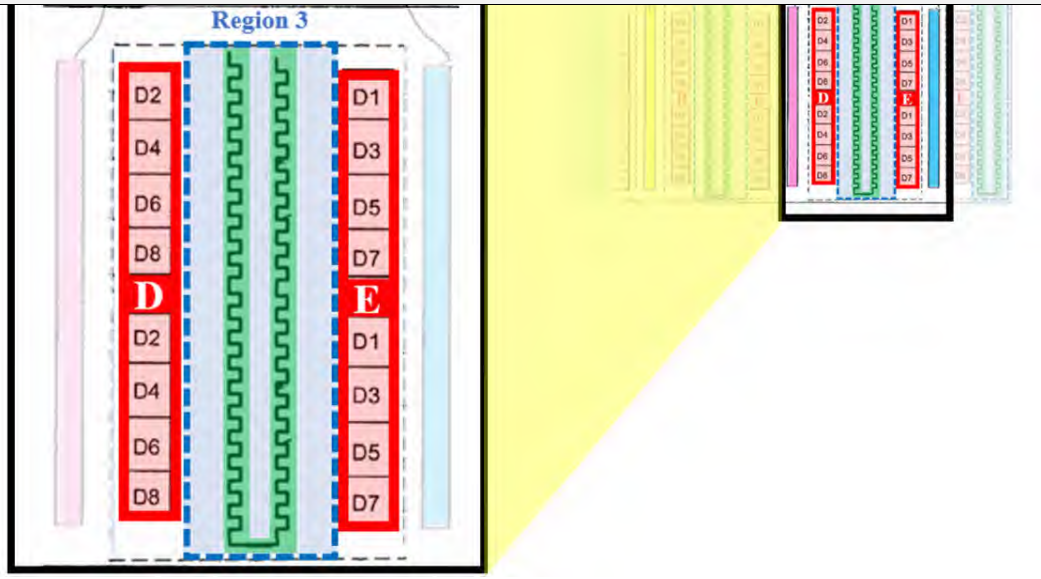
Ex.1004 and Ex.1005, (The Benjamin-Giere673 Combination)



185. Moreover, because the second region of the printhead die [e.g., Region 3, *blue below*] shares a border with the same two adjacent heater arrays that are positioned equidistant from the TSR—Heater Array D and the Heater Array E—the

TSR within Region 3 is not only substantially centrally disposed in Region 3, but also substantially adjacent to both Heater Array D and E.

Ex.1004 and Ex.1005, (The Benjamin-Giere673 Combination)

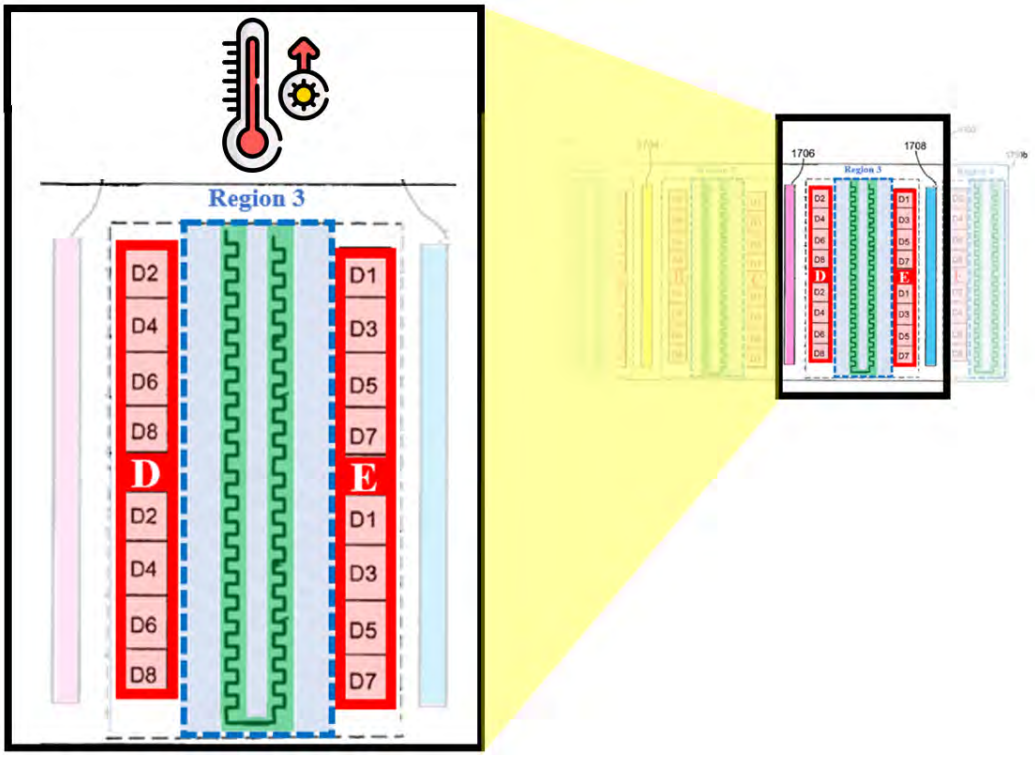


186. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses that the second temperature sensing element [e.g., TSR 510] is "substantially centrally disposed with respect to the second region [e.g., Region 3] and substantially adjacent to both the third heater array and fourth heater array [e.g., Heater Array D and the Heater Array E]."

13. 1[L] "the third heater array and the fourth heater array are operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region"

187. Claim 1 of the ’823 Patent further recites “Wherein the third heater array and the fourth heater array are operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region.”

188. In my opinion, Benjamin-Giere673 combination discloses this limitation for the same reasons as in 1[F].

The Benjamin-Giere673 Combination


189. Accordingly, it is my opinion that the Benjamin-Giere673 combination discloses that “the third heater array and the fourth heater array [e.g., Heater Arrays D and E] are operable to receive heating responsive to the temperature of the second

region [e.g., Region 3] sensed by the temperature sensing element [e.g., TSR], and wherein the received heating regulates the temperature of the region [e.g., generate firing voltages and activates heater elements]."

B. Claim 2

190. Claim 2 of the '823 patent depends from Claim 1. The Benjamin-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 2 further adds: "wherein the temperature sensing element comprises a temperature sensing resistor." In my opinion, the Benjamin-Giere673 Combination discloses this limitation.

191. As I explained above for 1[D], Benjamin discloses a "temperature sense resistor" (Ex.1004 at 79:60-65), and Giere673 discloses "a thermal sense resistor (TSR) 510" (Ex.1004, 4:49-55), and the printhead of the Benjamin-Giere673 combination positions a TSR within each region of Benjamin's printhead die.

192. Therefore, it is my opinion that the Benjamin-Giere673 combination discloses that "the temperature sensing element comprises a temperature sensing resistor [*i.e.*, TSR 510].

C. Claim 3

193. Claim 3 of the '823 patent depends from Claim 2. The Benjamin-Giere673 Combination discloses Claim 2 for the reasons discussed above. Claim 3 further adds: "wherein the temperature sensing element comprises a thermal sense

resistor." In my opinion, the Benjamin-Giere673 Combination discloses this limitation.

194. As I explained above for 1[D], Benjamin discloses a "temperature sense resistor" (Ex.1004 at 79:60-65), and Giere673 discloses "a thermal sense resistor (TSR) 510" (Ex.1004, 4:49-55), and the printhead of the Benjamin-Giere673 combination positions a TSR within each region of Benjamin's printhead die.

195. Therefore, it is my opinion that the Benjamin-Giere673 combination discloses that "the temperature sensing element comprises a thermal sense resistor [*i.e.*, TSR]."

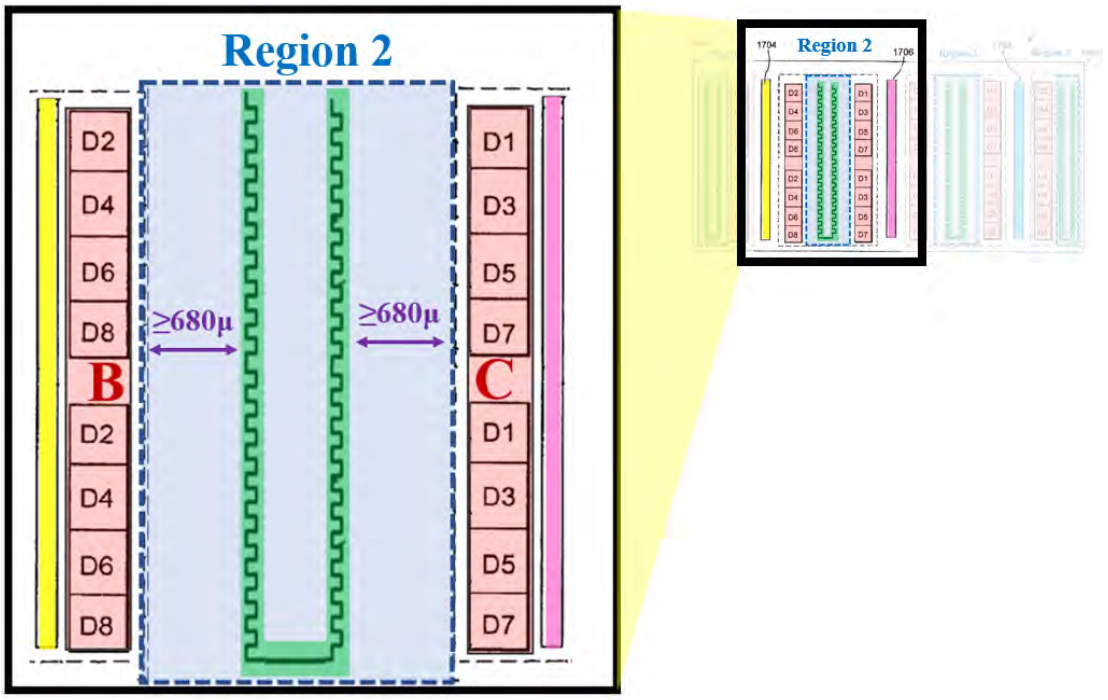
D. Claim 5

196. Claim 5 of the '823 patent depends from Claim 1. The Benjamin-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 5 further adds: "wherein the temperature sensing element is positioned at least 300 microns from each of the first heater array and the second heater array." In my opinion, the Benjamin-Giere673 Combination discloses this limitation.

197. Giere673 discloses that "[t]he TSR 510 can have two legs that are **approximately 680 µm inboard from the center of the columns of ink ejection elements 416**." Ex.1005 at 5:10-12. Since 1 µm (micrometer) is equal to 1 µ (micron), Giere673 teaches positioning the TSR 510 approximately 680 microns from the center of the columns of ink ejection elements 416, which a PHOSITA

would recognize as being the "drop generators 60 disposed along each of the opposing ink feed slot sides," as shown in my illustration below.

Ex.1004 and Ex.1005, (The Benjamin-Giere673 Combination)



198. Therefore, it is my opinion that the Benjamin-Giere673 combination discloses that "the predetermined distance is at least 300 microns [*i.e.*, approximately 680 microns]."

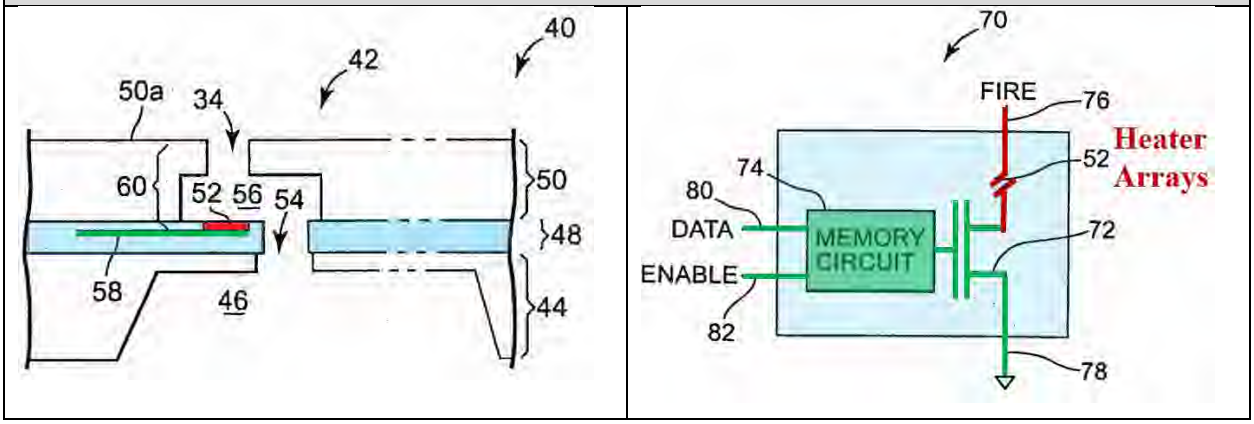
E. Claim 6

199. Claim 6 of the '823 patent depends from Claim 1. The Benjamin-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 6 further adds: "wherein the temperature sensing element is positioned substantially

planar to each of the first heater array and the second heater array." In my opinion, the Benjamin-Giere673 Combination discloses this limitation.

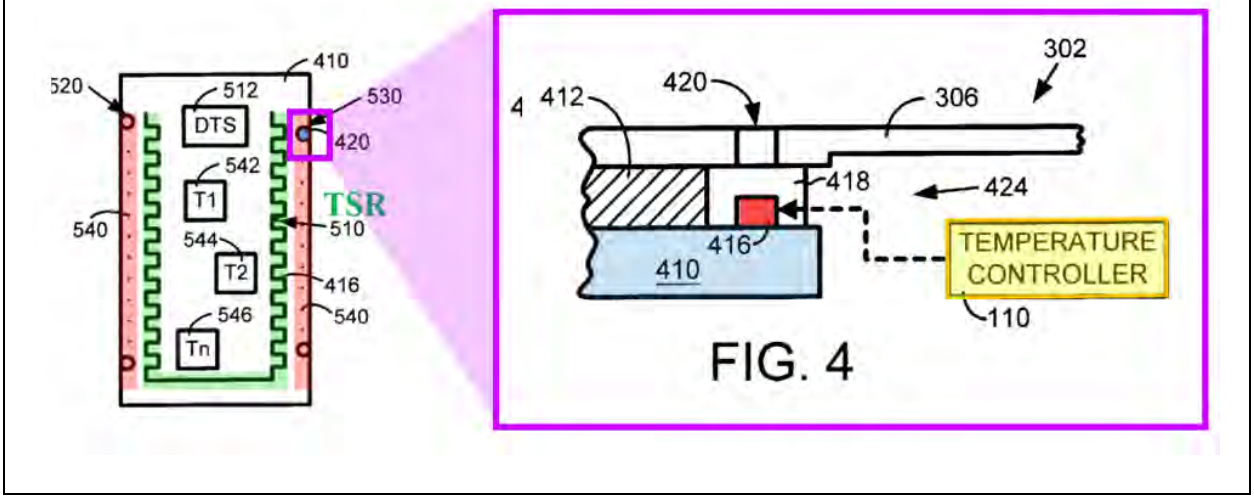
200. Referring to Figs. 2 and 4, Benjamin teaches forming a firing circuit 71 "in the thin-film structure 48 and on substrate 42" of printhead die 40 to charge the firing resistors 52, and states that this firing circuit 71 includes not only the "firing resistors 52" (*red*), but also "the circuitry that controls the application of electrical current through firing resistor 52" (*green*)—*e.g.*, "a resistor drive switch 72 and a memory circuit 74." Ex.1004 6:8-9; *see below id.* at Fig. 4. Since the printhead die 40 may also include "a thermal sense resistor (TSR) that is read to provide a TSR value" for "determ[ing] the temperature of the printhead 40," a PHOSITA would know that the circuitry for receiving TSR values may be disposed in the same "thin-film structure 48 and on substrate 40 (*blue*)" as the circuitry for controlling the firing resistors 52 (*green*), thereby allowing the TSR to be positioned *substantially* planar to both of heater arrays 52 with that region, particularly given that the '823 Patent treats "substantially planar" to mean "the temperature sensing element is not positioned directly above the first or second heater arrays." Ex.1001 at 3:11-13.

Ex.1004, Figs. 2 and 4



201. The Benjamin-Giere673 Combination positions the TSR 510 (*green*) at a predetermined distance away from each of the two adjacent heating elements 416 within that region—*i.e.*, "approximately 680 µm ***inboard from*** the center of the columns of ink ejection elements 416," which means that the TSR 510 must be substantially planar to the ink ejection elements 416, at least under the '823 Patent's definition of that term. Ex.1001 at 3:13. Figures 2 and 4 of Giere673 confirm that TSR 510 is substantially planar to each column of firing elements 416 because Figure 5 shows the right leg of TSR 510 (*green*) spaced apart from nozzle 530 (*blue*) and Figure 4 shows firing elements 416 (*red*) directly under the nozzle 420 (*blue*), which means that TSR 510 is *substantially planar* because it is not "positioned directly above the [] heater arrays." Ex.1001 at 3:15-16.

Ex.1005, Figs. 4 and 5

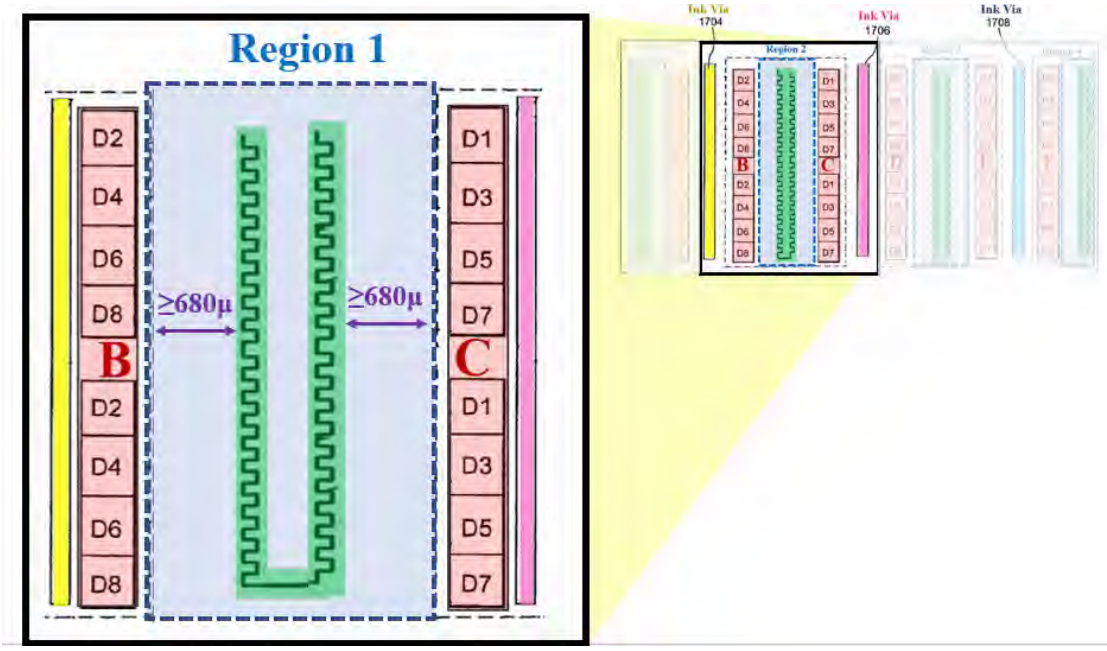


202. To be sure, Giere673 teaches that "thermal head assembly 302 includes a substrate 410 and a barrier layer 412 located between the nozzle member 306 and the substrate 410 … forming a plurality of ink ejection chambers 418," as well as "a corresponding plurality of heating elements 416 disposed on the substrate." Ex.1005 at 4:12-18. Giere673 teaches using TSRs 510 "to provide an approximation of the mean temperature of the substrate." Ex.1005 at 4:55-56. By ensuring that the TSRs 510 are "not located adjacent to any particular heating element," Giere673 discloses that the TSRs 510 can sense the "temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005 at 4:58-60; *see also id.* at 4:60-61 ("The TSR 510 therefore reports a temperature that reflects heating element firings that have already occurred.").

203. As just one example, Giere673 teaches positioning the TSRs 510 "along the length of the substrate 410 … approximately 680 um inboard from the

center of the columns of ink ejection elements 416," so that each TSR 510 is substantially planar to the columns of ink ejection elements 416. Ex.1005 at 5:10-12. When adding Giere673's TSRs 510 to Benjamin's printhead die 1700, a PHOSITA would likewise position the TSRs along the length of the substrate … approximately 680 microns inboard from the center of the columns of "drop generators 60 disposed along each of the opposing ink feed slot sides," so that the TSR (*green*) in the region between ink feed slot 1704 and 1706 is positioned substantially planar to the first array of drop generators 60 (*red*) disposed on side 1704b of ink feed slot 1704 and side 1706a of ink feed slot 1706, as shown in my illustration below.

Ex.1004 and Ex.1005, (The Benjamin-Giere673 Combination)



204. Alternatively, it would be obvious to a PHOSITA to position the temperature sensing element in substantially the same plane as the first and second heater arrays as doing so would reduce manufacturing costs and time required to manufacture the printhead die.

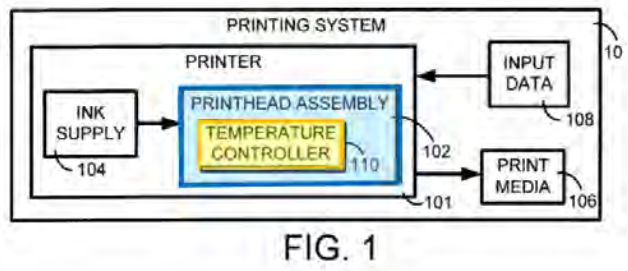
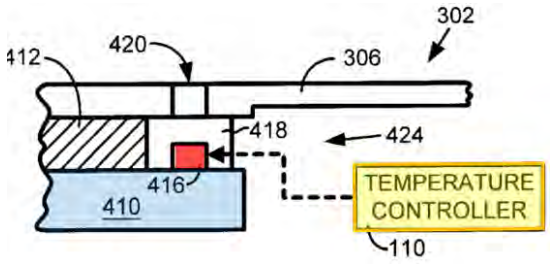
205. Therefore, it is my opinion that the Benjamin-Giere673 combination further discloses that "the temperature sensing element [*i.e.*, TSR 510] is positioned substantially planar to each of the first heater array and the second heater array [*e.g.*, the array of firing resistors 51 in drop generators 60 disposed on side 1704b of ink feed slot 1704 and the array of firing resistors 551 in drop generators 60 disposed on side 1706a of ink feed slot 1706]."

F. Claim 7

206. Claim 7 of the '823 patent depends from Claim 1. The Benjamin-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 7 further adds: "at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array." In my opinion, the Benjamin-Giere673 Combination discloses this limitation.

207. Giere673 discloses "a temperature control system 110 (*yellow*) for predicting dynamic thermal conditions of the printhead assembly 102," including "the substrate" (*blue*) Ex.1004, 2:48-52; Figs. 1 and 4. "To control[] the temperature

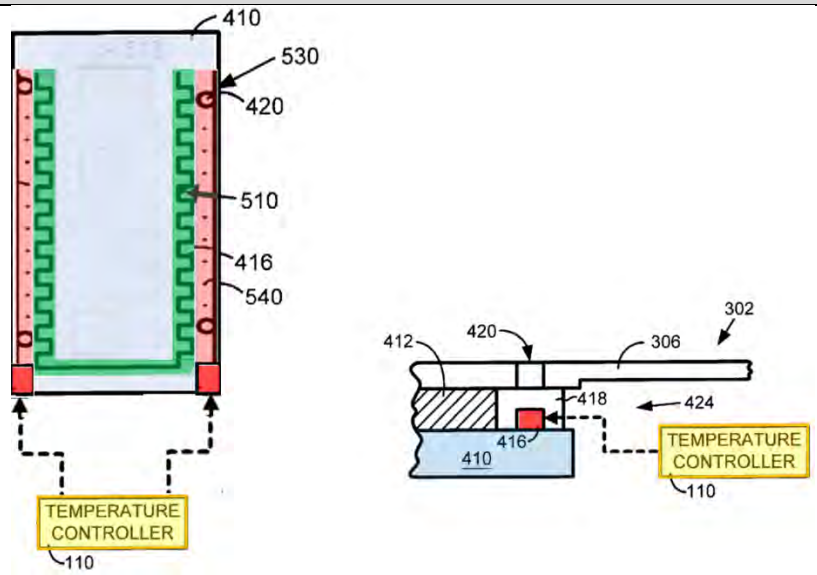
of the substrate and the temperature of each ejection chamber or nozzle chamber," Giere673 discloses that "[t]he temperature controller 110 is coupled to multiple temperature sensors (not shown)," which "determine, at a given time, a mean or ***average temperature of the substrate*** and an ***actual local temperature profile near designated ink ejection elements***." Ex.1005 at 2:57-62. Thereafter, "[t]he temperature controller 110 uses the input data 108 [supplied by the temperature sensors] to predict thermal conditions of particular ejection chambers for selectively firing the associated heating elements." Ex.1004, 3:1-6

Ex.1004, Fig. 1	**Ex.1004, Fig. 4**
 FIG. 1	

Ex.1004, 2:62-65 ("The temperature controller 110 … ***controls the mean temperature*** of the substrate of the printhead through a feedback loop.").

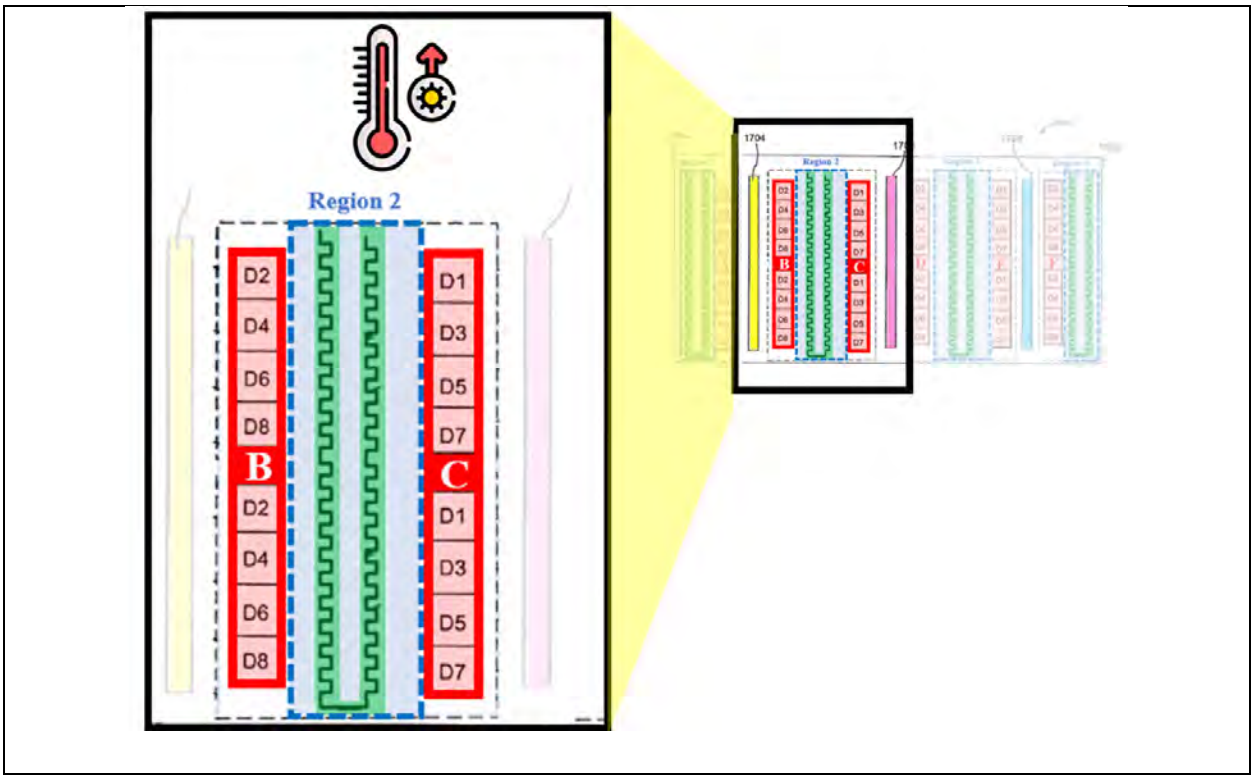
208. In my opinion, PHOSITA would understand from Giere673 that "the temperature controller 110 of FIG. 1 is coupled to at least one measurement sensor," such as "a thermal sense resistor (TSR) 510" that "provide[s] an approximation of the mean temperature of the substrate," which the temperature controller 110 uses

the mean temperature sensed by the TSR 510 "to control the temperature." Ex.1004, 4:49-5:5.

Ex.1004, Figs.1,5


209. Based upon the temperature of the region sensed by the TSR and provided to the temperature controller 100, Giere673 teaches that the heater arrays receive heating "so that the **temperature of the heater array** [], and therefore the temperature of the ink in the chamber array [], are maintained at an **optimum temperature for the formation of ink droplets**." Ex. 1004, 7:41-45; 9:8-19. For example, Giere673 teaches that "[t]he temperature logic system [] **generates firing Voltages 814** and **activates heater elements** that do not eject ink 816.").

Benjamin-Giere673



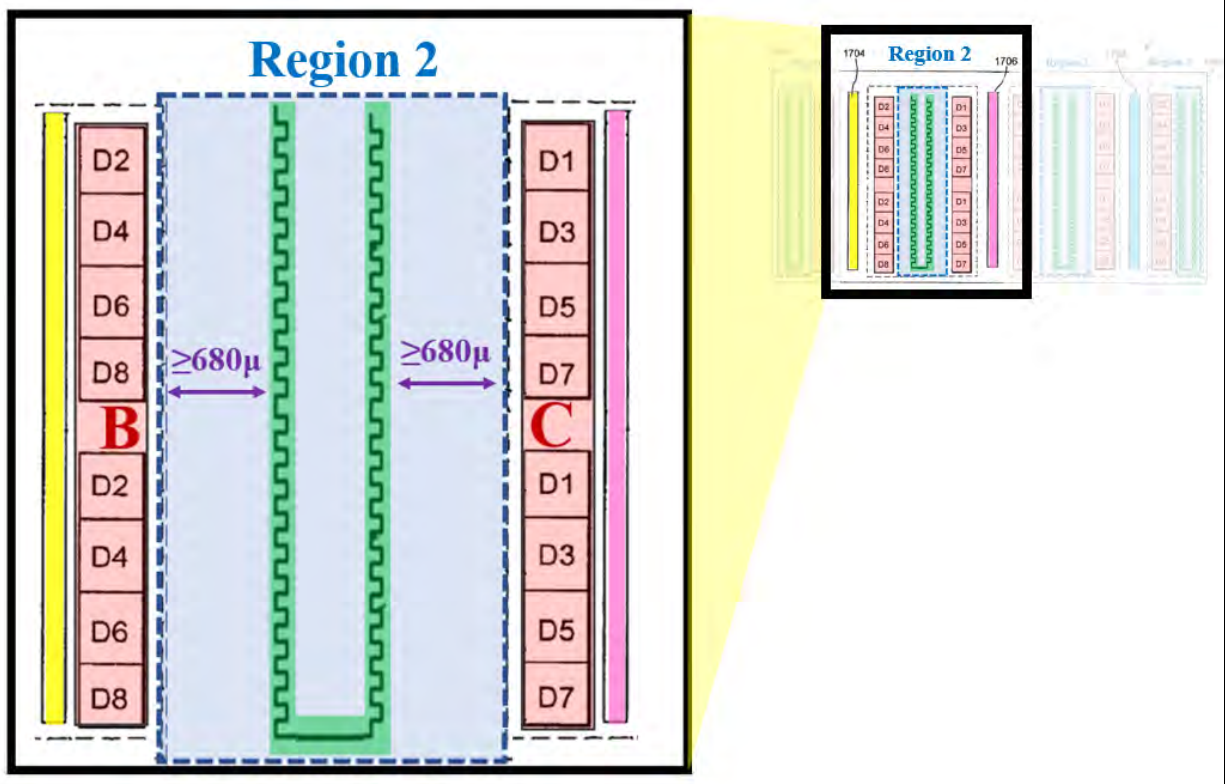
210. Therefore, t is my opinion that the Benjamin-Giere673 combination discloses "at least one control element [*i.e.*, temperature controller 100] operable to receive a temperature measured by the temperature sensing element [*i.e.*, TSR]."

G. Claim 8

211. Claim 8 of the '823 patent depends from Claim 1. The Benjamin-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 8 further adds: "wherein the temperature sensing element positioned between the first heater array and the second heater array is different than the second temperature sensing element positioned between the third heater array and the fourth heater array."

212. As I explained in 1[D], incorporated here, Benjamin-Giere673 includes a single temperature sense resistor (TSR, *green*) in the first region (Region 1) between Heater Array B disposed along the side 1706 b of the Yellow Ink Via and Heater Array C disposed along the side 1706 a of the Magenta Ink Via, which the TSR senses to provide a mean temperature value for the first region.

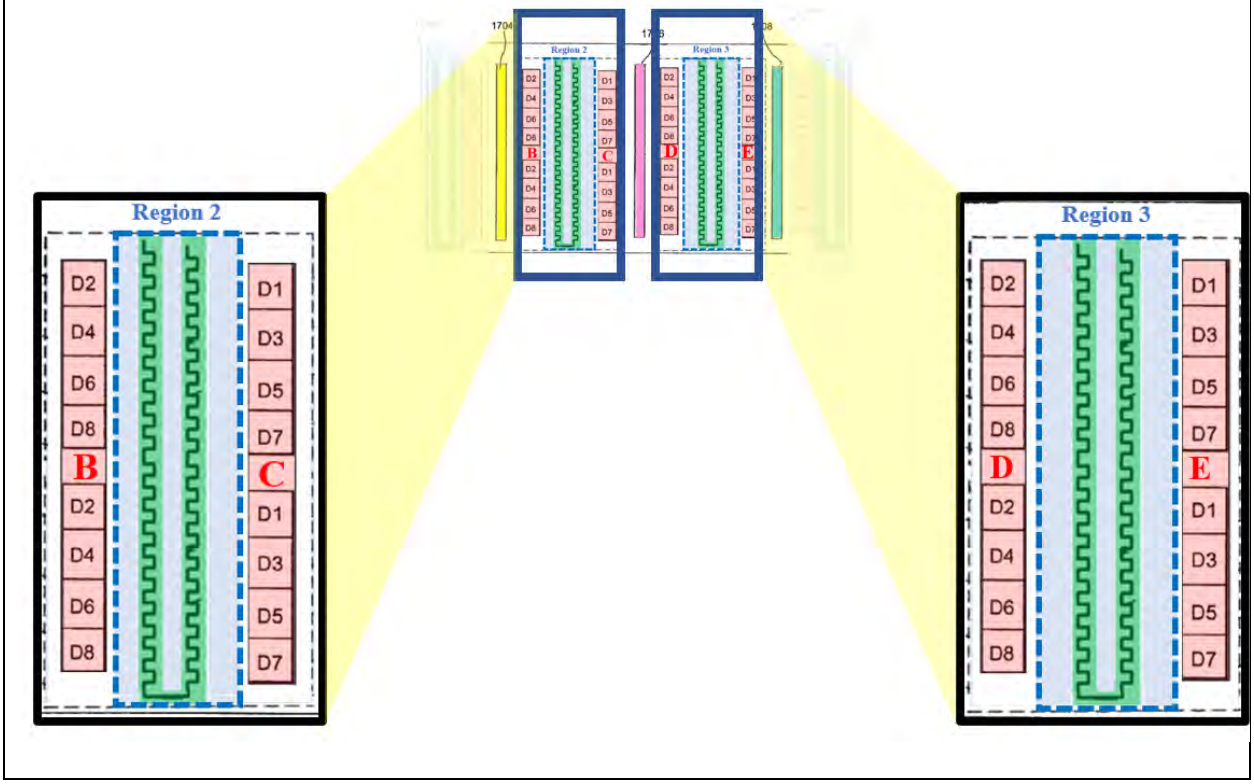
The Benjamin-Giere673 Combination



213. For the reasons I provided in 1[J], incorporated here, Benjamin-Giere673 also includes a single temperature sense resistor (TSR, *green*) in the second region (Region 2) between the Heater Array D disposed along the side 1706

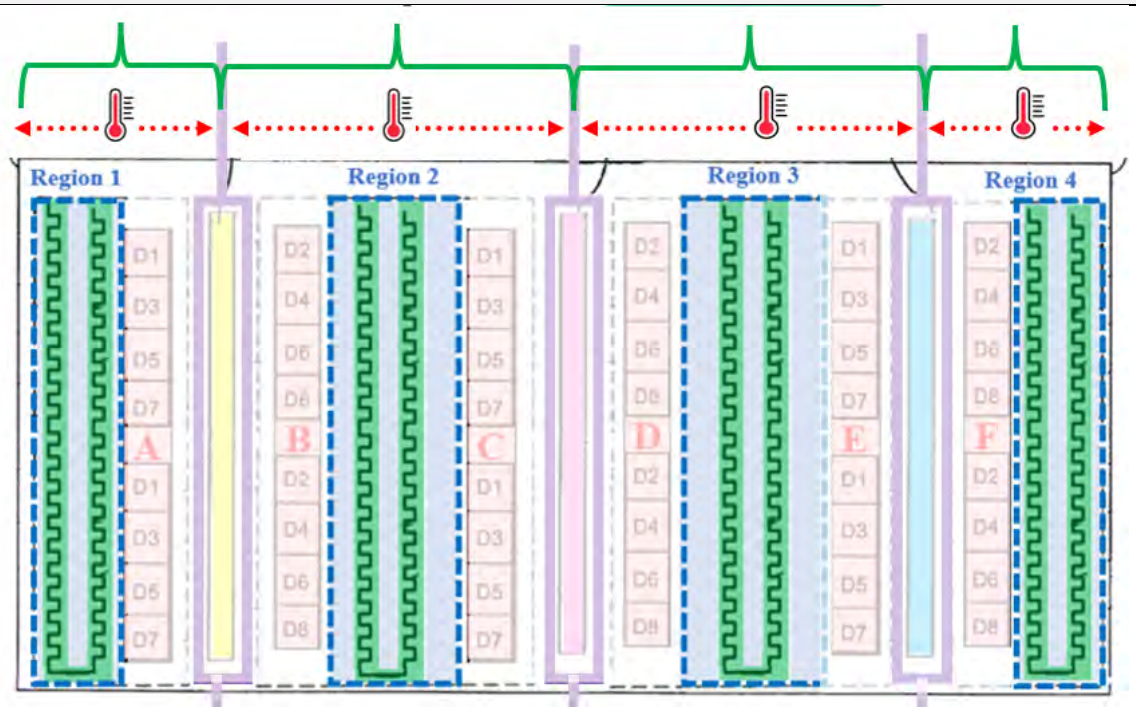
b of the Magenta Ink Via and Heater Array E disposed along the side 1708 a of the Cyan Ink Via, which the TSR senses to provides a mean temperature value for the second region.

The Benjamin-Giere673 Combination



214. In my opinion, a PHOSITA would not only understand that Benjamin-Giere673 provides two independent TSRs, one in each region of the Benjamin printhead die, but also that TSRs are different than each other because they are in different regions of the printhead die, associated with different heater arrays, have different electrical connections, and produce different temperature measurements.

Benjamin-Giere673



215. Therefore, it is my opinion that Benjamin-Giere673 further discloses that "the temperature sensing element [e.g., TSR] positioned between the first heater array and the second heater array [e.g., Heater Arrays B and C] is different than the second temperature sensing element [e.g., TSR] positioned between the third heater array and the fourth heater array [e.g., Heater Arrays D and E]."

H. Claim 9

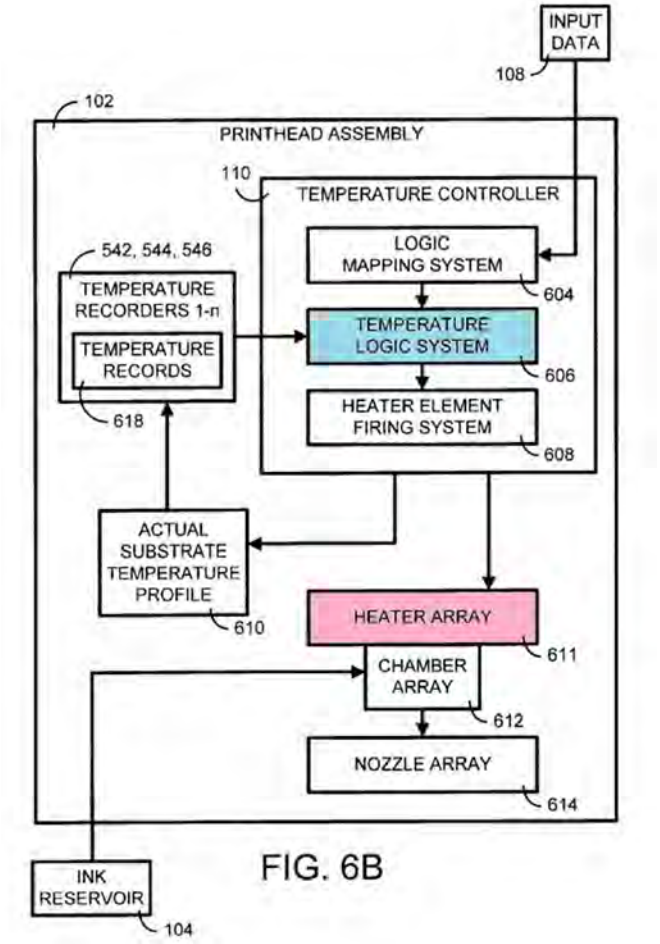
216. Claim 9 of the '823 patent depends from Claim 1. The Benjamin-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 9 further adds: "wherein the first heater array and the second heater array are operable to receive non-nucleating heating responsive to the temperature of the region sensed

by the temperature sensing element." In my opinion, the Benjamin-Giere673 combination discloses this limitation.

217. Giere673's "**temperature controller 110 aids in controlling the temperature of the substrate** and the temperature of each ejection chamber or nozzle chamber" which "results in improved print quality and printhead life because the printhead 102 will consequently operate closer to its optimum temperature." Ex.1005 at 3:7-12.

218. The temperature controller 110 uses a "closed loop" method wherein in response to the temperature of the region sensed by the temperature sensing elements generating "printing parameters," including pulse widths to heaters and warming using non-ejecting devices, that are used to regulate the substrate temperature. Temperature controller 110 includes "**temperature logic system 606**" that generates various printing parameters. Ex.1004 at 6:21-28.

Ex.1005, Fig. 6A



219. During operation of the printhead, an actual temperature profile is created that includes the current temperature of the substrate. Giere673 discloses that the "temperature logic system uses these temperature and printing inputs…to generate printing parameters and then output them in a closed loop system to the actual substrate temperature profile 610." Ex.1005 at 6:46-52. Giere673 further explains that the "printing parameters can include **pulse widths, pulse rates, ink**

ejection chambers 418 to be fired and when they will be fired, warming using non-ejecting devices, and firing voltages that act as the inputs for the actual substrate temperature profile 610." Ex.1005 at 6:52-57; *see also* Ex.1005 at 9:33-38 ("since the firing system limits the rate, voltage or pulse width of firing of heater elements, less energy will be used"). Giere673 then states that "**[t]his rate, width and order of firing are programmed, and if necessary, adjusted in the programming, so that the temperature of the heater array 611 [*pink, below*], and therefore the temperature of the ink in the chamber array 612, are maintained at an optimum temperature for the formation of ink droplets**." Ex.1005 at 9:13-18.

220. Non-nucleating heating (NNH) refers to a technique of applying short pulses to heater resistors, i.e., too short to eject an ink drop (nucleation), but sufficient to warm the substrate and ensure the heater chip operates at a desired temperature range. Thus, Giere673 discloses that the heater arrays receive non-nucleating heating (e.g., adjustments to pulse width) responsive to the sensed temperature.

221. Moreover, like the '823 Patent, Giere673 also discloses using a non-nucleating heating method to control its heating elements: "The temperature logic system also generates firing voltages 814 and **activates heater elements that do not**

eject ink 816." Ex.1005 at 9:18-20; see also id. at 6:52-57 ("warming using non-ejecting devices").

222. Accordingly, it is my opinion that Benjamin-Giere678 discloses that "the first heater array [e.g., Heater Array B] and the second heater array [e.g., Heater Array C] are operable to receive non-nucleating heating [e.g., adjustments to firing rate, firing voltage, or pulse width] responsive to the temperature of the region sensed by the TSR.

I. Claim 10

223. Claim 10 of the '823 patent depends from Claim 9. The Benjamin-Giere673 Combination discloses Claim 9 for the reasons discussed above. Claim 10 further adds: "wherein the the non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element is of a short duration such that ink will not be ejected from the first via or the second via during the non-nucleating heating." In my opinion, the Benjamin-Giere673 discloses this limitation for the same reasons as 1[9].

224. Additionally, it is my opinion that the pulse width adjustments in the Benjamin-Giere673 combination will be of a short duration such that ink will not be ejected from the heater arrays. For example, Giere673 specifically states that "[t]he temperature logic system also generates firing voltages 814 and **activates heater elements that do not eject ink 816**." Ex.1005 at 9:18-20; see also id. at 6:52-57

("warming using non-ejecting devices"). Giere673 also describes limiting, e.g., shortening, the pulse width. Ex.1005 at 9:33-38 ("since the firing system limits the rate, voltage or pulse width of firing of heater elements, less energy will be used").

225. Therefore, it is my opinion that the Benjamin-Giere673 combination discloses that "the the non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element is of a short duration such that ink will not be ejected from the first via or the second via during the non-nucleating heating."

J. Claim 11

226. As shown below, the limitations of claim 11 mirror those of claims 1 and 7.

11[p]	A method of fabricating chips for use with a printing device, comprising	**1[p]**	A chip for use with a printing device
11[a]	providing a first heater array positioned substantially adjacent a first via;	**1[a]**	a first heater array positioned substantially adjacent a first via
11[b]	providing a second heater array positioned substantially adjacent a second via;	**1[b]**	a second heater array positioned substantially adjacent a first via
11[c]	positioning a temperature sensing element in a region adjacent to and immediately between the first heater array and the second heater array and substantially adjacent to both the first heater array and second heater array;	**1[c]**	a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array

	wherein the temperature sensing element is operable to sense a temperature of the region, the temperature being representative of the region and wherein the temperature sensing element extends substantially the length of the first heater array and second heater array;	**1[d]**	a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region
		1[e]	wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array
11[d]	responsive to the temperature of the region sensed by the temperature sensing element, heating the first heater array and the second heater array to regulate the temperature of the region;	**1[f]**	wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region
11[e]	providing at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array;	**7**	at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array
11[f]	providing a third heater array substantially adjacent the second via;	**1[g]**	a third heater array[,] positioned substantially adjacent the second via
11[g]	providing a fourth heater array substantially adjacent a third via;	**1[h]**	a fourth heater array, positioned substantially adjacent a third via
11[h]	positioning a second temperature sensing element in a second region located between the third heater array and the fourth heater array. wherein	**1[i]**	a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to

	the temperature sensing element is operable to sense the temperature of the second region, and wherein the temperature sensing element is substantially centrally disposed with respect to the second region and is substantially adjacent to both the third heater array and fourth heater array.		the third heater array and the fourth heater array
		1[j]	a second temperature sensing element operable to sense the temperature of the second region,
		1[k]	wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array

227. Thus, for the same reasons that I provided above for claim 1, incorporated here, it is my opinion that the Benjamin-Giere673 Combination also discloses every limitation of Claim 11.

K. Claim 12

228. Claim 12 of the ’823 patent depends from Claim 11. The Benjamin-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 12 further adds: “wherein positioning a temperature sensing element in the region comprises positioning a temperature sensing element in substantially [in] the center of the region.”

229. In my opinion, Benjamin-Giere673 discloses this limitation for same reasons as 1[D] and 1[J] because a temperature sensor that is positioned “substantially the center” of a region [claim 12] is also “substantially centrally” disposed within that region [Claim 1].

230. Thus, it is my opinion that the Benjamin-Giere673 Combination discloses the added limitation of Claim 11.

L. Claim 13

231. Claim 13 of the ’823 patent depends from Claim 11. The Benjamin-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 11 further adds: “wherein positioning a temperature sensing element in the region comprises positioning a thermal resistor in the region.” This limitation is identical to the added limitation of Claim 3 and thus the Benjamin-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 3, incorporated here.

232. Thus, it is my opinion that the Benjamin-Giere673 Combination discloses the added limitation of Claim 13.

M. Claim 15

233. Claim 15 of the ’823 patent depends from Claim 11. The Benjamin-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 15 further adds: “wherein positioning a temperature sensing element in the region between the first heater array and the second heater array comprises positioning the temperature sensing element at least 300 microns from each of the first heater array and the second heater array.” This limitation is identical to the added limitation of

Claim 5 and thus the Benjamin-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 5, incorporated here.

234. Thus, it is my opinion that the Benjamin-Giere673 Combination discloses the added limitation of Claim 15.

N. Claim 16

235. Claim 16 of the ’823 patent depends from Claim 15. The Benjamin-Giere673 Combination discloses claim 15 for the reasons discussed above. Claim 16 further adds: “wherein positioning a temperature sensing element in the region between the first heater array and the second heater array comprises positioning the temperature sensing element substantially planar to each of the first heater array and the second heater array.” This limitation is identical to the added limitation of Claim 6 and thus the Benjamin-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 6, incorporated here.

236. Thus, it is my opinion that the Benjamin-Giere673 Combination discloses the added limitation of Claim 16.

O. Claim 17

237. Claim 17 of the ’823 patent depends from Claim 11. The Benjamin-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 17 further adds: “wherein heating the first heater array and the second heater array to regulate the temperature of the region comprises heating the first heater array and

the second heater array using non-nucleating heating." This limitation is identical to the added limitation of Claim 9 and thus the Benjamin-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 9, incorporated here.

238. Thus, it is my opinion that the Benjamin-Giere673 Combination discloses the added limitation of Claim 17.

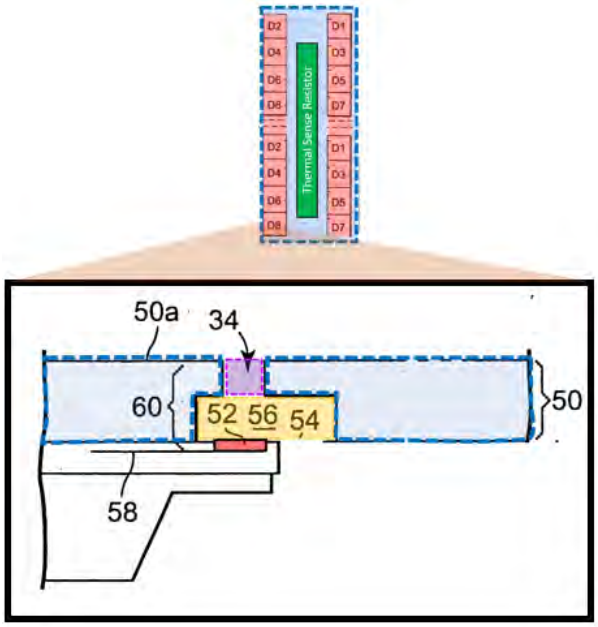
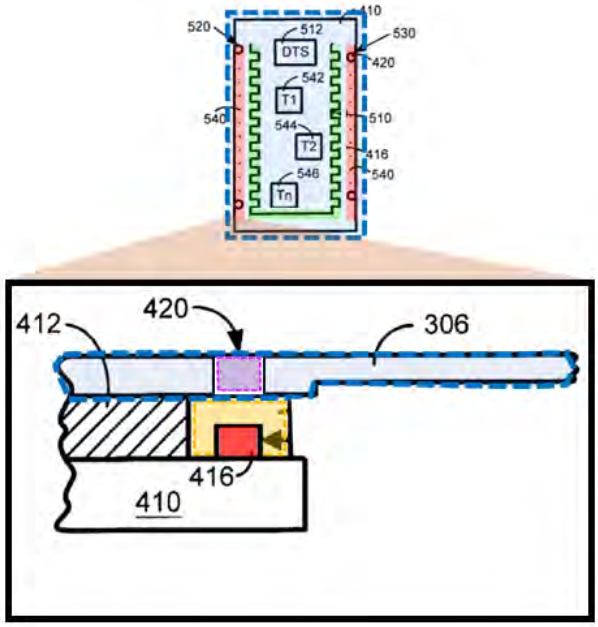
P. Ample Motivation Existed to Make the Combination

239. As I explained in detail above, while Benjamin does not say *where* on the printhead die the TSR should be disposed, Giere673 does and provides an optimal location for a TSR on Benjamin's printhead die. In my opinion, there was plenty of motivation to combine Benjamin and Giere673, which any PHOSITA would have recognized.

240. As an initial mater, Benjamin and Giere673 both qualify as analogous art to the claimed invention at least because they are both in the same field of endeavour as the '832 patent—namely, regulating operational temperature of a printhead die. At the very least, both Benjamin and Giere673 are both reasonably pertinent to maintaining the optimal temperature of a multi-via heater chip allegedly solved by the inventors of the '823 patent.

241. As another point, it is my opinion that ample motivation existed to combine Benjamin with Giere673.

242. *First*, because Benjamin fails to specify where the TSR should be disposed to optimize print quality, it is my opinion that a PHOSITA would have looked beyond Benjamin and considered Giere673. Benjamin and Giere673 both share to the same assignee—*viz.*, Hewlett-Packard Development Company L.P. (Ex.1004, 1; Ex.1005, 1)—and both involve the same field of endeavour— *viz.*— regulating operational temperature of a printhead die for a printing device—and similar printing devices within that field. Referring to the illustration below, the printhead dies of Benjamin and Giere673 both include at least two adjacent ink channels (*not shown*) for feeding ink into a chamber (*yellow below*) and at least two adjacent heater arrays (*red*) for vaporizing the ink within each channel and ejecting drops of the vaporized ink through a nozzle (*purple*) onto a print media, such as paper.

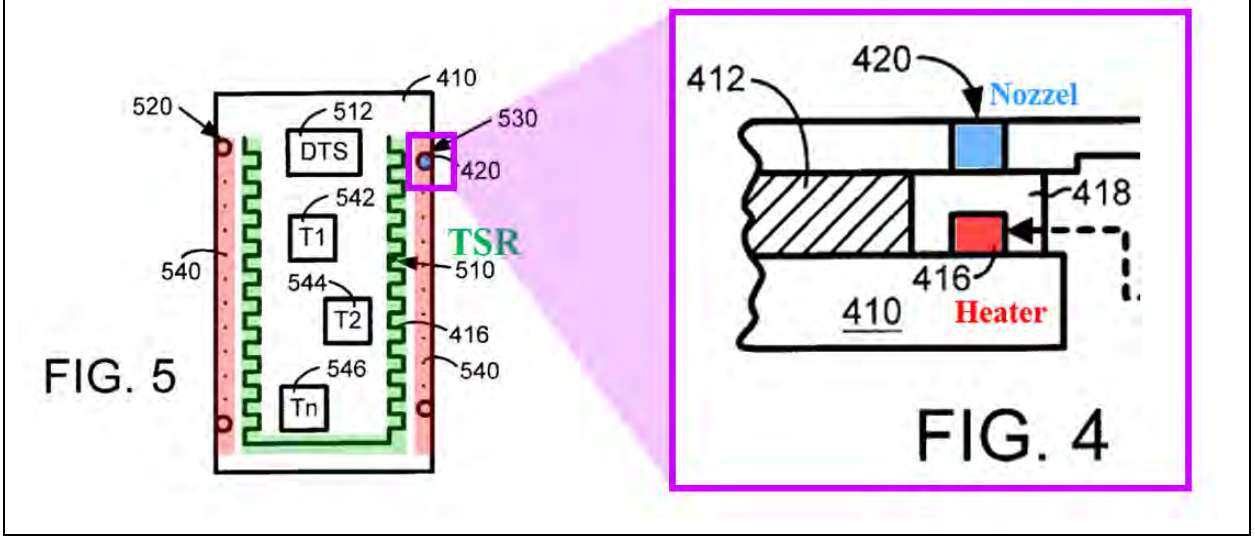
Printhead Region of Benjamin (Ex.1004)	Printhead Region of Giere673 (Ex.1005)
	

243. Moreover, as set forth in greater detail below in Section XI.A.9, Benjamin and Giere673 both address similar problems in their shared field— *viz.*, reduced print quality caused by the printhead die operating outside its optimal temperature —and both provide a similar solution to that problem— *viz.*, disposing a temperature sense resistor (TSR, *green*) on the printhead for determining the mean temperature of the printhead and using a controller to maintain the printhead at its optimal temperature by, for example, lengthening and shortening the firing pulses sent to the heater arrays.

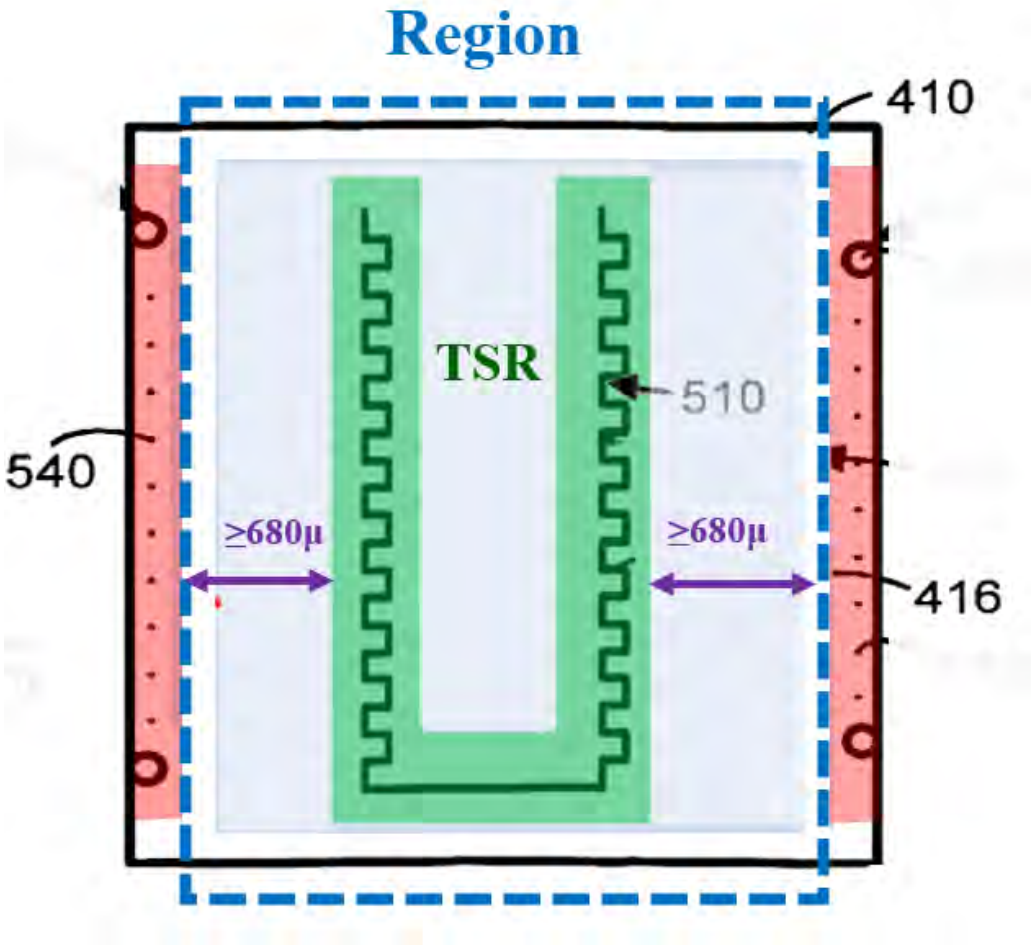
244. Like Benjamin, Giere673 uses "**[o]ne** or multiple TSRs 510 [to] provide an approximation of the ***mean temperature*** of the substrate [410]." Ex.1005

at 4:55-56. And just like Benjamin, Giere673 optimizes the print quality of the inkjet printer based upon the temperature value provided by the TSR. But unlike Benjamin, Giere673 explicitly discloses *where* on the printhead the TSR should be located for providing a sufficiently accurate temperature value to meaningfully improve print quality (e.g., approximately 680 µm inboard from the center of the columns of ink ejection elements and along their length). Not only does Giere673 teach positioning a single temperature sensor—i.e., "temperature sensor resistor (TSR) 510 [*green below*]—between two heater arrays [*red*], but also that the TSR 510 "preferably is not located adjacent to any ***particular*** heating elements" so that the obtained TSR value "reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005, 2:50, 4:51-56. To be sure, Giere673 teaches that "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are approximately 680 µm inboard from the center of the columns of ink ejection elements 416," [*red in Figs. 4 and 5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12.

Ex.1005, Figs. 4 and 5

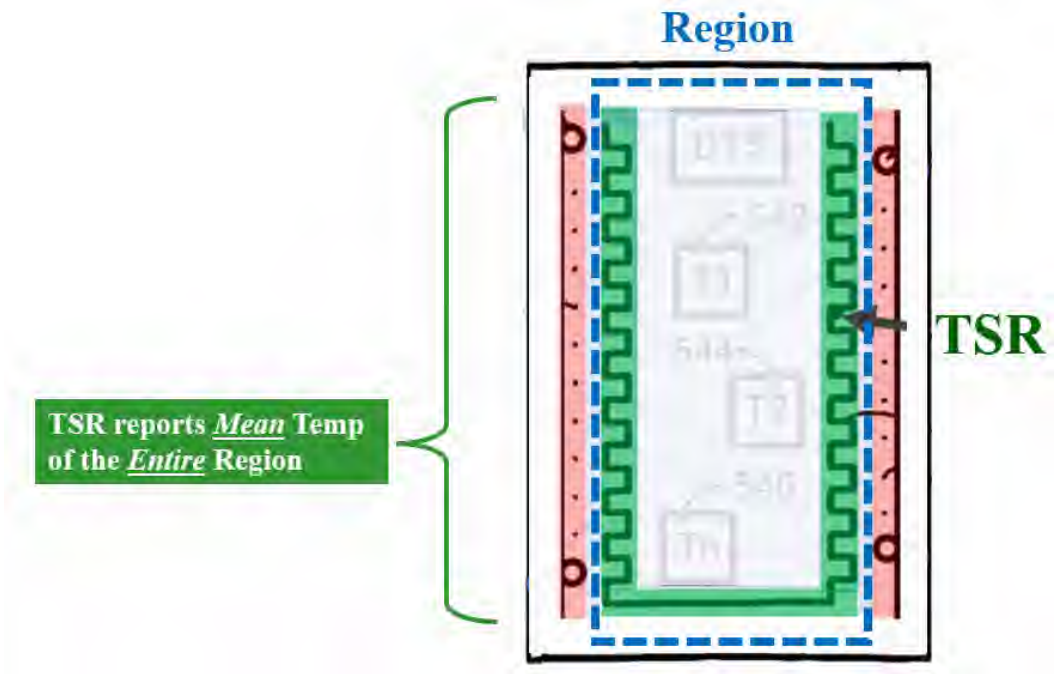


245. *Second*, Giere673 itself expressly motivates the combination. Giere673 teaches disposing a single temperature sense resistor (TSR) [*i.e.*, serpentine TSR 510, *green below*] in a region on the printhead die [region of the substrate 410, *blue*] adjacent two heater arrays [columns of ink ejection elements 416 and 516, *red*], and positioning that TSR equidistant from the two heater arrays but no less than "approximately 680 µm inboard from the center of the [heater arrays]."

Ex.1005, Fig. 5


246. By positioning the TSR 510 in the centre of the region, Giere673 teaches that the TSR value obtained by TSR 510 "reflects heating elements firing that have already occurred," which "more accurately reflects the ***mean temperature*** of the substrate 410," as illustrated below. Ex.1005 at 4:57-59.

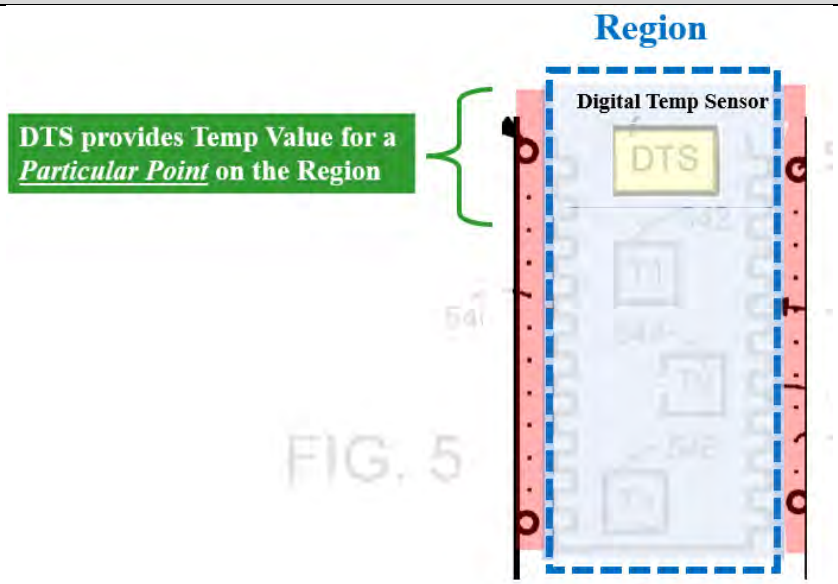
Ex.1005, Fig. 5



247. Conversely, Giere673 positions an optional "a point sensor"—*i.e.*, Digital Temperature Sensor (DTS) 512 (yellow)—"at the top of the substate" without expressing any similar preference on location because, unlike the TSR, the DTS 510 "reflects the temperature ***at that point***, it does not give an accurate temperature for other heating elements on the substrate." *Id.*, 4:67-5:2. In my opinion, a PHOSITA would not position a TSR in the same location as Giere673's DTS 510 (top of the region) because Benjamin's system "determine[s] a temperature of the ***printhead die*** based upon a measurement of the **resistor**"—not the temperature of a ***particular point on that die*** based on the measurement of a **digital**

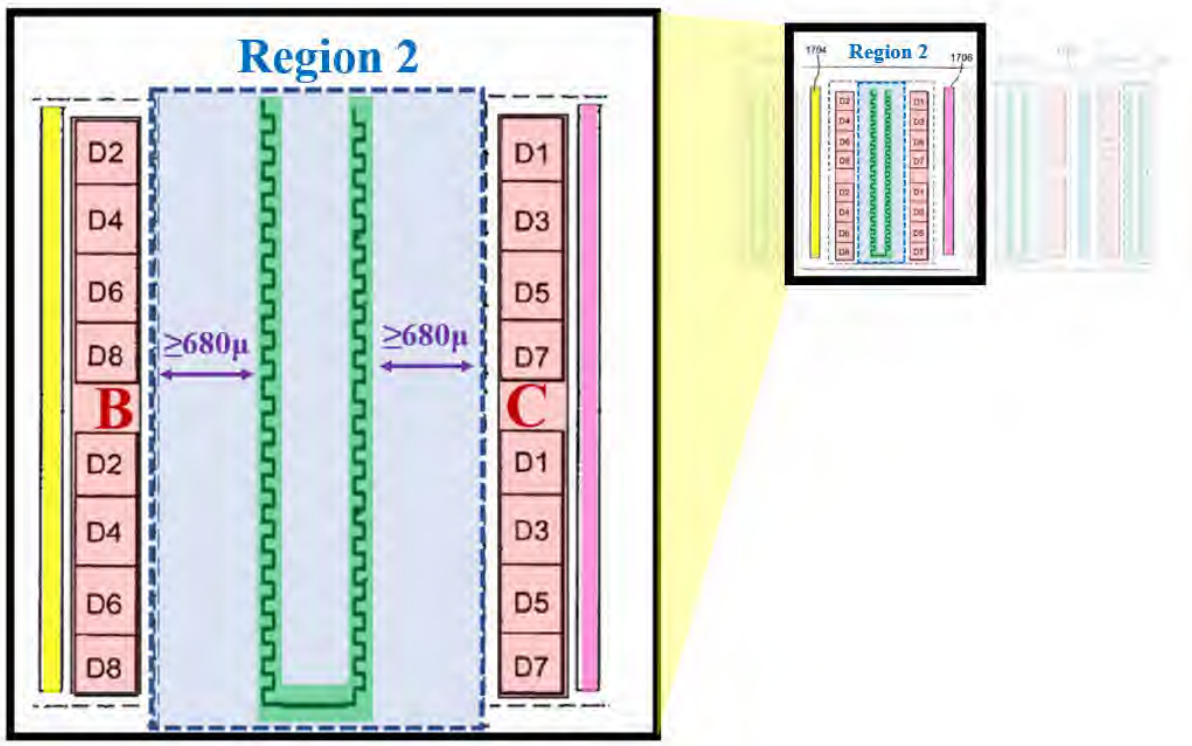
sensor—and positioning the TSR near the top of the region would not provide a value reflecting an accurate temperature for the other heating elements in that region.

Ex.1005, Fig. 5



248. Given the structural similarities between Benjamin and Giere673's printhead dies, a PHOSITA would have applied Giere673's teachings to Benjamin by (1) disposing a single TSR within a region of Benjamin's printhead formed between two adjacent heater arrays [*e.g.*, Region 2, *blue below*], and (2) positioning the TSR equidistant from both heater array within the region but no less than approximately 680 µm inboard from the center of the heater arrays, as shown below, to ensure that the temperature value provided by the TSR reflects the mean temperature of the region. Ex.1005 at 4:57-59..

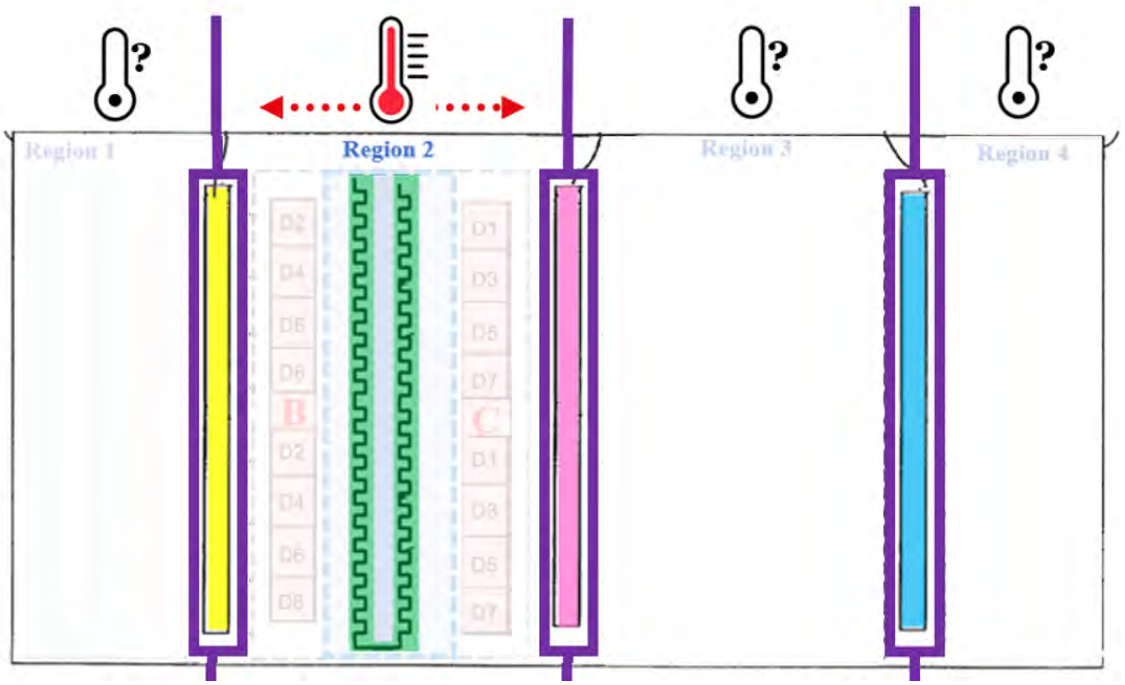
Ex.1004, Fig. 21 (Simplified)



249. However, a PHOSITA would have known that placing the TSR within Region 2 *alone* would not be an ideal location to accurately report the mean temperature of the ***entire printhead die***, which Giere673 attributes to meaningfully regulating operational temperature, because the two ink vias adjacent to the TSR [*e.g.*, ink feed slot 1704, *yellow below*, and ink feed slot 1706, *magenta*, for Region 2, *blue*] act as thermal insulators between other regions of Benjamin's printhead [Regions 1, 3, and 4], making the temperature value read by the TSR reflective of the temperature of Region 2, but not the mean temperature of the entire printhead. Ex.1001 at 5:52-55; Ex.1008 (Yabe) at 3:16-21 ("it is found that in the mode of the side shooter recording head, a plurality of ink supply ports provided for the heater

board demonstrate the heat insulating characteristic against the heater board material…").

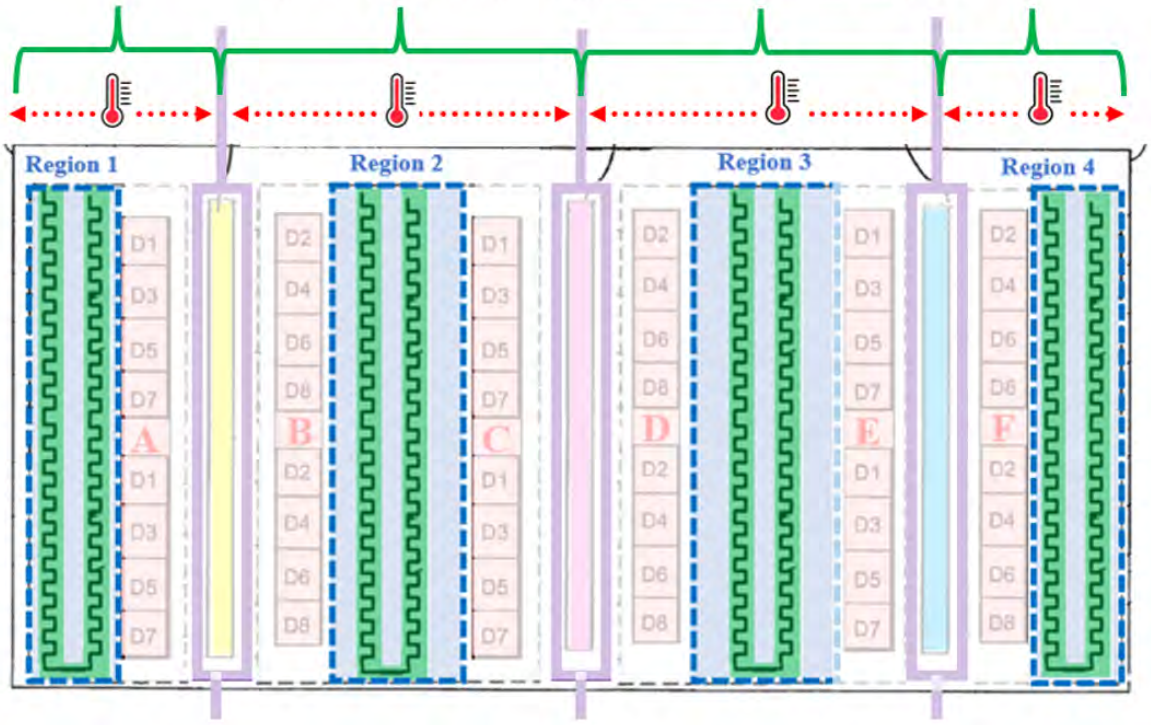
Ex.1004, Fig.21



250. To regulate the operational temperature of Benjamin's printhead die and optimize the printing quality of the inkjet printing device, it is my opinion that a PHOSITA would have further configured Benjamin to determine a mean temperature of the ***entire printhead*** by disposing a single TSR within each of the remaining regions [e.g., Region 1, 3, and 4, blue below] so that the temperature value

collectively provided by the TSRs within Regions 1-4 reflect the mean temperature of Benjamin's printhead die, as illustrated below.

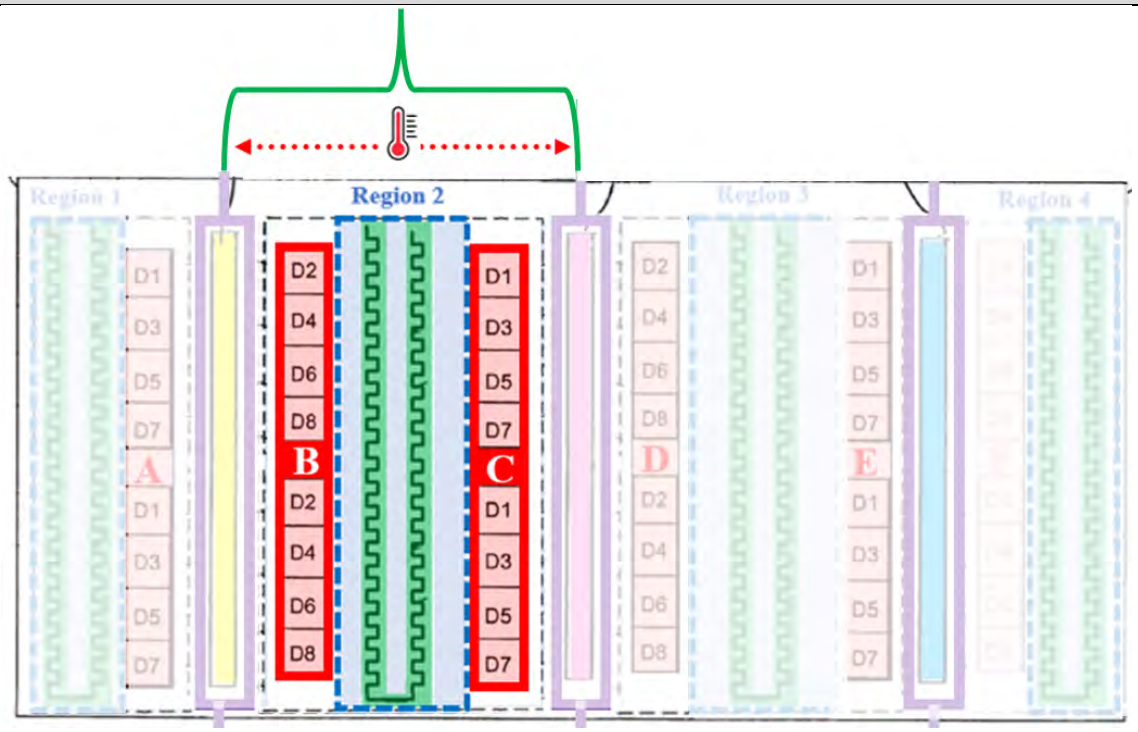
Benjamin-Giere673



251. Because the ink vias act as thermal insulators between the four different regions of Printhead Die 1700, it is further my opinion that a PHOSITA would further understand that the temperature values provided by TSR would not accurately represent the temperature of the entire printhead die, but rather only the temperature of the substrate between the two adjacent ink vias. Conversely, a PHOSITA would know that the temperature sensed by each TSR represents the

temperature of its region because the region is positioned between, not outside, the two adjacent ink vias.

Benjamin-Giere673



252. *Fourth*, [a] PHOSITA would further understand why the temperature regulation design illustrated above in Fig. 21 (i.e., temperature sensors in each region) would be advantageous. Thermal inkjet devices, like the one disclosed in Benjamin, are designed to operate optimally at a nominal temperature that is chosen with the temperature management strategy in mind. Since passive cooling is the most affordable cooling method, a PHOSITA will choose an elevated temperature as the nominal temperature and use active measures to raise the ink temperature to

this nominal temperature if the ambient temperature, where the printer is operating, is lower. The printhead temperature will be elevated to the nominal temperature by some means, such as intermittent non-printing energy pulses to the heater resistors. Thermal inkjet devices produce acceptable printing results within a narrow range of temperatures above and below the chosen nominal operating temperature. Attempting to operate the thermal inkjet printhead outside the acceptable temperature range results in reduced or unacceptable print quality. If the ink temperature is too low, the nucleated bubble which expels the ink may be too small which could produce visible white streaks in the image or color hue shifts as the mix of cyan, yellow, and magenta ink amounts in an image area is imprecise. If the ink temperature is somewhat too large, then dark streaks or objectionable color hue shifts may be visible.

253. Hard failure modes may occur if operation is attempted well outside the acceptable ink temperature range. If the ink temperature is very low, the nucleated bubble may be too small to eject a drop at all. Visible white streaks will appear in the image. Dribbling of ink or the firing of an ink mist may occur resulting in mist contamination of other printer components or the smearing of ink on the print media and media transport surfaces. If the ink temperature is very high, then bubble volume may be so large that the bubble breaks out through the nozzle, causing air to be ingested into the printhead. The user may have to initiate a printhead maintenance

cycle whereby the nozzles are vacuumed clear of air by a maintenance station vacuum pump. Another failure can occur if a too hot ink nucleates too early in the drop firing pulse. As soon as the bubble is nucleated, the heater resistor surface can no longer transfer heat to the ink efficiently, causing the heater surface to get much hotter than designed, leading to the "burn out" of the heater resistor and, potentially, the permanent failure of that drop generator.

254. To operate over the widest range of environmental temperatures and the heaviest printing (drop firing) loads, a PHOSITA would know that Benjamin's printhead die must be monitored in a manner that adequately allows for countermeasures against the soft and hard failure modes known to occur. First, knowing the overall temperature of the thermal inkjet printhead substrate can allow the avoidance of the above-described hard failure modes. For example, experimental testing of the printhead will have determined that air ingestion nearly always occurs if the printhead is operated above a certain temperature and that ink mist or dribbling usually occurs if operated below another certain temperature. A single temperature sensor representative of the printhead substrate temperature can warn that these high and low temperature hard failure boundaries are being approached, allowing the system controller to slow or pause printing until the temperature condition can be brought within an acceptable range. A PHOSITA also would know to utilize a temperature sensor to forecast soft failure modes affecting print quality by

implementing countermeasures when temperatures are measured somewhat outside the nominal operating temperature.

255. However, to optimize the printing quality of Benjamin's printhead die and other multi-via printhead dies with two heater arrays per ink via, a PHOSITA would know that the temperature should be measured on a per-via basis—*i.e.*, disposing a TSR adjacent each and every ink via on the printhead die, rather than disposing one TSR on the entire printhead die; otherwise, the temperature value obtained by the TSR may not accurately reflect the temperature of each color since ink vias act as thermal insulators. Moreover, a PHOSITA would also know that a multi-via printhead die with multiple TSRs will provide more accurate temperatures values for every different-colored ink via than would a single TSR because a multi-color, multi-ink supply via thermal inkjet printhead die fabricated on a silicon substrate has thermal conduction pathways that are greatly affected by ink via slots. This is due to the differences between the thermal conductivities of single crystal silicon (~ 70 – 75 W/m^{o}K at ~ 50 ^{o}C), water-based ink (~ 0.64 W/m^{o}K at ~ 50 ^{o}C), and plastic ink supply manifold materials (~ 0.23 W/m^{o}K at ~ 23 ^{o}C).[5]

[5] https://analyzing-testing.netzsch.com/en-US/applications/photovoltaics/silicon-wafer-thermophysical-properties; https://www.engineeringtoolbox.com/water-liquid-gas-thermal-conductivity-temperature-pressure-d_2012.html; https://www.professionalplastics.com/professionalplastics/ThermalPropertiesofPlasticMaterials.pdf

256. The low thermal conductivity of the ink via spaces and any plastic manifold materials interfacing the silicon thermal inkjet chip causes these regions to restrict heat flow relative to the heat flow in the silicon material itself. The heat introduced by the heater resistors to fire drops will be conducted away much more rapidly into the adjacent silicon regions that into the ink supply vias or plastic printhead components. A PHOSITA will recognize that the silicon regions between ink supply vias and between outer ink supply vias and printhead chip edges achieve thermal equilibrium far more rapidly than the overall printhead and ink supply structures. These regions are both relatively thermally isolated and quickly come to a same temperature or thermal equilibrium. These regions are therefore the most cost-effective places in which to add multiple temperature sensors to better capture the temperature conditions of the multiple color ink drop generators. Sensing the temperature in multiple regions allows the system controller to better maintain the desired ink operating temperature for all ink colors over a larger range of environmental temperatures and printing duty conditions. Thus, to further "optimize print quality" in Benjamin's printhead die over a larger range of conditions encountered by the user, a PHOSITA would be motivated to dispose a TSR adjacent each of the ink feed slots on the printhead die 1700 (i.e., yellow ink via 1704, magenta ink via 1706, and cyan ink via 1708), but dispose no more than one TSR within each region adjacent a heater array (e.g., Regions 1-4), as shown below.

257. *Fifth*, a PHOSITA would also know that excessive *localized* heating of the substrate without compensation for the substrate temperature change can lead to degradation in print quality. Ex.1007 at 5:36-51. For example, Giere178 describes a situation where excessive printing of one color ink in one region of the printhead die, e.g., magenta ink, can increase the temperature of that color's ink ejection chambers thereby increasing the mass of the magenta ink drops beyond the desired print size. Ex.1007 at 5:52-6:3. Giere178 explains that in this situation, print quality will degrade because excessive magenta ink will alter the desired print colors. *Id*. Giere178 states that the "rate at which signals are supplied to resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead" and "*localized heating* of the substrate can occur from firing nozzles at a greater frequency *in a particular region of the printhead*." Ex.1007 at 5:44-46. Giere178 explains that "[i]f at least some compensation is not made for these temperature changes, a perceptible degradation in print quality can result." Id. at 5:49-51. For example, in the magenta example described above, Giere178 states that "as a result of the excessive quantity of magenta ink applied, the hue of the region formed [in combination with cyan and yellow] will be shifted toward the magenta hue," "undesired shifts in the chroma and the luminance of [print] regions" can occur, and an "increase in the mass of ejected ink drops can reduce the sharpness of the edges when the image is formed onto paper." Ex.1007 at 5:62-6:3. Giere178

discloses a solution to the localized heating issue by placing multiple temperature sensing "resistive elements" on the substrate (between ink vias and associated heater arrays) "so that they will each assume the temperature of the local region of substrate [] on which they are placed." Ex.1007 at 8:51-54; *see also* Sections IX.B.4, XIII.A.6-7, and XIV.C. Giere178 states that its "temperature compensation system" with localized temperature sensors "may be used to control a quantity of ink deposited on a region in response to the measured temperature," or "may be used to control resistive heating elements thermally coupled to [the] substrate [] so that the temperature of [the] substrate [] is controlled substantially at a desired temperature," or "may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of [the] substrate [] is controlled substantially at a desired temperature." *Id*. at 9:50-60. As such, Giere178 corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere673, would have been further motivated to modify Benjamin's printhead die by disposing a single temperature sensor within each other region so that the TSRs collectively determine a mean temperature of Benjamin's printhead die and regulate temperature on a per-color basis.

258. *Sixth*, the '823 Patent readily admits that, during the prior art time period, it was well known to those skilled in the art that "ink vias [] act as thermal barriers between the colors," and "without accurate temperature readings, the

method of providing fire pulses to regulate thermal conditions [for a multi-via printhead] would also be subject to error." Ex.1001 at 2:10-12; 2:47-50. To overcome these challenges, the '823 Patent admits that prior art heater chips "provid[ed] for temperature sensing on a per-color basis" by placing "three temperature sensors 220, 222, and 224 [green below] in close proximity to each of the heater arrays, each situated on the same side of their respective vias," thereby "ensuring that there is only a small amount of thermal crosstalk between the temperature sensors." Ex.1001 at 2:3-15. Put differently, the '823 Patent corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere673, would have been further motivated to modify Benjamin's printhead die by disposing a single temperature sensor within each region so that the TSRs collectively determine a mean temperature of Benjamin's printhead die because it was well known to those skilled in the art that this arrangement "provid[es] for temperature sensing on a per-color basis." Ex.1001 at 2:2.

The Applicant-Admitted Prior Art Corroborates My Opinion

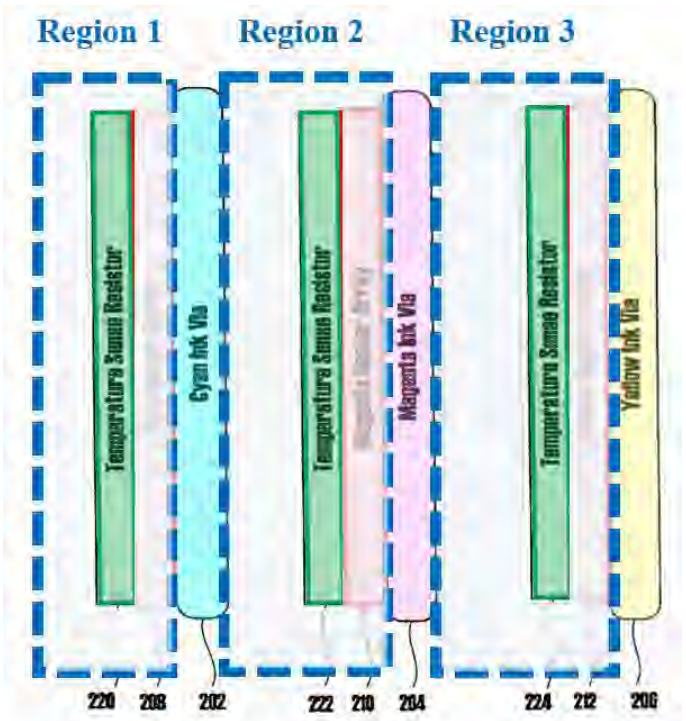


FIG. 2
(Prior Art)

259. *Finally*, a PHOSITA would have also had a reasonable expectation of success adding the temperature controller 110 and TSRs 510 from Giere673 to the printhead die 1700 of Benjamin's printhead assembly. To be sure, Giere673 recognizes that the temperature controller and thermal sensor resistors of "the present invention can be incorporated in any printhead configuration." Ex.1005 at 4:7-8. Moreover, while certain figures and descriptions in Benjamin and Giere673 refer to different embodiments, these embodiments are disclosed in adjacent figures, and both Benjamin and Giere673 confirm the interchangeable nature of the various embodiments. Ex.1004 at 80:19-26 ("Although specific embodiments have been

illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein."); Ex.1005 at 9:42-47 ("The above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that workers may make variations in those embodiments skilled in the art without departing from the scope of the present invention as defined by the following claims.").

260. *Finally*, given the interchangeable nature of various features in the disclosed embodiments, it would have been a routine and obvious matter for a PHOSITA to combine, replace, and even modify various features from Benjamin's various embodiments, as well as the embodiments of Giere673. Moreover, as I explained above, the printing system components from Benjamin and Giere673 are common to all embodiments. As such, the simple, routine, and low-cost nature of adding a temperature controller and thermal sense resistors to a printhead assembly and printhead die, respectively, would have further motivated a person of ordinary skill in the art. Furthermore, given that Benjamin expressly articulates the interchangeability and modification of the disclosed embodiments, a PHOSITA

would have had a reasonable expectation of success in combining and modifying features of the embodiments together.

261. Thus, in my opinion, ample motivation existed for a PHOSITA to make the Benjamin- Giere673 Combination.

XII. GROUND 2: BENJAMIN AND GIERE673 IN FURTHER VIEW OF PARISH RENDERS CLAIMS 4 and 14 OBVIOUS

262. In my opinion, the Benjamin-Giere673 combination in view of Parish renders claims 4 and 14 of the ’823 Patent obvious.

A. Claim 4

263. Claim 4 of the ’823 patent depends from Claim 3. The Benjamin-Giere673 Combination discloses Claim 3 for the reasons discussed above. Claim 4 further adds: “wherein the temperature sensing element comprises an n-type implant donor thermal sensing resistor.” Although Giere673 discloses that the temperature sensor may include a thermal sense resistor (TSR) 510, Giere673 does not explicitly say that the TSR 510 is an n-type implant donor thermal sensing resistor. However, in my opinion, Parish discloses this limitation.

264. According to Parish, the temperature sense element is or comprises a temperature sense resistor (TSR) 64,” which “can include a **N-type source drain (NSD) material**, a N-well layer material, a P-type source drain (PSD) material, a lightly doped drain (LDD) material or another suitable material.” Ex.1006 at 5:35-39.

265. Therefore, it is my opinion that the Benjamin-Giere673 combination in further view of Parish discloses that "the temperature sensing element [*i.e.*, TSRs 510] comprises an n-type implant donor thermal sensing resistor."

B. Claim 14

266. Claim 14 of the '823 patent depends from Claim 13. The Benjamin-Giere673 Combination discloses Claim 13 for the reasons discussed above. Claim 14 further adds: "wherein positioning a temperature sensing element in the region comprises positioning an n-type implant donor thermal sensing resistor in the region." Although Giere673 discloses positioning a thermal sense resistor (TSR) 510 in the region, Giere673 does not explicitly say that the TSR 510 is an n-type implant donor thermal sensing resistor. However, in my opinion, Parish discloses this limitation.

267. According to Parish, the temperature sense element is or comprises a temperature sense resistor (TSR) 64," which "can include a **N-type source drain (NSD) material**, a N-well layer material, a P-type source drain (PSD) material, a lightly doped drain (LDD) material or another suitable material." Ex.1006 at 5:35-39.

268. Therefore, it is my opinion that the Benjamin-Giere673 combination in further view of Parish discloses that "positioning a temperature sensing element in

the region [*i.e.*, TSRs 510] comprises positioning an n-type implant donor thermal sensing resistor in the region."

C. Ample Motivation Existed to Modify the Benjamin-Giere673 Combination in View of Parish

269. A PHOSITA would have combined Benjamin and Giere673 for the reasons I stated above, incorporated here.

270. As an initial mater, Benjamin, Giere673, and Parish all qualify as analogous art to the claimed invention at least because they are both in the same field of endeavour as the '832 patent—namely, regulating operational temperature of a printhead die. At the very least, Benjamin, Giere673, and Parish are reasonably pertinent to maintaining the optimal temperature of a multi-via heater chip allegedly solved by the inventors of the '823 patent.

271. For claims 4 and 13 in particular, it is my opinion that ample motivation existed to combine Benjamin with Giere673.

272. *First*, because Benjamin fails to specify *what* type of TSR should be use to optimize print quality, it is my opinion that a PHOSITA would have looked beyond Benjamin and considered Giere673.

273. *Second*, a PHOSITA would have understood that an n-type thermal sense resistor is a common material choice for thermal sensor resistors and known amongst the skilled in the art as particularly suited for use in printing applications. Thus, in my opinion, Benjamin and Giere673's failure to identify a particular type

of thermal sense resistor does not mean that the thermal sensor disclosed by Benjamin and Giere673 does not already comprise an n-type implant donor thermal sense resistor.

274. *Third*, a PHOSITA would have been motivated to select an n-type implant donor thermal sensing resistor for any TSR disposed on a multi-via printhead die, as taught by Parish, because doing so would improve the temperature control and compensation features of the Benjamin-Giere673 combination as thermal sensors made from an n-type material are more precise and therefore provide more accurate readings than those from metal resistive elements, such as aluminium, as discussed in further detail below.

275. Knowing the above, and in light of Benjamin and Giere673's failure to explicitly identify the material composition of the temperature sense resistors used in their respective printhead dies, a PHOSITA wanting to make the Benjamin-Giere673 combination in the manner described above for claim limitations 1[E] and 1[G], would have been motivated to look to another reference, such as Parish, to identify a thermal sense resistor with a material particularly suited for use in a printing device.

276. *Fourth*, a PHOSITA would also have had a reasonable expectation of success of replacing each TSR within the printhead die of the Benjamin-Giere673 combination with a n-type implant donor thermal sense resistor. Even the '823

Patent concedes that n-type materials were well-known in the art and long been used in inkjet printing applications. Ex.1001 at 6:25-29 ("According to an exemplary embodiment of the present invention, the temperature sensing elements are n-type implant donor thermal sensing resistors (NSD sense resistors), as will be understood by those skilled in the art."). Moreover, the advantages of using NSD materials for temperature sense resistors on thermal inkjet printheads (over metal temperature sense resistors, for example, were also well-known. Ex.1014 at 1:26-29 ("Previous designs include a temperature sense resistor (TSR) integrated into the heater chip to monitor the substrate temperature."); Ex.1014 at 4:37-41 ("While N-Well is the preferred implant for TSRs, **many implants** (**such as NSD**, LDD, and PSD) used in the geometry shown in FIG. 2 **will provide the same advantages over metal TSRs**, and are included in the scope of the present invention."); Ex.1014 at 4:37-41 ("The **temperature sense resistors** preferably comprise N-Well material, but could also **comprise NSD material**, LDD material, or PSD material, for example.").

277. Moreover, to the extent that the printhead die of the Benjamin-Giere673 combination does not already comprise an n-type material, it is likewise my opinion that a PHOSITA would also have had a reasonable expectation of success of replacing the thermal sensing elements n-type implant donor thermal sensing resistors (as taught by Parish) as Giere178's thermal sensing elements. To be sure, Giere178 emphasizes the interchangeability of components from distinct

embodiments of these prior art printing systems and printhead dies. Ex.1007 at 12:57-61. ("Although embodiments of the temperature measurement system have been illustrated and described, it is readily apparent to those of ordinary skill in the art that various modifications may be made to these embodiments without departing from the scope of the appended claims.").

278. *Finally*, it would have been a routine task for a PHOSITA to modify any components/features from the printhead die of the Benjamin-Giere673 combination in order to integrate an n-type implant donor TRS within the printing system. As explained above, the temperature control components and features from the printhead dies of Benjamin and Giere673 were commonly known in the industry. As such, a PHOSITA would have been further motivated by the simple and routine nature of replacing the thermal sense resistor in each of the regiosn with n-type resistors (as taught by Parish). Furthermore, given that Giere673 expressly articulate the interchangeability and modification of the disclosed embodiments, a PHOSITA would have had a reasonable expectation of success in combining and modifying features of the embodiments together.

279. Thus, in my opinion, ample motivation existed for a PHOSITA to make the Benjamin-Giere673-Parish Combination.

280. Although Benjamin discloses sensing the temperature of the heater arrays adjacent to each region, Benjamin does not explicitly teach using a single

temperature sensing element to sense a temperature temperature representative of the heater arrays adjacent to the region. However, it is my opinion that Giere673 discloses this limitation.

281. Giere673 discloses that "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are **approximately 680 µm inboard from the center of the columns of ink ejection elements 416**." Ex.1005 at 5:10-12. Since the ink ejection elements of 416 are heater arrays, a PHOSITA would position the TSR 510 approximately 680 µm from the center of Benjamin's corresponding column of heater arrays—viz., the "firing resistors 52 of drop generators 60 disposed along each of the opposing ink feed slot sides," as shown in my illustration below.

Ex.1004 Fig. 3 (Modified) and Fig. 21 (Annotated)

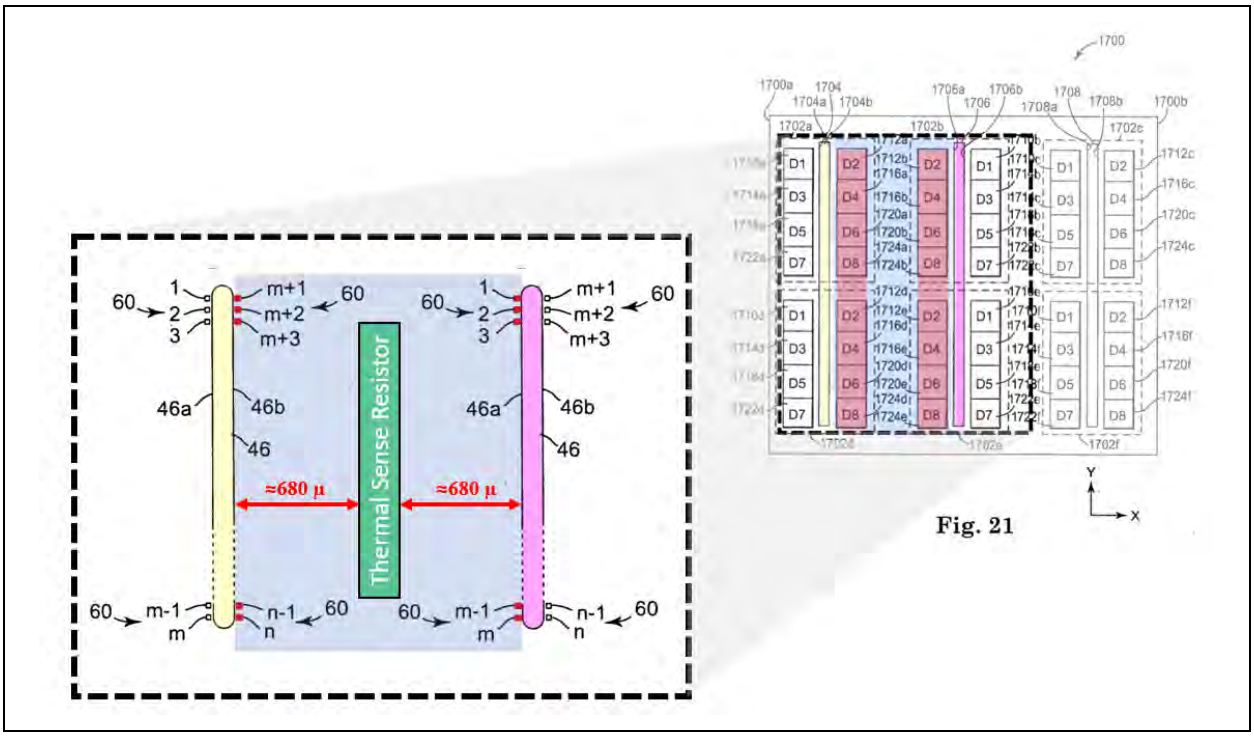


Fig. 21

282. Accordingly, it is my opinion that Giere673 discloses "dispos[ing] [the temperature sensing element *i.e.*, the TSR 510 from Giere673] at a predetermined distance away from adjacent heater arrays [*i.e.*, the firing resistors 52 of drop generators 60 disposed along each of the opposing ink feed slot sides from the printhead die 1700 of Benjamin]."

283. Accordingly, it is my opinion that Giere673 discloses this limitation.

XIII. GROUND 3: BENJAMIN IN VIEW OF GIERE178 RENDERS OBVIOUS CLAIMS 1-3, 5-13, and 15-17

284. In my opinion, the Benjamin-Giere178 combination discloses all of the limitations of claims 1-3, 5-12, and 15-17 of the '823 Patent.

A. Claim 1

1. 1[P] "A chip for use with a printing device"

285. I have been informed by counsel that a preamble is generally not limiting unless it is necessary to give life, meaning, and vitality to the claim. I understand that the preamble here is not limiting because it merely states the intended use of the purported invention and is not a limitation of the independent claim.

286. To the extent the preamble is determined to be limiting, it is my opinion that Benjamin discloses "a chip for use with a printing device."

287. Benjamin discloses a "an inkjet printing system 20"—*e.g.*, an inkjet printer or other printing device—that comprises, among other things, (i) an "inkjet printhead assembly 22" (*yellow in Figure 1 below*) with at least "one printhead or **printhead die 40**" (*magenta*) that "causes characters, symbols, and/or other graphics or images to be printed upon [a] print medium 36" (*orange*) "such as paper," (ii) an "ink supply assembly 24" that supplies liquid ink from an ink reservoir (*cyan*) to the printheads 40 on the printhead assembly, and (iii) an "electronic controller" (*green*) that controls the printhead die 40 and "defines a pattern of ejected ink drops that form characters, symbols, and/or other graphics or images on print medium 36." Ex.1004 at 3:32-33.

Ex.1004, Fig. 1

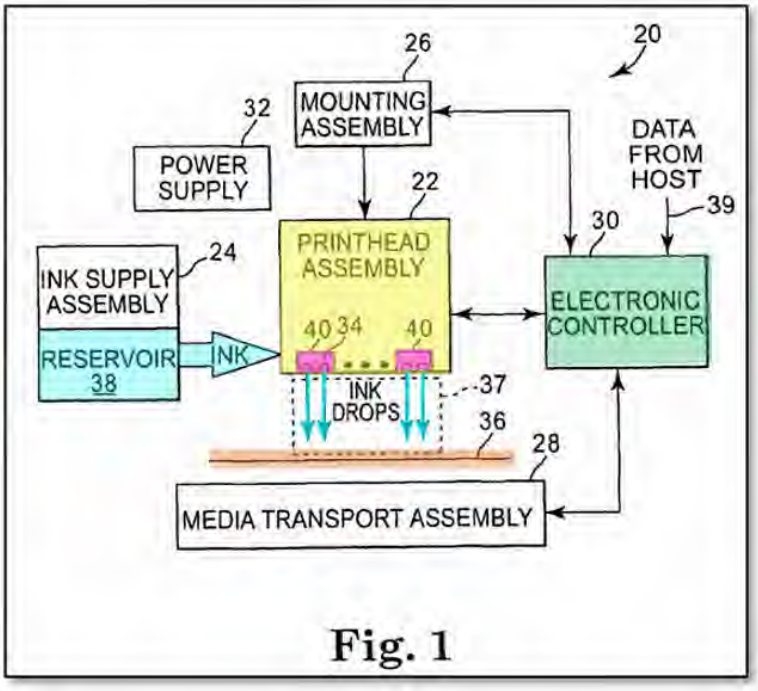
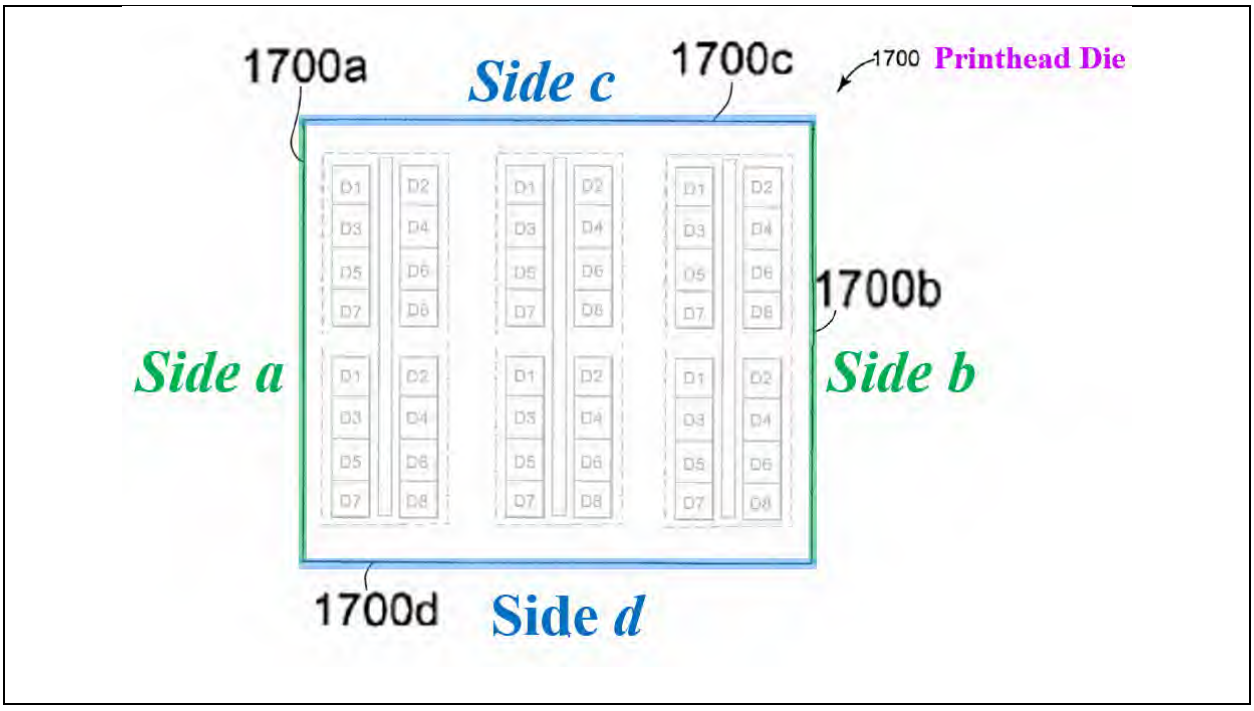


Fig. 1

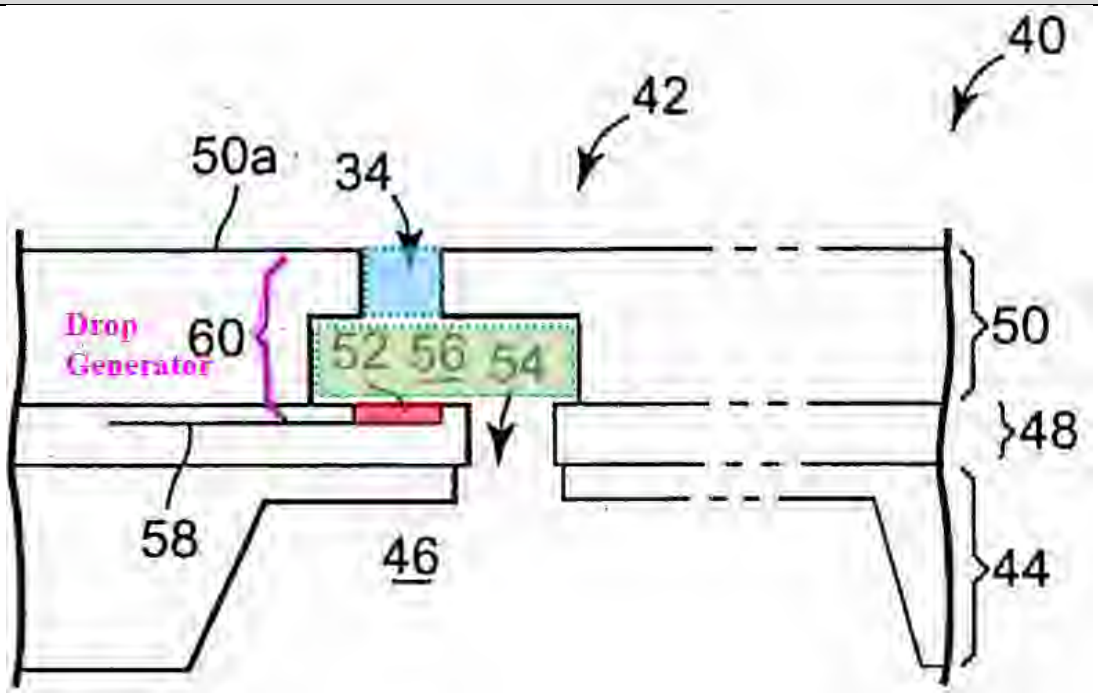
288. Turning first to the printhead, Benjamin teaches that the printhead die has a left and right edge (e.g., side 1700a and 1700b, *green below*) and top and bottom edge (side 1700c and 1700d, *blue*), each of which converges with another edge to form a distinct corner of the printhead die 1700. Ex.1004 at 69:67-70:3 (describing printhead die has having four corners bound by two of its four sides, such as a first "corner bounded by printhead die sides 1700b and 1700c," and a second "corner bounded by printhead die sides 1700a and 1700d.").

Ex.1004, Fig. 21 (Modified)



289. Consistent with a "typical thermal inkjet printing system," Benjamin teaches that the printhead die "eject[s] ink drops through nozzles [34, *purple*] by rapidly heating small volumes of ink located in vaporization chambers [56]" which "causes the ink to vaporize and be ejected through the nozzles." Ex.1004 at 1:32-38. Referring to Figure 2 below, Benjamin teaches that "the ink is heated with small electric heaters, such as thin film resistors referred to herein as **firing resistors** [52, *red*]," which together with the vaporization chamber 56 [*outlined in green]* and nozzle opening 34 [*blue*] collectively form a drop generator 60 [*annotated in purple*]. Ex.1004 at 6:8-10. "The firing resistors 52 of drop generators 60 are energized in a controlled sequence to eject fluid from vaporization chambers 56 and through nozzles 34 to print an image on print medium 36." Ex.1004 at 6:3-5; *see below id.* at Figs. 2 and 3.

Ex.1004, Fig. 2



290. Because the term "die" is another name for a chip,[6] it is my opinion that a PHOSITA would have understood that the printhead die 40 used in Benjamin's printing system 20 is synonymous with the term "chip for use with a printing device." To be sure, the '823 Patent admits that "[a] number of printers, copiers, and multi-function products utilize **heater chips in their printheads** for discharging ink drops from one or more ink vias. The ink is supplied through one or more ink vias in the chip. These heater chips typically provide only one heater array for each ink via that is disposed along one side of the ink via." Ex.1001 at 1:21-26. In other

[6] *See* https://en.wikipedia.org/wiki/Die_(integrated_circuit).

words, the ’823 Patent explains that conventional prior art printers included a chip located on the printhead and contained ink vias and heaters located next to the ink vias.

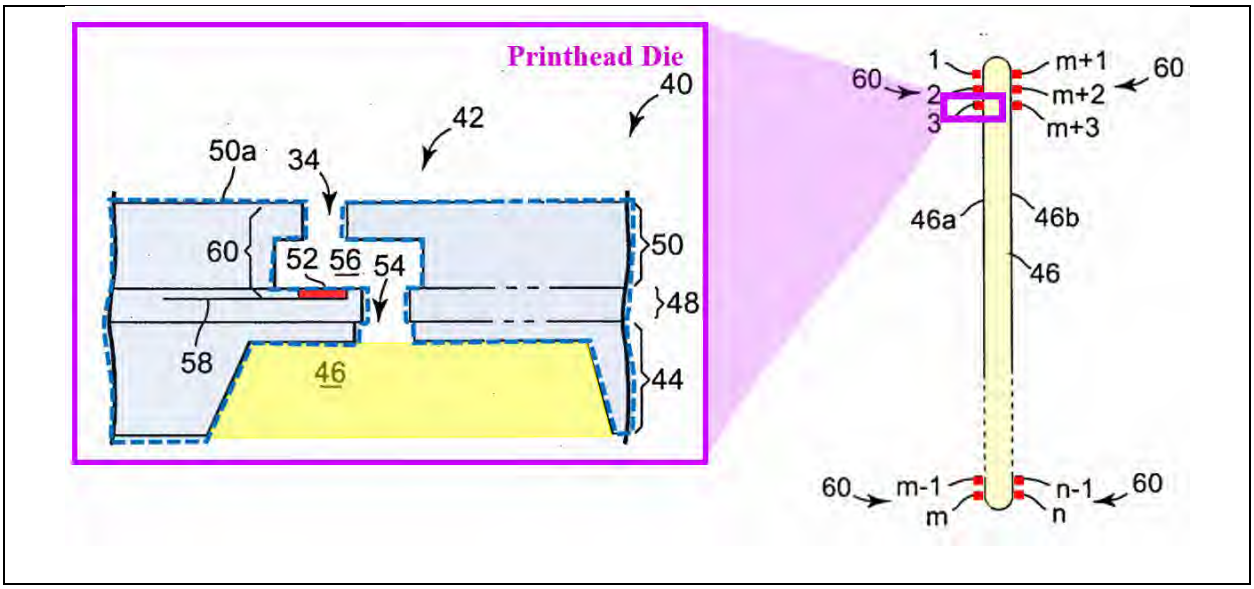
291. Accordingly, it is my opinion that Benjamin discloses “a chip [e.g., printhead die 1700] for use with a printing device [e.g., inkjet printing system such as an inkjet printer].”

2. 1[A] “a first heater array positioned substantially adjacent a first via”

292. Claim 1 of the ’823 Patent recites “a first heater array positioned substantially adjacent a first via.” In my opinion, Benjamin discloses this element.

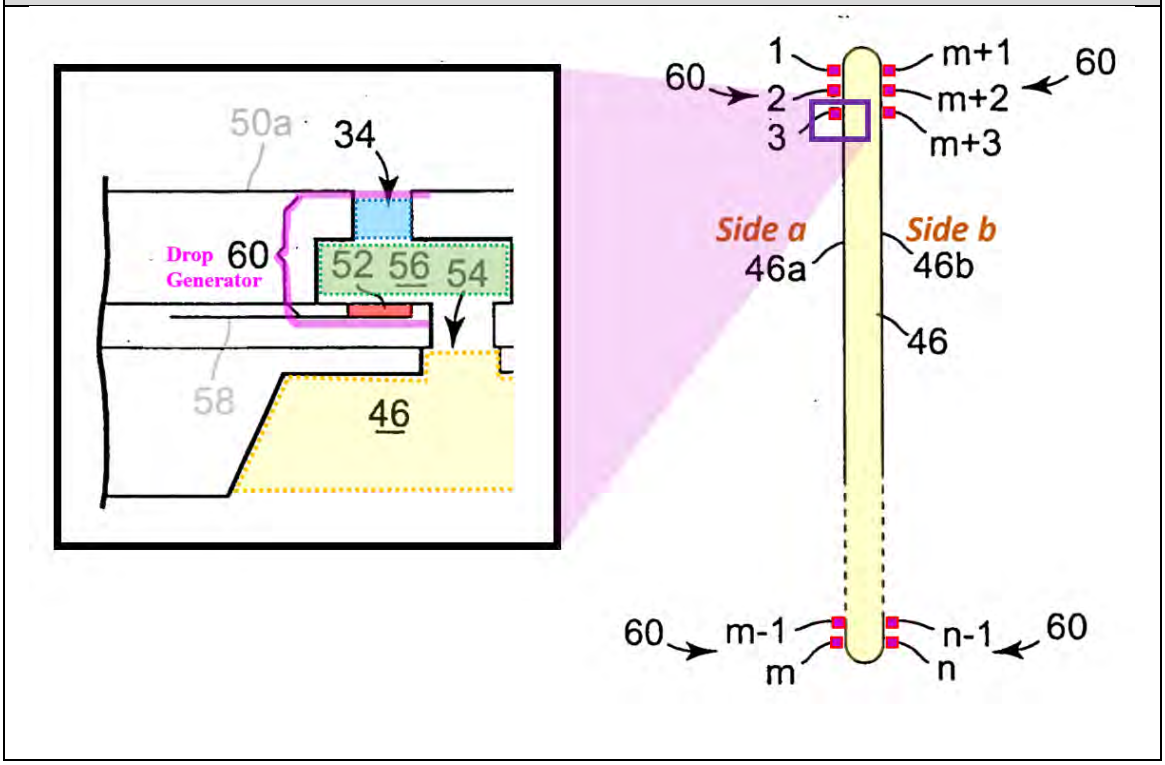
293. Benjamin’s printhead die 40 includes “an **array of printing or fluid ejecting elements 52**” [*red*] that are “formed on a substrate 44” [*blue below*] with an “ink feed slot 46 [*yellow*] formed therein.” Ex.1004 at 4:57-61; *see below id.* at Fig. 2. According to Benjamin, “ink feed slot 46 provides a supply of liquid ink to printing elements 42” through, for example, “corresponding individual ink feed holes feeding corresponding vaporization chambers and multiple shorter ink feed trenches that each feed corresponding groups of fluid ejecting elements.” Ex.1004 at 4:61-5:1.

Ex.1004, Figs. 2 and 3



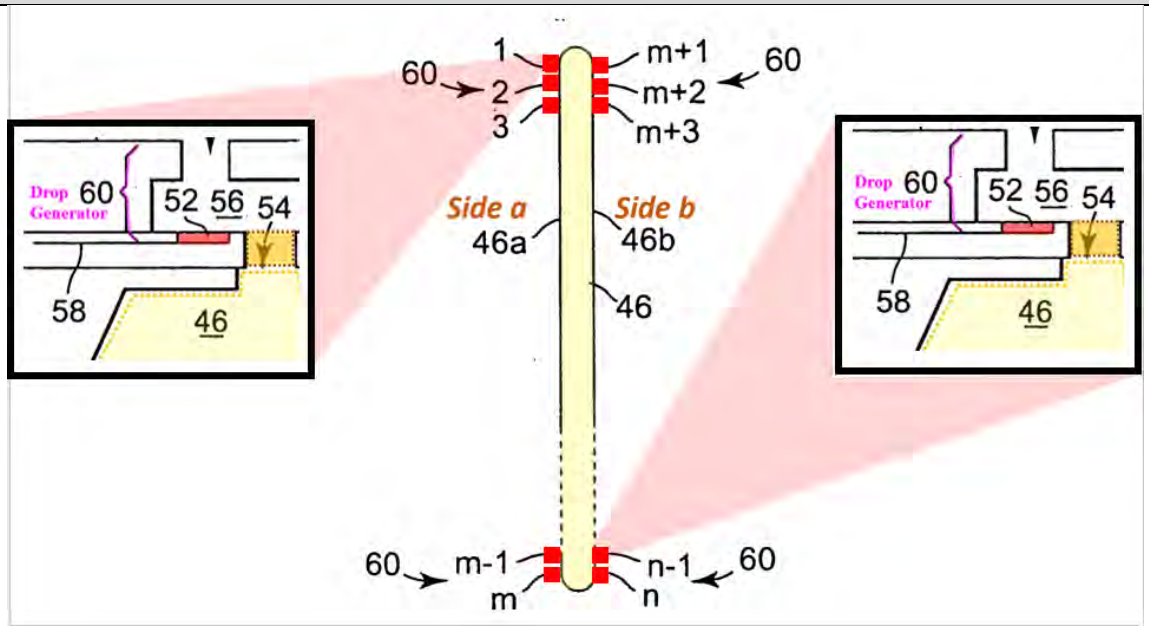
294. Benjamin's printhead includes one or more **ink feed slots 46**— each of which is fluidically coupled to a column of drop generators 60 [*purple*] disposed adjacent to each of its longitudinal sides. Ex.1004, 5:53-54. "A drop generator 60 [*purple*] as referred to herein includes firing resistor 52 [*red*], nozzle chamber or vaporization chamber 56 [*green*] and nozzle opening 34 [*blue*]." Ex.1004, 5:11-14. "During printing, ink flows from ink feed slot 46 [*yellow in Figure 2 below*] to vaporization chamber 56 **via ink feed channel 54**]," and "nozzle opening 34 [*blue*] is operatively associated with firing resistor 52 such that droplets of ink within vaporization chamber 56 are ejected through nozzle opening 34 (e.g., substantially normal to the plane of firing resistor 52) and toward print medium 36 upon energizing of firing resistors 52." Ex.1004, 5:3-30.

Ex.1004, Fig. 2



295. Moreover, as illustrated above and below, Benjamin discloses that "[a] firing resistor 52 [*red*] is positioned within vaporization chamber 56 and leads 58 electrically couple firing resistor 52 to circuitry controlling the application of electrical current through selected firing resistors." Ex.1004 at 5:8-14. "During printing, ink flows from ink feed slot 46 to vaporization chamber 56 via ink feed channel 54," and thereafter "[n]ozzle opening 34 is operatively associated with firing resistor 52 such that droplets of ink within vaporization chamber 56 are ejected through nozzle opening 34 (e.g., substantially normal to the plane of firing resistor 52) and toward print medium 36 upon energizing of firing resistor 52." Ex.1004 at 5:15-21

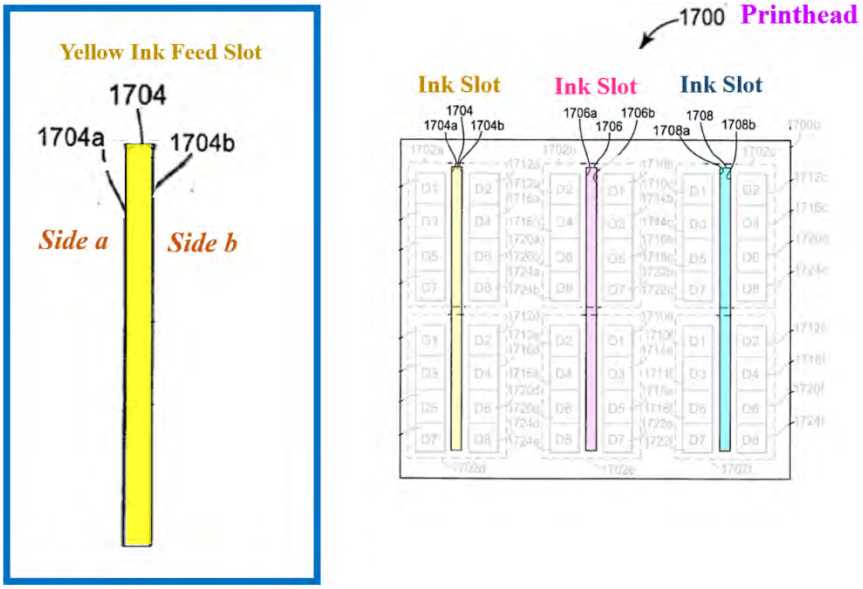
Ex.1004, Fig. 2



296. Figure 21 of Benjamin provides "a diagram illustrating an example layout of one embodiment of a printhead die 1700." Ex.1004 at 63:20-21. "In this embodiment, ink feed slot 1704 supplies yellow colored ink, ink feed slot 1706 supplies magenta colored ink and ink feed slot 1708 supplies cyan colored ink." Ex.1005 at 63:20-21. According to Benjamin, each ink feed slot has two longitudinal sides—longitudinal side "a" (purple) and longitudinal side "b" (*orange*)—that extend along the y-direction of the printhead die 1700—*viz.*, "ink feed slot 1704 includes opposing sides 1704 a and 1704 b that extend along the y-direction of printhead die 1700," Ex.1004 at 65:34-36; "ink feed slot 1706 includes opposing sides 1706 a and 1706 b that extend along the y-direction of printhead die 1700," Ex.1004 at 66:37-39; and "ink feed slot 1708 includes opposing sides 1708

a and 1708 b that extend along the y-direction of printhead die 1700," Ex.1004 at 67:37-39. "The ink feed slots 1704, 1706 and 1708 are located **parallel to one another** and each ink feed slot 1704, 1706 and 1708 includes a length that extends along the y-direction of printhead die 1700." Ex.1004 at 64:63.

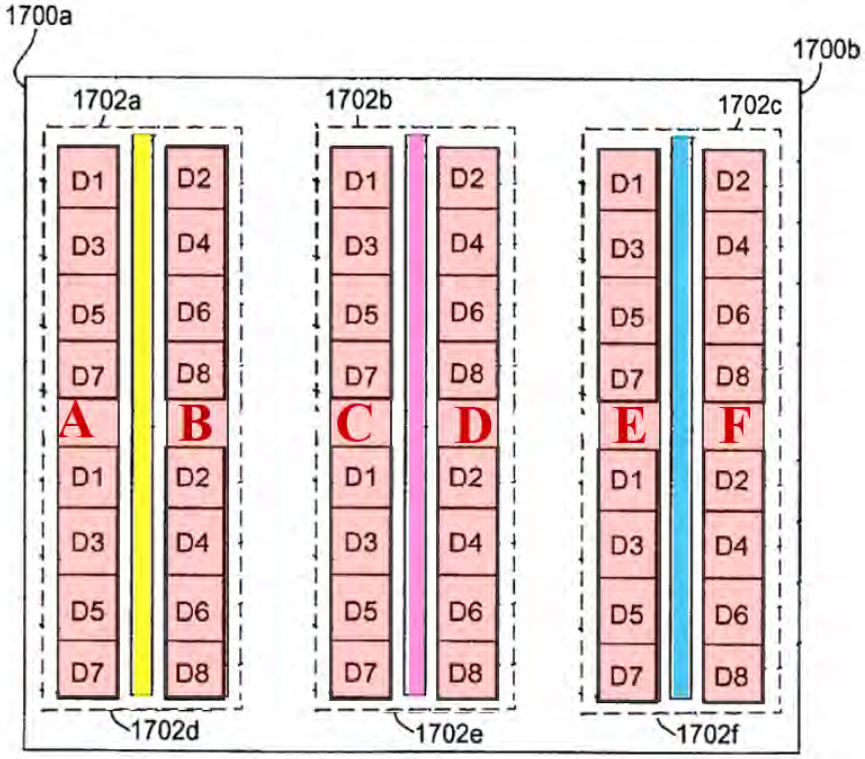
Ex.1004, Fig. 21



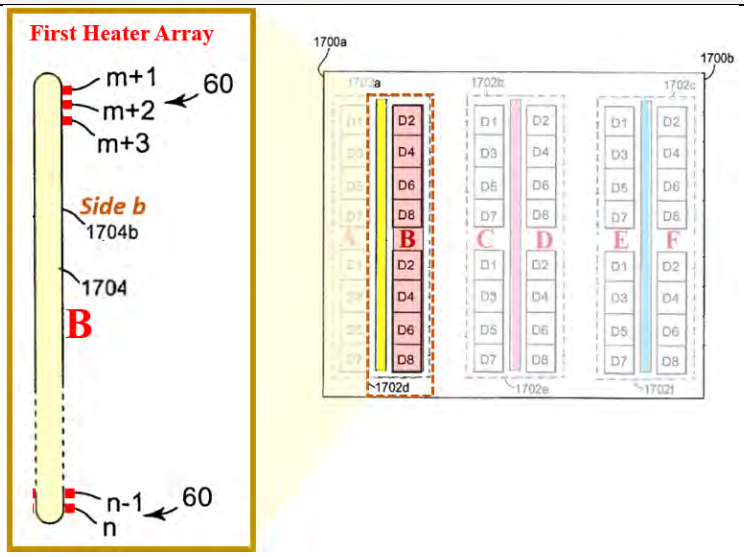
297. Benjamin's "printhead die 1700 includes six fire groups 1702a-1702f ***disposed along*** [the] three ink fluid feed sources, here depicted as feed slots 1704 [yellow], 1706 [magenta] and 1708 [cyan]." Ex.1004, 63:21-24; *id.* at 64:66-65:1 Benjamin further explains that "[t]he fire groups 1702a-1702f are divided into eight data line groups, indicated at D1-D8 and that "[e]ach data line group D1-D8 includes

pre-charged firing cells 120 from each of the fire groups 1702a-1702f." Ex.1005, 63:39-42.

Ex.1004, Fig. 21 (simplified)



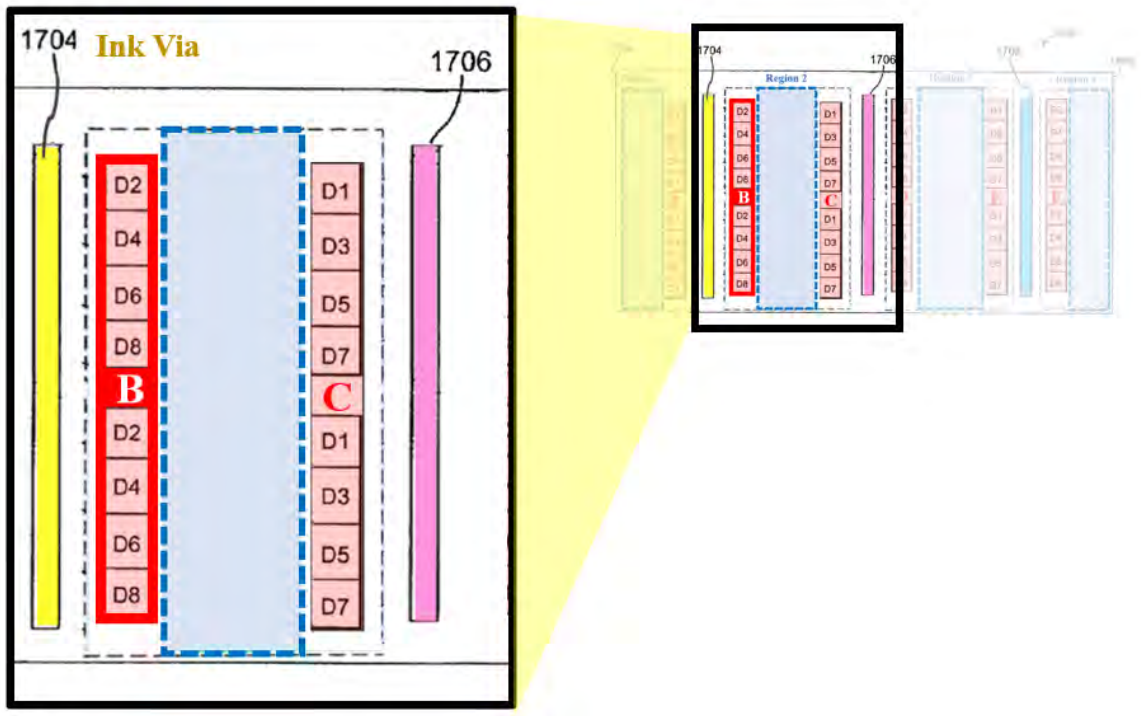
298. Looking at Heater Array B, for example, Benjamin's Printhead 1700 includes an array of firing resistors 52 (Heater Array B, *red*) formed from the ink drop generators 60 disposed on side 1704 b of the yellow ink feed slot 1704.

Ex.1004, Figs. 3 and 21


299. To be sure, Benjamin teaches that "Fire group one (FG1) ***1702 a*** is disposed along one half of the length of ink feed slot 1704," and "[t]he drop generators 60 in FG1 1702 *a* are disposed along each of the opposing sides 1704 a and 1704 b of ink feed slot 1704," and "[F]ire group four (FG4) 1702 d is disposed along the other half of the length of ink feed slot 1704," and that "[t]he drop generators 60 in FG4 1702 d are disposed along opposing sides 1704 a and 1704 b of ink feed slot 1704." Ex.1004 at 65:33-66:7; Ex.1004 at 66:36-67:8 (stating the same for ink feed slot 1706); Ex.1004 at 67:36-68:7 (stating the same for ink feed slot 1708).

300. Moreover, Benjamin teaches that Heater Array B is disposed next to the yellow ink feed slot 1704, and therefore, is substantially adjacent the Yellow Ink Via.

Ex.1004, Fig. 21(simplified)



301. Accordingly, it is my opinion that Benjamin discloses "a first heater array [e.g., Heater Array B] positioned substantially adjacent a first via [e.g., positioned next to the Yellow Ink Via]."

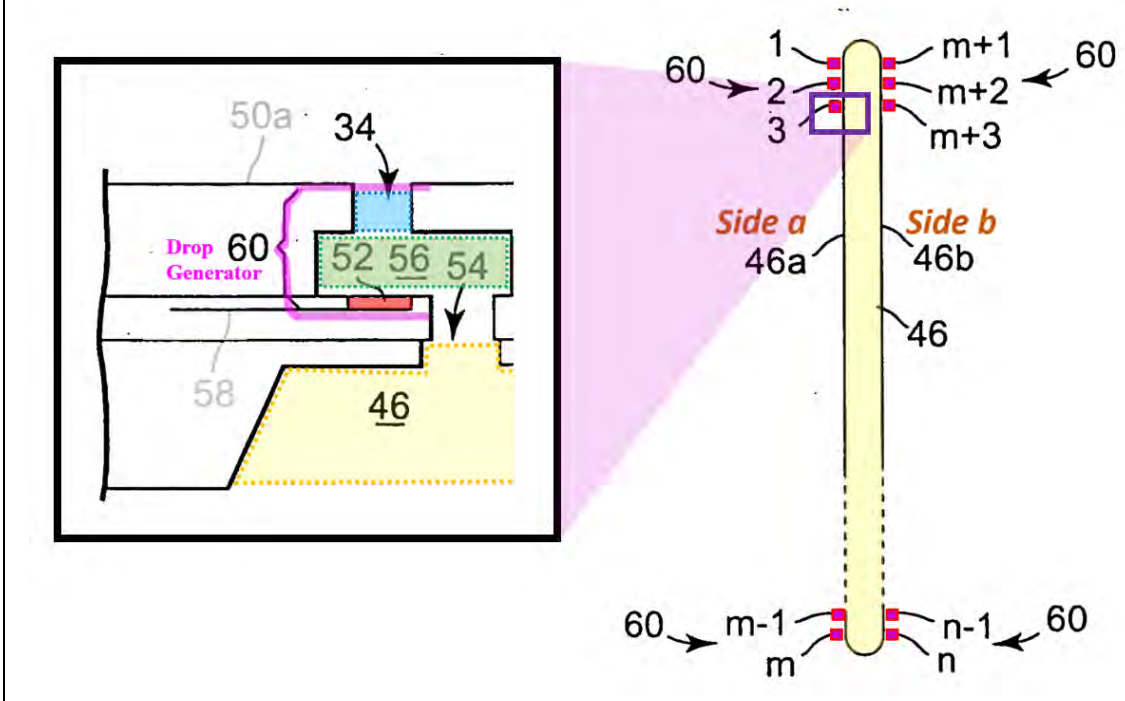
3. 1[B] "a second heater array positioned substantially adjacent a second via"

302. Claim 1 of the '823 Patent recites "a second heater array positioned substantially adjacent a second via." In my opinion, Benjamin discloses this limitation.

303. As I explain above for 1[A], incorporated here, Benjamin's printhead includes one or more ink feed slots 46— each of which is fluidically coupled to a

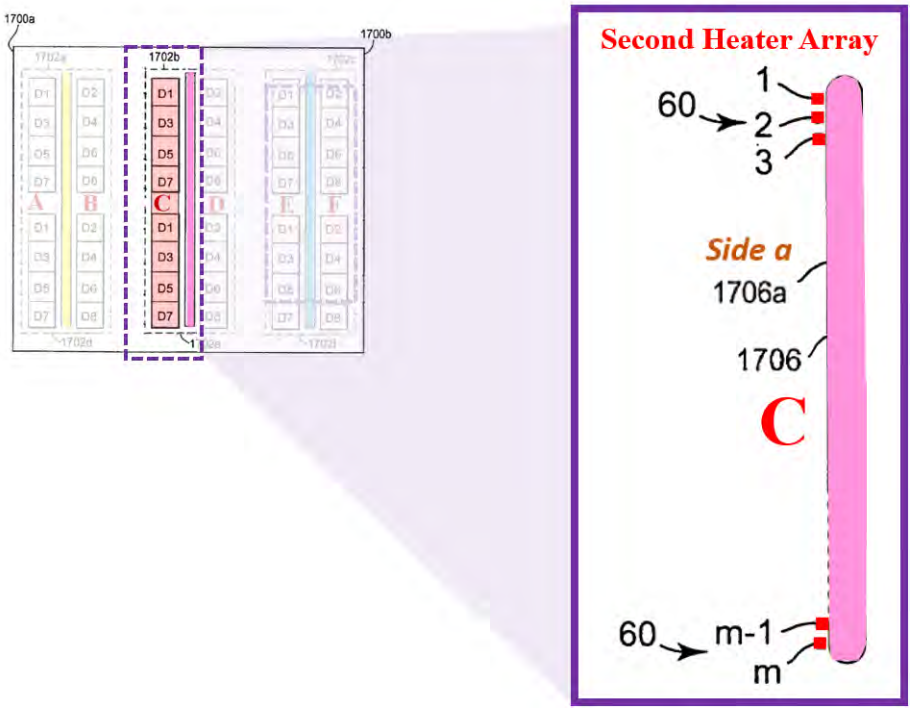
column of drop generators 60 [*purple*] disposed adjacent to each of its longitudinal sides. Ex.1004, 5:53-54. "A drop generator 60 [*purple*] as referred to herein includes firing resistor 52 [*red*], nozzle chamber or vaporization chamber 56 [*green*] and nozzle opening 34 [*blue*]." Ex.1004, 5:11-14. "During printing, ink flows from ink feed slot 46 [*yellow in Figure 2 below*] to vaporization chamber 56 **via ink feed channel 54**]," and "nozzle opening 34 [*blue*] is operatively associated with firing resistor 52 such that droplets of ink within vaporization chamber 56 are ejected through nozzle opening 34 (e.g., substantially normal to the plane of firing resistor 52) and toward print medium 36 upon energizing of firing resistors 52." Ex.1004, 5:3-30.

Ex.1004, Fig. 2



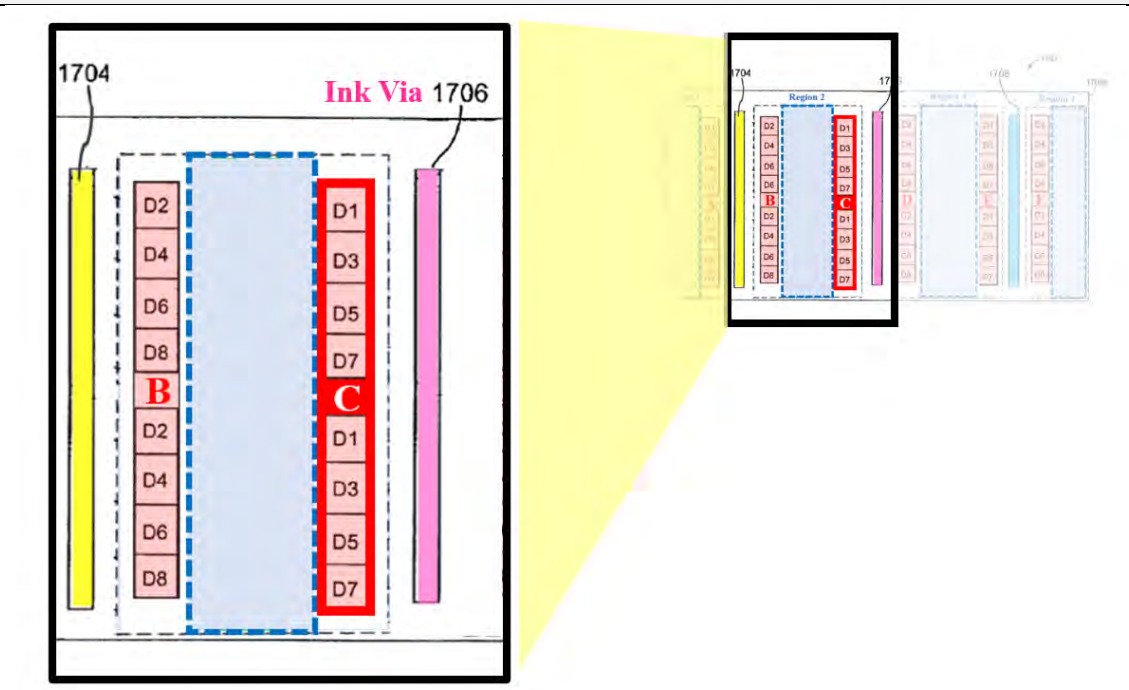
304. For example, Benjamin's Printhead 1700 includes an array of firing resistors 52 [e.g., Heater Array C] formed by the ink drop generators 60 disposed on side 1706 a of the magenta ink feed slot 1706. Ex.1004 at 66:36-67:8

Ex.1004, Figs. 3 and 21



305. Heater Array C is disposed next to the magenta ink feed slot 1706, and therefore, substantially adjacent the Magenta Ink Via.

Ex.1004, Figs.3,21



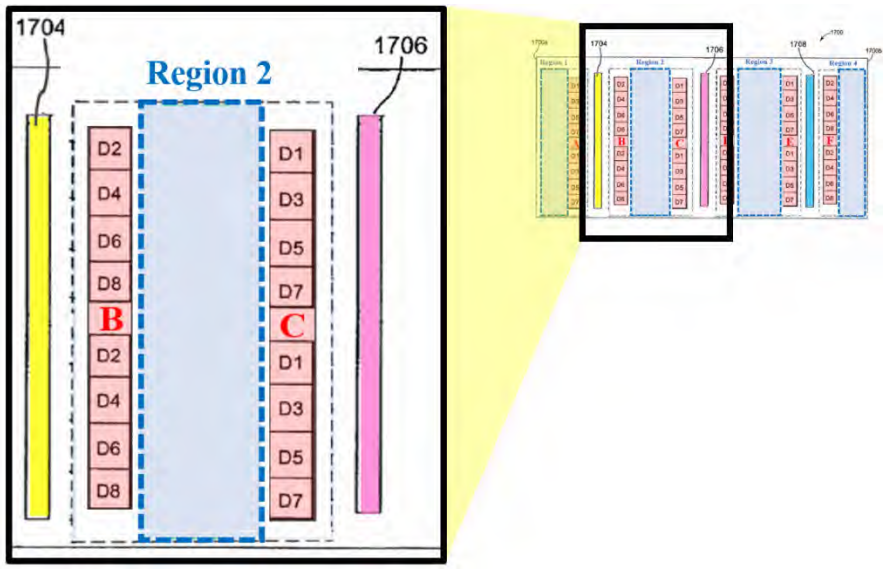
306. Accordingly, it is my opinion that Benjamin discloses "a second heater array [e.g., Heater Array C] positioned substantially adjacent a second via [e.g., positioned next to the Magenta Ink Via.]."

4. 1[C] "a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array"

307. Claim 1 of the '823 Patent further recites "a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array." In my opinion, Benjamin discloses this element.

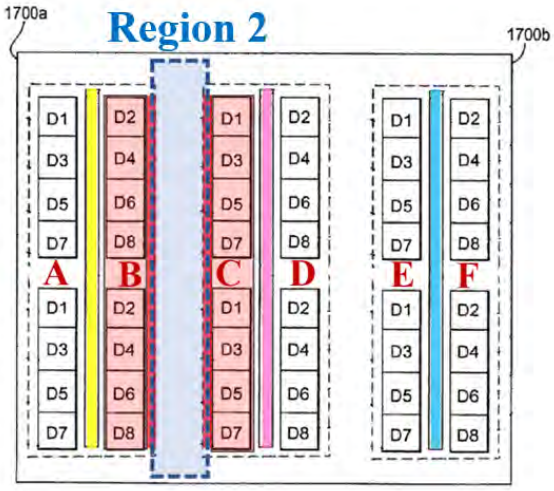
308. Referring to the printhead die 1700 shown in Figure 21, Benjamin discloses a first region on the printhead die 1700 [*e.g.*, Region 2 *blue below*) positioned between the first heater array [e.g., Heater Array B] and the Second Heater Array [*e.g.*, Heater Array C]. Ex.1004, Fig. 21.

Ex.1004, Fig. 21 (simplified)



309. Region 2 of Benjamin's Printhead Die 1700 is also substantially adjacent to the first heater array because it is next to, and even shares a border with, the first and second array of firing resistors 52 [e.g., Heater Arrays B and C, *shared borders outlined red*].

Ex.1004, Fig. 21 (simplified)



310. Accordingly, it is my opinion that Benjamin discloses "a region [e.g., Region 2] positioned between the first heater array and the second heater array and also positioned substantially adjacent to the first heater array and the second heater array [e.g., positioned between and next to Heater Arrays B and C."

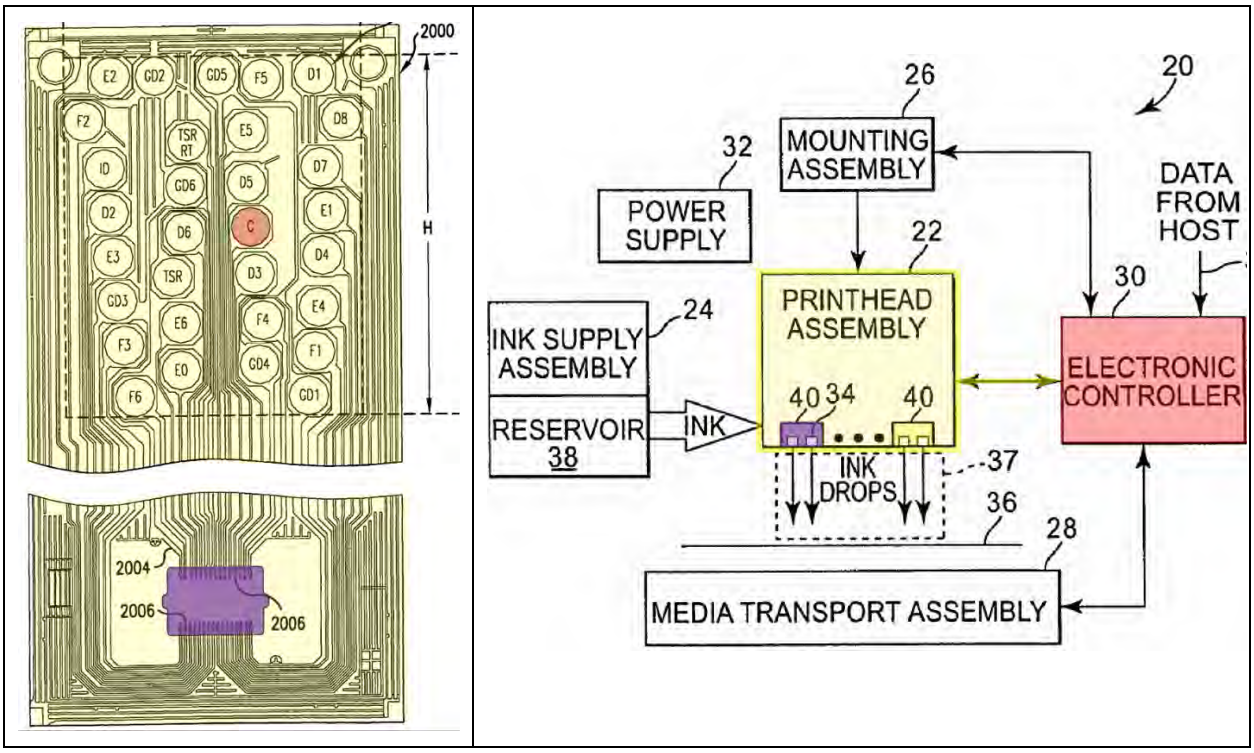
5. 1[D] "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region"

311. Claim 1 of the '823 Patent further recites "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region." In my opinion, Benjamin in view of Giere178 (the Benjamin-Giere178 combination) also discloses this limitation

312. Benjamin's printing system determines the temperature of a printhead die using temperature sense resistors on the die. Ex.1004 at 79:60-67. *First*, Benjamin describes the means to electrically couple the printer and printhead

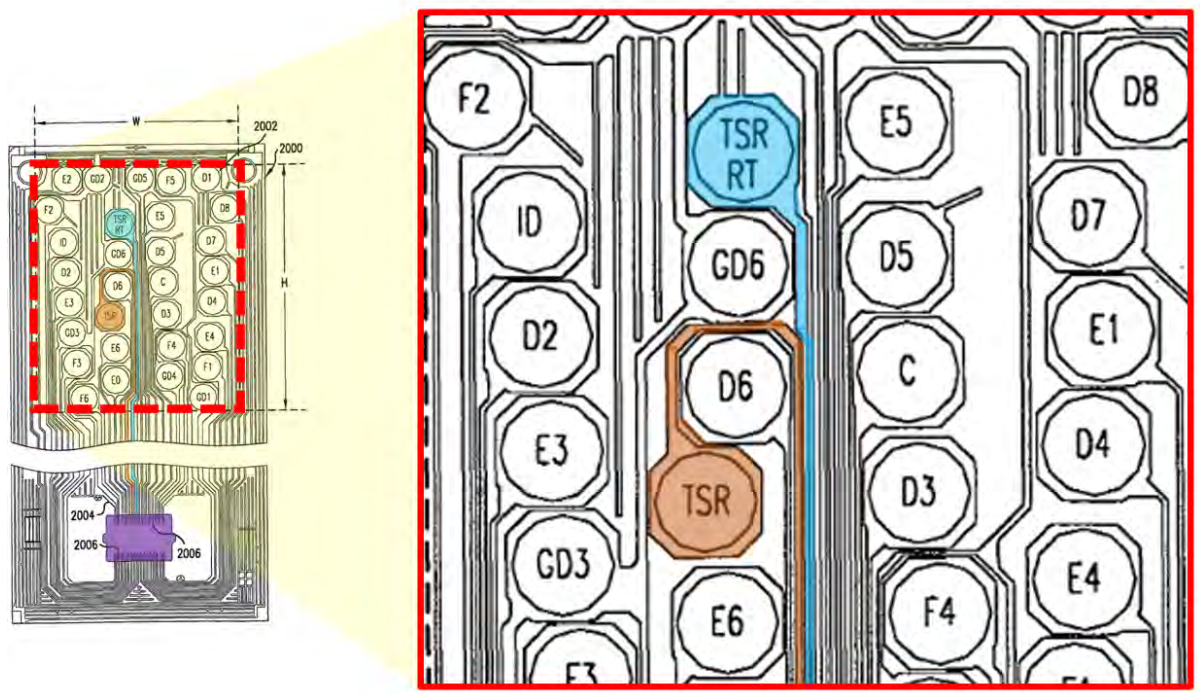
assembly to the printhead die. Referring to the flex circuit shown in Figures 25A and 25B, Benjamin teaches "electrically couple[ing] via conductive paths 2004" the "contact areas 2000 of a flex circuit 2002" to "contacts 2006," which provide coupling to the printhead die." Ex.1004 at 79:32-34.. Once electrically coupled to the contact areas of the flex circuit (yellow below), Benjamin teaches that the printhead die (*purple*) may "receive [different] signals from an external source," including, for example, "[c]ontact area C [which] is configured to receive a signal for controlling the internal operation of the printhead die, *e.g*. the CSYNC signal" from electronic controller 30," (*red*). Ex.1004 at 79:57-59; *compare* Ex.1004, Fig. 25B *with* Fig. 1; *see also, e.g.*, Ex.1004 at 79:46-48 ("[C]ontact areas D1-D8 are configured to receive data signals which provide print data representative of an image to be printed"), Ex.1004 at 79:50-52 ("Fire line contact areas F1-F6 configured to receive energy pulses" that "provide energy signals along fire lines Fire1-Fire6 to the appropriate fire groups.").

Ex.1004, Fig. 25B	**Ex.1004, Fig. 1**



313. Benjamin further teaches that "[t]emperature sense resistor contact area TSR (*brown below*) allows a printer coupled to an ink jet cartridge to determine a **temperature of the printhead die**, based upon a measurement of the resistor. A temperature sense resistor return contact area TSR-RT (*teal*) provides a return path for signals provided at temperature sense resistor contact area TSR." Ex.1004 at 79:60-65.

Ex.1004, Fig. 25B



314. Although Figures 25A and 25B do not depict the actual temperature sensor (just the **contact areas TSR and TSR TW** associated with the actual temperature **sense resistor** on the printhead die), a PHOSITA would understand that the temperature sense resistor (TSR) is incorporated into the printhead die based on Benjamin's disclosure that "the resistor" determines "the temperature ***of the printhead die***." In my opinion, a PHOSITA would know that contact fingers 2006 of the flex circuit are provided to be thermosonically bonded to bondpads on the silicon configured to receive, from the TSR on the printhead die, a temperature sense resistance (TSR) value indicative of the temperature of the printhead die.

315. To be sure, Benjamin teaches that the flex circuit also includes an "identification bit contact area ID [that] is coupled to identification circuitry on printhead die that allows a printer to determine the operating parameters of the printhead die and print cartridge," such as the temperature of the printhead die. Ex.1004, 80:1-4. To show how the identification circuitry "utiliz[es] a temperature sense resistor" on the printhead die, Benjamin incorporates by reference "co-owned patent application serial no. [Ser. No. 11/849,078; issued as U.S. Patent No. 7,278,703 (Ex.1019; Benjamin703)]," entitled "Fluid Ejection Device With **Identification Cells**,"[7] Ex.1004, 71:44-50, which teaches electrically coupling the "identification bit contact area ID" referenced by Benjamin to "identification cells" configured to store and provide "identification information indicating a thermal sense resistance value as determined at a selected temperature, such as 32 degrees centigrade." Ex.1019 at 18:19-28. Like Benjamin, Benjamin 703 states that the "printhead includes a thermal sense **resistor** (TSR) that is read to provide a TSR value," which then "is compared to the thermal sense resistance value stored in the identification cells to determine the temperature of the printhead." Ex.1019 at 18:25-

[7] Benjamin contains a typographical error of omission because it abruptly ends the sentence without actually providing the serial number of the co-owned application. However, it is quite clear that Benjamin intended to incorporate-by-reference Benjamin 703, which was filed on the same day, shares the same specification as Benjamin, and concerns the "identification circuitry" referenced by Benjamin in the subsequent sentence.

28. Put differently, upon electrically coupling the "temperature sense resistor **contact area** TSR" on the flex circuit to the actual "temperature sense **resistor** (TSR) on the printhead die via "identification circuity on the printhead die," Benjamin's printhead die using "TSR information to optimize print quality" by (1) reading the thermal sense resistor (TSR) on the printhead die to "provide a TSR value," (2) comparing the value obtained from the TSR "to the to the thermal sense resistance value stored in the identification cells to determine the temperature of the printhead," and (3) regulating the printhead's temperature "to optimize printing quality." Ex.1004, 79:60-66.

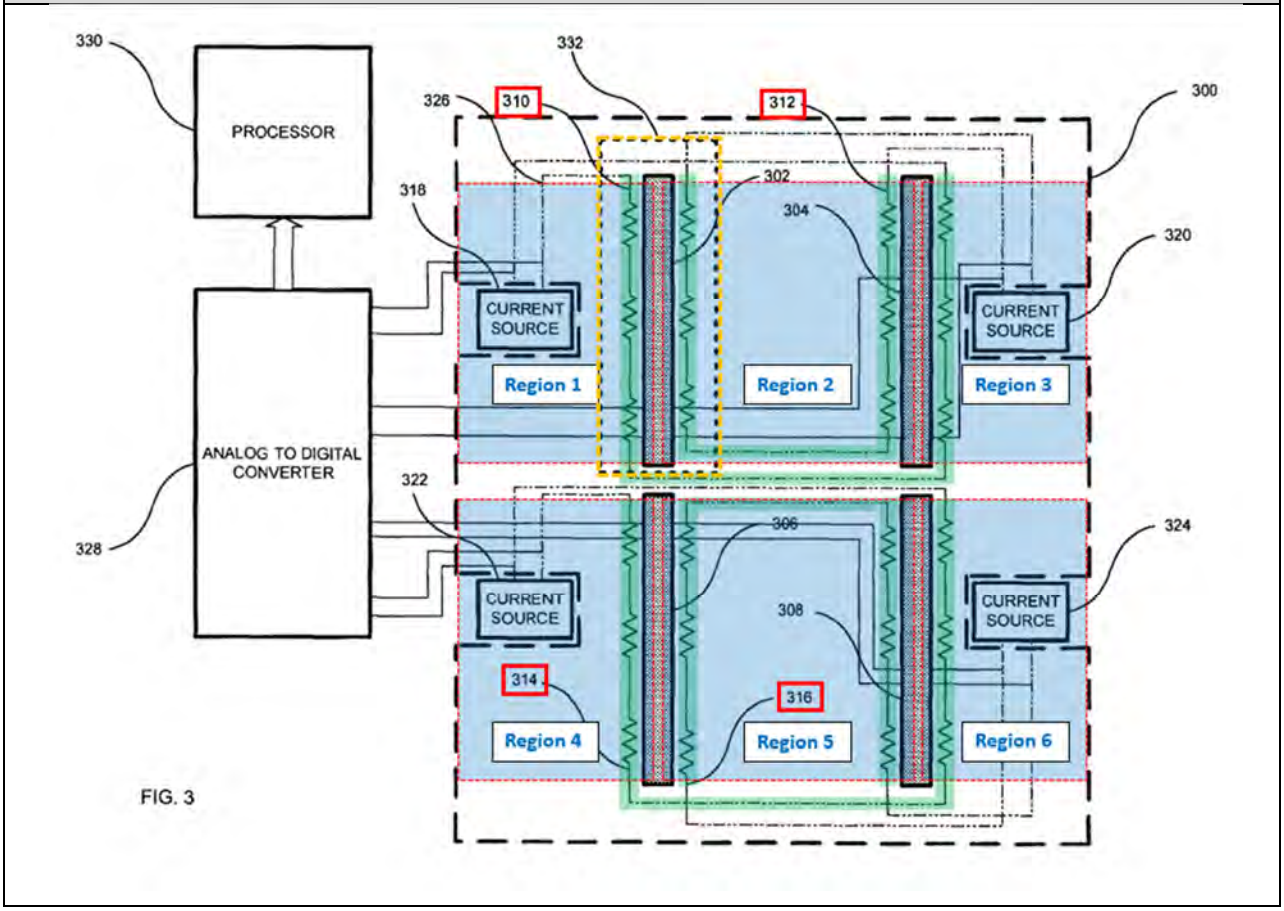
316. While Benjamin teaches disposing a TSR on the printhead die, it does not say *where* on the printhead die the TSR should be disposed. Given Benjamin's failure to specify where the TSR should be disposed to optimize print quality, it is my opinion that a PHOSITA would have looked beyond Benjamin and considered Giere178 for several reasons.

317. As an initial mater, Benjamin and Giere178 both qualify as analogous art to the claimed invention at least because they are both in the same field of endeavour as the '823 patent—namely, regulating operational temperature of a printhead die. At the very least, both Benjamin and Giere178 are both reasonably pertinent to maintaining the optimal temperature of a multi-via heater chip allegedly solved by the inventors of the '823 patent.

318. As another point, it is my opinion that ample motivation existed to combine Benjamin with Giere178 for several reasons.

319. *First*, because Benjamin fails to specify *where* the TSR should be disposed to optimize print quality, it is my opinion that a PHOSITA would have looked beyond Benjamin and considered Giere178. Giere178's temperature measurement system includes ***four*** temperature sensing elements each located in a region of the substrate 300 (e.g., Region 1-6) to detect the temperature of the substrate. Specifically, Giere178 discloses that on either side of each region (302, 304, 306, and 308), "**resistive elements 310, 312, 314, and 316** [*green*] are formed from material having a known temperature coefficient of resistivity." Ex.1007 at 8:49-51.

Ex.1007, Fig. 3

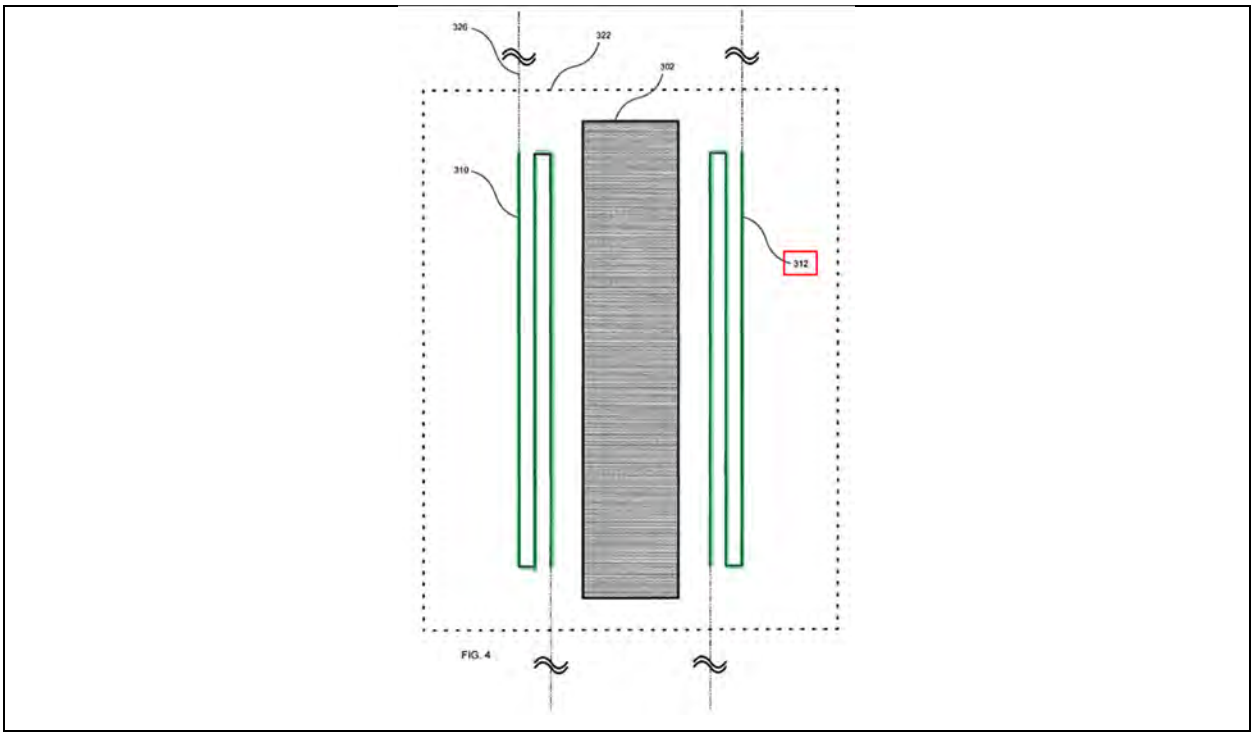


320. The four resistive elements (310, 312, 314, and 316) are each temperature sensing elements. Like the '823 Patent's temperature sensing element, Giere178 discloses that its resistive elements can have a serpentine path. Ex.1001 at 1:57-59 ("The temperature of the heater chip shown in FIG.1 is measured by way of a **metal serpentine temperature sense resistor 120.").** Giere178 discloses that "[r]esistive elements 310 and 312 are implemented using a **serpentine routing** of the traces in the region corresponding to the resistive element to increase the fraction of the total temperature induced resistance change (from the trace and the serpentine

routed resistive element) that corresponds to the **serpentine routed resistive element**." Ex.1007 at 10:24-29. Giere178 further discloses that "the cross sectional area and length (by **following a serpentine path** for example) of the resistive element would be controlled to **increase the resistance of the resistive element.**" Ex.1007 at 11:24-30. Thus, Giere178's resistive elements are the same as an embodiment of the '823 Patent's "temperature sensing element."

321. Giere178's Figure 4 is a schematic diagram corresponding to portion 332 in Figure 3, above. The serpentine path of the resistive elements are illustrated in Figure 4. The double-tildes indicated that the length of the resistive element continues outside of portion 332. For example, the serpentine path of resistive element 312 extends across Region 2 (between regions 302 and 304), as illustrated in Figure 3 above.

Ex.1007, Fig. 4

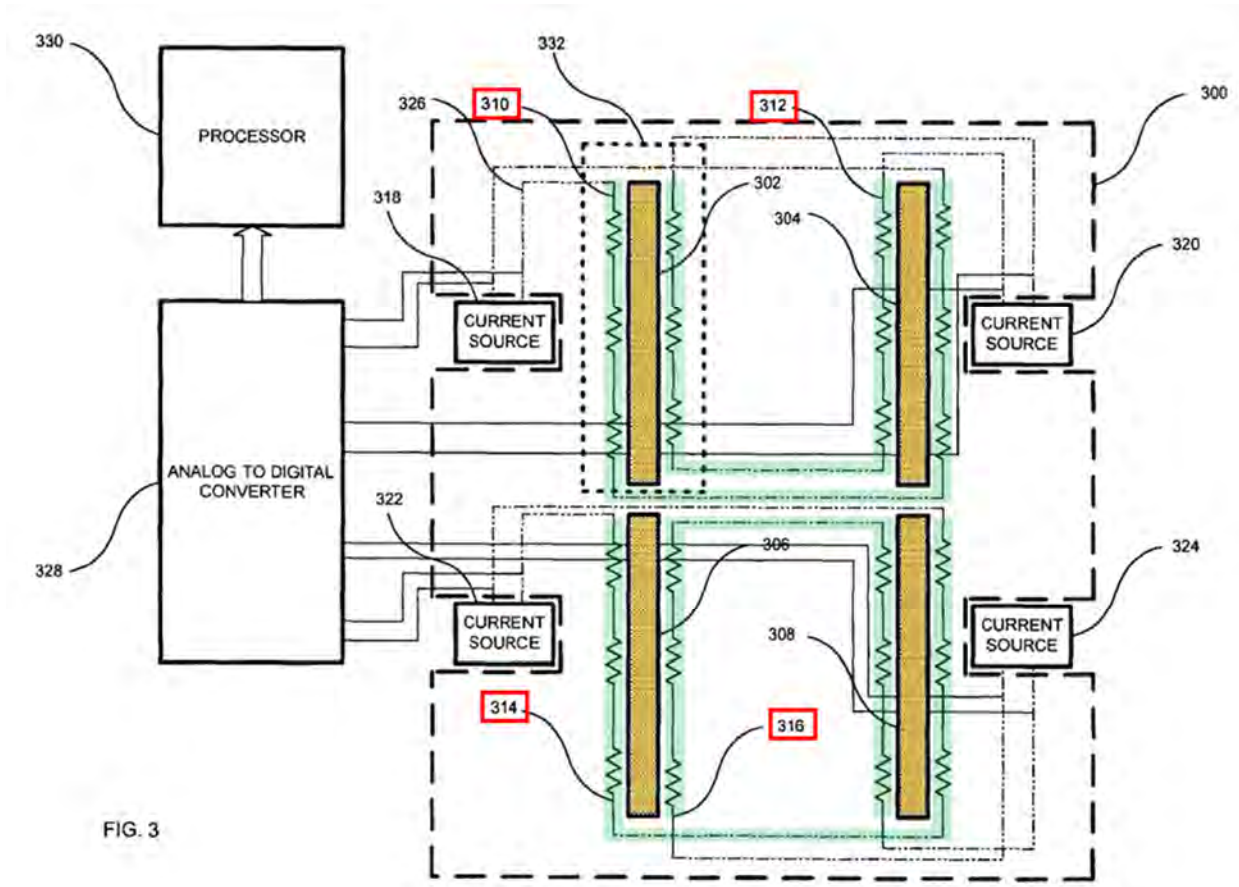


322. Giere178's resistive elements are also temperature sensing element because they are "**located so that they will each assume the temperature of the local region of substrate 300 on which they are placed."** Ex.1007 at 8:41-54. ("[r]esistive elements 310, 312, 314, and 316 are **located so that they will each assume the temperature of the local region of substrate 300 on which they are placed**."). Giere178 further discloses that "current sources 318, 320, 322, and 324 are configured to supply electrical power to resistive elements 310, 312, 314, and 316" and "[e]ach of current sources 318, 320, 322, and 324 supply a substantially constant and known current to, respectively, resistive elements 310, 312, 314, and 316 when power is applied to them." Ex.1007 at 8:55-60. According to Giere178, "the voltage resulting from the application of current to each of resistive elements

310, 312, 314, and 316 changes according to temperature induced changes in the resistance, thereby providing **signals related to the temperatures of the regions**." Ex.1007 at 8:63-64. In sum, as Giere178 explains, "[b]y knowing how the resistance changes with temperature and the magnitude of the current supplied to resistive elements 310, 312, 314, and 316, measurement of the voltages can be used to estimate **changes in the temperature in the regions of substrate 300**." Ex.1007 at 10:7-8.

323. As illustrated in Figure 3, each Region only includes a single temperature sensing element. In other words, each region has a resistive element and there are never two resistive elements in any one Region. For example, as illustrated in Figure 3, above, a single temperature sensing element, i.e., resistive element **312** is included in Region 2. Regions 1 and 3 also include a single temperature sensing element, i.e., resistive element **310**. Region 5 includes a single temperature sensing element, i.e., resistive element **316**. And Regions 4 and 6 also include a single temperature sensing element, i.e., resistive element **314**.

Ex.1007, Fig. 3



324. Moreover, a PHOSITA would also know that Giere178 is including a single temperature sensor in each region because it describes a problem of excessive *localized* heating of the substrate without compensation for the substrate temperature change that can lead to degradation in print quality. Ex.1007 at 5:36-51. For example, Giere178 describes a situation where excessive printing of one color ink in one region of the printhead die, e.g., magenta ink, can increase the temperature of

that color's ink ejection chambers thereby increasing the mass of the magenta ink drops beyond the desired print size. Ex.1007 at 5:52-6:3.

325. Giere178 explains that in this situation, print quality will degrade because excessive magenta ink will alter the desired print colors. *Id*. Giere178 states that the "rate at which signals are supplied to resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead" and "*localized heating* of the substrate can occur from firing nozzles at a greater frequency *in a particular region of the printhead*." Ex.1007 at 5:44-46. Giere178 explains that "[i]f at least some compensation is not made for these temperature changes, a perceptible degradation in print quality can result." Id. at 5:49-51. For example, in the magenta example described above, Giere178 states that "as a result of the excessive quantity of magenta ink applied, the hue of the region formed will be shifted toward the magenta hue," "undesired shifts in the chroma and the luminance of [print] regions" can occur, and an "increase in the mass of ejected ink drops can reduce the sharpness of the edges when the image is formed onto paper." Ex.1007 at 5:62-6:3. Giere178 discloses a solution to the localized heating issue by placing multiple temperature sensing "resistive elements" on the substrate—one in each region—"so that they will each assume the temperature of the local region of substrate [] on which they are placed." Ex.1007 at 8:51-54.

326. Giere178 states that its "temperature compensation system" with localized temperature sensors "may be used to control a quantity of ink deposited on a region in response to the measured temperature," or "may be used to control resistive heating elements thermally coupled to [the] substrate [] so that the temperature of [the] substrate [] is controlled substantially at a desired temperature," or "may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of [the] substrate [] is controlled substantially at a desired temperature." *Id*. at 9:50-60

327. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses this limitation.

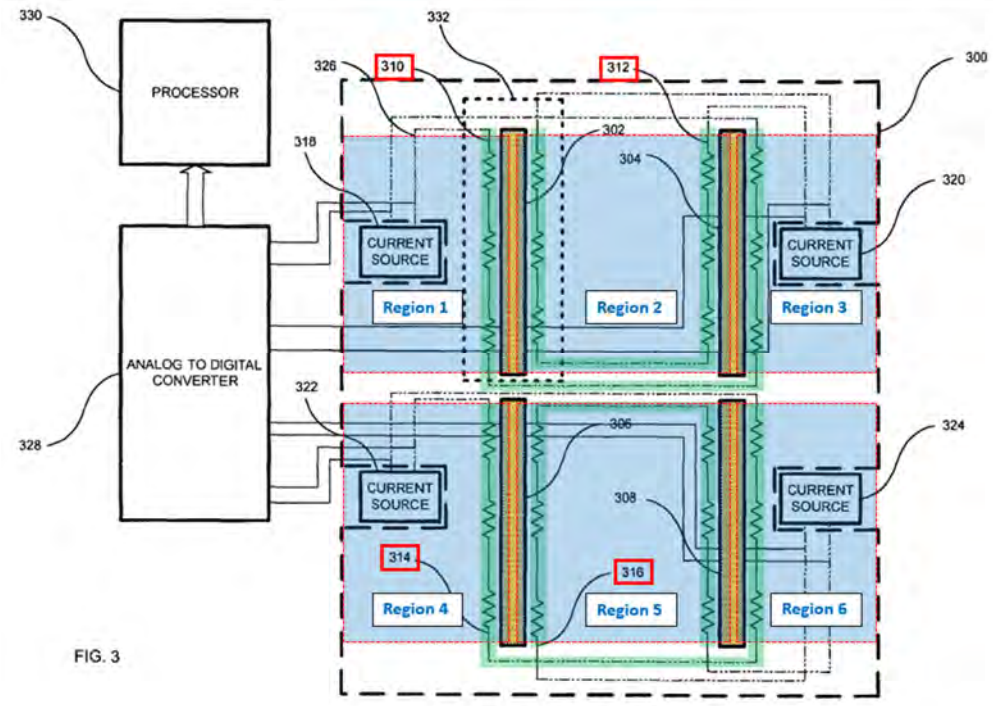
6. 1[E] "wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array"

328. Claim 1 of the '823 Patent further recites "wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array." In my opinion, the Benjamin-Giere178 combination discloses this limitation.

329. Upon review of Figure 3 of Giere178, a PHOSITA would have understood that "the temperature sense resistor [e.g., resistive element 312]" is at

least in *substantially* a center portion—if not exactly in the center—of the region (Region 2) disposed between the two heater arrays (i.e., one column of firing resistors on the right side of the cyan ink feed slot in region 302 and one column of firing resistors on the left side of the magenta ink feed slot in region 304), especially since Giere178 states that "[r]esistive elements 310, 312, 314, and 316 are located so that they will each assume the temperature of the local region of substrate 300 on which they are placed." Ex.1007 at 8:51-54. A PHOSITA would understand that placing the element in *substantially* a center portion would achieve the goal of the element assuming the temperature of the local region of substrate 300.

Ex.1007, Fig. 3



330. In my opinion, the position of Giere178's resistive element 312 is either directly on center or so close to the claimed arrangement that, a PHOSITA would have expected to have the same properties. My position here is supported by the '823 Patent's failure to discuss how positioning a temperature sensor in *substantially* a center portion would improve the accuracy of the temperature readings. *See* Ex.1001 (failing to provide any details about the position of the temperature sensor).

331. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses this limitation.

7. 1[F] "wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region"

332. Claim 1 of the '823 Patent further recites "wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region." In my opinion, the Benjamin-Giere178 combination discloses this limitation.

333. Giere178 discloses that "[r]esistive elements 310, 312, 314, and 316 are located so that they will each **assume the temperature of the local region of substrate 300 on which they are placed**." Giere178, explains that current sources 318, 320, 322, and 324 supply a substantially constant and known current to the

resistive element 310, 312, 314, and 316. Ex.1007 at 8:55-60 ("current sources 318, 320, 322, and 324 are configured to supply electrical power to restrictive elements 310, 312, 314, and 316…[e]ach of current sources 318, 320, 322, and 324 supply a substantially constant and known current to, respectively, resistive elements 310, 312, 314, and 316 when power is applied to them."). In turn, "the voltage resulting from the application of current to each of resistive elements 310, 312, 314, and 316 changes according to temperature induced changes in the resistance, thereby providing **signals related to the temperatures of the regions**." Ex.1007 at 8:60-64; *see also id.* at Ex.1007 at 10:4-8 ("[b]y knowing how the resistance changes with temperature and the magnitude of the current supplied to resistive elements 310, 312, 314, and 316, **measurement of the voltages can be used to estimate changes in the temperature in the regions of substrate 300**.").

334. Giere178 discloses that these signals are converted to digital values that are used to determine the temperature of the regions of the substrate where the resistive elements are located. Ex.1007 at 9:44-48 ("By comparing the digital values after pulses have applied to the firing resistors and before pulses have been applied to the firing resistors, a measurement of the temperature change of regions of substrate 300 can be determined.").

335. Giere178 explains that the substrate temperature is based on the heat generated from the firing resistors (i.e., adjacent heater arrays). Ex.1007 at 5:36-38

("The **rate at which signals are supplied to [firing] resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead**."); *id.* at 5:39-43 ("For a printhead where there is no attempt made to stabilize the temperature of the substrate, the temperature of the substrate can change substantially during use of the printhead depending upon changes in the firing frequency of the nozzles over time."); *id*. at 5:44-46 ("Localized heating of the substrate can occur from firing nozzles at a greater frequency in a particular region of the printhead.").[8] In other words, the substrate temperature is representative of the heater arrays adjacent to the region because the substrate temperature is a direct result of heat generated by the firing resistors. Thus, the resistive elements 310, 312, 314, and 316 are operable to sense a temperature representative of the heater arrays adjacent to the region because they are located so that they will each assume the temperature of the local region of substrate 300 on which they are placed.

336. Moreover, because the ink feed slots with regions 302, 304, 306, and 308 act as thermal insulators between the regions, a PHOSITA would understand that the resistive elements 310, 312, 314, and 316 are designed to sense the

[8] Giere178 also explains that its temperature measurement system relies on the temperature related values generated by the resistive elements 310, 312, 314, and 316 to control the substrate temperature using processor 330. Ex.1007 at 9:50-54– ("One embodiment of the temperature compensation system may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of substrate 300 is controlled substantially at a desired temperature.").

temperature of the substrate region it is positioned in, and since each region includes two arrays of firing resistors, a PHOSITA would also know that the temperature sensed by each resistive elements 310, 312, 314, and 316 would represent the temperature of the two heater arrays in its region.

337. For example, a PHOSITA would know that the resistive element 312 within Region 2 senses the temperature of the area between the two adjacent ink feed slots and 1706 because of their insulating nature of the ink feed slots, and for that same reason, a PHOSITA would know that a temperature sensed by resistive element 312 would necessarily represent the temperature of both heater arrays within Region 2—*i.e.*, the firing resistors disposed on the right side of the cyan ink feed slot in region 302 and the firing resistors disposed on the left side of the magenta ink feed slot in region 304.

338. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses this limitation.

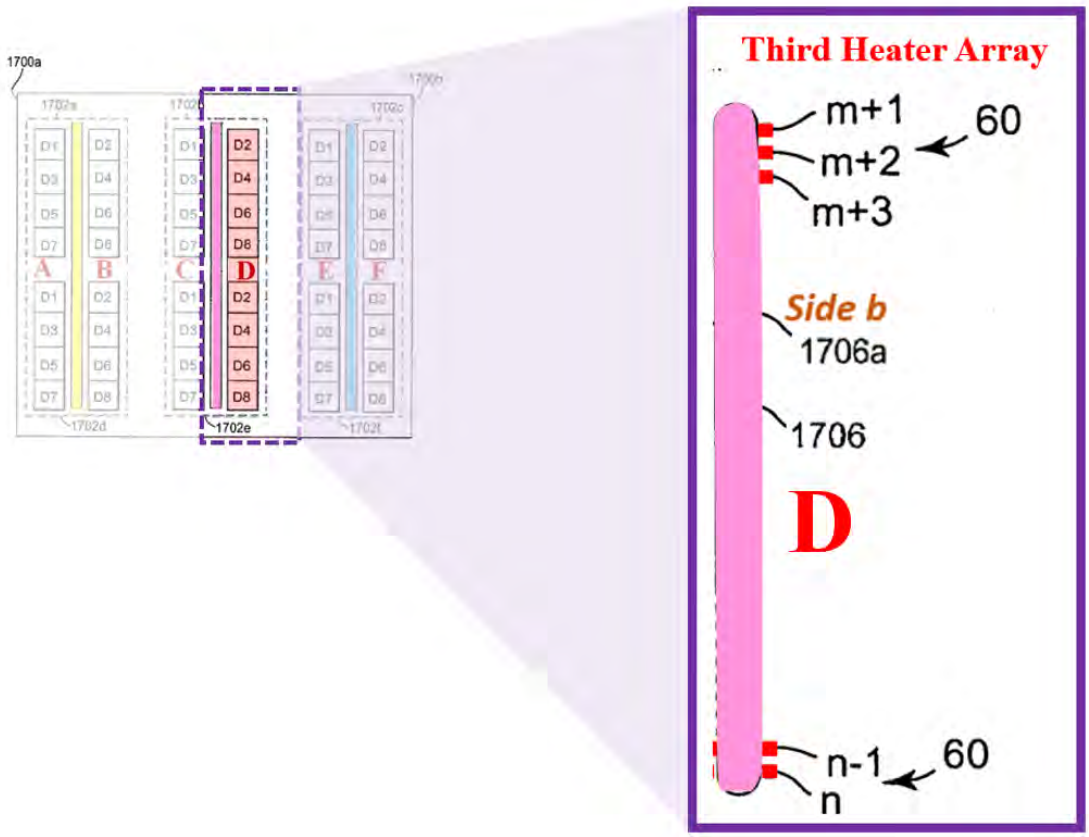
8. 1[G] "a third heater array[,] positioned substantially adjacent the second via"

339. Claim 1 of the '823 Patent further recites "a third heater array[,] positioned substantially adjacent the second via." In my opinion, the Benjamin-Giere178 combination discloses this limitation.

340. The printhead die 1700 includes a third array of firing resistors 52 (*e.g.*, Heater Array D) from the drop generators 60 associated with side 1706*b* of the

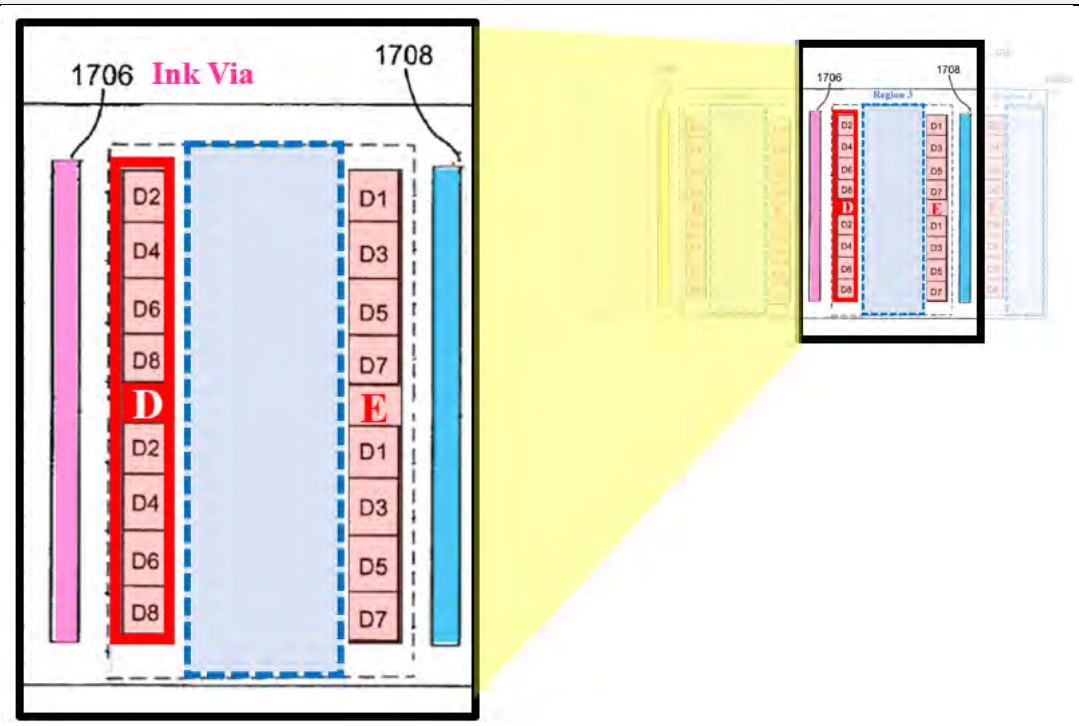
magenta ink feed slot 1706—*e.g.*, "[t]he drop generators 60 in FG2 1702*b* [and in FG4 1702*e*] are disposed along each of the opposing sides 1706 *a* and 1706 *b* of ink feed slot 1706." Ex.1004 at 66:36-67:8.

Ex.1004, Fig. 21 (simplified)



341. Heater Array D is disposed next to the magenta ink feed slot 1706, and therefore, substantially adjacent the Magenta Ink Via.

Ex.1004, Figs. 3, 21



342. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses "a third heater array[,] [e.g., Heater Array D] positioned substantially adjacent a second via [e.g., Magenta Ink Via].

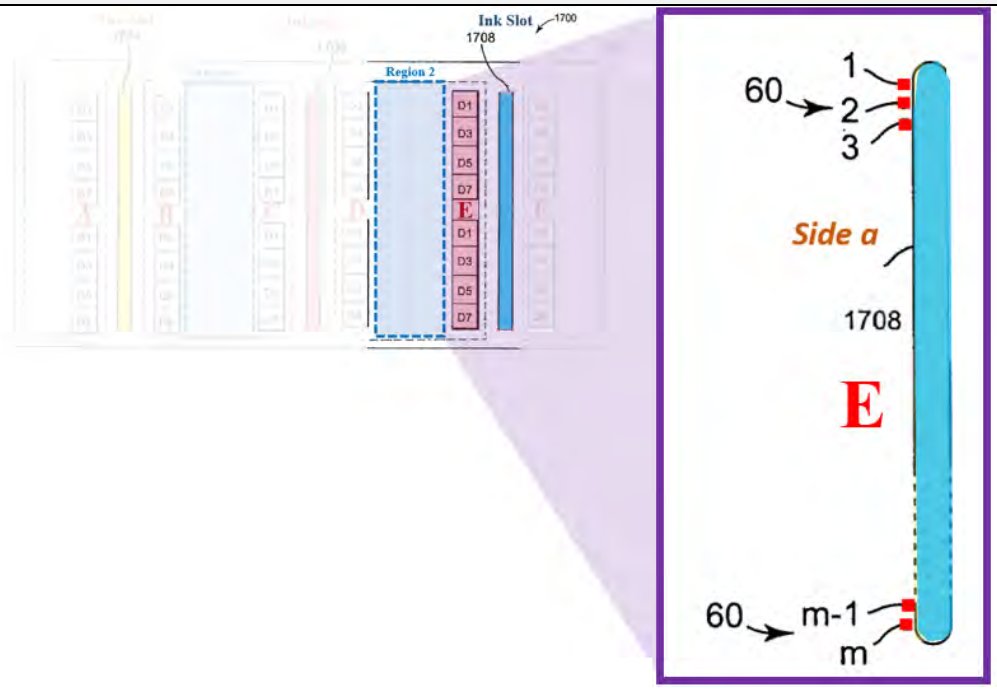
9. 1[H] "a fourth heater array, positioned substantially adjacent a third via"

343. Claim 1 of the '823 Patent further recites "a fourth heater array, positioned substantially adjacent a third via." In my opinion, the Benjamin-Giere178 combination discloses this limitation.

344. The printhead die 1700 includes a fourth array of firing resistors 52 (*e.g.*, Heater Array E) from the drop generators 60 associated with side 1708*a* of the

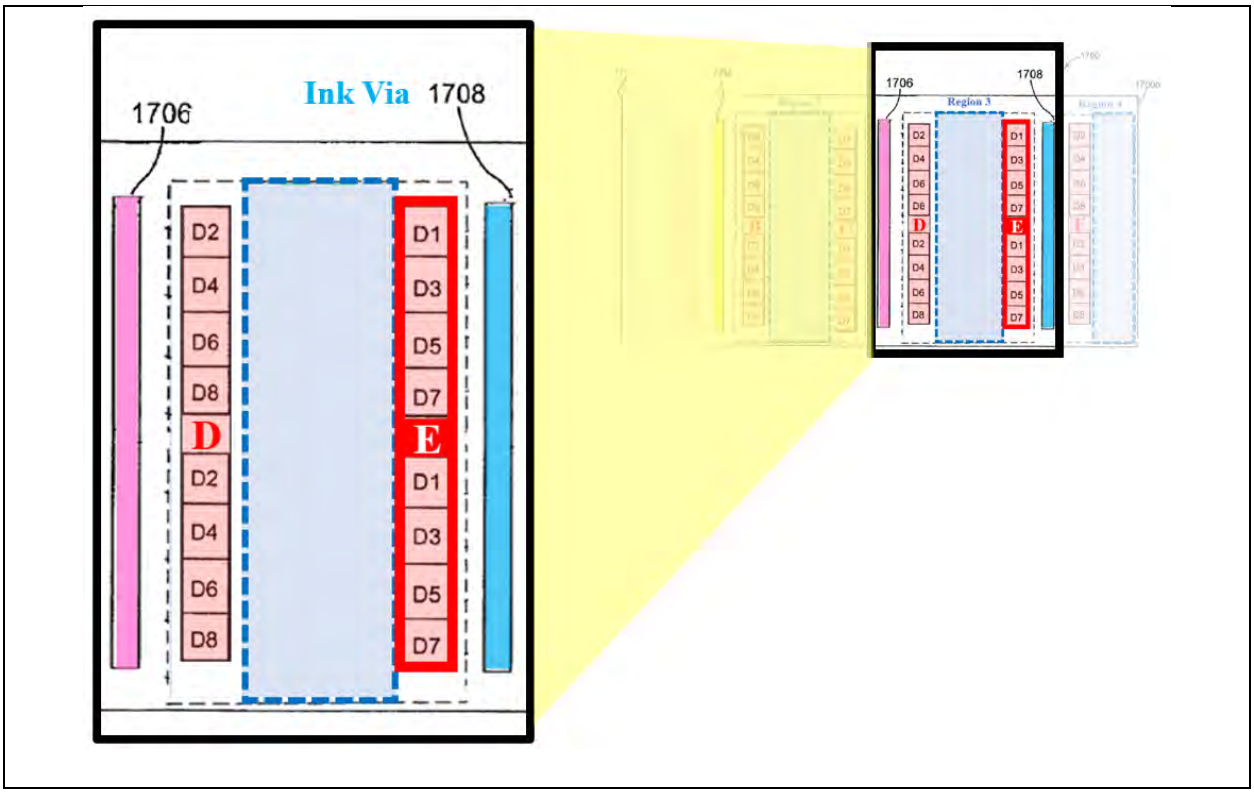
cyan ink feed slot 1708—*e.g.*, "[t]he drop generators 60 in FG3 1702*c* [and in FG6 1702*f*] are disposed along each of the opposing sides 1708 *a* and 1708 *b* of ink feed slot 1708." Ex.1004 at 66:36-67:8.

Ex.1004, Fig.3,21(simplified)



345. Heater Array E is disposed next to the cyan ink feed slot 1708, and therefore, substantially adjacent the Cyan Ink Via.

Ex.1004, Fig.21(simplified)



346. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses "a fourth heater array, [e.g., Heater Array E] positioned substantially adjacent a third via" [*e.g.*, Cyan Ink Via].

10. 1[I] "a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array"

347. Claim 1 of the '823 Patent further recites "a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array." In my opinion, the Benjamin-Giere178 combination discloses this limitation.

348. Claim 1 of the ’823 Patent further recites “a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array.” In my opinion, the Benjamin-Giere178 combination discloses this limitation.

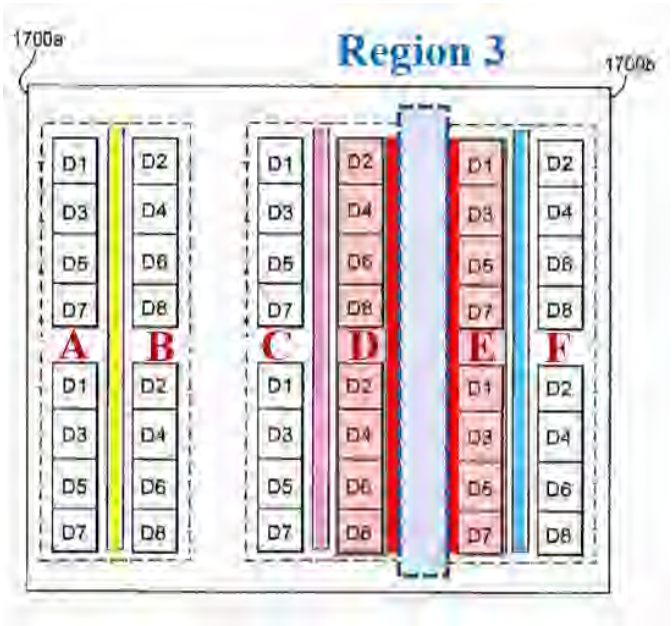
349. The Printhead die 1700 includes a second region [*e.g.*, Region 3, *blue below*] positioned between Heater Array D and Heater Array E (*red*).

Ex.1004, Fig.21 (simplified)



350. Region 3 of Printhead Die 1700 is also positioned immediately next to, and shares a border with, both Heater Array D and E, and therefore, is substantially immediately adjacent each heater array.

Ex.1004, Fig.21



351. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses "a second region [e.g., Region 3], positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array [e.g., positioned between and immediately next to and sharing a border with Heater Arrays D and E]."

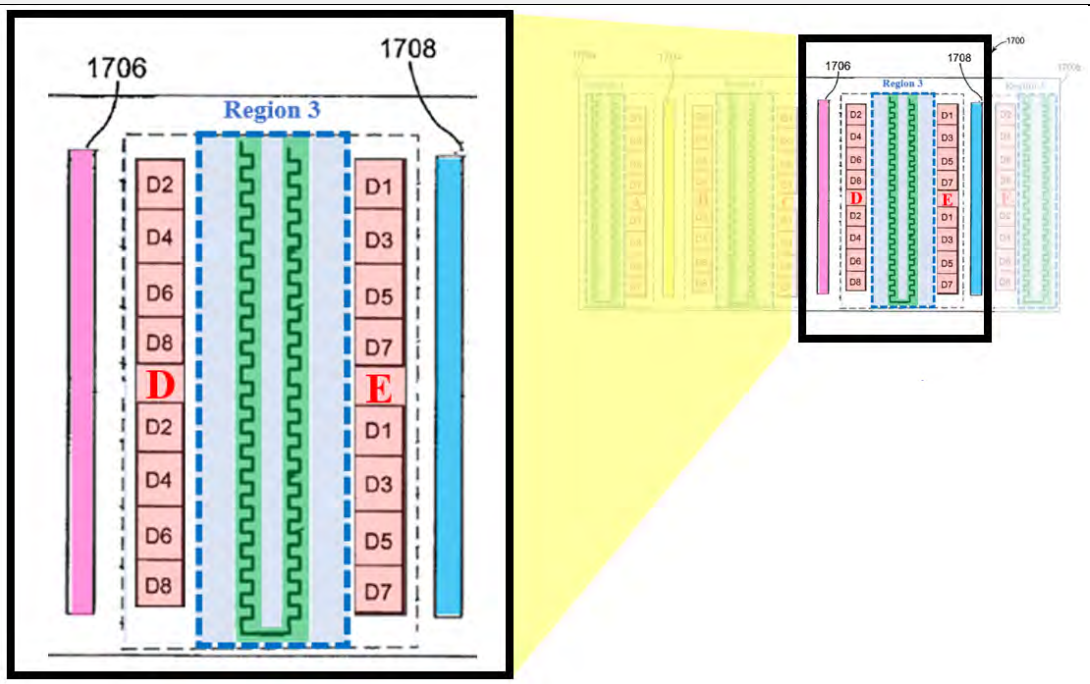
11. 1[J] "a second temperature sensing element operable to sense the temperature of the second region"

352. Claim 1 of the '823 Patent further recites "a second temperature sensing element operable to sense the temperature of the second region."

353. Claim 1 of the '823 Patent further recites "a second temperature sensing element operable to sense the temperature of the second region." As I explained in greater detail above for 1[d], the printhead die resulting from the Benjamin-Giere178 combination includes a single temperature sense resistor [e.g., TSR, *green below*]

within each of the thermal regions on the printhead die [e.g., Regions 1-4, *blue*], including the thermal region between the Heater Array D and Heater Array E [*e.g.*, Region 3], which the TSR senses to provide a temperature value for the second region.

Ex.1004 and Ex.1005, (The Benjamin-Giere178 Combination)



354. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses "a second temperature sensing element [*e.g.*, TSR] operable to sense the temperature of the second region. [e.g., Region 3].".

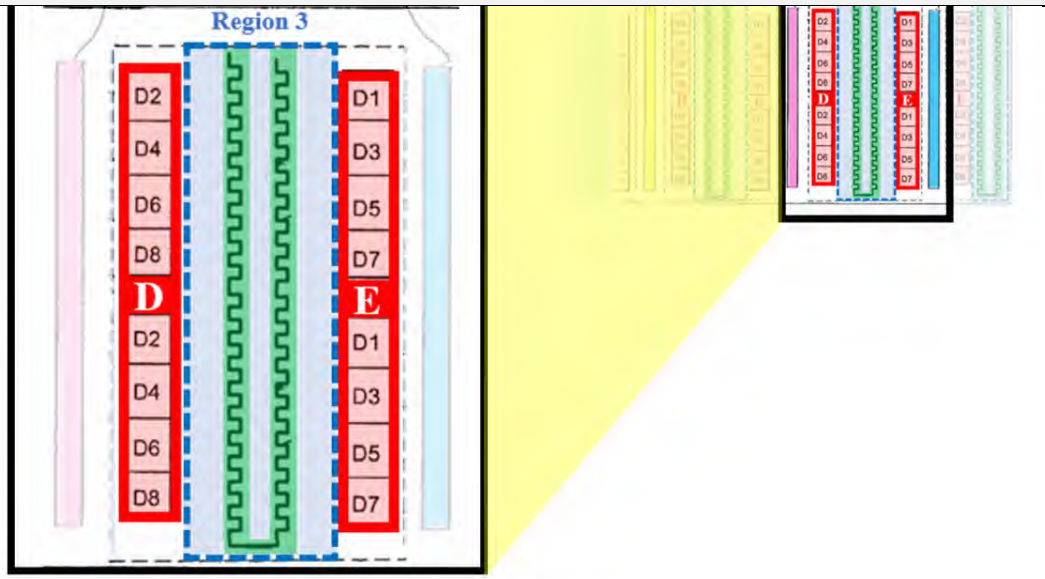
12. 1[K] "wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array"

355. Claim 1 of the ’823 Patent further recites “wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array.” In my opinion, the Benjamin-Giere178 combination discloses this limitation.

356. As I explained in greater detail above for Claim 1[d] and 1[e], the printhead die resulting from the Benjamin-Giere178 combination positions each TSR substantially in the center of the each region, including the region between the magenta and cyan ink vias [e.g., Region 3] and substantially adjacent to both the third heater array and fourth heater array [e.g., Heater Array D and the Heater Array E] so that, *individually*, each TSR provides a temperature value reflective of the temperature of its region, including the heater arrays adjacent those regions, *and collectively*, the values provided by the TSRs reflect the mean temperature of the entire printhead die.

357. Moreover, because the second region of the printhead die [e.g., Region 3, *blue below*] shares a border with the same two adjacent heater arrays that are positioned equidistant from the TSR—Heater Array D and the Heater Array E—the TSR within Region 3 is not only substantially centrally disposed in Region 3, but also substantially adjacent to both Heater Array D and E.

Ex.1004 and Ex.1005, (The Benjamin-Giere178 Combination)



358. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses that the second temperature sensing element [e.g., TSR 510] is "substantially centrally disposed with respect to the second region [e.g., Region 3] and substantially adjacent to both the third heater array and fourth heater array [e.g., Heater Array D and the Heater Array E].

13. 1[L] "the third heater array and the fourth heater array are operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region"

359. Claim 1 of the '823 Patent further recites "Wherein the third heater array and the fourth heater array are operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and

wherein the received heating regulates the temperature of the region." In my opinion, the Benjamin-Giere178 combination discloses this limitation.

360. Giere178 discloses that "[r]esistive elements 310, 312, 314, and 316 are located so that they will each **assume the temperature of the local region of substrate 300 on which they are placed**." Giere178, explains that current sources 318, 320, 322, and 324 supply a substantially constant and known current to the resistive element 310, 312, 314, and 316. Ex.1007 at 8:55-60 ("current sources 318, 320, 322, and 324 are configured to supply electrical power to restrictive elements 310, 312, 314, and 316…[e]ach of current sources 318, 320, 322, and 324 supply a substantially constant and known current to, respectively, resistive elements 310, 312, 314, and 316 when power is applied to them."). In turn, "the voltage resulting from the application of current to each of resistive elements 310, 312, 314, and 316 changes according to temperature induced changes in the resistance, thereby providing **signals related to the temperatures of the regions**." Ex.1007 at 8:60-64; *see also id.* at Ex.1007 at 10:4-8 ("[b]y knowing how the resistance changes with temperature and the magnitude of the current supplied to resistive elements 310, 312, 314, and 316, **measurement of the voltages can be used to estimate changes in the temperature in the regions of substrate 300**.").

361. Giere178 discloses that these signals are converted to digital values that are used to determine the temperature of the regions of the substrate where the

resistive elements are located. Ex.1007 at 9:44-48 ("By comparing the digital values after pulses have applied to the firing resistors and before pulses have been applied to the firing resistors, a measurement of the temperature change of regions of substrate 300 can be determined.").

362. Giere178 explains that the substrate temperature is based on the heat generated from the firing resistors (i.e., adjacent heater arrays). Ex.1007 at 5:36-38 ("The **rate at which signals are supplied to [firing] resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead**."); *id.* at 5:39-43 ("For a printhead where there is no attempt made to stabilize the temperature of the substrate, the temperature of the substrate can change substantially during use of the printhead depending upon changes in the firing frequency of the nozzles over time."); *id*. at 5:44-46 ("Localized heating of the substrate can occur from firing nozzles at a greater frequency in a particular region of the printhead.").[9] In other words, the substrate temperature is representative of the heater arrays adjacent to the region because the substrate temperature is a direct result of heat generated by the firing resistors. Thus, the resistive elements 310, 312,

[9] Giere178 also explains that its temperature measurement system relies on the temperature related values generated by the resistive elements 310, 312, 314, and 316 to control the substrate temperature using processor 330. Ex.1007 at 9:50-54– ("One embodiment of the temperature compensation system may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of substrate 300 is controlled substantially at a desired temperature.").

314, and 316 are operable to sense a temperature representative of the heater arrays adjacent to the region because they are located so that they will each assume the temperature of the local region of substrate 300 on which they are placed.

363. Moreover, because the ink feed slots with regions 302, 304, 306, and 308 act as thermal insulators between the regions, a PHOSITA would understand that the resistive elements 310, 312, 314, and 316 are designed to sense the temperature of the substrate region it is positioned in, and since each region includes two arrays of firing resistors, a PHOSITA would also know that the temperature sensed by each resistive elements 310, 312, 314, and 316 would represent the temperature of the two heater arrays in its region.

364. For example, looking at Region 2 in Figure 3, a PHOSITA would know that the resistive element 312 within Region 2 senses the temperature of the area between the two adjacent ink feed slots and 1706 because of their insulating nature of the ink feed slots, and for that same reason, a PHOSITA would know that a temperature sensed by resistive element 312 would necessarily represent the temperature of both heater arrays within Region 2—*i.e.*, the firing resistors disposed on the right side of the cyan ink feed slot in region 302 and the firing resistors disposed on the left side of the magenta ink feed slot in region 304.

365. Accordingly, it is my opinion that the Benjamin-Giere178 combination discloses this limitation.

B. Claim 2

366. Claim 2 of the ’823 patent depends from Claim 1. The Benjamin-Giere178 Combination discloses Claim 1 for the reasons discussed above. Claim 2 further adds: “wherein the temperature sensing element comprises a temperature sensing resistor.” In my opinion, the Benjamin-Giere178 Combination discloses this limitation.

367. As I explained above for 1[D], Benjamin discloses a “temperature sense resistor” (Ex.1004 at 79:60-65), and Giere178 discloses a “serpentine routed resistive element” (Ex.1007 at 10:24-29), and the printhead of the Benjamin-Giere178 combination positions a TSR within each region of Benjamin’s printhead die because Benjamin teaches by using a temperature sense resistor to measure the mean temperature of the substrate on printhead die 1700, and Giere178 teaches placing “resistive elements 310, 312, 314, and 316” in each region of a printhead die so that they will “each assume the temperature of the local region of substrate 300 on which they are placed.”

368. To be sure, Giere178 discloses that “[r]esistive elements 310, 312, 314, and 316 are located so that they will each assume the temperature of the local region of substrate 300 on which they are placed.” Giere178, explains that current sources 318, 320, 322, and 324 supply a substantially constant and known current to the resistive element 310, 312, 314, and 316. Ex.1007 at 8:55-60 (“current sources 318,

320, 322, and 324 are configured to supply electrical power to restrictive elements 310, 312, 314, and 316…[e]ach of current sources 318, 320, 322, and 324 supply a substantially constant and known current to, respectively, resistive elements 310, 312, 314, and 316 when power is applied to them."). In turn, "the voltage resulting from the application of current to each of resistive elements 310, 312, 314, and 316 changes according to temperature induced changes in the resistance, thereby providing signals related to the temperatures of the regions." Ex.1007 at 8:60-64; 10:4-8 ("[b]y knowing how the resistance changes with temperature and the magnitude of the current supplied to resistive elements 310, 312, 314, and 316, measurement of the voltages can be used to estimate changes in the temperature in the regions of substrate 300.").

369. Therefore, it is my opinion that the Benjamin-Giere178 combination discloses that "the temperature sensing element comprises a temperature sensing resistor [*i.e.*, TSR].

C. Claim 3

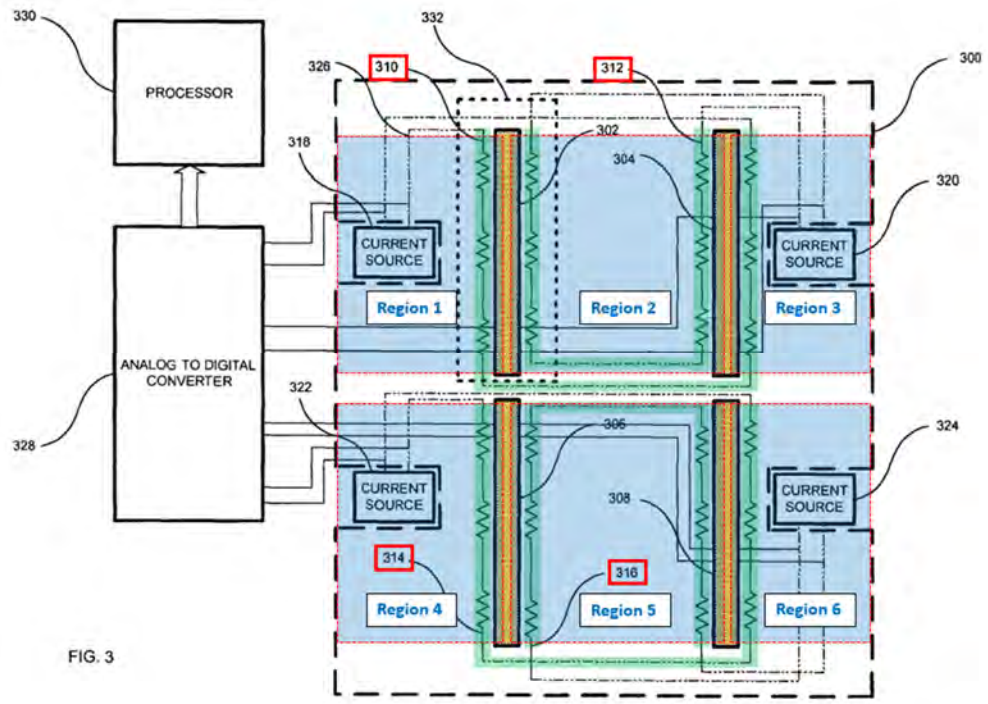
370. Claim 3 of the '823 patent depends from Claim 2. The Benjamin-Giere178 Combination discloses Claim 2 for the reasons discussed above. Claim 3 further adds: "wherein the temperature sensing element comprises a thermal sense resistor." In my opinion, the Benjamin-Giere178 Combination discloses this limitation.

371. As I explained above for 1[D], Benjamin discloses a "temperature sense resistor" (Ex.1004 at 79:60-65), and Giere178 discloses a "serpentine routed resistive element" (Ex.1007 at 10:24-29), and the printhead of the Benjamin-Giere178 combination positions a TSR within each region of Benjamin's printhead die because Benjamin teaches by using a temperature sense resistor to measure the mean temperature of the substrate on printhead die 1700, and Giere178 teaches placing "resistive elements 310, 312, 314, and 316" in each region of a printhead die so that they will "each assume the temperature of the local region of substrate 300 on which they are placed."

372. To be sure, Giere178 discloses that "[r]esistive elements 310, 312, 314, and 316 are located so that they will each assume the temperature of the local region of substrate 300 on which they are placed." Giere178, explains that current sources 318, 320, 322, and 324 supply a substantially constant and known current to the resistive element 310, 312, 314, and 316. Ex.1007 at 8:55-60 ("current sources 318, 320, 322, and 324 are configured to supply electrical power to restrictive elements 310, 312, 314, and 316…[e]ach of current sources 318, 320, 322, and 324 supply a substantially constant and known current to, respectively, resistive elements 310, 312, 314, and 316 when power is applied to them."). In turn, "the voltage resulting from the application of current to each of resistive elements 310, 312, 314, and 316

changes according to temperature induced changes in the resistance, thereby providing signals related to the temperatures of the regions." Ex.1007 at 8:60-64; 10:4-8 ("[b]y knowing how the resistance changes with temperature and the magnitude of the current supplied to resistive elements 310, 312, 314, and 316, measurement of the voltages can be used to estimate changes in the temperature in the regions of substrate 300.").

Ex.1007, Fig. 3



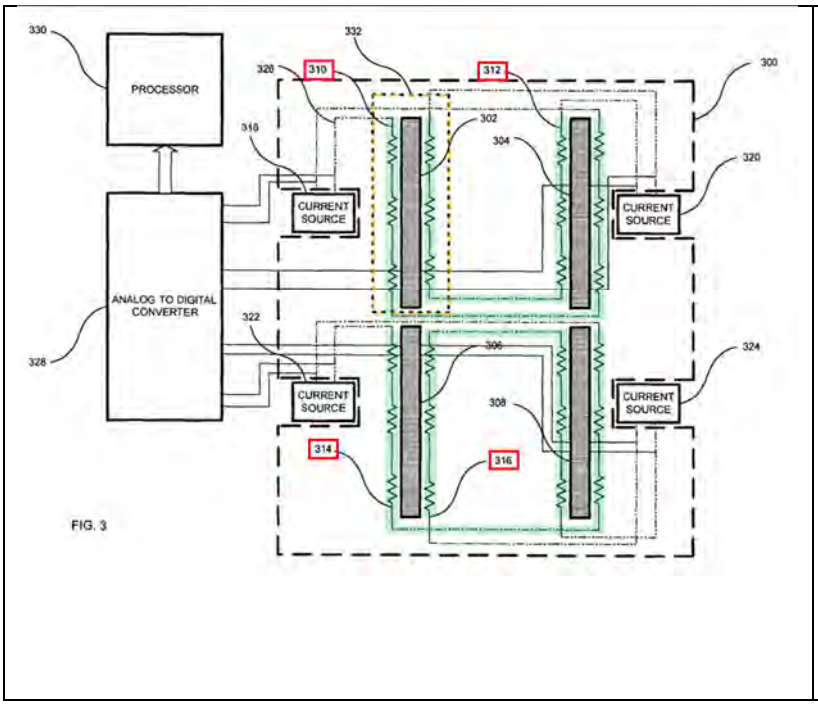
373. Therefore, it is my opinion that the Benjamin-Giere178 combination discloses that "the temperature sensing element comprises a thermal sense resistor [*i.e.*, TSR]."

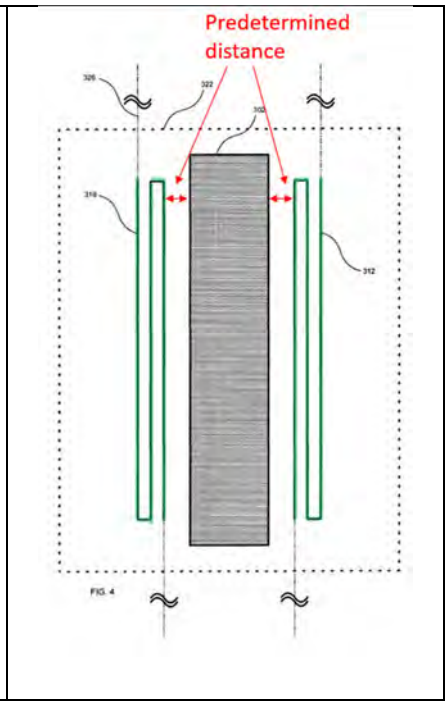
D. Claim 5

374. Claim 5 of the ’823 patent depends from Claim 1. The Benjamin-Giere178 Combination discloses Claim 1 for the reasons discussed above. Claim 5 further adds: “wherein the temperature sensing element is positioned at least 300 microns from each of the first heater array and the second heater array.” In my opinion, the Benjamin-Giere178 Combination discloses this limitation

375. As discussed above in limitation 1[G] and incorporated here, Giere178’s resistive elements are disposed at a predetermined distance from the heater arrays. Giere178 discloses that resistive elements (310, 312, 314, and 316) are located outside the regions (302, 304, 306, and 308) that include the nozzle arrays and associated firing resistors for ejecting ink. As such, because Giere178 discloses that its temperature sensing elements “assume the temperature of the local region of substrate 300 on which they are placed,” i.e., the region of the substrate 300 outside the outside regions (302, 304, 306, and 308), a PHOSITA would understand that the temperature sensing elements are at a fixed distance away from the heater arrays that are located within regions 302, 304, 306, and 308.

Ex.1007, Figs. 3, 4





376. It would be obvious to a PHOSITA that Giere178's resistive elements could be located a predetermined distance of at least 300 microns from its heater arrays because Giere178 discloses resistive element designs (including varying widths and layouts) that include positioning the resistive element at any point within its respective region of substrate 300 without restriction on exactly where in that region the element must be placed. Ex.1007 at Fig. 3. In other words, Giere178 discloses that "[r]esistive elements 310, 312, 314, and 316 are located so that they will each assume the temperature of the local region of substrate 300 on which they are placed" and there is no restriction on exactly where in that region the element must be placed. Ex.1007 at 8:51-54. In other words, a predetermined distance of 300 microns would be a design choice.

377. As such, it would be obvious to a PHOSITA that Giere178's resistive elements could be located a predetermined distance of at least 300 microns.

378. Accordingly, it is my opinion that, Benjamin-Giere178 discloses this limitation.

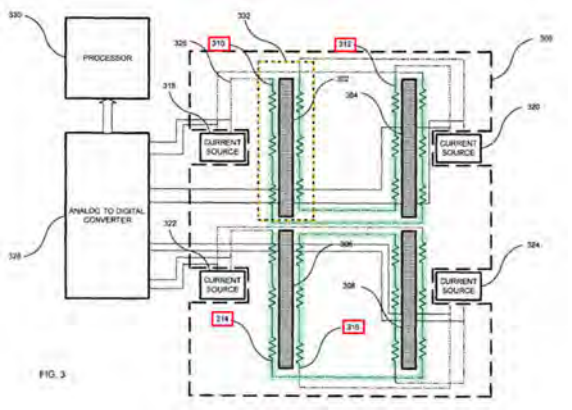
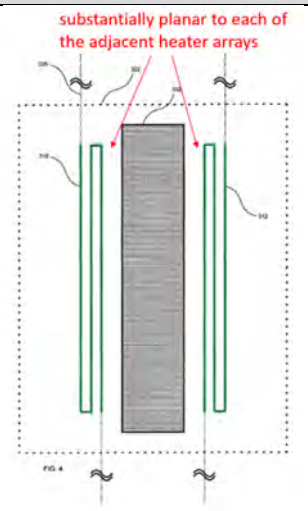
E. Claim 6

379. Claim 6 of the '823 patent depends from Claim 1. The Benjamin-Giere178 Combination discloses Claim 1 for the reasons discussed above. Claim 6 further adds: "wherein the temperature sensing element is positioned substantially planar to each of the first heater array and the second heater array." In my opinion, the Benjamin-Giere178 Combination discloses this limitation.

380. Giere178 defines a typical inkjet printhead as "a silicon substrate having a plurality of thin film layers, **structures built on the substrate**, and connections to the substrate." Ex.1007, 2:59-61; 8:45-46. A PHOSITA would have understood that because structures built on a plurality of a substrate's thin film layers each of the structures would be in substantially the same plane. As such, Giere178's "resistive elements" are positioned substantially planar to each of the adjacent heater arrays (e.g., arrays of ink firing resistors in regions 302, 304, 306, and 308) because they are structures built on substrate 300. *Id*.

381. As illustrated in Figures 3 and 4 (below), resistive elements 310, 312, 314, and 316 are positioned substantially planar along the entire length of the ink via

and heater array region, *but not positioned directly above or overlapping the ink via and heater array region*, as required by the ’823 Patent. Ex.1007, 10:23-26; Ex.1001, 3:11-13. Alternatively, it would be obvious to a PHOSITA to position the temperature sensing element in substantially the same plane as the first and second heater arrays as doing so would reduce manufacturing costs and time required to manufacture the printhead die.

Ex.1007, Figs. 3 and 4	
	

382. Accordingly, it is my opinion that Benjamin-Giere178 discloses this limitation.

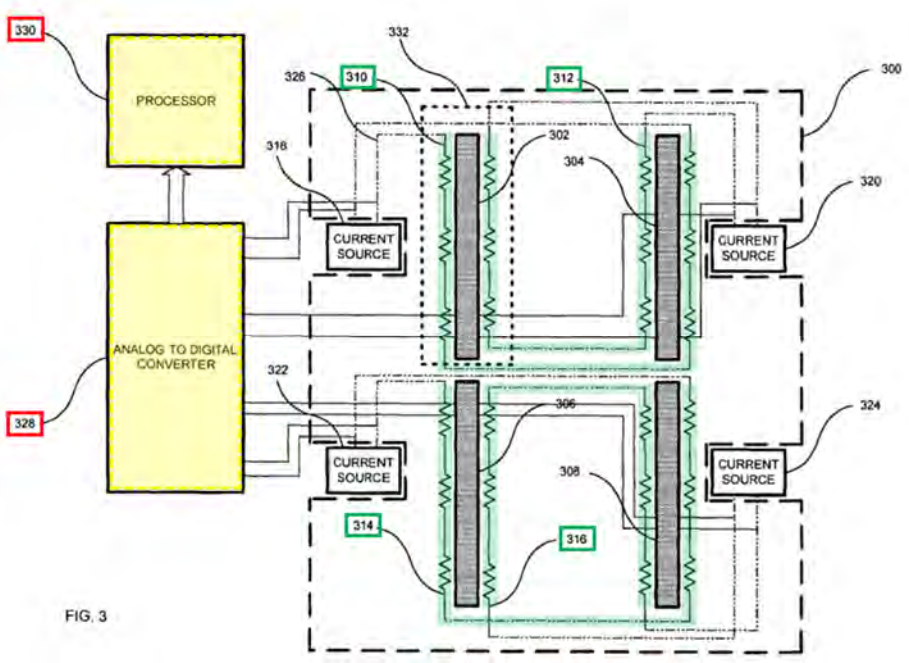
F. Claim 7

383. Claim 7 of the ’823 patent depends from Claim 1. The Benjamin-Giere178 Combination discloses Claim 1 for the reasons discussed above. Claim 7 further adds: “at least one control element operable to receive a temperature

measured by the temperature sensing element and to heat the first heater array and the second heater array." In my opinion, the Benjamin-Giere178 Combination discloses this limitation.

384. As illustrated in Fig. 3 (below), Giere178 discloses "[a]n embodiment of a measuring device, such as **analog to digital converter 328** [*yellow*] includes 4 channels that each **receive a voltage value related to the voltage across resistive elements 310, 312, 314, and 316** resulting from the flow of current" and "[a]nalog to digital converter 328 converts each of the voltages it receives to corresponding digital values." Ex.1007 at 9:10-15; *see below id.* at Fig. 3. Giere178 further discloses that "[t]hese digital values are received by an embodiment of a processing device, **processor 330** [*yellow*]" that "converts, either by using look up tables or computationally, the digital values received from analog to digital converter 328 to **digital values that are related to temperatures of substrate 300 in the vicinity of regions 302, 304, 306, and 308**." Ex.1007 at 9:29-33; *see below id.* at Fig. 3.

Ex.1007, Fig. 3



385. Giere178 further discloses that "[u]sing these temperature related digital values, **processor 330 operates an embodiment of a temperature compensation system**." Ex.1007 at 9:58-50. For example, "[o]ne embodiment of the temperature compensation system may adjust the pulse width of the drive signals supplied to the firing resistors so that the **temperature of substrate 300 is controlled** substantially at a desired temperature." Ex.1007 at 9:50-53. Giere178 states that "[a]nother embodiment of the temperature compensation system may be used to **control resistive heating elements** thermally coupled to substrate 300 so that the temperature of substrate 300 is **controlled** substantially at a desired temperature." Ex.1007 at 9:54-58 "Yet another embodiment of the temperature

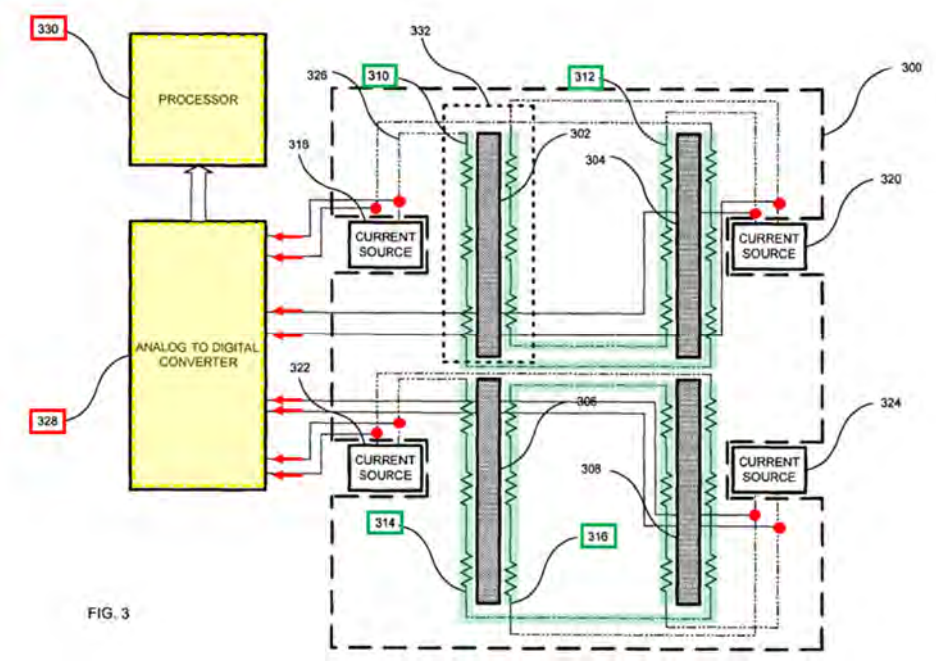
compensation system may be used to **control a quantity of ink** deposited on a region in response to the measured temperature. In addition, other embodiments of the temperature compensation system could be implemented that **combine control of several of the previously mentioned performance aspects**." Ex.1007 at 9:58-64. As such, Giere178 discloses at least one control element (e.g., Analog to Digital Converter 328[10] and Processor 330) operable to receive a temperature measured by the temperature sensing element (e.g., resistive elements 310, 312, 314, and 316).

386. Additionally, as a result of its dependence on claim 1, claim 7 requires that the at least one control element be located on a "chip". Ex.1001 at Claim 7 ("The *chip of claim 1*, further comprising at least one control element operable to receive a temperature measured by the temperature sensing element."). Although Giere178 does not expressly direct a PHOSITA to place the control element (i.e., Analog to Digital Converter 328 and Processor 330) on substrate 300, it would be within the possibilities available to a PHOSITA to place the Analog to Digital Converter 328 and Processor 330 there. Moreover, a PHOSITA would be motivated to do so as it would reduce the number of external connections from the substrate to the printer making the substrate design simpler and cheaper to manufacture.

[10] The 708 Patent discloses that "**A/D converter may be included in an Application Specific Integrated Circuit (ASIC)** that controls the functioning of the printhead." Ex.1001 at 7:22-25.

387. For example, Giere178 explains that "[a]n embodiment of a measuring device, such as analog to digital converter 328 includes *4 channels* that each receive a voltage value related to the voltage across resistive elements 310, 312, 314, and 316 resulting from the flow of current." As illustrated in Figure 3 (below), the "4 channels" requires **8 separate bond wires** (red arrows) from the Analog to Digital Converter 328 to the connection traces on the substrate 300 (e.g., 326) for receiving voltage values, and **8 separate bond pads** (indicated by red dots) on the substrate 300 to connect the Analog to Digital Converter's bond wires to those connection traces.

Ex.1007, Fig. 3



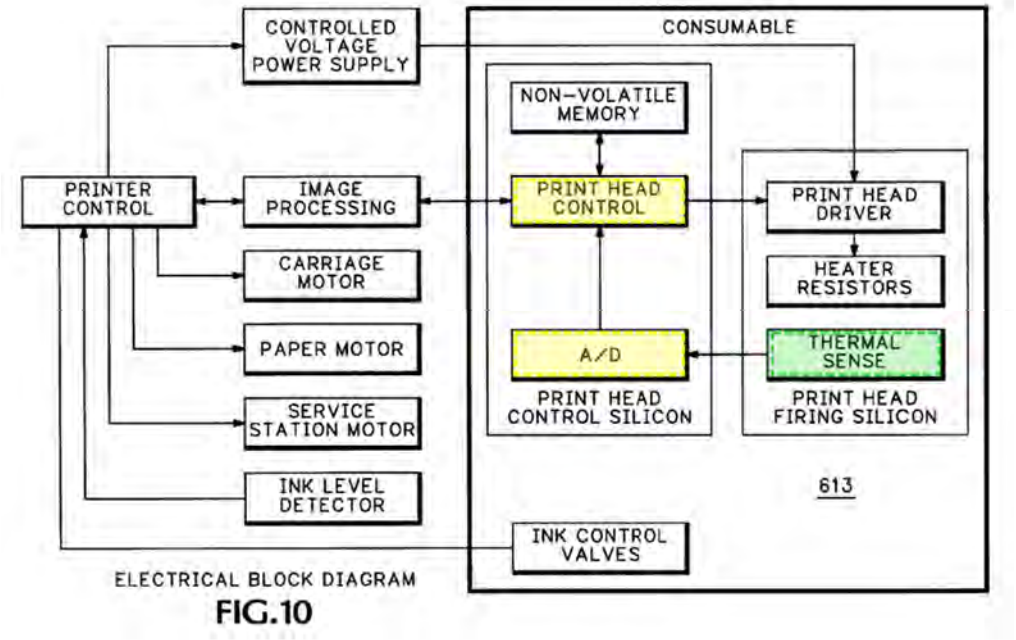
388. A PHOSITA would understand that by locating the Analog to Digital Converter 328 and Processor 330 *directly on the substrate* one could reduce the number of bond wires and pads required to connect the substrate to the printer. For example, instead of eight bond pads required to connect the substrate 300 to the Analog to Digital Converter 328, a single, bond pad on the substrate 300 (from the Processor 330) to the printer could be used instead. A PHOSITA would be motivated to implement this design because reducing the number of external connections from the substrate to the printer makes the printhead simpler and cheaper to manufacture.

389. Furthermore, a PHOSITA would understand the advantage in terms of improving the signal-to-noise reliability of the temperature sensor measurements by having the very small analog voltage signals involved captured on-chip, close to their sources, the thermal sense resistors, and communicated off-chip by digital signals rather than analog signals. If the Analog to Digital Converter 328 is off-chip, the very small voltage signals it must analyse necessarily share a connecting flexible circuit cable with the numerous timing and drop firing power pulse signals needed to operate the thermal inkjet process, causing an electrically noisy environment for measuring small analog voltage signals. A PHOSITA would be motivated to integrate the operational amplifier and analog-to-digital circuitry needed to obtain a reliable and useful temperature measurement from each TSR onto to the inkjet device substrate to minimize the interference of drop firing and timing pulses with temperature measurements.

390. In fact, such designs were known in the art and incorporated by reference into Giere178. Giere178 incorporates by reference U.S. Patent No. 6,082,854 (Axtell) ("Ex.1011"). Ex.1007 at 8:27-40 (Giere178 ("printheads included within these ink cartridges include hardware associated with an embodiment of the temperature measurement system described later in this specification" and that "[f]urther detail on embodiments of **imaging mechanisms used in color inkjet printers** can be found in U.S. Pat. No. 6,082,854, entitled

MODULAR INK-JET HARD COPY APPARATUS AND METHODOLOGY, issued to Axtell et al., and assigned to Hewlett-Packard Company…")). Axtell discloses at least one control element (e.g., an A/D converter and a print head control) operable to receive a temperature measured by the temperature sensing element. For example, with reference to Figure 10 (below), Axtell discloses an integrated circuit on the printhead silicon that includes "print head control" (*yellow*) and an "A/D converter" (yellow) that receives data from the thermal sensors to control substrate temperature. Ex.1011 at 24:16-24 ("The **writing engine controller can thus be an integrated circuit which controls** ink droplet sequencing, firing, pulse timing, firing energy control, **temperature control**, drop volume scaling, dot position correction, color conversion algorithms, color maps, print mode algorithms, interface protocols, and the like as may be current in the state of the art for ink-jet print head operations, and also writing instrument servicing and refilling algorithms."). As illustrated, only a single connection is required from the "print head control" (yellow) of the printhead (consumable) to the printer (printer control via image processor). Axtell's disclosure, as incorporated by reference into Giere178, further corroborates my opinion that it would be obvious, and within the possibilities available, to a PHOSITA to place Giere178's Analog to Digital Converter 328 and Processor 330 on Giere178's substrate 300.

Ex.1011, Fig. 10



391. Thus, it is my opinion that Benjamin-Giere178 discloses this limitation.

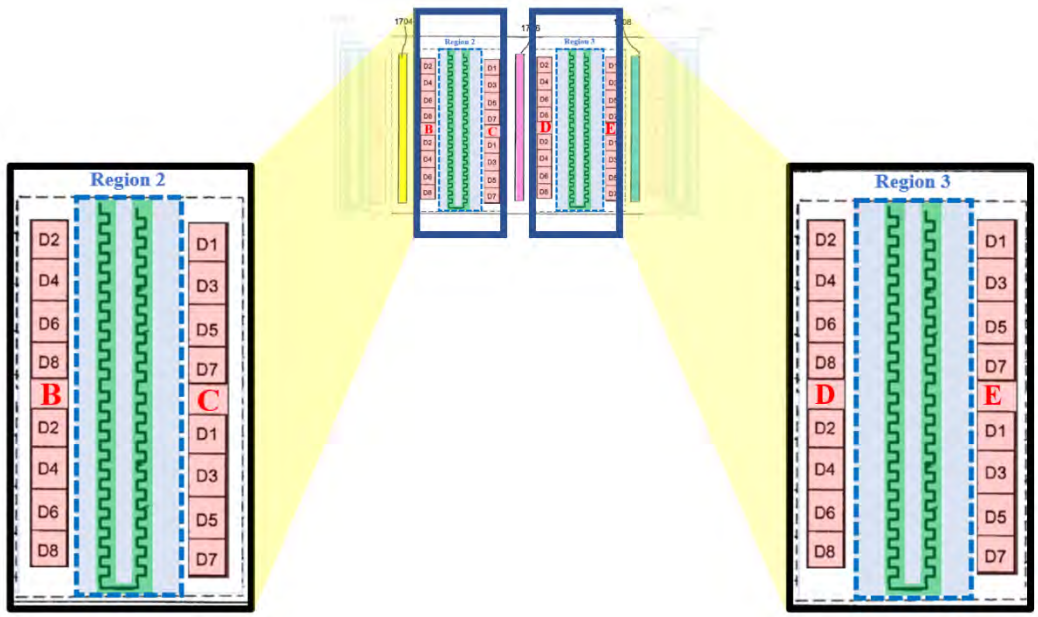
G. Claim 8

392. Claim 8 of the ’823 patent depends from Claim 1. The Benjamin-Giere178 Combination discloses Claim 1 for the reasons discussed above. Claim 8 further adds: “wherein the temperature sensing element positioned between the first heater array and the second heater array is different than the second temperature sensing element positioned between the third heater array and the fourth heater array.” In my opinion, Benjamin-Giere178 discloses claim 8.

393. As I explained above in 1[D], incorporated here, the printhead of the Benjamin-Giere178 includes a single temperature sense resistor (e.g., TSR, *green*)

in the first region (e.g., Region 2, *blue*) between Heater Array B and Heater Array C, which the TSR senses to provide a mean temperature value for the first region, and as I explained in 1[J[], it also includes a second temperature sense resistor (TSR, *green*) in the second region (e.g., Region 3) between the Heater Array D disposed along the side 1706 b of the Magenta Ink Via and Heater Array E disposed along the side 1708 a of the Cyan Ink Via, which the TSR senses to provides a mean temperature value for the second region.

The Benjamin-Giere178 Combination



394. In my opinion, a PHOSITA would not only understand that Benjamin-Giere178 provides two independent TSRs one in each region of the Benjamin printhead die, but also that these TSRs are different than each other because they are

in different regions of the printhead die, associated with different heater arrays, have different electrical connections, and produce different temperature measurements.

395. Therefore, it is my opinion that the Benjamin-Giere178 combination discloses this limitation.

H. Claim 9

396. Claim 9 of the ’823 patent depends from Claim 1. The Benjamin-Giere178 Combination discloses Claim 1 for the reasons discussed above. Claim 9 further adds: “wherein the first heater array and the second heater array are operable to receive non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element.” In my opinion, the Benjamin-Giere178 combination discloses this limitation.

397. As explained above, the printhead die resulting from the Benjamin-Giere178 combination makes adjustments to firing rate, firing voltage, or pulse width responsive to the temperature of the region sensed by the TSR.

398. Therefore, it is my opinion that the Benjamin-Giere178 Combination discloses that “the first heater array and the second heater array are operable to receive non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element.”

I. Claim 10

399. Claim 10 of the ’823 patent depends from Claim 9. The Benjamin-Giere178 Combination discloses Claim 9 for the reasons discussed above. Claim 10 further adds: “wherein the non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element is of a short duration such that ink will not be ejected from the first via or the second via during the non-nucleating heating.” In my opinion, the Benjamin-Giere178 discloses this limitation for the same reasons as 1[9].

400. Because the printhead die resulting from the Benjamin-Giere178 combination makes adjustments to firing rate, firing voltage, or pulse width responsive to the temperature of the region sensed by the TSR, it is further my opinion that the pulse width adjustments in the Benjamin-Giere178 combination will be of a short duration such that ink will not be ejected from the heater arrays.

401. Therefore, it is my opinion that the Benjamin-Giere178 Combination discloses that “the non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element is of a short duration such that ink will not be ejected from the first via or the second via during the non-nucleating heating.”

J. Claim 11

402. As shown below, the limitations of claim 11 mirror those of claims 1 and 7.

11[p]	A method of fabricating chips for use with a printing device, comprising	**1[p]**	A chip for use with a printing device
11[a]	providing a first heater array positioned substantially adjacent a first via;	**1[a]**	a first heater array positioned substantially adjacent a first via
11[b]	providing a second heater array positioned substantially adjacent a second via;	**1[b]**	a second heater array positioned substantially adjacent a first via
11[c]	positioning a temperature sensing element in a region adjacent to and immediately between the first heater array and the second heater array and substantially adjacent to both the first heater array and second heater array; wherein the temperature sensing element is operable to sense a temperature of the region, the temperature being representative of the region and wherein the temperature sensing element extends substantially the length of the first heater array and second heater array;	**1[c]**	a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array
		1[d]	a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region
		1[e]	wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array
11[d]	responsive to the temperature of the region sensed by the temperature sensing element, heating the first heater array and the second heater array to regulate the temperature of the region;	**1[f]**	wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region

11[e]	providing at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array;	**7**	at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array
11[f]	providing a third heater array substantially adjacent the second via;	**1[g]**	a third heater array[,] positioned substantially adjacent the second via
11[g]	providing a fourth heater array substantially adjacent a third via;	**1[h]**	a fourth heater array, positioned substantially adjacent a third via
11[h]	positioning a second temperature sensing element in a second region located between the third heater array and the fourth heater array. wherein the temperature sensing element is operable to sense the temperature of the second region, and wherein the temperature sensing element is substantially centrally disposed with respect to the second region and is substantially adjacent to both the third heater array and fourth heater array.	**1[i]**	a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array
		1[j]	a second temperature sensing element operable to sense the temperature of the second region,
		1[k]	wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array

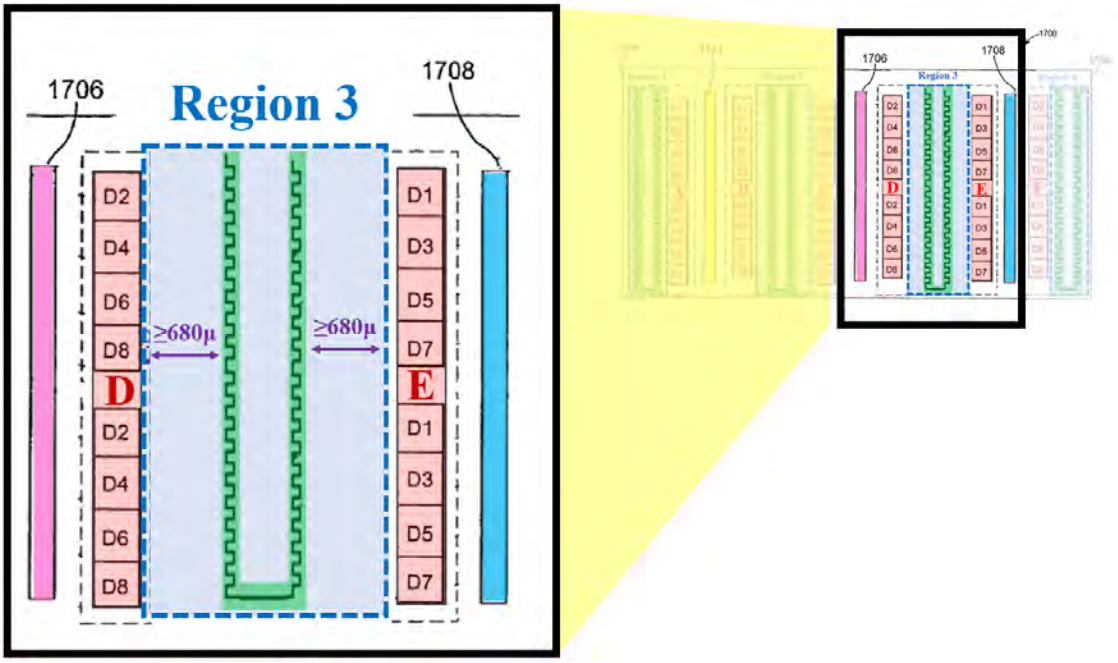
403. Thus, for the same reasons that I provided above for Claim 1, incorporated here, it is my opinion that the Benjamin-Giere178 Combination also discloses every limitation of Claim 11.

K. Claim 12

404. Claim 12 of the ’823 patent depends from Claim 11. The Benjamin-Giere178 Combination discloses Claim 11 for the reasons discussed above. Claim 12 further adds: “wherein positioning a temperature sensing element in the region comprises positioning a temperature sensing element in substantially [in] the center of the region.”

405. In my opinion, Benjamin-Giere178 discloses this limitation for same reasons as 1[D] and 1[J] because a temperature sensor that is positioned “substantially the center” of a region [claim 12] is also “substantially centrally” disposed within that region [Claim 1].

The Benjamin-Giere178 Disclosures



406. Thus, it is my opinion that the Benjamin-Giere178 Combination discloses the added limitation of Claim 11.

L. Claim 13

407. Claim 13 of the ’823 patent depends from Claim 11. The Benjamin-Giere178 Combination discloses Claim 11 for the reasons discussed above. Claim 11 further adds: “wherein positioning a temperature sensing element in the region comprises positioning a thermal resistor in the region.” This limitation is identical to the added limitation of Claim 3 and thus the Benjamin-Giere178 Combination discloses this limitation for the same reasons I provided above for Claim 3, incorporated here.

408. Thus, it is my opinion that the Benjamin-Giere178 Combination discloses the added limitation of Claim 13.

M. Claim 15

409. Claim 15 of the ’823 patent depends from Claim 11. The Benjamin-Giere178 Combination discloses Claim 11 for the reasons discussed above. Claim 15 further adds: “wherein positioning a temperature sensing element in the region between the first heater array and the second heater array comprises positioning the temperature sensing element at least 300 microns from each of the first heater array and the second heater array.” This limitation is identical to the added limitation of

Claim 5 and thus the Benjamin-Giere178 Combination discloses this limitation for the same reasons I provided above for Claim 5, incorporated here.

410. Thus, it is my opinion that the Benjamin-Giere178 Combination discloses the added limitation of Claim 15.

N. Claim 16

411. Claim 16 of the ’823 patent depends from Claim 15. The Benjamin-Giere178 Combination discloses claim 15 for the reasons discussed above. Claim 16 further adds: “wherein positioning a temperature sensing element in the region between the first heater array and the second heater array comprises positioning the temperature sensing element substantially planar to each of the first heater array and the second heater array.” This limitation is identical to the added limitation of Claim 6 and thus the Benjamin-Giere178 Combination discloses this limitation for the same reasons I provided above for Claim 6, incorporated here.

412. Thus, it is my opinion that the Benjamin-Giere178 Combination discloses the added limitation of Claim 16.

O. Claim 17

413. Claim 17 of the ’823 patent depends from Claim 11. The Benjamin-Giere178 Combination discloses Claim 11 for the reasons discussed above. Claim 17 further adds: “wherein heating the first heater array and the second heater array to regulate the temperature of the region comprises heating the first heater array and

the second heater array using non-nucleating heating." This limitation is identical to the added limitation of Claim 9 and thus the Benjamin-Giere178 Combination discloses this limitation for the same reasons I provided above for Claim 9, incorporated here.

414. Thus, it is my opinion that the Benjamin-Giere178 Combination discloses the added limitation of Claim 17.

P. Ample Motivation Existed to Make the Combination

415. As I explained in detail above, while Benjamin does not say *where* on the printhead die the TSR should be disposed, Giere178 does and provides an optimal location for a TSR on Benjamin's printhead die. In my opinion, there was plenty of motivation to combine Benjamin and Giere178, which any PHOSITA would have recognized.

416. As an initial mater, Benjamin and Giere178 both qualify as analogous art to the claimed invention at least because they are both in the same field of endeavour as the '832 patent—namely, regulating operational temperature of a printhead die. At the very least, Benjamin and Giere178 are both reasonably pertinent to maintaining the optimal temperature of a multi-via heater chip allegedly solved by the inventors of the '823 patent.

417. As another point, it is my opinion that ample motivation existed to combine Benjamin with Giere178.

418. *First*, Benjamin and Giere178 both share to the same assignee—*viz.*, Hewlett-Packard Development Company L.P. (Ex.1004, 1; Ex.1006, 1)—and both involve the same field of endeavour— *viz.*—regulating operational temperature of a printhead die for a printing device—and similar printing devices within that field. The printhead dies of Benjamin and Giere178 both include at least two adjacent ink channels for feeding ink into a chamber and at least two adjacent heater arrays (*red*) for vaporizing the ink within each channel and ejecting drops of the vaporized ink through a nozzle onto a print media, such as paper.

419. Benjamin and Giere178 also both address similar problems in their shared field— *viz.*, reduced print quality caused by the printhead die operating outside its optimal temperature—and both provide a similar solution to that problem— *viz.*, disposing a temperature sense resistor on the printhead die for determining the temperature of the printhead die.

420. *Second*, Giere178 provides a solution for Benjamin because it describes a situation where excessive printing of one color ink in one region of the printhead die, e.g., magenta ink, can increase the temperature of that color's ink ejection chambers thereby increasing the mass of the magenta ink drops beyond the desired print size. Ex.1007, 5:52-6:3. Giere178 explains that in this situation, print quality will degrade because excessive magenta ink will alter the desired print colors. *Id.* Giere178 states that the "rate at which signals are supplied to resistors associated

with the ink ejection chambers affects the temperature of the substrate of the printhead" and "*localized heating* of the substrate can occur from firing nozzles at a greater frequency *in a particular region of the printhead*." Ex.1007, 5:44-46. Giere178 explains that "[i]f at least some compensation is not made for these temperature changes, a perceptible degradation in print quality can result." Id. at 5:49-51.

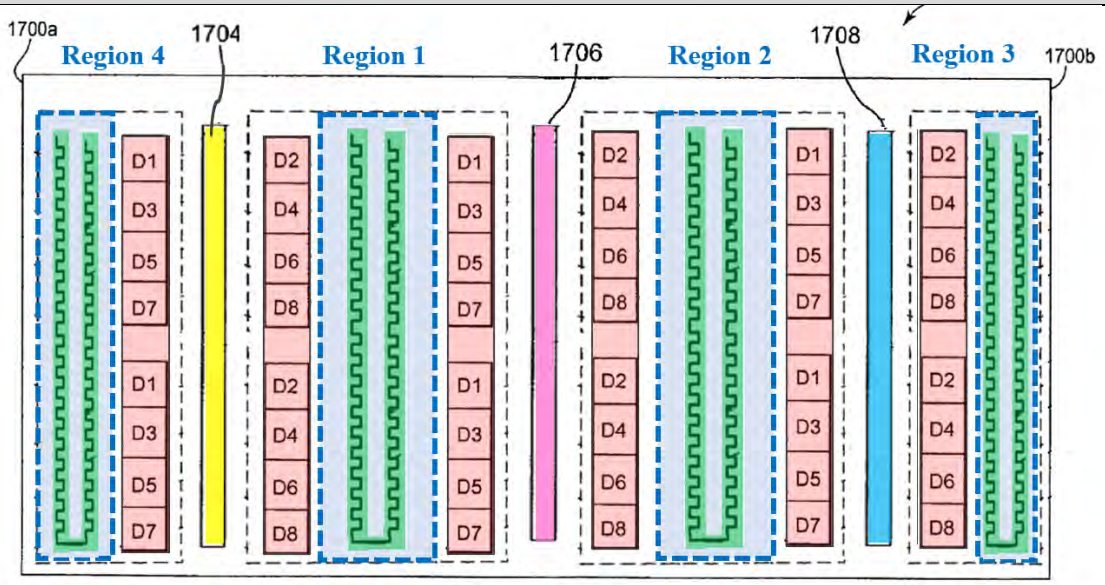
421. For example, in the magenta example described above, Giere178 states that "as a result of the excessive quantity of magenta ink applied, the hue of the region formed [in combination with cyan and yellow] will be shifted toward the magenta hue," "undesired shifts in the chroma and the luminance of [print] regions" can occur, and an "increase in the mass of ejected ink drops can reduce the sharpness of the edges when the image is formed onto paper." Ex.1007, 5:62-6:3. Giere178 discloses a solution to the localized heating issue by placing multiple temperature sensing "resistive elements" on the substrate (between ink vias and associated heater arrays) "so that they will each assume the temperature of the local region of substrate [] on which they are placed." Ex.1007, 8:51-54.

422. Giere178 states that its "temperature compensation system" with localized temperature sensors "may be used to control a quantity of ink deposited on a region in response to the measured temperature," or "may be used to control resistive heating elements thermally coupled to [the] substrate [] so that the

temperature of [the] substrate [] is controlled substantially at a desired temperature," or "may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of [the] substrate [] is controlled substantially at a desired temperature." *Id.* at 9:50-60. In view of Giere178's teachings, a PHOSITA would have known that excessive *localized* heating of the substrate without compensation for the substrate temperature change can lead to degradation in print quality. Ex.1007 at 5:36-51.

423. To regulate the operational temperature of Benjamin's printhead die and optimize the printing quality of the inkjet printing device, it is my opinion that a PHOSITA would have disposed a single TSR within each region [e.g., Region 1, 3, and 4, blue below] so that the temperature value *collectively* provided by the TSRs within Regions 1-4 reflect the mean temperature of Benjamin's printhead die, as illustrated below.

Ex.1004, Fig.21

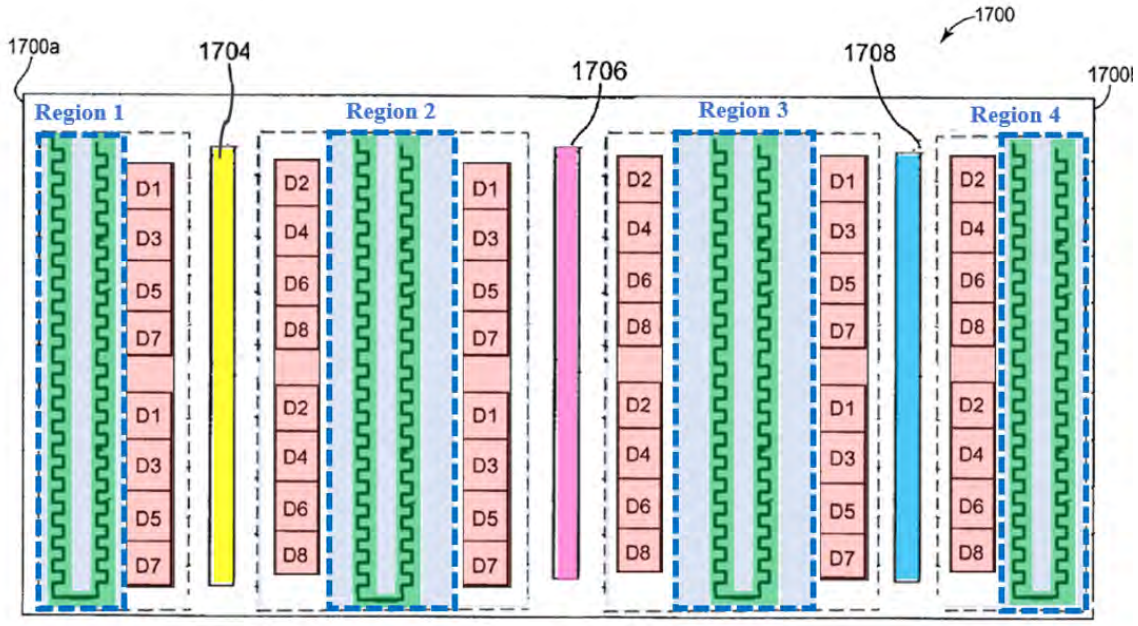


424. A PHOSITA would further understand why the temperature regulation design illustrated above in Fig. 21 (i.e., temperature sensors in each region) would be advantageous for the reasons stated above in Section XIII.P.

425. The low thermal conductivity of the ink via spaces and any plastic manifold materials interfacing the silicon thermal inkjet chip causes these regions to restrict heat flow relative to the heat flow in the silicon material itself. The heat introduced by the heater resistors to fire drops will be conducted away much more rapidly into the adjacent silicon regions that into the ink supply vias or plastic printhead components. A PHOSITA will recognize that the silicon regions between ink supply vias and between outer ink supply vias and printhead chip edges achieve thermal equilibrium far more rapidly than the overall printhead and ink supply structures. These regions are both relatively thermally isolated and quickly come to

a same temperature or thermal equilibrium. These regions are therefore the most cost-effective places in which to add multiple temperature sensors to better capture the temperature conditions of the multiple color ink drop generators. Sensing the temperature in multiple regions allows the system controller to better maintain the desired ink operating temperature for all ink colors over a larger range of environmental temperatures and printing duty conditions. Thus, to further "optimize print quality" in Benjamin's printhead die over a larger range of conditions encountered by the user, a PHOSITA would be motivated to dispose a TSR adjacent each of the ink feed slots on the printhead die 1700 (i.e., yellow ink via 1704, magenta ink via 1706, and cyan ink via 1708), but dispose no more than one TSR within each region adjacent an ink feed slot (e.g., Regions 1-4), as shown below.

Ex.1004, Fig. 21



426. Moreover, the ’823 Patent readily admits that, during the prior art time period, it was well known to those skilled in the art that “ink vias [] act as thermal barriers between the colors,” and “without accurate temperature readings, the method of providing fire pulses to regulate thermal conditions [for a multi-via printhead] would also be subject to error.” Ex.1001 at 2:28-29; 2:47-49. To overcome these challenges, the ’823 Patent admits that prior art heater chips “provid[ed] for temperature sensing on a per-color basis” by placing “three temperature sensors 220, 222, and 224 [green below] in close proximity to each of the heater arrays, each situated on the same side of their respective vias,” thereby “ensuring that there is only a small amount of thermal crosstalk between the temperature sensors.” Ex.1001 at 2:1-15. Put differently, the ’823 Patent corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere178, would have been further motivated to modify Benjamin’s printhead die by disposing a single temperature sensor within each region so that the TSRs collectively determine a mean temperature of Benjamin’s printhead die because it was well known to those skilled in the art that this arrangement “provid[es] for temperature sensing on a per-color basis.” Ex.1001 at 2:1-2.

The Applicant-Admitted Prior Art Corroborates My Opinion

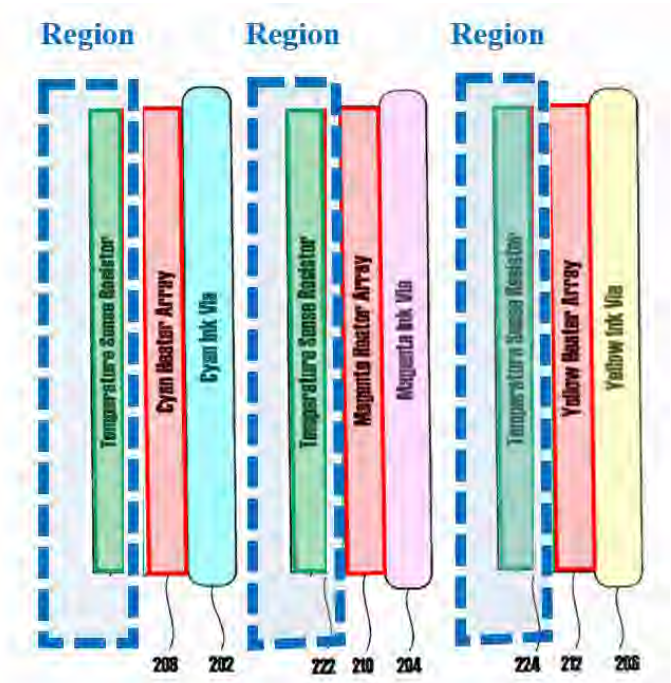


FIG. 2
(Prior Art)

XIV. GROUND 4: YABE IN VIEW OF GIERE673 RENDERS OBVIOUS CLAIMS 1-3, 5-10, 11-13, AND 15-17

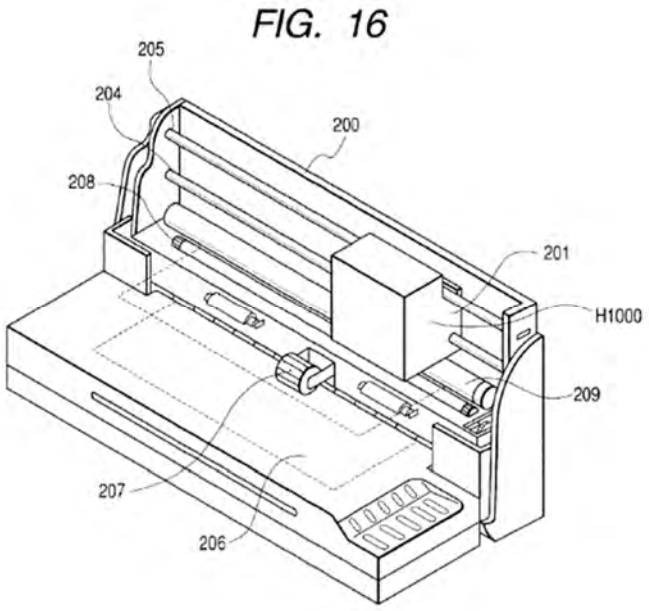
427. In my opinion, a Yabe-Giere673 Combination renders obvious all of the limitations of claims 1-3, 5-10, 11-13, and 15-17 of the ’823 Patent.

A. Claim 1

1. 1[P] “A chip for use with a printing device”

428. To the extent the preamble is determined to be limiting, in my opinion Yabe discloses a chip for use with a printing device. For example, Yabe’s Figure 16 illustrates a printing device (i.e., **ink jet recording apparatus**) that mounts a **recording head cartridge H1000**.

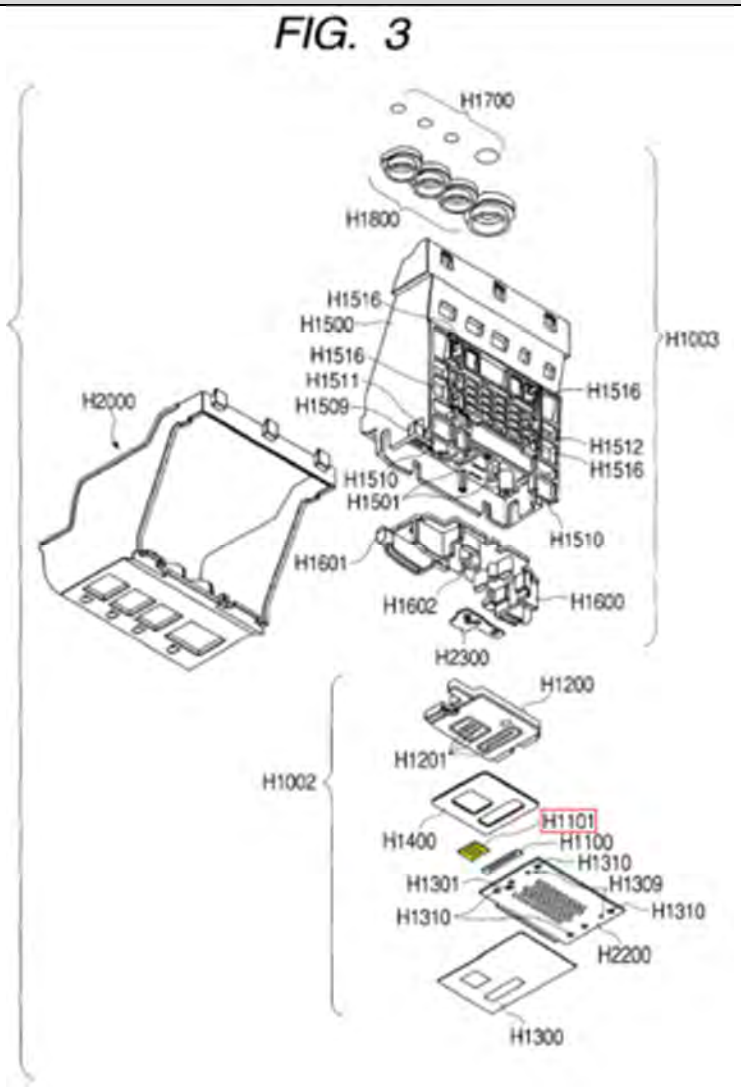
Ex.1008, Fig. 16



429. Yabe's recording head cartridge H1000 comprises "a **recording head H1001**; ink tanks H1900 (H1901, H1902, H1903, and H1904) which are installed on the recording head H1001 freely attachable or detachable." Ex.1008 at 7:3-5. According to Yabe. "[t]he **recording head H1001** is the one which is the side shooter type using the bubble jet method that records using electrothermal converting devices (recording elements) to generate thermal energy for creating film boiling in ink in accordance with electric signals." Ex.1008 at 7:27-31. Canon's inventors often use the term "side shooter" to designate the thermal inkjet configuration that other inventors term a "roofshooter," i.e., the geometry illustrated in the Background Section discussing Bhaskar's Fig. 1. wherein the ink drop is expelled through a nozzle in a direction perpendicular to the heater resistor surface

430. As illustrated in Yabe's Figure 3 below, **recording head H1001** comprises a "**recording element unit H1002**; an ink supply unit H1003; and a tank holder H2000." Ex.1008 at 7:36-45; *see also id.* at 11:17-20; *see below id.* at Fig. 3. Yabe's recording element unit H1002 comprises two chips—a first recording element base plate H1100 and a second recording element base plate H1101.

Ex.1008, Fig. 3



431. Yabe's second recording element base plate H1101 including silicon base plate H1110 (*pink*) is illustrated in Yabe's Figure 5 below. Yabe's Fig. 14, also shown below, illustrates a layout for the heater board that corresponds to the layout of H1101 shown in Yabe's Fig. 5. Ex.1008 at 16:31-34 ("The heater board H2 shown in FIG. 14 corresponds to the Si base plate H1110 provided with the electrothermal converting devices (heaters) H1103 for the recording element base plate H1101 represented in FIG. 5"). Silicon base plate H1110 is shown in pink below in both Figures 5 and 14.

Ex.1008, Figs. 5 and 14

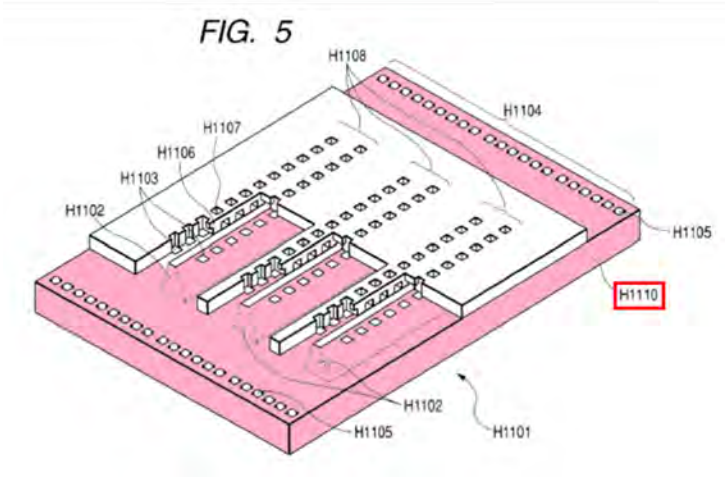
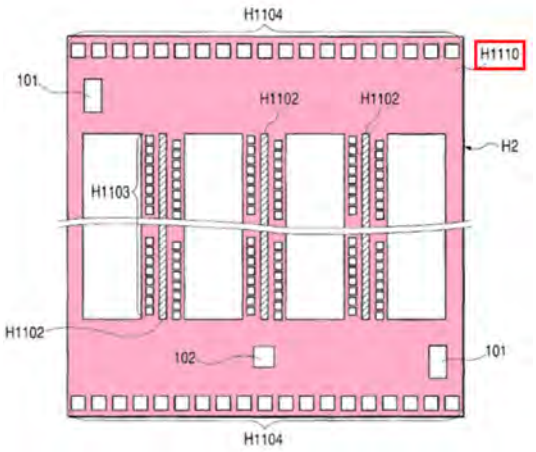


FIG. 14



432. Accordingly, it is my opinion that Yabe discloses **a chip** (e.g., second recording element base plate H1101 having silicon base plate H1110) **for use with a printing device** (e.g., inkjet recording apparatus).

2. 1[A] "a first heater array positioned substantially adjacent a first via"

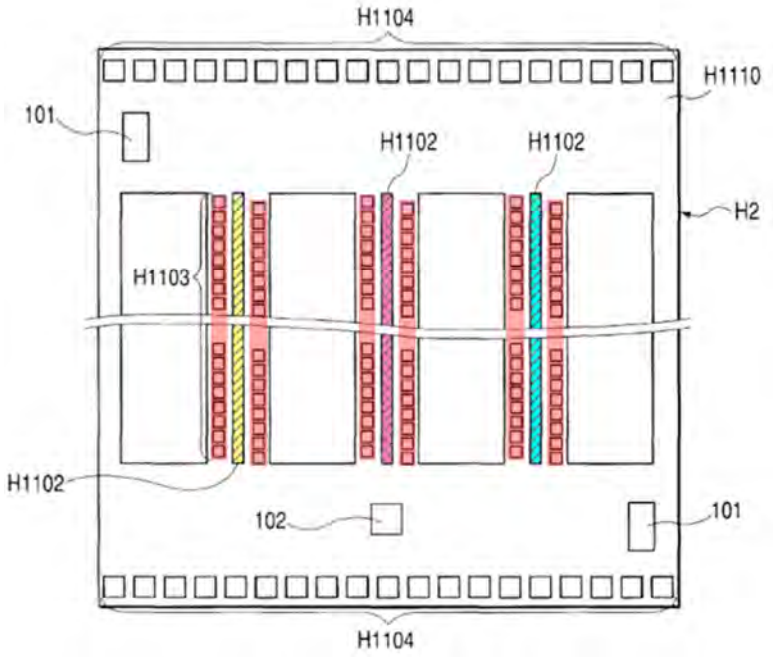
433. Claim 1 of the '823 Patent recites "a **first heater array positioned substantially adjacent a first via**." In my opinion, Yabe discloses this limitation.

434. Yabe discloses heaters (i.e., **electrothermal converting devices H1103**) that generate thermal energy for creating film boiling in ink in accordance with electric signals. Ex.1008 at 16:31-34 ("The heater board H2 shown in FIG. 14 corresponds to the Si base plate H1110 provided with the **electrothermal converting devices (heaters) H1103** for the recording element base plate H1101 represented in FIG. 5."); *id*. at 7:27-31 ("The recording head H1001 is the one which

is the side shooter type using the bubble jet method that records using electrothermal converting devices (recording elements) to generate thermal energy for creating film boiling in ink in accordance with electric signals."); *id*. at 8:38-43 ("Since the discharge ports H1107 are arranged to face the electrothermal converting devices H1103, ink supplied from the ink supply port H1102 is discharged from the discharge ports H1107 by means of the bubbles generated by the heating action of the electrothermal converting devices H1103."); *id*. at 12:6-11 ("ink is supplied to the bubbling chamber where the electrothermal converting device H1103 and the discharge port H1107 are arranged, and ink is discharged toward a recording sheet serving as a recording medium by the application of thermal energy generated by the electrothermal converting device H1103."). As illustrated in Figure 14 below, Yabe discloses multiple lines of electrothermal converting devices H1103 (e.g., heater arrays) (*pink*).

Ex.1008, Fig. 14

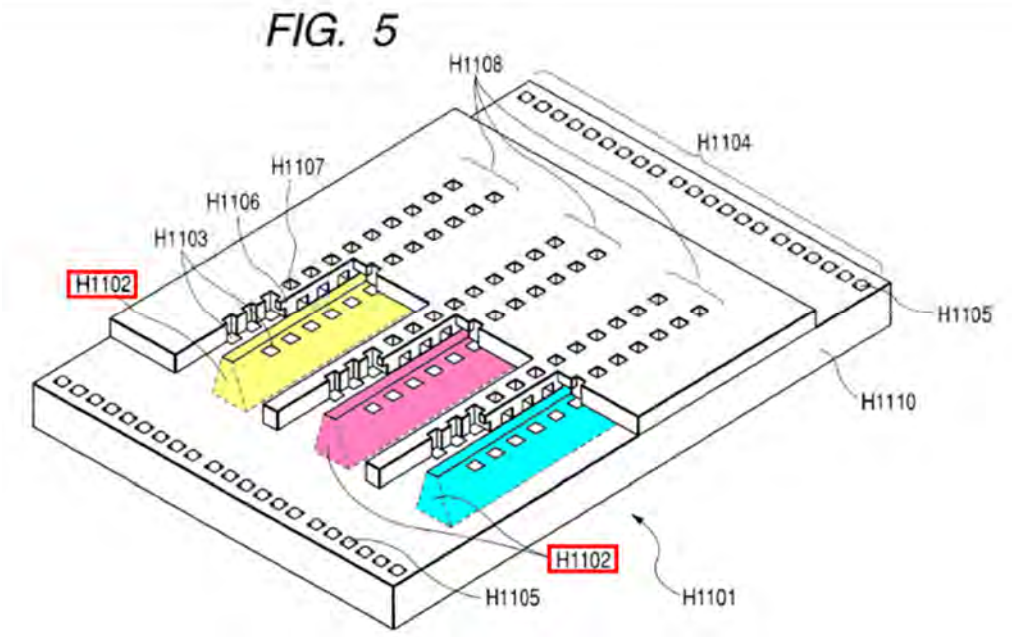
FIG. 14



435. Yabe also discloses a chip having a plurality of ink vias (i.e., **ink supply ports H1102**) arranged parallel to one another, each of the ink via having two longitudinal sides. For example, with respect to Figure 5 (below), Yabe discloses a recording element base plate (H1101) for discharging three colors of ink. Yabe discloses that "**[t]hree ink supply ports H1102 [*yellow, magenta, cyan*] are formed in parallel**, and **electrothermal converting devices H1103** and ink discharge ports H1107 **are formed on both sides having each of the ink supply ports H1102 between them**." Ex.1008 at 8:46-51. Yabe discloses that "ink supply port H1102 for supplying ink to a plurality of ink flow paths is formed to be open to

the face on the opposite side (reverse side)" where it will receive ink from ink tanks in the ink supply unit. Ex.1008 at 7:60-62; *see also id.* at Figs. 1 and 3.

Ex.1008, Fig. 5



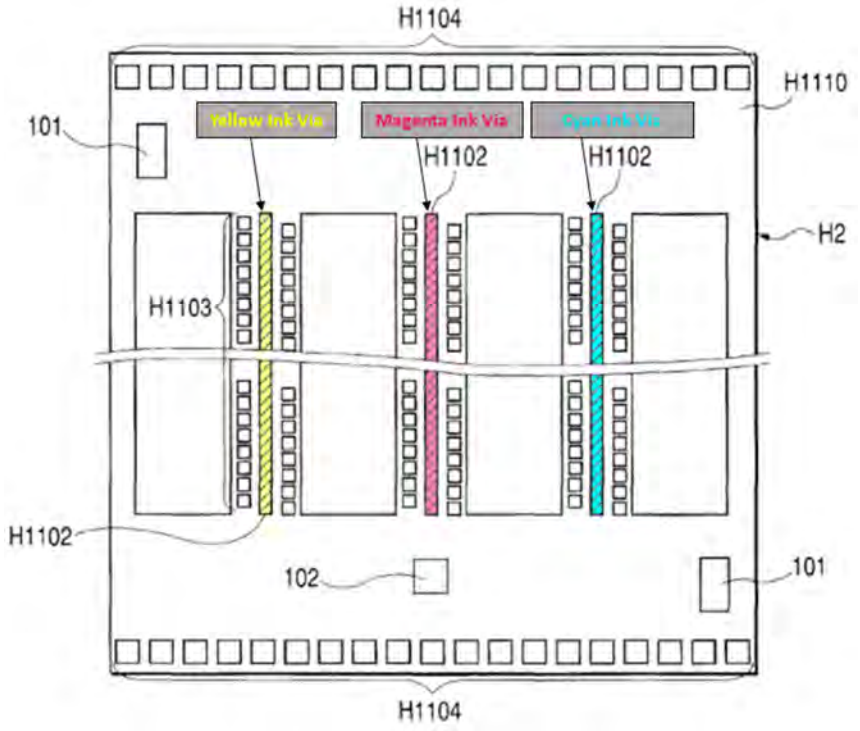
436. As described in Sections IX.B.5 and VII.A above, it is my opinion that Yabe's "ink supply ports" are synonymous with the claimed "ink vias" because, like ink vias, the "ink supplied from the ink supply port H1102 is discharged from the discharge ports H1107 by means of the bubbles generated by the heating action of the electrothermal converting devices H1103." Ex.1008 at 8:39-43. Moreover, a PHOSITA understands that ink vias and ink supply ports are both long through openings etched into a printhead's silicon substrate. Ex.1008 at 8:11-21 ("ink supply port H1102 is formed by means of anisotropic etching, sand blasting, or the like that

utilizes the Si crystalline orientation…[and][i]n this way, the etching is made in a desired depth to form the ink supply port H1102 having the through opening in the form of elongated groove.").

437. Yabe's Fig. 14, shown below, illustrates a layout for the heater board that corresponds to the layout shown in Yabe's Fig. 5. Ex.1008 at 16:31-34 ("The heater board H2 shown in FIG. 14 corresponds to the Si base plate H1110 provided with the electrothermal converting devices (heaters) H1103 for the recording element base plate H1101 represented in FIG. 5"); *see also id.* at Fig. 5. Like its corresponding Figure 5, Figure 14 illustrates Si base plate H1110 having a "plurality of ink supply ports H1102 [*yellow, magenta, cyan*]" arranged parallel to one another. Ex.1008 at 16:43; *see below id.* at Fig. 14.

Ex.1008, Fig. 14

FIG. 14

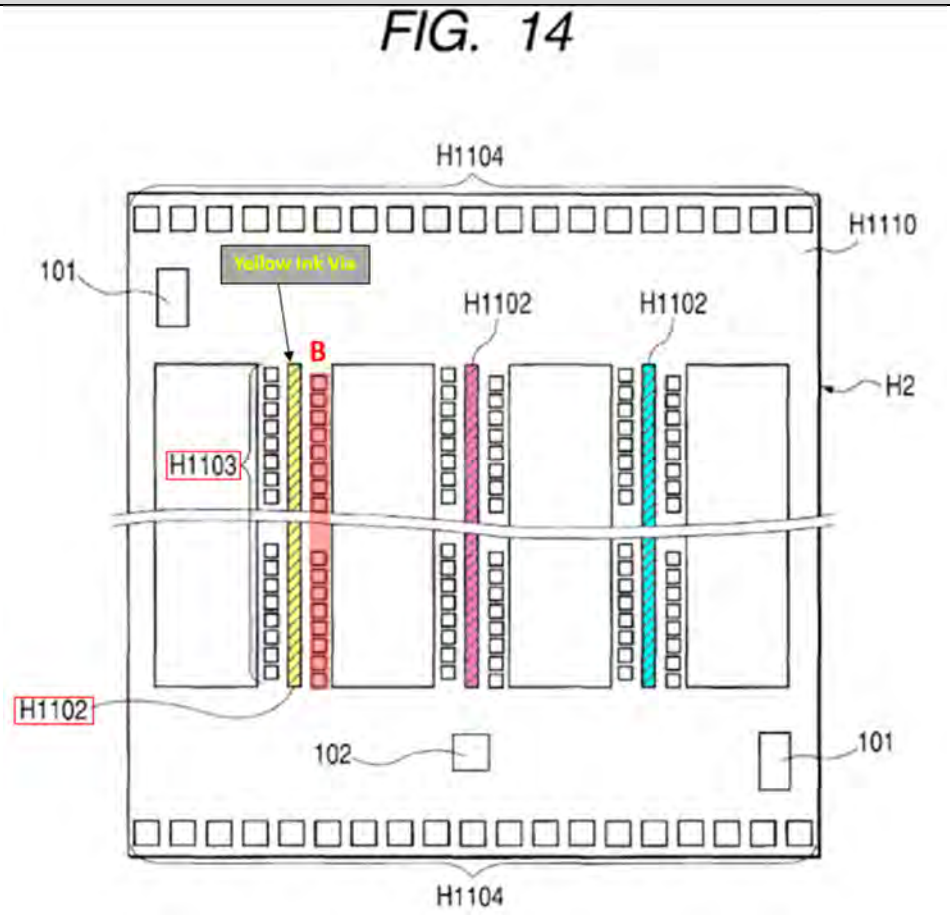


438. Yabe further discloses that its electrothermal converting devices (heaters) H1103 are arranged in a line (e.g., an array) substantially adjacent a first via. For example, Yabe discloses that "**[e]ach one line of the electrothermal converting devices H1103 is arranged** in the zigzag form, respectively, **on both side across the ink supply port H1102**." Ex.1008 at 8:21-23; *see also id.* at 8:47-51 ("Three ink supply ports H1102 are formed in parallel, and electrothermal converting devices H1103 and ink discharge ports H1107 are formed on both sides

having each of the ink supply ports H1102 between them."); *see also id.* at 8:48-51 ("electrothermal converting devices H1103 and ink discharge ports H1107 are formed on both sides having each of the ink supply ports H1102 between them.").

439. As illustrated in corresponding Figure 14 below, Yabe discloses electrothermal converting devices H1103 arranged in six arrays. A line of electrothermal converting devices H1103, i.e., Heater Array B (*pink*), is substantially adjacent a first ink via (e.g., yellow ink via H1102).

Ex.1008, Fig. 14



440. A PHOSITA would also understand that Yabe's electrothermal converting devices H1103 (e.g., Heater Array B, *pink*) are positioned substantially adjacent a first ink via (e.g., yellow ink supply port H1102) because the array of heaters are lying next to the ink supply port. *See* Ex.1012; Ex.1013.

441. Accordingly, it is my opinion that Yabe discloses "a first heater array [e.g., electrothermal converting devices H1103, Heater Array B] positioned substantially adjacent a first via [e.g., yellow ink supply port H1102]."

3. 1[B] "a second heater array positioned substantially adjacent a second via"

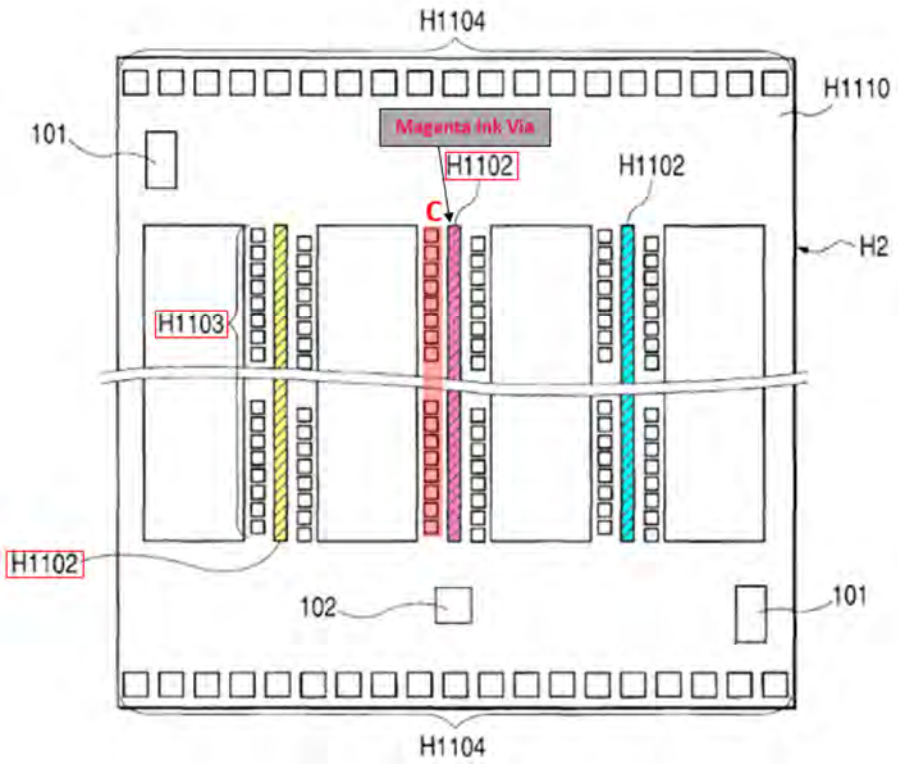
442. Claim 1 of the '823 Patent recites "a second heater array positioned substantially adjacent a second via." In my opinion, Yabe discloses this limitation.

443. In my opinion, as discussed above in Section XIV.A.2 and incorporated here, Yabe discloses a chip having six arrays of heaters (i.e., **electrothermal converting devices H1103**) and a plurality of ink vias (i.e., **ink supply ports H1102**) arranged parallel to one another.

444. Yabe discloses that its electrothermal converting devices (heaters) H1103 are arranged in a line (e.g., an array) substantially adjacent a second via. As illustrated in corresponding Figure 14 below, a line of electrothermal converting devices H1103, i.e., Heater Array C (*pink*), is substantially adjacent a second ink via (e.g., magenta ink via H1102).

Ex.1008, Fig. 14

FIG. 14



445. A PHOSITA would understand that Yabe's electrothermal converting devices H1103 (e.g., Heater Array C, *pink*) are positioned substantially adjacent a second ink via (e.g., magenta ink supply port H1102) because the array of heaters are lying next to the (magenta) ink supply port.

446. Accordingly, it is my opinion that Yabe discloses "a second heater array [e.g., electrothermal converting devices H1103, Heater Array C] positioned substantially adjacent a second via [e.g., magenta ink supply port H1102]."

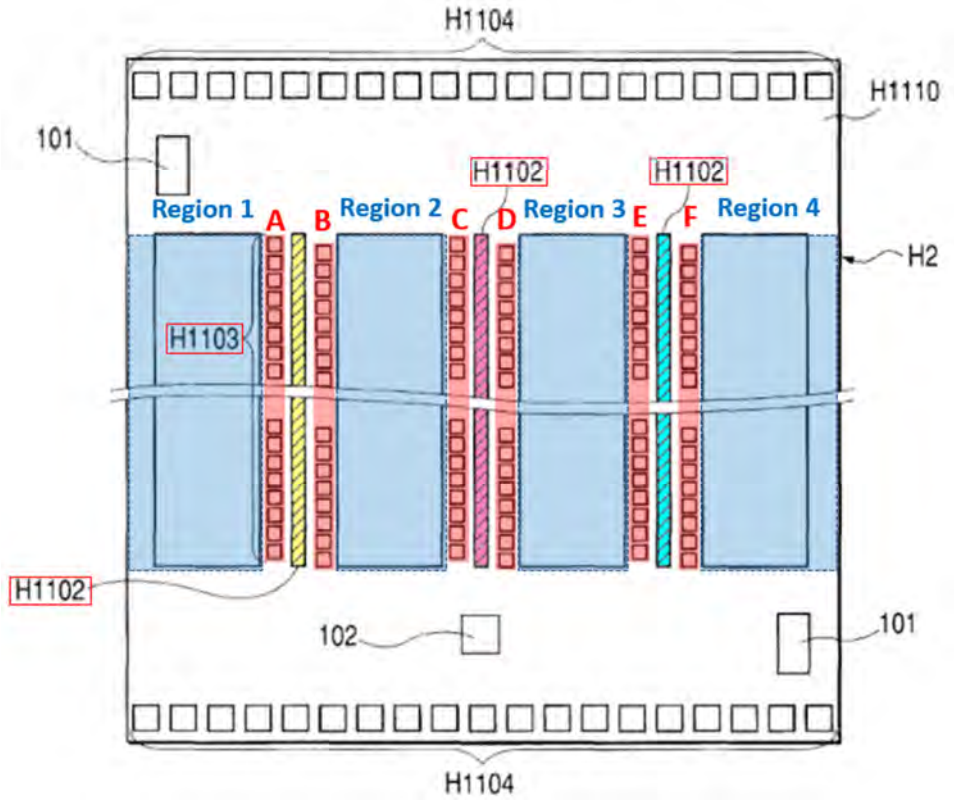
4. 1[C] "a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array"

447. Claim 1 of the '823 Patent further recites "a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first heater array and the second heater array." In my opinion, Yabe discloses this element.

448. As illustrated in Figure 14 below, Yabe discloses four regions [Regions 1, 2, 3, and 4, **blue**] adjacent each heater array (e.g., electrothermal converting devices H1103) and situated either between two ink vias (e.g., ink supply ports H1102) or between an ink via and an edge of the silicon substrate (H1110). As illustrated, each region [**blue**] is also adjacent each heater array (e.g., electrothermal converting devices H1103 [*pink*]).

Ex.1008, Fig. 14

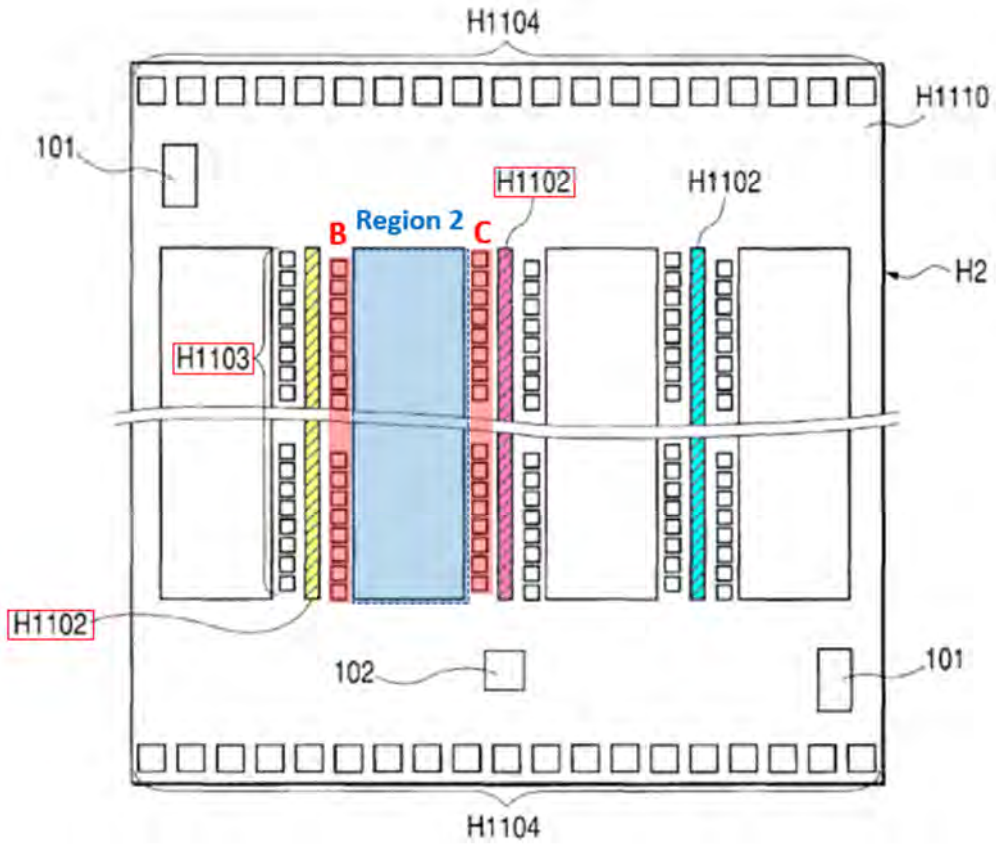
FIG. 14



449. As shown in Figure 14 (below) and discussed in detail below, Yabe discloses a region (e.g., **Region 2**, blue) positioned between a first heater array (e.g., Heater Array B, *pink*) and a second heater array (e.g., Heater Array C, *pink*), and also positioned substantially adjacent to the first heater array (e.g., Heater Array B, *pink*) and the second heater array (e.g., Heater Array C, *pink*).

Ex.1008, Fig. 14

FIG. 14



450. A PHOSITA would understand that because Yabe discloses three ink supply ports in parallel with heaters formed on both sides of each ink supply port there will be a substrate region located *between* supply ports and corresponding heaters, as illustrated in Yabe's Figure 5 and Figure 14 (above). Ex.1008 at 8:46-51 ("[t]hree ink supply ports H1102 are formed in parallel, and electrothermal converting devices H1103 and ink discharge ports H1107 are formed on both sides having each of the ink supply ports H1102 between them.").

451. A PHOSITA would also understand that Yabe's Region 2 is positioned substantially adjacent to the first heater array (Heater Array B) and the second heater array (Heater Array C) because the region is lying next to each of the first and second heater arrays.

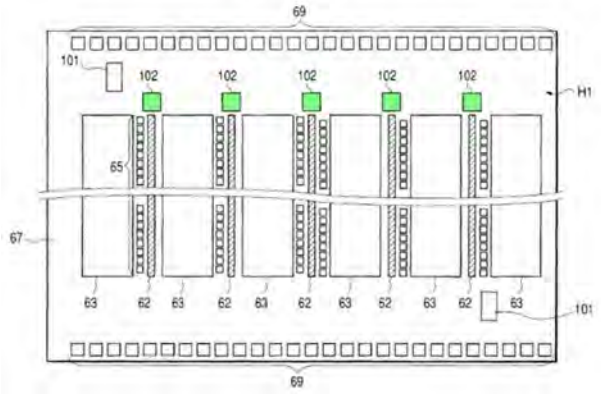
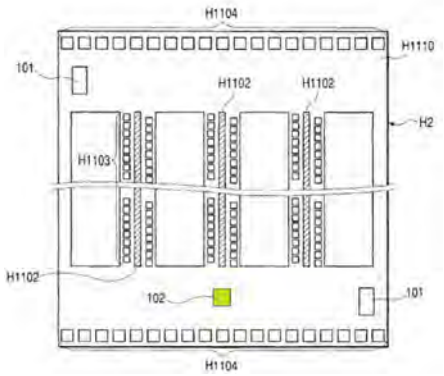
452. Accordingly, it is my opinion that Yabe discloses "a region [e.g., Region 2, *blue*] positioned between the first heater array [e.g., Heater Array B, *pink*] and the second heater array [e.g., Heater Array C, *pink*], and also positioned substantially adjacent to the first heater array [e.g., Heater Array B, *pink*] and the second heater array [e.g., Heater Array C, *pink*]."

5. 1[D] "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region, wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array"

453. Claim 1 of the '823 Patent further recites "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region, wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array." In my

opinion, Yabe combined with Giere673 (Yabe-Giere673 Combination) discloses this limitation.

454. Yabe discloses "temperature detecting means" and states that "there should be provided **means for measuring the temperature of the heater board** more efficiently in accordance with the temperature characteristics obtainable by temperature detecting means, as well as means for controlling the temperature of the heater board efficiently in accordance with such measurement information." 2:11-12; 2:49-54. As illustrated below in Yabe's Figure 12 and 14, although Yabe discloses one or more "temperature detecting means 102" (*green*) on silicon base plate H1110, it does not *explicitly* teach disposing "temperature detecting means 102" substantially centrally with respect to the region substantially adjacent to both the first heater array and second heater array and further extending substantially the length of the first heater array and second heater array. It is my opinion that a PHOSITA would have looked beyond Yabe and considered Giere673 because it is analogous art for the reasons described in Section XIV.P.

Ex.1008, Fig. 12	
FIG. 12 	FIG. 14 

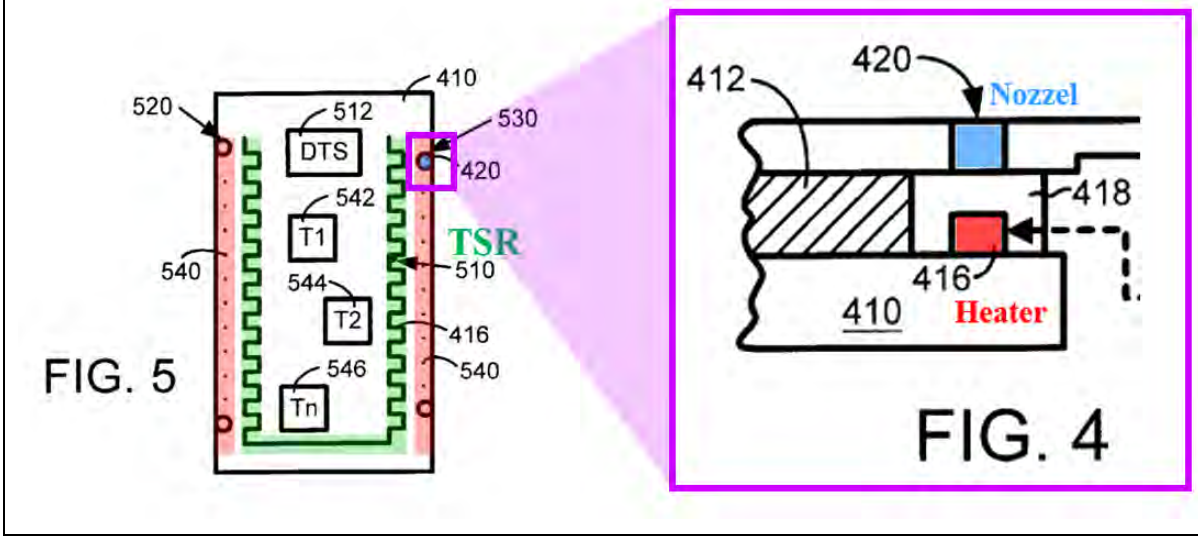
a. 1[d1] "a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region"

455. It is my opinion that Yabe combined with Giere673 in the manner described in Section XIV.P below (the Yabe-Giere673 combination) discloses a temperature sensing element operable to sense a temperature of the region where the temperature is representative of the region, as required by this claim.

456. Giere678 uses "[o]ne or multiple TSRs 510 [to] provide an approximation of the ***mean temperature*** of the substrate [410]." Ex.1005 at 4:55-56. And just like Yabe, Giere678 optimizes the print quality of the inkjet printer based upon the temperature value provided by the TSR. But unlike Yabe, Giere678 explicitly discloses putting the TSR between heater arrays (and extending the length of the arrays) to provide a sufficiently accurate temperature value to meaningfully improve print quality. Not only does Giere673 teach positioning a single

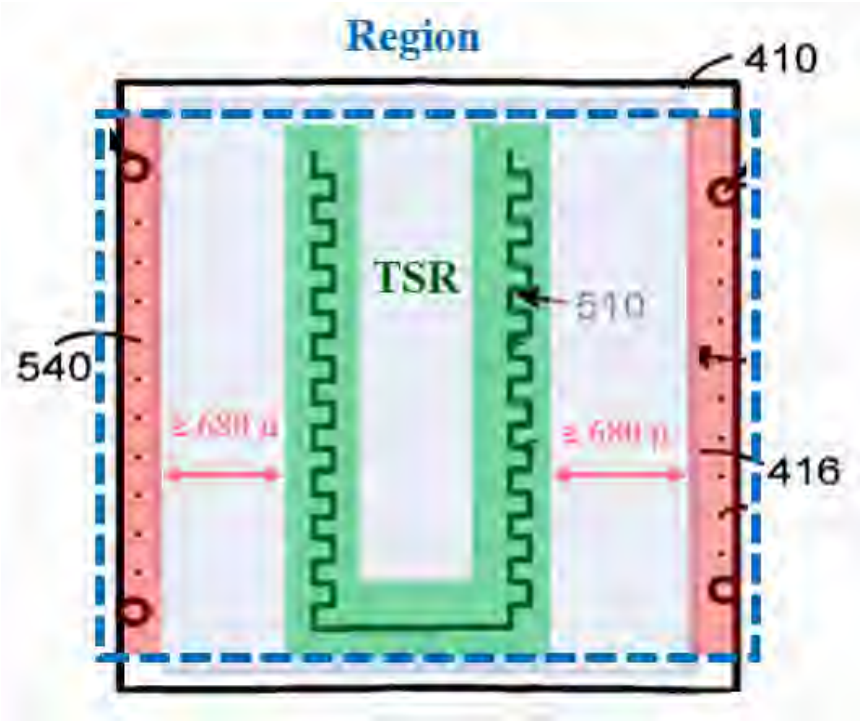
temperature sensor—i.e., "temperature sensor resistor (TSR) 510 [*green below*]—between two heater arrays [*red*], but also that the TSR 510 "preferably is not located adjacent to any ***particular*** heating elements" so that the obtained TSR value "**reflects the temperature of the substrate 410** after heat has moved from the heating elements to the TSR 510." Ex.1005, 2:50, 4:51-56. To be sure, Giere673 teaches that "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are approximately 680 µm inboard from the center of the columns of ink ejection elements 416," [*red in Figs. 4 and 5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12.

Giere673, Figs. 4 and 5



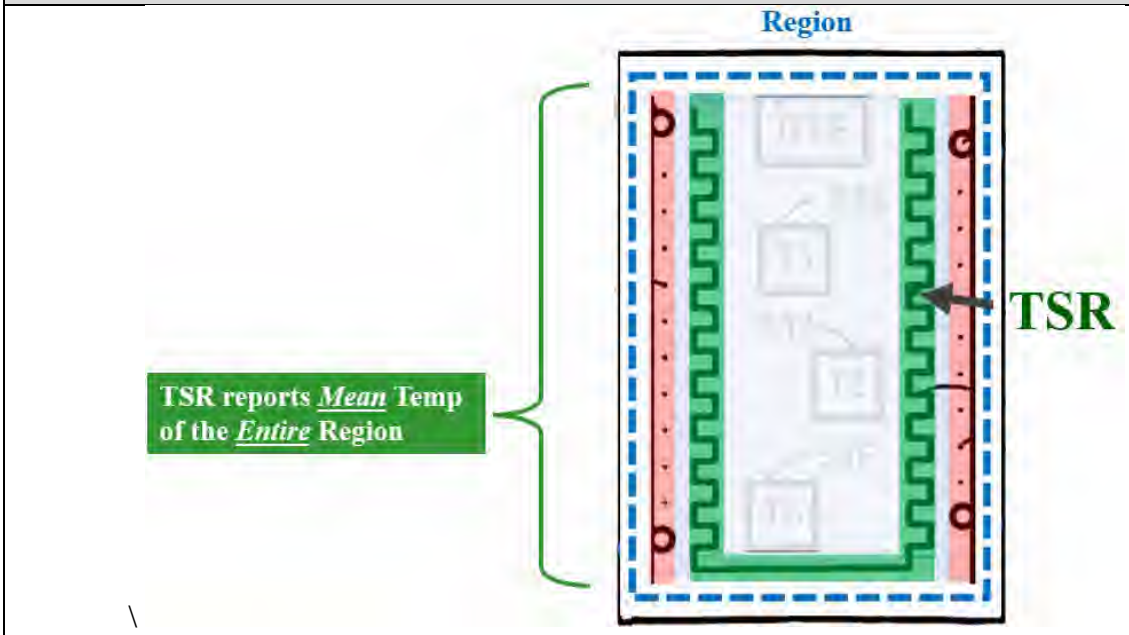
457. Put differently, Giere673 teaches disposing a single temperature sense resistor (TSR) [*i.e.*, TSR 510, *green below*] in a region on the printhead die [region

of the substrate 410, *blue*] adjacent two heater arrays [columns of ink ejection elements 416 and 540, *red*], and positioning that TSR equidistant from the two heater arrays but no less than "approximately 680 µm inboard from the center of the [heater arrays]." Ex.1005 at 5:10-12.

Ex.1005, Fig. 5


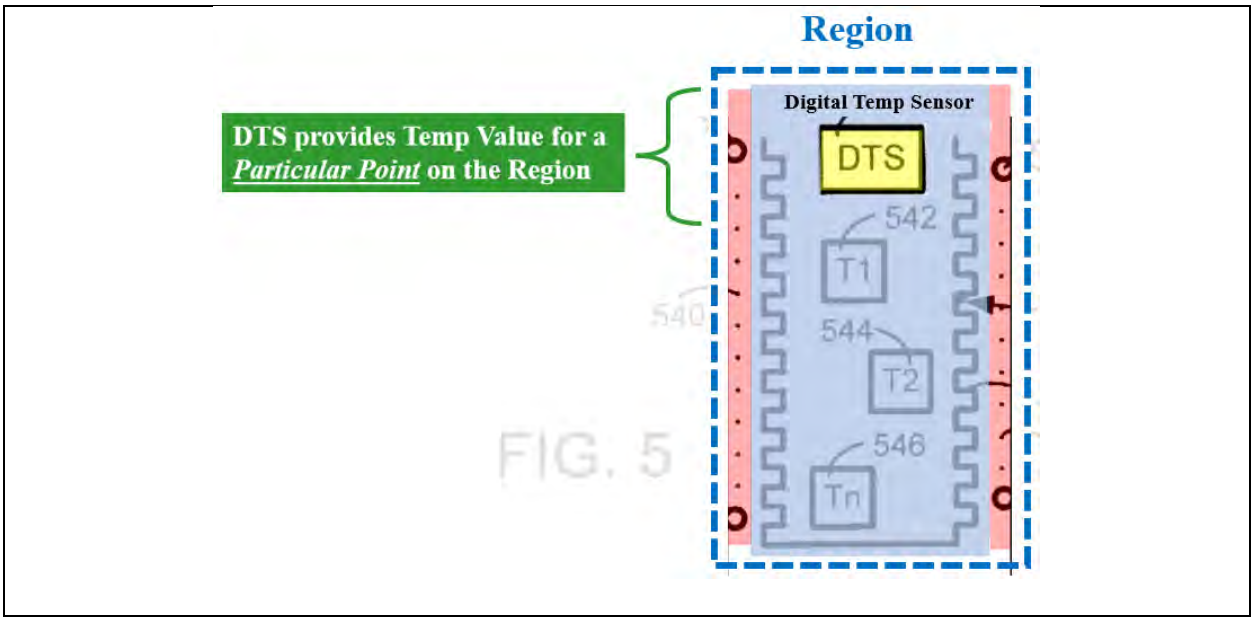
458. By positioning the TSR 510 in the centre of the region, Giere673 teaches that the TSR value obtained by TSR 510 "reflects heating elements firing that have already occurred," which "more accurately reflects the ***mean temperature*** of the substrate 410," as illustrated below. Ex.1005 at 4:57-59. As such, TSR 510 is able to sense the temperature that is representative of the region in which it is located.

Ex.1005, Fig. 5



459. Conversely, Giere673 positions an optional "point sensor"—*i.e.*, Digital Temperature Sensor (DTS) 512 (yellow)—"at the top of the substate" without expressing any similar preference on location because, unlike the TSR, the DTS 510 "reflects the temperature ***at that point***, it does not give an accurate temperature for other heating elements on the substrate." Ex.1005, 4:67-5:2. In my opinion, a PHOSITA would position a temperature sense resistor in the same location as Giere673's TSR (i.e., along the length of the heater arrays) if it sought to obtain a value reflecting an accurate temperature for all the heating elements in that region, and not use Giere673's digital point sensor (DTS 510) positioned just near the top of the region.

Ex.1005, Fig. 5

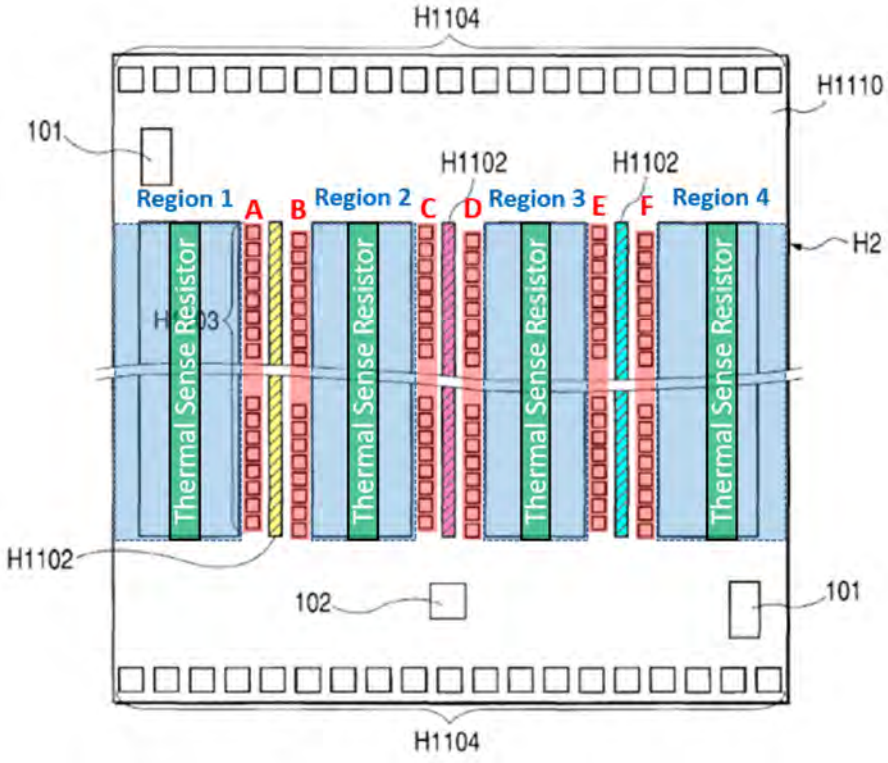


460. Moreover, a PHOSITA would have known that placing the TSR within Region 2 *alone* would not be an ideal location to accurately report the mean temperature of the ***entire printhead die***, which Giere673 attributes to meaningfully regulating operational temperature, because the two ink vias adjacent to the TSR [*e.g.*, yellow ink supply port H1102 and magenta ink supply port H1102, for Region 2, *blue*] would act as thermal insulators between other regions of Yabe's printhead die [Regions 1, 3, and 4], making the temperature value read by the TSR reflective of the temperature of Region 2, but not the mean temperature of the entire printhead die. Ex.1001 at 5:52-55; Ex.1008 (Yabe) at 3:16-21 ("it is found that in the mode of the side shooter recording head, a plurality of ink supply ports provided for the heater board demonstrate the heat insulating characteristic against the heater board material…").

461. To regulate the operational temperature of Yabe's printhead die and optimize the printing quality of the inkjet printing device, it is my opinion that a PHOSITA would have further configured Yabe to determine a mean temperature of the ***entire printhead die*** by disposing a single TSR within each of the remaining regions [e.g., Region 1, 3, and 4, blue] as shown below so that the temperature value *collectively* provided by the TSRs within Regions 1-4 reflect the mean temperature of Yabe's printhead die.

Ex.1008, Fig. 14

FIG. 14



462. A PHOSITA would further understand why the temperature regulation design illustrated above in Fig. 21 (i.e., temperature sensors in each region) would be advantageous. Thermal inkjet devices, like the one disclosed in Yabe, are designed to operate optimally at a nominal temperature that is chosen with the temperature management strategy in mind. Since passive cooling is the most affordable cooling method, a PHOSITA will choose an elevated temperature as the nominal temperature and use active measures to raise the ink temperature to this nominal if the ambient temperature where the printer is operating is lower. The printhead temperature will be elevated to the nominal temperature by some means, such as intermittent non-printing energy pulses to the heater resistors. Thermal inkjet devices produce acceptable printing results within a narrow range of temperatures above and below the chosen nominal operating temperature. Attempting to operate the thermal inkjet printhead somewhat outside the acceptable temperature range results in soft failure modes, such as reduced or unacceptable print quality. If the ink temperature is somewhat too low, the nucleated bubble which expels the ink may be too small which could produce visible white streaks in the image or color hue shifts as the mix of cyan, yellow, and magenta ink amounts in an image area is wrong. If the ink temperature is somewhat too large, then dark streaks or objectionable color hue shifts may be visible

463. Hard failure modes may occur if operation is attempted well outside the acceptable ink temperature range. If the ink temperature is very low, the nucleated bubble may be too small to eject a drop at all. Visible white streaks will appear in the image. Dribbling of ink or the firing of an ink mist may occur resulting in mist contamination of other printer components or the smearing of ink on the print media and media transport surfaces. If the ink temperature is very high, then bubble volume may be so large that the bubble breaks out through the nozzle, causing air to be ingested into the printhead. The user may have to initiate a printhead maintenance cycle whereby the nozzles are vacuumed clear of air by a maintenance station vacuum pump. Another failure can occur if a too hot ink nucleates too early in the drop firing pulse. As soon as the bubble is nucleated, the heater resistor surface can no longer transfer heat to the ink efficiently, causing the heater surface to get much hotter than designed, leading to the "burn out" of the heater resistor and, potentially, the permanent failure of that drop generator.

464. To operate over the widest range of environmental temperatures and the heaviest printing (drop firing) loads, a PHOSITA would know that Yabe's printhead die must be monitored in a manner that adequately allows for countermeasures against the soft and hard failure modes known to occur. To first order, knowing the overall temperature of the thermal inkjet printhead substrate can allow the avoidance of the above-described hard failure modes. For example,

experimental testing of the printhead will have determined that air ingestion nearly always occurs if the printhead is operated above a certain temperature and that ink mist or dribbling usually occurs if operated below another certain temperature. A single temperature sensor representative of the printhead substrate temperature can warn that these high and low temperature hard failure boundaries are being approached, allowing the system controller to slow or pause printing until the temperature condition can be brought within an acceptable range. A PHOSITA also would know to utilize a temperature sensor to forecast soft failure modes affecting print quality by implementing countermeasures when temperatures are measured somewhat outside the nominal operating temperature

465. However, to optimize the printing quality of Yabe's printhead die and other multi-via printhead dies with two heater arrays per ink via, a PHOSITA would know that the temperature should be measured on a per-via basis—*i.e.*, disposing a TSR adjacent each and every ink via on the printhead die, rather than disposing a diode sensor, for example; otherwise, the temperature value obtained by the diode may not accurately reflect the temperature of each color since ink vias act as thermal insulators.

466. Indeed, a PHOSITA would also know that excessive *localized* heating of the substrate without compensation for the substrate temperature change can lead to degradation in print quality. Ex.1007 at 5:36-51. For example, Giere178

describes a situation where excessive printing of one color ink in one region of the printhead die, e.g., magenta ink, can increase the temperature of that color's ink ejection chambers thereby increasing the mass of the magenta ink drops beyond the desired print size. Ex.1007 at 5:52-6:3. Giere178 explains that in this situation, print quality will degrade because excessive magenta ink will alter the desired print colors. *Id*. Giere178 states that the "rate at which signals are supplied to resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead" and "*localized heating* of the substrate can occur from firing nozzles at a greater frequency *in a particular region of the printhead*." Ex.1007 at 5:44-46. Giere178 explains that "[i]f at least some compensation is not made for these temperature changes, a perceptible degradation in print quality can result." Id. at 5:49-51. For example, in the magenta example described above, Giere178 states that "as a result of the excessive quantity of magenta ink applied, the hue of the region formed [in combination with cyan and yellow] will be shifted toward the magenta hue," "undesired shifts in the chroma and the luminance of [print] regions" can occur, and an "increase in the mass of ejected ink drops can reduce the sharpness of the edges when the image is formed onto paper." Ex.1007 at 5:62-6:3. Giere178 discloses a solution to the localized heating issue by placing multiple temperature sensing "resistive elements" on the substrate (between ink vias and associated heater arrays) "so that they will each assume the temperature of the local region of substrate

[] on which they are placed." Ex.1007 at 8:51-54; *see also* Sections IX.B.4, XIII.A.6-7, and XIV.C. Giere178 states that its "temperature compensation system" with localized temperature sensors "may be used to control a quantity of ink deposited on a region in response to the measured temperature," or "may be used to control resistive heating elements thermally coupled to [the] substrate [] so that the temperature of [the] substrate [] is controlled substantially at a desired temperature," or "may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of [the] substrate [] is controlled substantially at a desired temperature." *Id*. at 9:50-60. As such, Giere178 corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere673, would have been further motivated to modify Yabe's printhead die by disposing a single temperature sensor within each other region so that the TSRs collectively determine a mean temperature of Yabe's printhead die and regulate temperature on a per-color basis.

467. Moreover, the '823 Patent readily admits that, during the prior art time period, it was well known to those skilled in the art that "ink vias [] act as thermal barriers between the colors," and "without accurate temperature readings, the method of providing fire pulses to regulate thermal conditions [for a multi-via printhead] would also be subject to error." Ex.1001 at 2:47-49, 2:10-11. To overcome these challenges, the '823 Patent admits that prior art heater chips

"provid[ed] for temperature sensing on a per-color basis" by placing "three temperature sensors 220, 222, and 224 [green below] in close proximity to each of the heater arrays, each situated on the same side of their respective vias," thereby "ensuring that there is only a small amount of thermal crosstalk between the temperature sensors." Ex.1001 at 2:14-15. Put differently, the '823 Patent corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere673, would have been further motivated to modify Yabe's printhead die by disposing a single temperature sensor within each region so that the TSRs collectively determine a mean temperature of Benjamin's printhead die because it was well known to those skilled in the art that this arrangement "provid[es] for temperature sensing on a per-color basis." Ex.1001 at 2:1-2.

468. As such, in my opinion, Yabe combined with Giere673 (Yabe-Giere673 Combination), discloses a temperature sensing element operable to sense a temperature of the region where the temperature is representative of the region for the reasons discussed above.

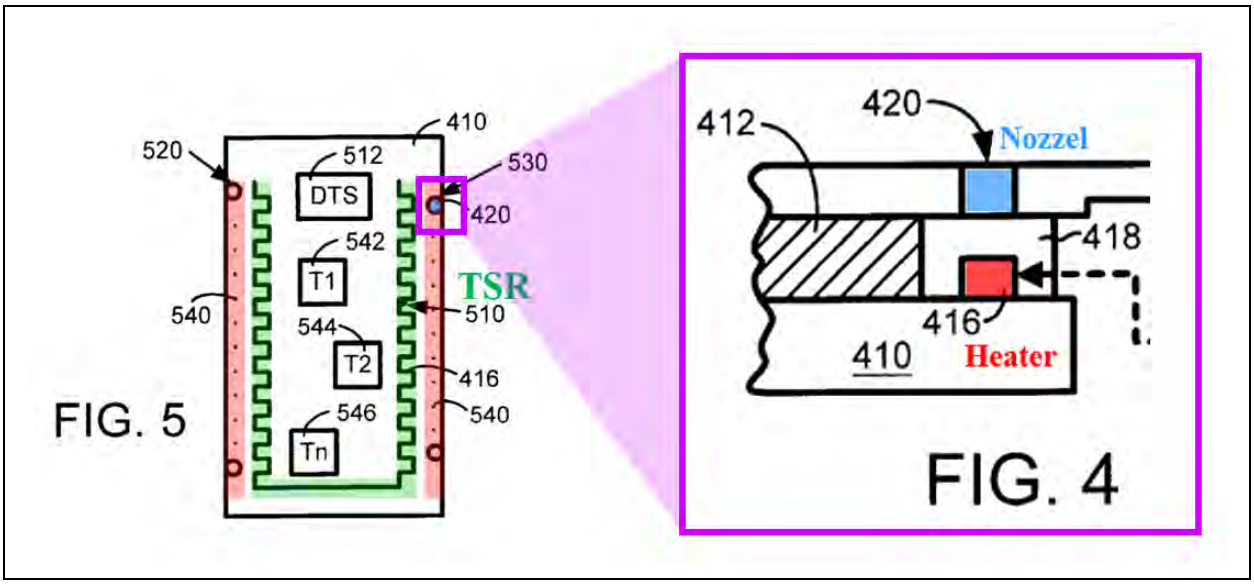
b. 1[d2] "wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array"

469. It is also my opinion that Yabe combined with Giere673 discloses that the temperature sensing element is substantially centrally disposed with respect to

the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array.

470. Upon review of Giere673's Figure 5, a PHOSITA would have understood that the temperature sense resistor (i.e., TSR 510 *green* below) is at least in *substantially* centrally disposed—if not exactly in the centre—of the region disposed between the two heater arrays (i.e., two vertical rows of heating elements 416 and 520, pink), especially since Giere673 states that the TSR 510 "preferably is not located adjacent to any ***particular*** heating elements" so that the obtained TSR value "reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005, 4:51-56; 4:57-61, 2:50. To be sure, Giere673 teaches that "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are approximately 680 μm inboard from the center of the columns of ink ejection elements 416," [*red in Fig.5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Fig. 4]. Ex.1005 at 5:5-12.

Ex.1005, Figs. 4 and 5

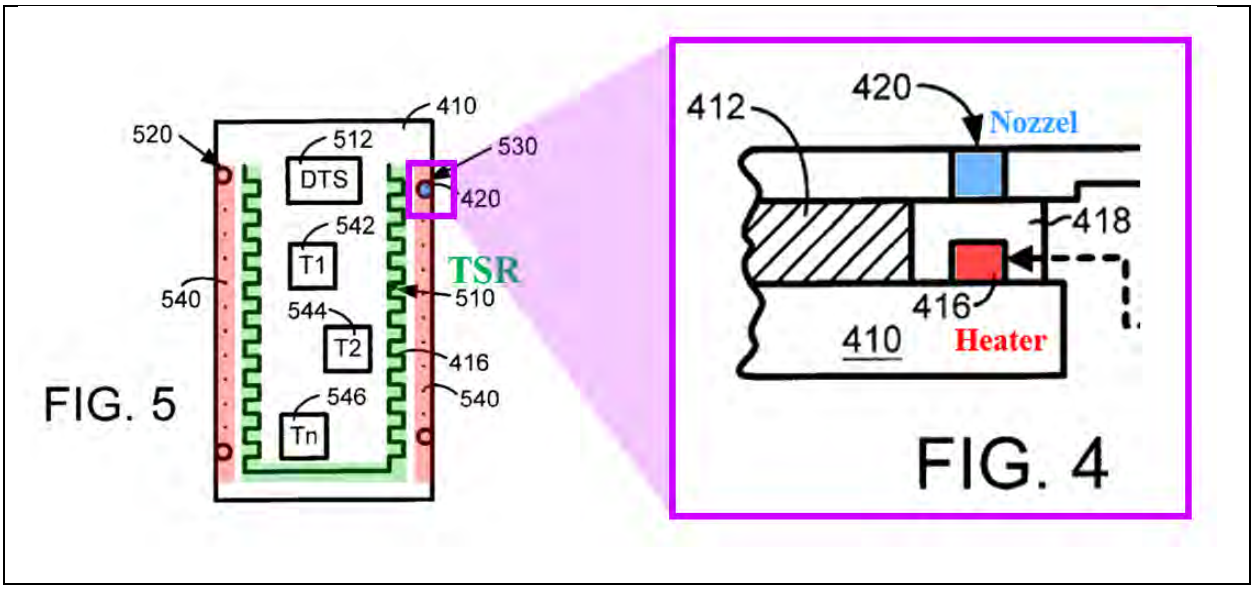


471. Put differently, Giere673 teaches disposing a single temperature sense resistor (TSR) [*i.e.*, serpentine TSR 510, *green below*] in a region on the printhead die [region of the substrate 410, *blue*] adjacent two heater arrays [columns of ink ejection elements 416 and 520, *red*], and substantially centrally disposed with respect to the region wherein the TSR is equidistant from the two heater arrays but no less than "approximately 680 µm inboard from the center of the [heater arrays]."

472. Moreover, in my opinion, the '823 Patent fails to discuss how positioning a temperature sensor in substantially a centre portion would improve the accuracy of the temperature readings. *See* Ex.1001, (failing to provide any details about the position of the temperature sensor). Rather, in my opinion, the '823 Patent demonstrates to a PHOSITA that the positioning of the temperature sensor within the region is not critical to the invention.

473. Upon further review of Figure 5 of Giere673, a PHOSITA would have also understood that the temperature sense resistor (i.e., TSR 510 green) is at least substantially adjacent to *both* the first heater array and second heater array and extends substantially the length of the first heater array and second heater array. As stated above, Giere673 discloses TSR 510 "preferably is not located adjacent to any particular heating element [*e.g., ink ejection elements 416 and 520, red*] and reflects the temperature of the substrate 410 ***after*** heat has ***moved from*** the heating elements to the TSR 510." Ex.1005 at 4:57-59. As one example, Giere673 teaches that TSR 510 "can have two legs that are approximately 680 μm inboard from the center of the columns of ink ejection elements 416 [*red in Figs. 4 and 5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12. As such, Giere673 teaches that its TSR 510 is not located adjacent either the left *or* right columns of ejection elements(red) but instead is positioned near or close to *both* columns of ink ejection elements so as to detect the mean temperature of the substrate as affected by the heat generated by both columns of ink ejection elements. Giere673 also teaches that the "[t]he TSR 510 is located **along the length** of the substrate 410" and as such, would also extend substantially the length of the left and right columns of ejection elements 416 (red), as shown in Figure 5 below.

Ex.1005, Figs. 4 and 5



474. In addition, it is also my opinion that a PHOSITA, through routine experimentation, would have eventually positioned the TSR in substantially the centre of the region and substantially adjacent to both the first heater array and second heater array and further extending substantially the length of the first heater array and second heater array. Indeed, I submit that it was common knowledge during the relevant time period to position temperature sensors away from any particular heater array and in the center of region being measured. *See, supra*, XIII.I.

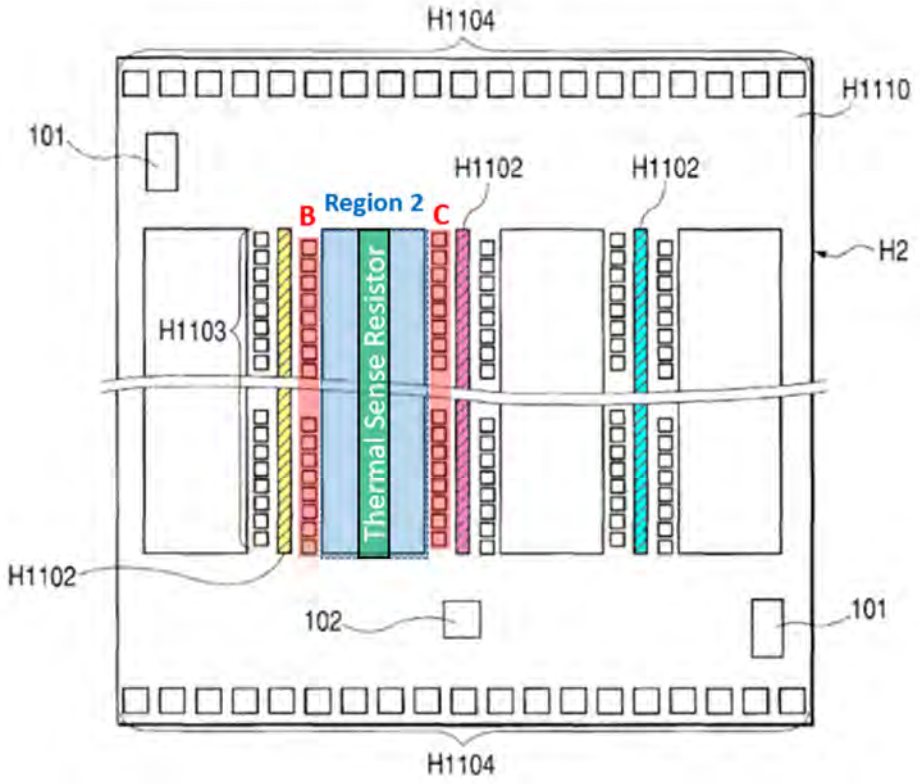
475. It is also my opinion that a PHOSITA would understand that it was logical to put the TSR in substantially the centre of the region and substantially adjacent to both the first heater array and second heater array because the high thermal conductivity and large cross-sectional area of the silicon base material between ink vias would cause those regions to rapidly reach an equilibrium

temperature, allowing one sensor in the middle of such regions to adequately measure the temperature.

476. As discussed above, since Giere673's ink ejection elements 416 form a column that runs along each longitudinal side of the ink channels similar to how Yabe's heaters (electrothermal converting devices H1103) form a heater array along each longitudinal side of the ink supply ports, a PHOSITA would know to place Giere673's TSR 510 in a similar location within each region of Yabe's silicon base plate H1110 by positioning a single TSR 510 substantially centrally disposed with respect to each region and substantially adjacent to both the first heater array (Heater Array B, pink) and second heater array (Heater Array C, pink) and further extended substantially the length of the first heater array and second heater array, as shown below.

Ex.1008, Fig. 14

FIG. 14



477. Accordingly, it is my opinion that Yabe combined with Giere673 discloses a "temperature sensing element [*e.g.*, TSR 510] operable to sense a temperature of the region [*e.g.*, Region 2, blue], the temperature being representative of the region, wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array [*e.g.*, Heater Array B, pink] and second heater array [*e.g.*, Heater Array C,

pink], and further extends substantially the length of the first heater array and second heater array."

6. 1[E] "wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region"

478. Claim 1 of the '823 Patent further recites "wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region." Although Yabe discloses one or more "temperature detecting means 102" on silicon base plate H1110 for detecting temperature on the heater board, Yabe does not *explicitly* teach using the temperature sensed by "temperature detecting means 102" to regulate the temperature of the regions of the silicon base plate H1110 using the first and second heater arrays. However, it is my opinion that Giere673 discloses this limitation.

479. First, according to the '823 Patent, "heater chip 400 may use non-**nucleating heating (NNH)** to maintain an adequate substrate temperature for the heater chip 400 in each region in order to ensure the best print quality." Ex.1001 at 7:57-60. It is my understanding that non-nucleating heating (NNH) can refer to a technique of applying short pulses to heater resistors, i.e., too short to eject an ink drop (nucleation), but sufficient to warm the substrate and ensure the heater chip

operates at a desired temperature range. The ’823 Patent describes NNH as “applying fire pulses to selected heater arrays 408, 410, 412, 413, 414, 416, 418 of a duration too short to cause nucleation and the subsequent ejection of an ink drop from an ink via 402, 404, 406, and 407.” Ex.1001 at 7:60-63. The ’823 Patent further states that “[i]Instructions for firing heaters may be provided via one or more data streams used to control heater address data, the printhead, and like elements.” *Id*. at at 8:3-6.

480. Giere673 discloses this limitation. Giere673 discloses that printing system 100 includes “a temperature control system 110 (*green*) for predicting dynamic thermal conditions of the printhead assembly 102,” including “the substrate” (*blue*) Ex.1005 at 2:48-52; *see below id*. at Figs. 1 and 4. To control[] the temperature of the substrate and the temperature of each ejection chamber, Giere673 further discloses that “[t]he temperature controller 110 is coupled to multiple temperature sensors (not shown),” which “determine, at a given time, a mean or ***average temperature of the substrate*** and an ***actual local temperature profile near designated ink ejection elements***.” Ex.1005 at 2:57-62. Thereafter, “[t]he temperature controller 110 uses the input data 108 [supplied by the temperature sensors] to predict thermal conditions of particular ejection chambers for selectively firing the associated heating elements.” Ex.1005 at 3:1-6

Ex.1005, Fig. 1	**Ex.1005, Fig. 4**

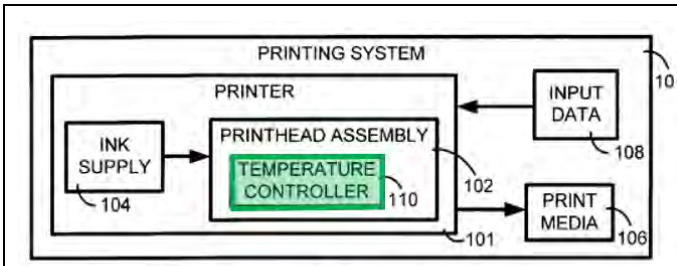


FIG. 1

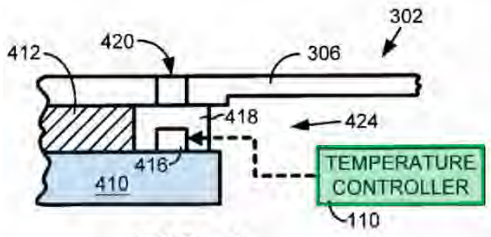


FIG. 4

Ex.1005 at 2:62-65 ("The temperature controller 110 can be an integrated circuit, firmware, a software printer driver or the like which controls the mean temperature of the substrate of the printhead through a feedback loop (discussed in detail below).").

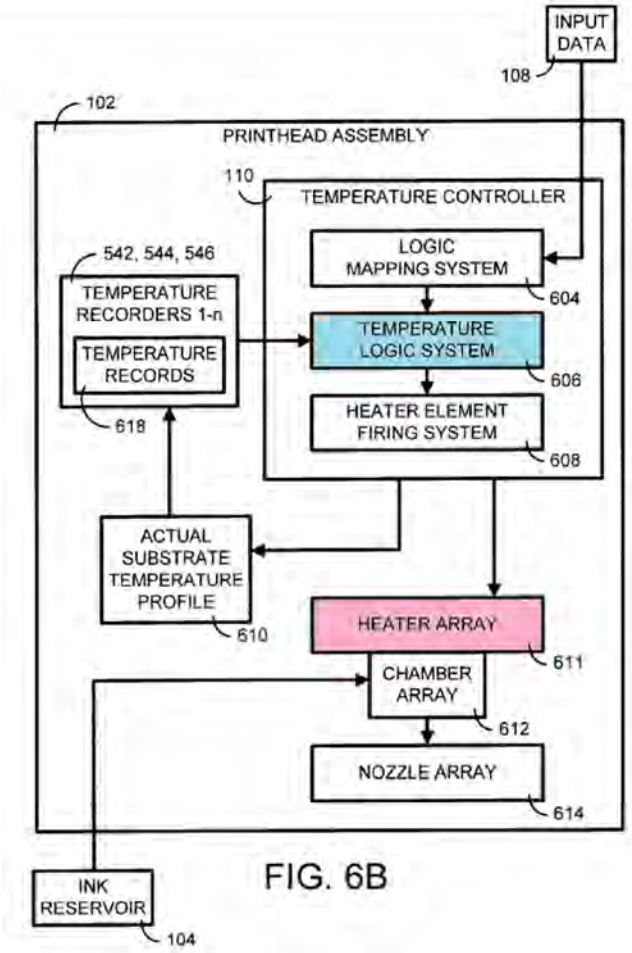
481. Fig. 5 of Giere673 is "a top view of the substrate" and, when viewed together with Figure 4, confirms that that "the temperature controller 110 of FIG. 1 is coupled to at least one measurement sensor, such as "a thermal sense resistor (TSR) 510" that "provide[s] an approximation of the mean temperature of the substrate" to "the temperature controller 110," which the temperature controller 110 uses the mean temperature sensed by the TSR 510 "to control the temperature." Ex.1005 at 4:49-5:5.

482. Giere673 states that "**temperature controller 110 aids in controlling the temperature of the substrate** and the temperature of each ejection chamber or nozzle chamber" which "results in improved print quality and printhead life because the printhead 102 will consequently operate closer to its optimum temperature." Ex.1005 at 3:7-12. Specifically, Giere673 discloses that temperature controller 110

uses a closed loop method wherein in response to the temperature of the region sensed by the temperature sensing elements generating "printing parameters," including pulse widths to heaters and warming using non-ejecting devices, that are used to regulate the substrate temperature. As illustrated in Fig. 6B (below), temperature controller 110 includes "temperature logic system 606 (*teal*)" that generates various printing parameters. Ex.1005 at 6:21-28. According to Giere673, during operation of the printhead, an actual temperature profile is created that includes the current temperature of the substrate. Giere673 discloses that the "temperature logic system uses these temperature and printing inputs…to generate printing parameters and then output them in a closed loop system to the actual substrate temperature profile 610." Ex.1005 at 6:46-52. Giere673 further explains that the "printing parameters can include **pulse widths, pulse rates, ink ejection chambers 418 to be fired and when they will be fired, warming using non-ejecting devices, and firing voltages** that act as the inputs for the actual substrate temperature profile 610." Ex.1005 at 6:52-57. Moreover, "[s]ince a true temperature profile is difficult to measure, this closed loop method allows approximation of a temperature profile to improve ink drop quality." *Id*. at 6:57-59. Giere673 also states that "[w]hen the **sensors detect that the mean temperature** of the substrate has dropped below a predefined baseline or threshold temperature, the

loop activates the heating elements in an effort to raise the substrate above the baseline temperature before printing." *Id*. at 2:66-3:3.

Ex.1005, Fig. 6B



483. As discussed above, Giere673's temperature controller 110 is operatively connected to the heating elements. Ex.1005 at 4:18-19. Giere673 explains that the controller's temperature logic system 606 "determines the firing rate and pulse width for each color controlled for pulse rate 802 and for pulse width 804, and forwards the firing order to the heater element firing system 608, through

the timing device 812." Ex.1005 at 9:9-13. Giere673 then states that "**[t]his rate, width and order of firing are programmed, and if necessary, adjusted in the programming, so that the temperature of the heater array 611 [*pink, above*], and therefore the temperature of the ink in the chamber array 612, are maintained at an optimum temperature for the formation of ink droplets**." Ex.1005 at 9:13-18.

484. Moreover, like the '823 Patent, Giere673 also discloses using a non-nucleating heating method to control its heating elements: "The temperature logic system also generates firing voltages 814 and **activates heater elements that do not eject ink 816**." Ex.1005 at 9:18-20; see also id. at 6:52-57 ("warming using non-ejecting devices").

485. Giere673 discloses an operational flow chart associated with Figure 6A's closed loop system describing process for using the substrate temperature to set operating conditions of the heaters so they operative at optimal temperature. Ex.1005 at 8:3-13. As illustrated below, Fig. 6C shows in step 670 that "a mean temperature of the printhead is sensed (step 672)." *Id*. at 7-8. In step 676, in response to the temperature of the region being sensed by the temperature sensing elements, "operating conditions for the certain ones of the subset are set so that the corresponding heating elements operate at an optimal temperature (step 676)." *Id*. at 11-13.

Ex.1005, Fig. 6C

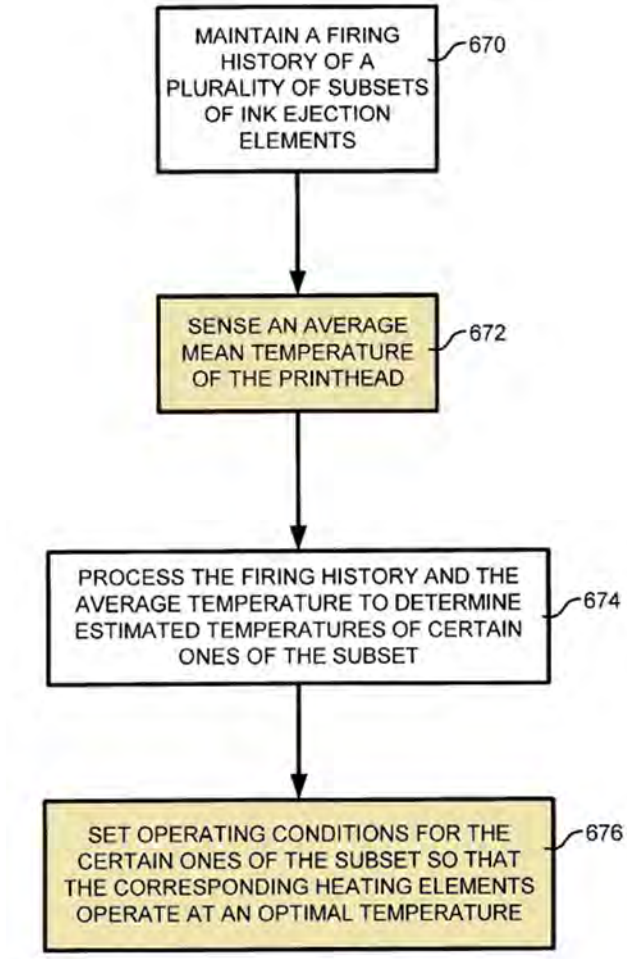


FIG. 6C

486. Furthermore, in my opinion, a PHOSITA would be motivated to use Giere673's method of regulating the temperature of the substrate region by making the heater arrays operable to receive heating (e.g., firing rate, firing voltage, or pulse width) in response to sensed temperatures because it is a logical way of regulating the substrate temperature using existing printhead components and thereby reducing costs. In other words, because the heater arrays are already being used for firing ink

and are connected using existing integrated circuitry, one could avoid the additional costs of adding more components simply to perform a "warming" function.

487. Additionally, a PHOSITA would recognize additional advantages of incorporating Giere673's temperature logic system 606 system into Yabe. For example, according to Giere673, because "the temperature logic system 606 therefore acts as a predictive system for maintaining the substrate at an optimum temperature for producing ink droplets," "the quality of the ink droplets will be increased." Ex.1005 at 9:30-33. Furthermore, "since the firing system limits the rate, voltage or pulse width of firing of heater elements, less energy will be used" and, as such, "the printhead assembly 102 will be easier to maintain with less residue being deposited on the heater array 611 or in the chamber array 612 or the nozzle array 614." Ex.1005 at 9:33-38.

488. Accordingly, based on the above, it is my opinion that Giere678 discloses wherein the first heater array (e.g., Heater Array B) and the second heater array (e.g., Heater Array C) are operable to receive heating (e.g., firing rate, firing voltage, or pulse width) responsive to the temperature of the region sensed by the temperature sensing element (TSR), and wherein the received heating regulates the temperature of the region.

7. 1[F] "a third heater array positioned substantially adjacent the second via"

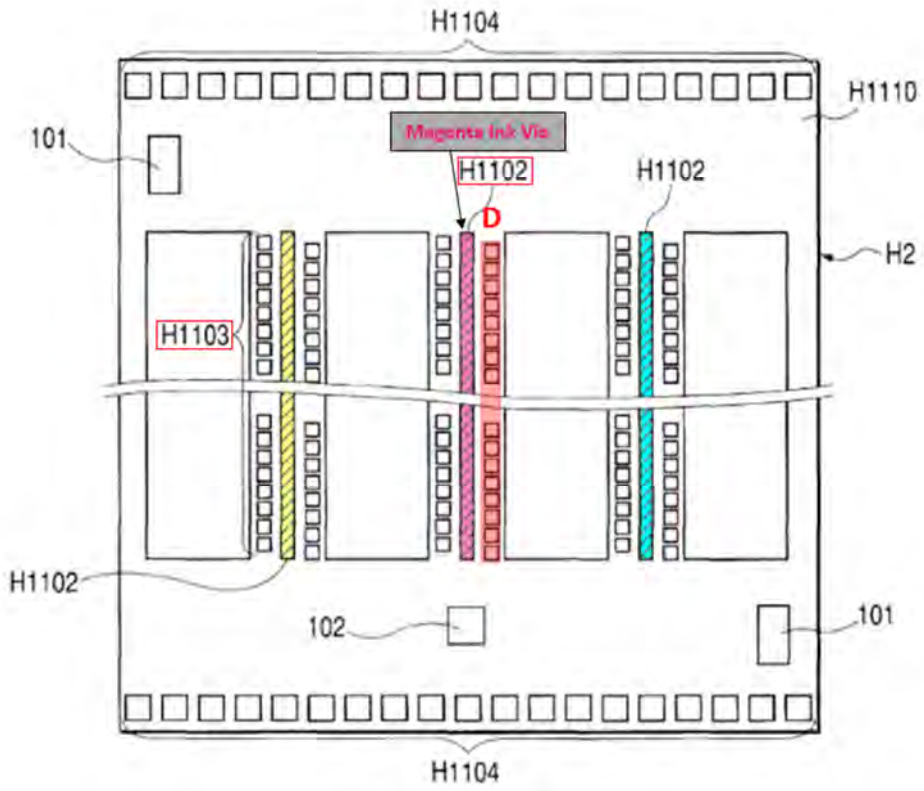
489. Claim 1 of the '823 Patent further recites "a third heater array positioned substantially adjacent the second via." In my opinion, Yabe discloses this limitation.

490. As discussed above in Section XIV.A.2 and incorporated here, Yabe discloses a chip having six arrays of heaters (i.e., **electrothermal converting devices H1103**) and a plurality of ink vias (i.e., **ink supply ports H1102**) arranged parallel to one another.

491. Yabe discloses that its electrothermal converting devices (heaters) H1103 are arranged in a line (e.g., an array) substantially adjacent a second via. As illustrated in corresponding Figure 14 below, a line of electrothermal converting devices H1103, i.e., Heater Array D (*pink*), is substantially adjacent a second ink via (e.g., magenta ink via H1102).

Ex.1008, Fig. 14

FIG. 14



492. A PHOSITA would understand that Yabe's electrothermal converting devices H1103 (e.g., Heater Array D, *pink*) are positioned substantially adjacent a second ink via (e.g., magenta ink supply port H1102) because the array of heaters are lying next to the ink supply port.

493. Accordingly, it is my opinion that Yabe discloses "a third heater array [e.g., electrothermal converting devices H1103, Heater Array D] positioned substantially adjacent a second via [e.g., magenta ink supply port H1102]."

8. 1[G] "a fourth heater array, positioned substantially adjacent a third via"

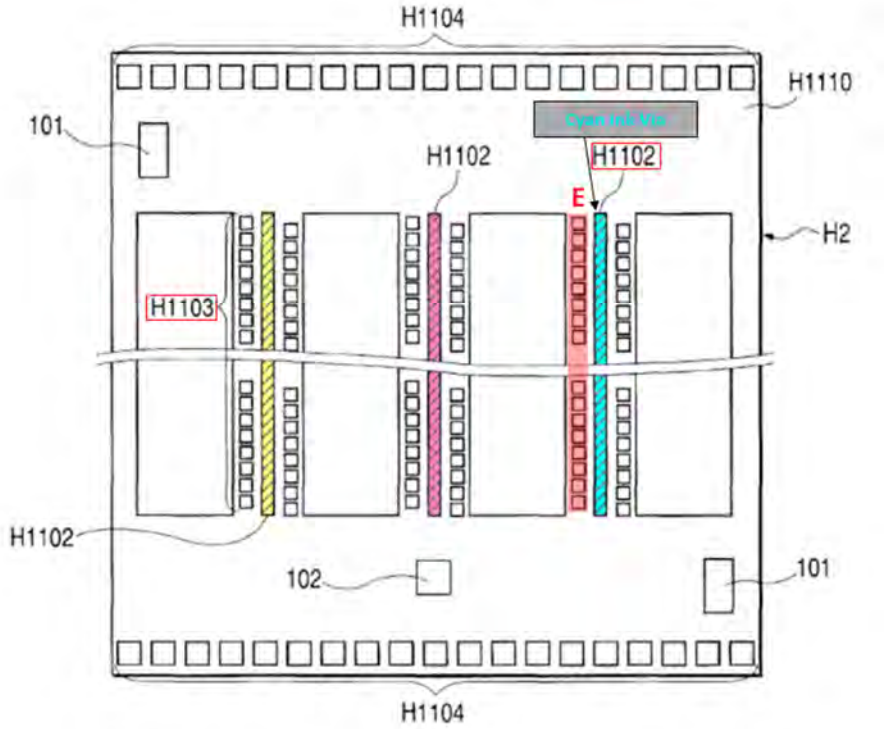
494. Claim 1 of the '823 Patent further recites "a fourth heater array, positioned substantially adjacent a third via." In my opinion, Yabe discloses this limitation.

495. As discussed above in Section XIV.A.2 and incorporated here, Yabe discloses a chip having six arrays of heaters (i.e., **electrothermal converting devices H1103**) and a plurality of ink vias (i.e., **ink supply ports H1102**) arranged parallel to one another, each of the ink via having two longitudinal sides.

496. Yabe discloses that its electrothermal converting devices (heaters) H1103 are arranged in a line (e.g., an array) substantially adjacent a third via. As illustrated in corresponding Figure 14 below, a line of electrothermal converting devices H1103, i.e., Heater Array E (*pink*), is substantially adjacent a third ink via (e.g., cyan ink via H1102).

Ex.1008, Fig. 14

FIG. 14



497. A PHOSITA would understand that Yabe's electrothermal converting devices H1103 (e.g., Heater Array E, pink) are positioned substantially adjacent a third ink via (e.g., cyan ink supply port H1102) because the array of heaters are lying next to the ink supply port.

498. Accordingly, it is my opinion that Yabe discloses "a fourth heater array [e.g., electrothermal converting devices H1103, Heater Array E] positioned substantially adjacent a third via [e.g., cyan ink supply port H1102]."

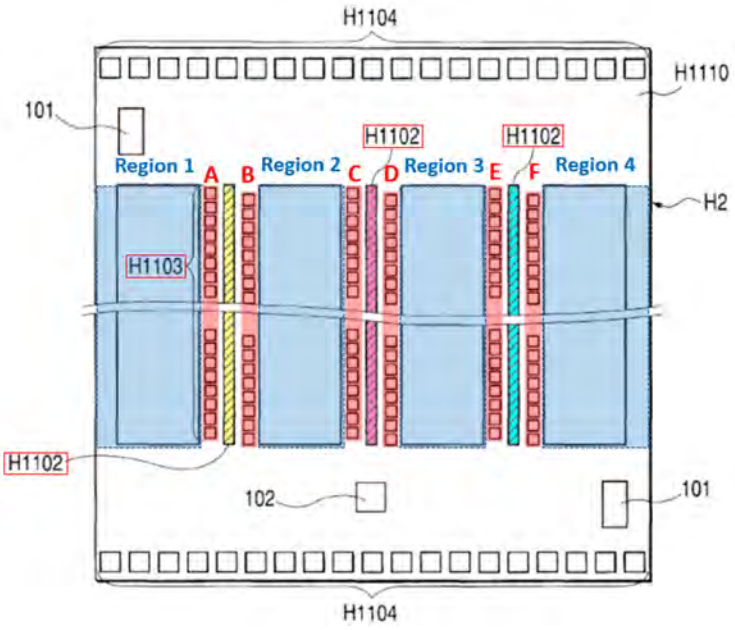
9. 1[H] "a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array"

499. Claim 1 of the '823 Patent further recites "a second region, positioned between the third heater array and the fourth heater array, and also positioned substantially immediately adjacent to the third heater array and the fourth heater array." In my opinion, Yabe discloses this element.

500. As illustrated in Figure 14 below, Yabe discloses four regions [Regions 1, 2, 3, and 4, **blue**] adjacent each heater array (e.g., electrothermal converting devices H1103) and situated either between two ink vias (e.g., ink supply ports H1102) or between an ink via and an edge of the silicon substrate (H1110). As illustrated, each region [**blue**] is also adjacent each heater array (e.g., electrothermal converting devices H1103 [*pink*]).

Ex.1008, Fig. 14

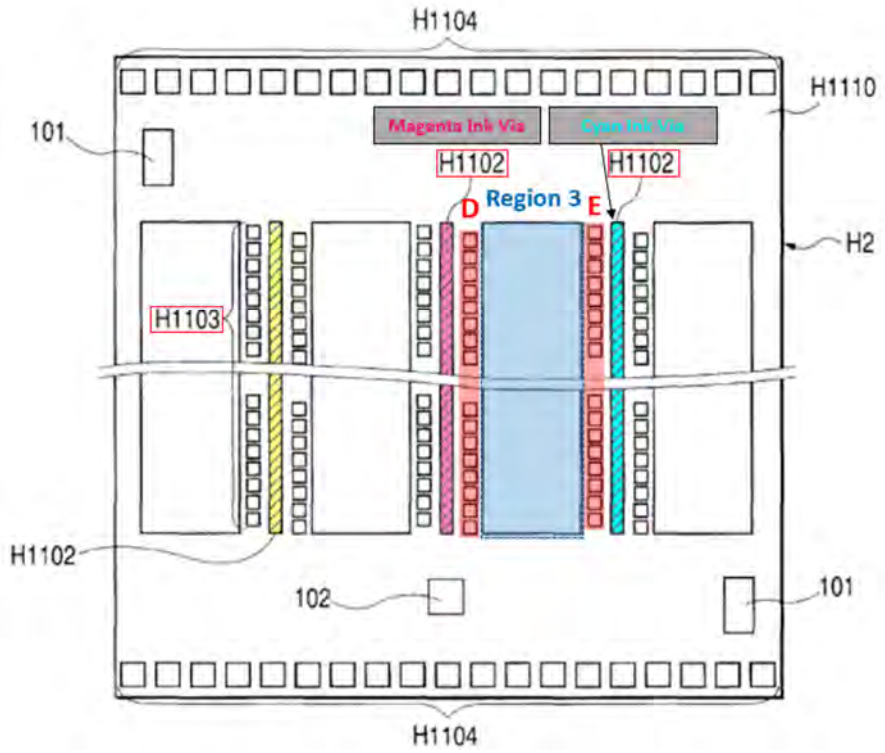
FIG. 14



501. As shown below in Figure 14, Yabe discloses a region (e.g., **Region 3**, blue) positioned between the third heater array (e.g., Heater Array D, pink) and the fourth heater array (e.g., Heater Array E, pink), and also positioned substantially adjacent to the first heater array (e.g., Heater Array D, pink) and the second heater array (e.g., Heater Array E, pink).

Ex.1008, Fig. 14

FIG. 14



502. A PHOSITA would understand that because Yabe discloses three ink supply ports in parallel with heaters formed on both sides of each ink supply port there will be a substrate region located between supply ports and corresponding heaters, as illustrated in Yabe's Figure 5 and Figure 14 (above). Ex.1008 at 8:46-51 ("[t]hree ink supply ports H1102 are formed in parallel, and electrothermal converting devices H1103 and ink discharge ports H1107 are formed on both sides having each of the ink supply ports H1102 between them.").

503. A PHOSITA would understand that Yabe's Region 3 is positioned substantially adjacent to the third heater array (Heater Array D) and the fourth heater array (Heater Array E) because the region is lying next to each of the third and fourth heater arrays. *See* Section XIV.A.2.

504. Accordingly, it is my opinion that Yabe discloses a second region (e.g., Region 3, blue) positioned between the third heater array (e.g., Heater Array D, pink) and the fourth heater array (e.g., Heater Array E, pink), and also positioned substantially adjacent to the third heater array (e.g., Heater Array D, pink) and the fourth heater array (e.g., Heater Array E, pink).

10. 1[I] "a second temperature sensing element operable to sense the temperature of the second region, wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array"

505. Claim 1 of the '823 Patent further recites "a second temperature sensing element operable to sense the temperature of the second region, wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array." In my opinion, Yabe combined with Giere673 discloses this limitation.

506. As discussed above in Section XIV.A.5 and incorporated here, Yabe discloses "temperature detecting means" and states that "there should be provided

means for measuring the temperature of the heater board more efficiently in accordance with the temperature characteristics obtainable by temperature detecting means, as well as means for controlling the temperature of the heater board efficiently in accordance with such measurement information." 3:45-54. Although Yabe discloses one or more "temperature detecting means 102" (*green*) on silicon base plate H1110 for detecting temperature on the heater board, it does not *explicitly* teach disposing "temperature detecting means 102" substantially centrally with respect to the region substantially adjacent to both the third heater array and the fourth heater array and further extending substantially the length of the arrays. It is my opinion that a PHOSITA would have looked beyond Yabe and considered Giere673 because it is analogous art for the reasons described in Section XIV.P.

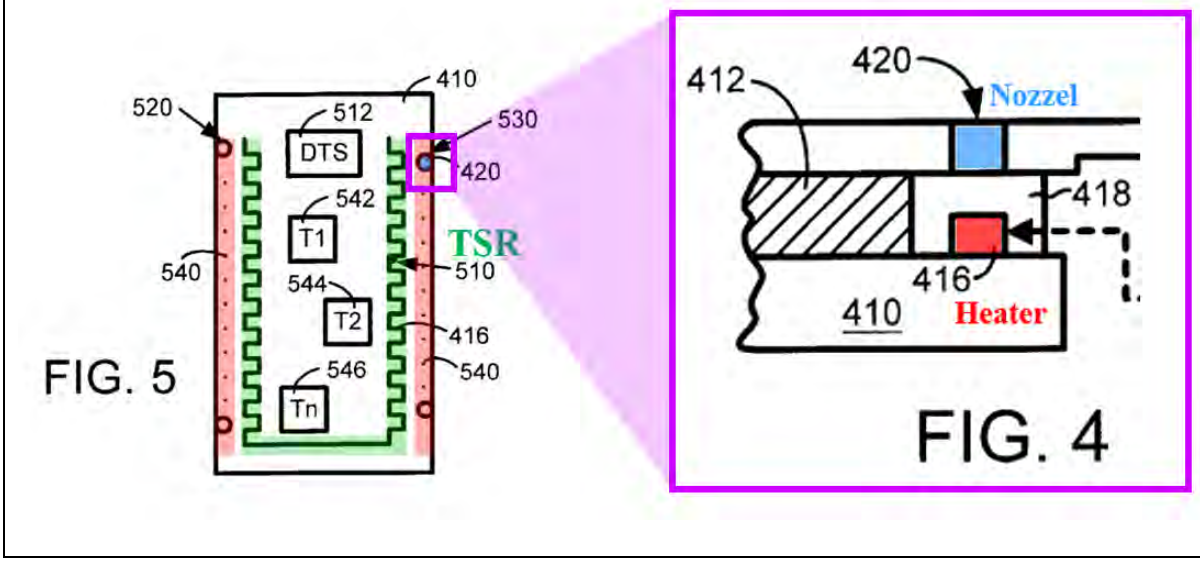
a. 1[i1] "a second temperature sensing element operable to sense the temperature of the second region"

507. It is my opinion that Yabe combined with Giere673 in the manner described in Section XIV.P below (the Yabe-Giere673 combination) also discloses a second temperature sensing element operable to sense a temperature of a second region, as required by this claim.

508. For example, as discussed above, Giere673's TSR 510 "preferably is not located adjacent to any particular heating element [e.g., ink ejection elements 416 in FIGs. 4 and 5, red] and reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005 at 4:57-59. As one

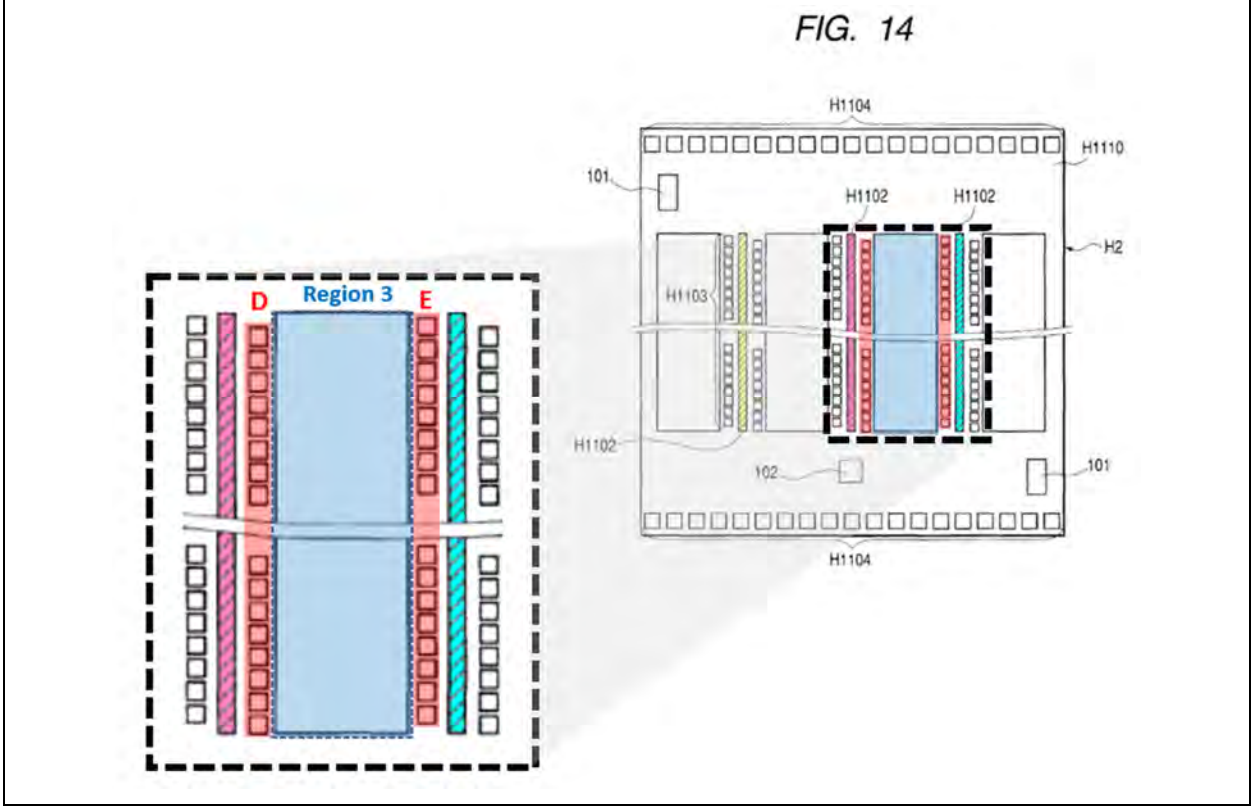
example, Giere673 teaches that the "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are approximately 680 µm inboard from the center of the columns of ink ejection elements 416," [red in Figs. 4 and 5]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12.

Ex.1005, Figs. 4 and 5



509. Since Giere673's ink ejection elements 416 and 520 (red) form a column that runs along each longitudinal side of the ink vias similar to how Yabe's heaters (electrothermal converting devices H1103) form a heater array along each longitudinal side of the ink supply ports, a PHOSITA would know to place Giere673's TSR 510 in a similar location within each region of Yabe's silicon base plate H1110 by positioning a single TSR 510 at least approximately 680 µm inboard from the center of the heater arrays, as shown below. Ex.1005 at 5:5-12.

Ex.1008, Fig. 14 (Annotated)

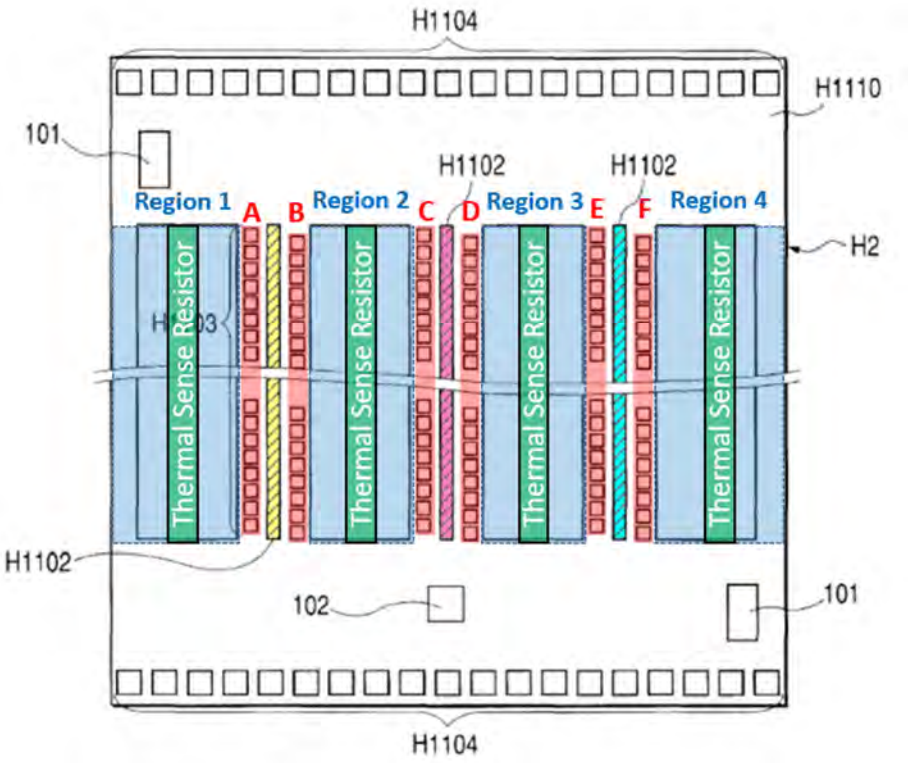


510. Moreover, for the reasons discussed above in XIV.A.5 and incorporated here, to regulate the operational temperature of Yabe's printhead die and optimize the printing quality of the inkjet printing device, it is my opinion that a PHOSITA would have further configured Yabe to determine a mean temperature of the ***entire printhead die*** by disposing a single TSR within each of the regions [e.g., Region 1, 2, 3, and 4, blue below] so that the temperature value *collectively* provided by the TSRs within Regions 1-4 reflect the mean temperature of Yabe's printhead die, as illustrated below. Moreover, for the reasons discussed above in XIV.A.5 and incorporated here, a PHOSITA would have been further motivated to modify Yabe's

printhead die by disposing a single temperature sensor within each other region so that the TSRs collectively regulate temperature on a per-color basis.

Ex.1008, Fig. 14

FIG. 14

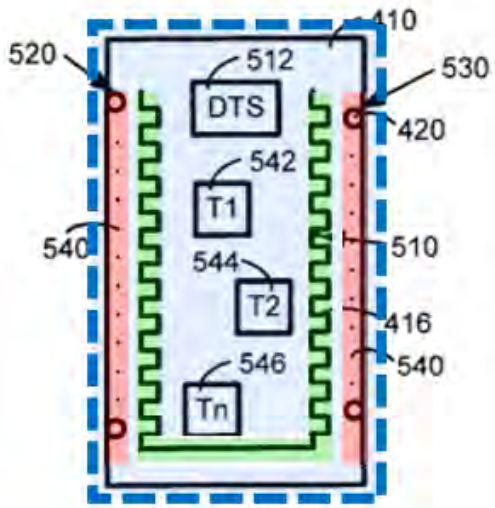


511. As such, in my opinion, Yabe alone or combined with Giere673 (Yabe-Giere673 Combination), discloses a second temperature sensing element operable to sense a temperature of the second region for the reasons discussed above.

b. 1[i2] "wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array"

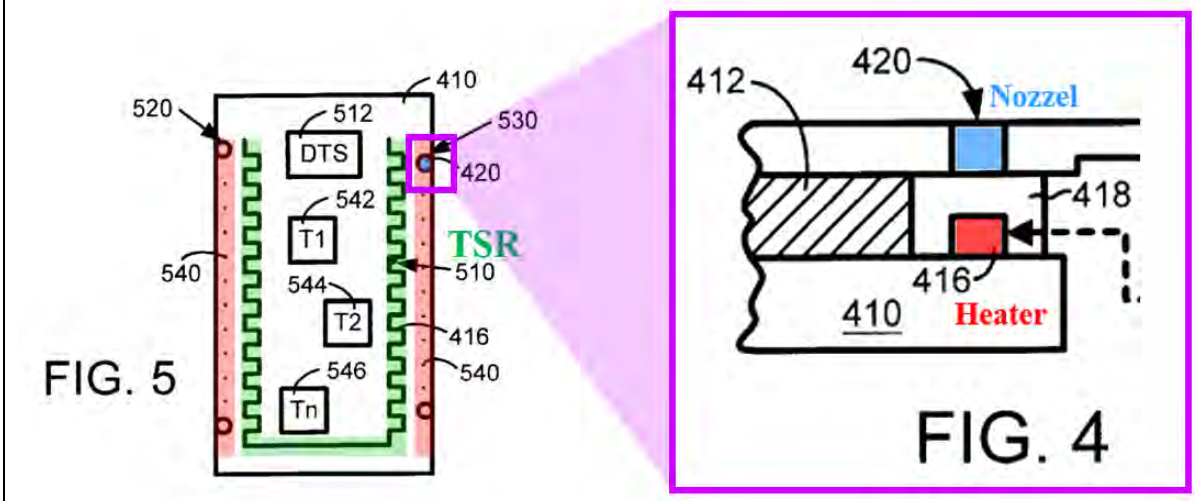
512. It is also my opinion that Yabe combined with Giere673 discloses that the second temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array.

513. Upon review of Figure 5 of Giere673, a PHOSITA would have understood that the temperature sense resistor (i.e., TSR 510 green below) is at least in substantially centrally disposed—if not exactly in the centre—of the region disposed between the two heater arrays (i.e., two vertical rows of heating elements 416), especially since Giere673 states that "[p]referably, [TSR 510] is not located adjacent to any particular heating element and reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." EX.1005 at 4:57-61.

Ex.1005, Fig. 5


514. As discussed above in Section XIV.A.5.b and incorporated here, upon further review of Figure 5 of Giere673, a PHOSITA would have understood that the temperature sense resistor (i.e., TSR 510 green) is at least substantially adjacent to *both* the first heater array and second heater array. Giere673 discloses that its printing system 100 includes "a temperature control system 110" that is "coupled to at least one measurement sensor"—namely, "a thermal sense resistor (TSR) 510" [*green in FIG. 4 below*] that "can be used to provide an approximation of the mean temperature of the substrate" 410. Ex.1005 at 2:50, 4:51-56. According to Giere673, TSR 510 "preferably is not located adjacent to any particular heating element [*e.g., ink ejection elements 416 in FIGs. 4 and 5, red*] and reflects the temperature of the substrate 410 ***after*** heat has ***moved from*** the heating elements to the TSR 510." Ex.1005 at 4:57-59. As one example, Giere673 teaches that TSR 510 "can have two legs that are approximately 680 μm inboard from the center of the columns of ink ejection elements 416 [*red in Figs. 4 and 5*]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12. As such, Giere673 teaches that its TSR 510 is not located adjacent either the left *or* right columns of ejection elements 416 (red in Figs. 4 and 5) but instead is positioned near or close to *both* columns of ink ejection elements so as to detect the mean temperature of the substrate as affected by the heat generated by both columns of ink ejection elements.

Ex.1005, Figs. 4 and 5



515. In addition, as discussed above in Section XIV.A.5 and incorporated here, it is also my opinion that a PHOSITA, through routine experimentation, would have eventually positioned the TSR in substantially the centre of the region and substantially adjacent to both the third heater array and fourth heater array. Indeed, I submit that it was common knowledge during the relevant time period to position temperature sensors away from any particular heater array and in the center of region being measured. *See, supra*, XIII.I.

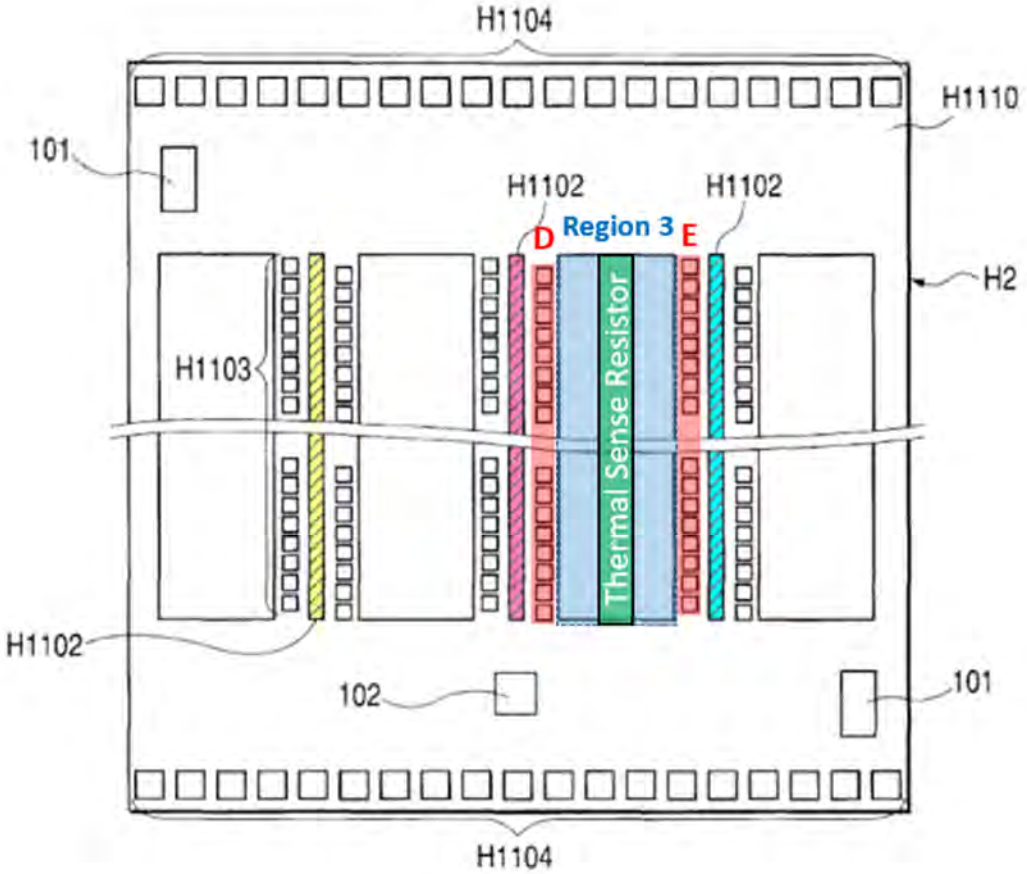
516. It is also my opinion that a PHOSITA would understand that it was logical to put the TSR in substantially the centre of the region and substantially adjacent to both the third heater array and fourth heater array because the high thermal conductivity and large cross-sectional area of the silicon base material between ink vias would cause those regions to rapidly reach an equilibrium

temperature, allowing one sensor in the middle of such regions to adequately measure the temperature.

517. As discussed above, since Giere673's ink ejection elements 416 and 520 form a column that runs along each longitudinal side of the ink vias similar to how Yabe's heaters (electrothermal converting devices H1103) form a heater array along each longitudinal side of the ink supply ports, a PHOSITA would know to place Giere673's TSR 510 in a similar location within each region of Yabe's silicon base plate H1110 by positioning a single TSR 510 substantially centrally disposed with respect to each region and substantially adjacent to both the third heater array (Heater Array D, pink) and fourth heater array (Heater Array E, pink), as shown below

Ex.1008, Fig. 14

FIG. 14



518. Accordingly, it is my opinion that Yabe combined with Giere673 discloses a second temperature sensing element [*e.g.*, TSR 510] operable to sense a temperature of the second region [*e.g.*, Region 3, blue], wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array [*e.g.*, Heater Array D, pink] and fourth heater array [*e.g.*, Heater Array E, pink].

11. 1[J] "the third heater array and the fourth heater array are operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region"

519. Claim 1 of the '823 Patent further recites wherein "the third heater array and the fourth heater array are operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region." Although Yabe discloses one or more "temperature detecting means 102" on silicon base plate H1110 for detecting temperature on the heater board, Yabe does not *explicitly* teach using the temperature sensed by "temperature detecting means 102" to regulate the temperature of the regions of the silicon base plate H1110 using the third and fourth heater arrays. However, it is my opinion that Giere673 discloses this limitation.

520. As discussed above in Section XIV.A.6 and incorporated here, Giere673's "**temperature controller 110 aids in controlling the temperature of the substrate** and the temperature of each ejection chamber or nozzle chamber" which "results in improved print quality and printhead life because the printhead 102 will consequently operate closer to its optimum temperature." Ex.1005 at 3:7-12. Specifically, Giere673 discloses that temperature controller 110 uses a closed loop method wherein in response to the temperature of the region sensed by the temperature sensing elements generating "printing parameters," including pulse

widths to heaters and warming using non-ejecting devices, that are used to regulate the substrate temperature. As illustrated in Fig. 6A (below), temperature controller 110 includes "temperature logic system 606 (*teal*)" that generates various printing parameters. Ex.1005 at 6:21-28. According to Giere673, during operation of the printhead, an actual temperature profile is created that includes the current temperature of the substrate. Giere673 discloses that the "temperature logic system uses these temperature and printing inputs…to generate printing parameters and then output them in a closed loop system to the actual substrate temperature profile 610." Ex.1005 at 6:46-52. Giere673 further explains that the "printing parameters can include **pulse widths, pulse rates, ink ejection chambers 418 to be fired and when they will be fired, warming using non-ejecting devices, and firing voltages** that act as the inputs for the actual substrate temperature profile 610." Ex.1005 at 6:52-57. Moreover, "[s]ince a true temperature profile is difficult to measure, this closed loop method allows approximation of a temperature profile to improve ink drop quality." *Id*. at 6:57-59. Giere673 also stets that "[w]hen the **sensors detect that the mean temperature** of the substrate has dropped below a predefined baseline or threshold temperature, the **loop activates the heating elements** in an effort to raise the substrate above the baseline temperature before printing." *Id*. at 2:66-3:3

Ex.1005, Fig. 6A

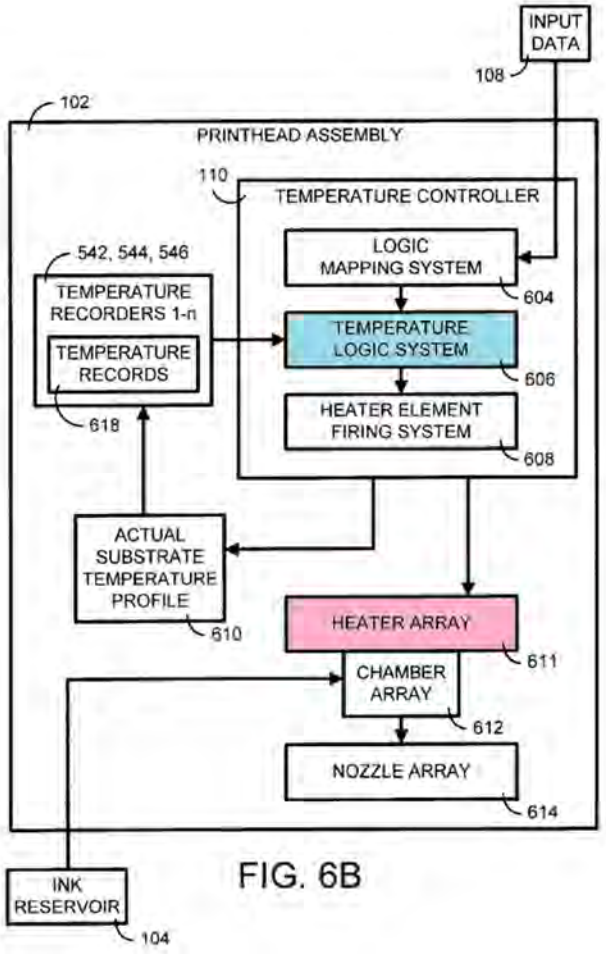


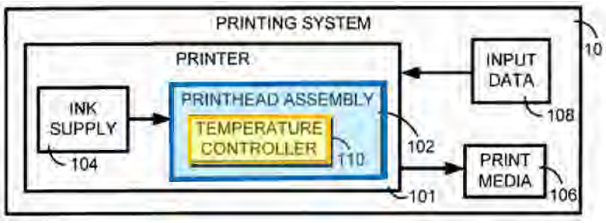
FIG. 6B

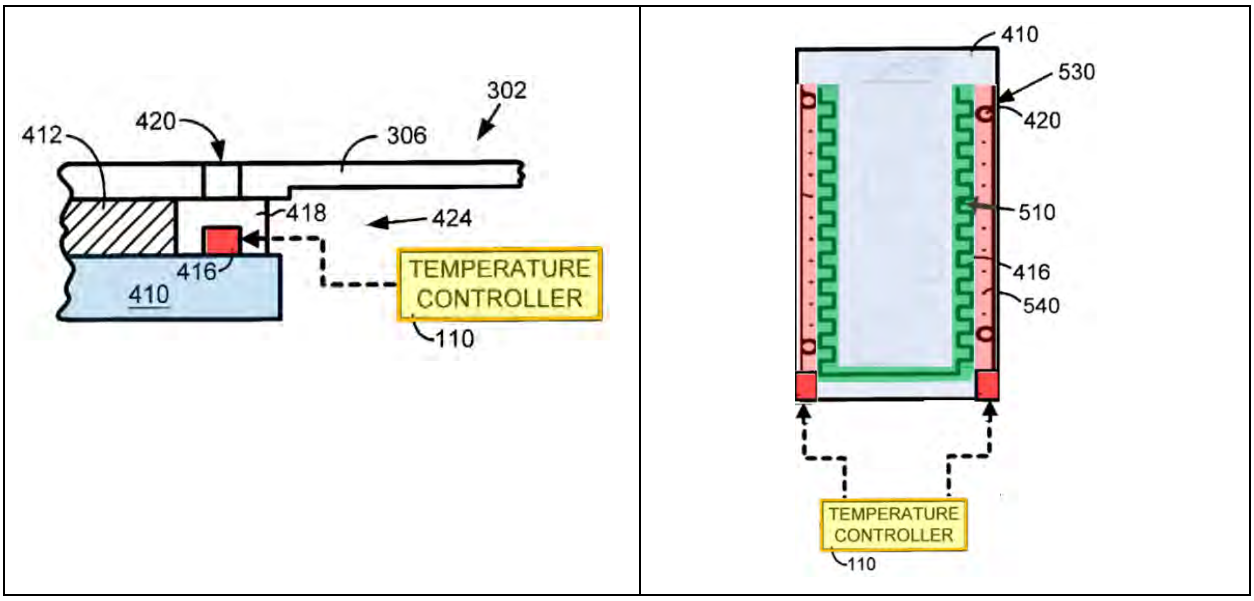
521. In my opinion, just like the first and second heater arrays discussed above in limitation 1[E] (*see* Section XIV.A.6), the third heater array (e.g., Heater Array D) and the fourth heater array (e.g., Heater Array E) are also operable to receive heating responsive to the temperature of the second region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region. Accordingly, it is my opinion that Giere673 discloses this limitation.

B. Claim 2

522. Claim 2 of the ’823 patent depends from Claim 1. The Yabe-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 2 further adds: “wherein the temperature sensing element comprises a temperature sensing resistor.” In my opinion, the Yabe-Giere673 Combination discloses this limitation.

523. Giere673 discloses that the “temperature controller 110” on the printhead assembly (green in FIGs. 1 and 4 below) is coupled to a “measurement sensor” that may comprise “a thermal sense resistor (TSR) 510” (green in FIG. 5 below) to sense the mean temperature of a region on the substrate 410. Ex.1005 at 4:49-55. A thermal sense resistor is a commonly used temperature sense resistor. Ex.1005 at 4:54-55. Indeed, Giere673 teaches that “[o]ne or multiple TSRs 510 can be used to provide an approximation of the mean temperature of the substrate.” Ex.1005 at 4:55-56.

Ex.1005, Figs. 1 and 4	Ex.1005, Fig. 5
	



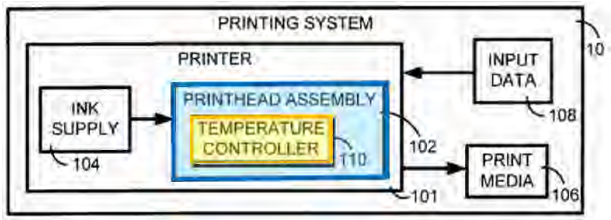
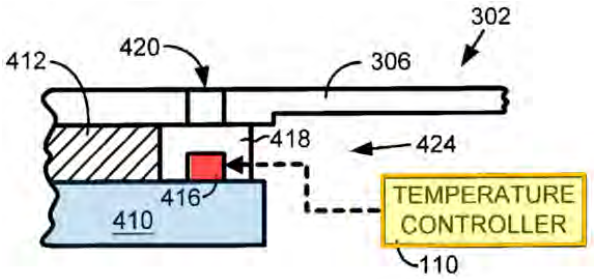
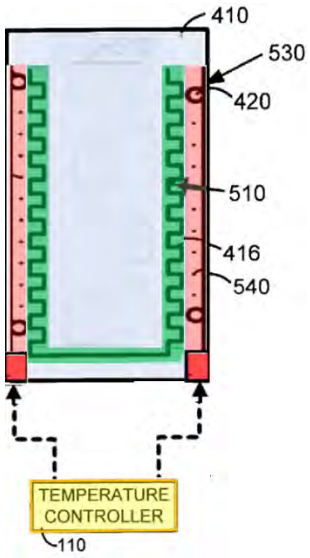
524. Therefore, it is my opinion that the Yabe-Giere673 combination discloses that "the temperature sensing element [i.e., measurement sensor] comprises a temperature sensing resistor [i.e., TSR 510]."

C. Claim 3

525. Claim 3 of the '823 patent depends from Claim 2. The Yabe-Giere673 Combination discloses Claim 2 for the reasons discussed above. Claim 3 further adds: "wherein the temperature sensing element comprises a thermal sense resistor." In my opinion, the Yabe-Giere673 Combination discloses this limitation.

526. Giere673 discloses that the "temperature controller 110" on the printhead assembly (green in FIGs. 1 and 4 below) is coupled to a "measurement sensor" that may comprise "a thermal sense resistor (TSR) 510" (green in FIG. 5 below) to sense the mean temperature of a region on the substrate 410. Ex.1005 at

4:49-55. Giere673 teaches that "[o]ne or multiple TSRs 510 can be used to provide an approximation of the mean temperature of the substrate." Ex.1005 at 4:55-56.

Ex.1005, Figs. 1 and 4	Ex.1005, Fig. 5
 	

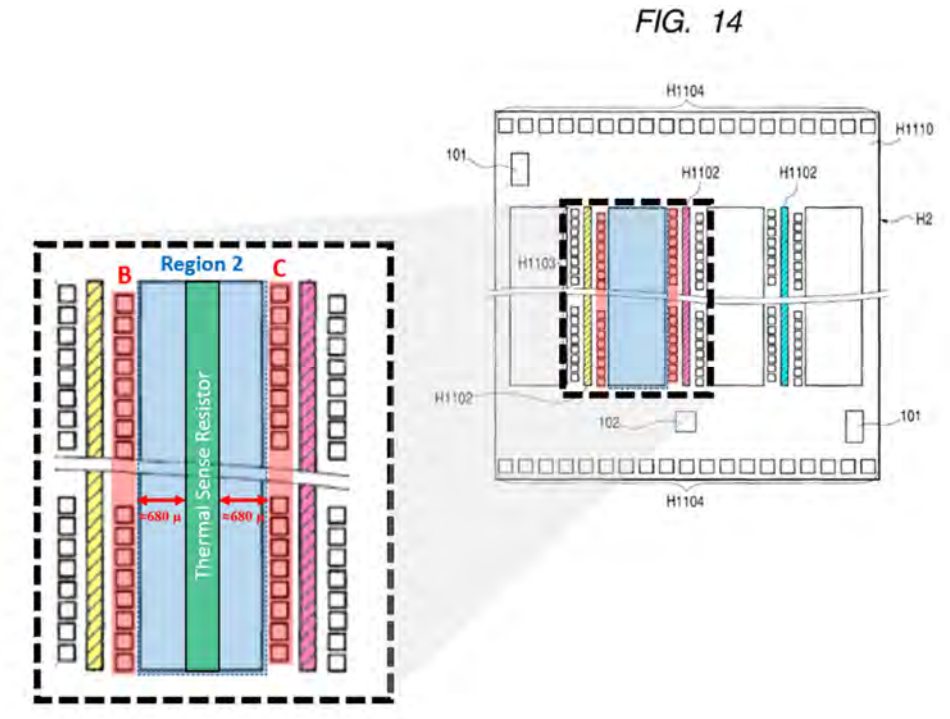
527. Therefore, it is my opinion that the Yabe-Giere673 combination discloses that "the temperature sensing element [*i.e.*, measurement sensor] comprises a thermal sense resistor [*i.e.*, TSR 510]."

D. Claim 5

528. Claim 5 of the '823 patent depends from Claim 1. The Yabe-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 5 further adds: "wherein the temperature sensing element is positioned at least 300 microns from each of the first heater array and the second heater array." In my opinion, the Yabe-Giere673 Combination discloses this limitation.

529. Giere673 discloses that "[t]he TSR 510 can have two legs that are **approximately 680 µm inboard from the center of the columns of ink ejection elements 416**." Ex.1005 at 5:10-12. Since 1 µm (micrometer) is equal to 1 µ (micron), Giere673 teaches positioning the TSR 510 approximately 680 microns from the center of the columns of ink ejection elements 416, which a PHOSITA would recognize as being the "drop generators 60 disposed along each of the opposing ink feed slot sides," as shown in my illustration below.

Ex.1008 (The Yabe-Giere673 Combination)



530. Therefore, it is my opinion that the Yabe-Giere673 combination discloses that "the temperature sensing element is positioned at least 300 microns

[*i.e.*, approximately 680 microns] from each of the first heater array and the second heater array.

E. Claim 6

531. Claim 6 of the ’823 patent depends from Claim 1. The Yabe-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 6 further adds: “wherein the temperature sensing element is positioned substantially planar to each of the first heater array and the second heater array.” In my opinion, the Yabe-Giere673 Combination discloses this limitation.

532. Yabe teaches recording element components are formed on the same silicon base plate (heater board). For example, Yabe discloses that “[i]n the same manner as forming the first recording element base plate H1100, the ink supply ports H1102, electrothermal converting devices H1103, electric wiring, electrodes H1104, and others are **formed on the Si base plate H1110**….” Ex.1008 at 8:51-55; *see also* Ex.1008 at 8:13-16 (“Si base plate H1110 has the crystal orientation of <100> in the wafer direction, and the crystal orientation of <111> in the thickness direction”).]. As illustrated in Yabe’s Figures 12 and 14 below, Yabe also discloses that “temperature sensing means 102” (green) are formed on the same silicon base plate H1110 with Yabe’s electrothermal converting devices H1103 (i.e., heat generating resistive elements). 14:37-32 (“As described above, for the **base plate (heater board) of the ink jet recording head, having thereon the heat generating**

resistive elements and wiring circuits described with reference to FIGS. 1A and 1B, and FIG. 2 to FIG. 11, **there are provided temperature detecting means for detecting the temperature of the heater board**…"); Ex.1008, Figs. 5, 12, 14.

Ex.1008, Fig. 12

FIG. 12

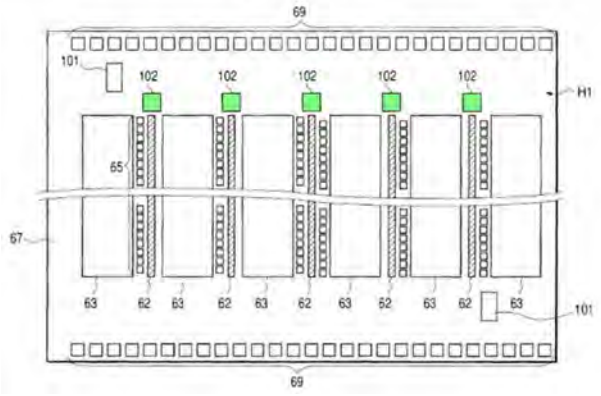
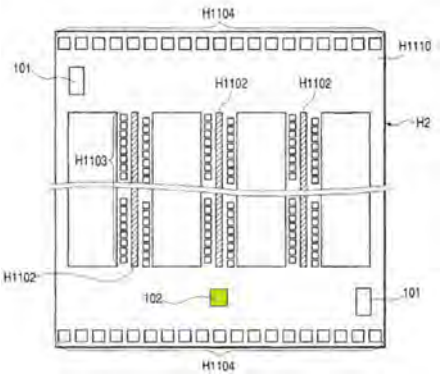


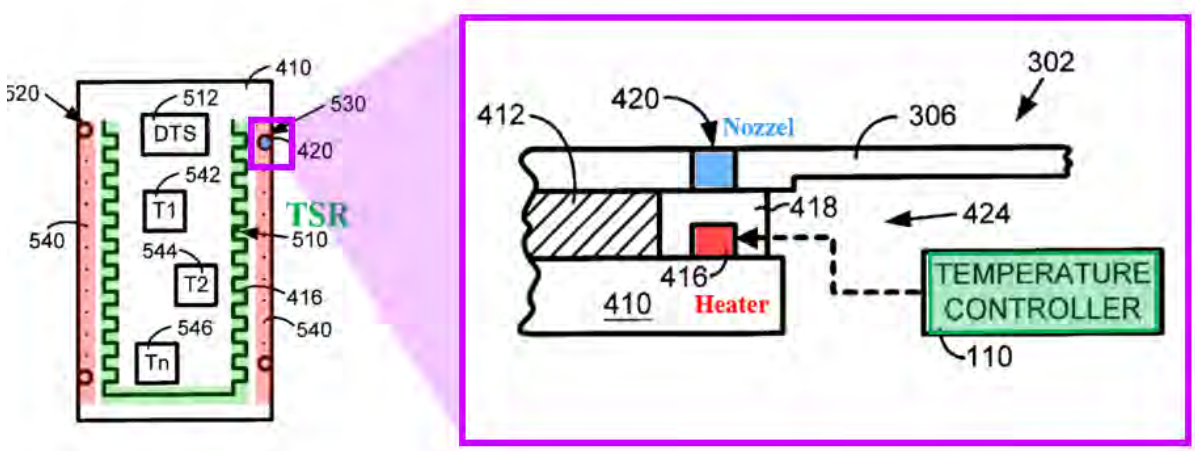
FIG. 14



533. Additionally, as I explained above, Giere673 positions the TSR 510 (*green*) at a predetermined distance away from each of the two adjacent heating elements 416 within that region—*i.e.*, "approximately 680 µm ***inboard from*** the center of the columns of ink ejection elements 416," which means that the TSR 510 must be substantially planar to the ink ejection elements 416, at least under 823 Patent's definition of that term. Ex.1005, 5:11-12. Figures 2 and 4 of Giere673 confirm that TSR 510 is substantially planar to each column of firing elements 416 because Figure 5 shows the right leg of TSR 510 (*green*) spaced apart from nozzle 530 (*blue*) and Figure 4 shows firing elements 416 (*red*) directly under the nozzle

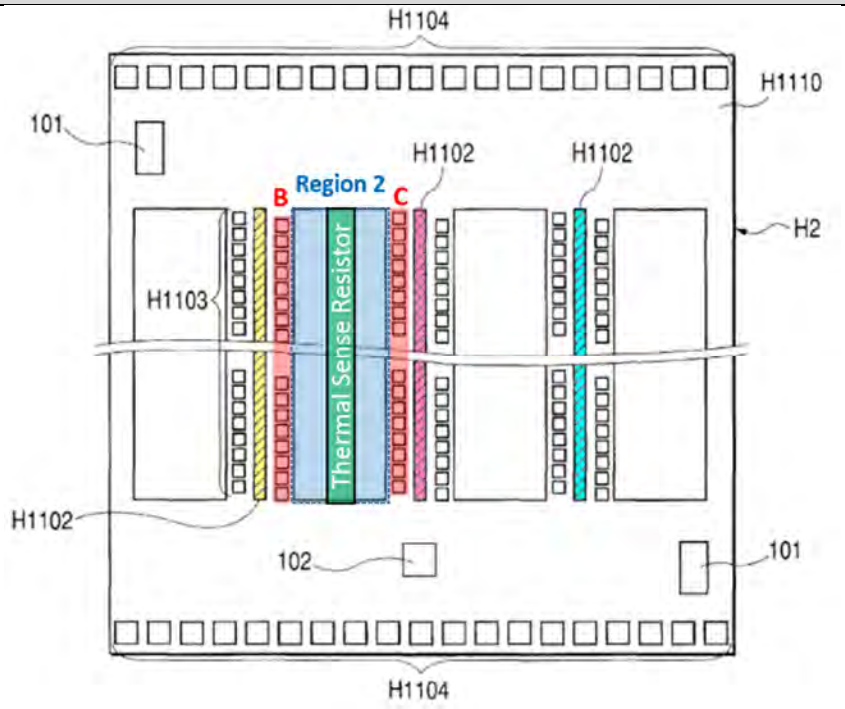
420 (*blue*), which means that TSR 510 is *substantially planar* because it is not "positioned directly above the [] heater arrays." Ex.1001, 3:15-16

Ex.1005, Figs. 4 and 5



534. When adding Giere673's TSRs 510 to Yabe's silicon base plate H1110, a PHOSITA would likewise position the TSRs along the length of the substrate … approximately 680 microns inboard from the center of the columns of "electrothermal converting devices H1103," so that the TSR (*green*) in the region between the yellow and magenta ink supply ports H1102, for example, is positioned substantially planar to the first heater array (e.g., Heater Array B) and the second heater array (e.g., Heater Array C), as shown in my illustration below.

Ex.1008, Fig. 14



535. A PHOSITA would also know to position the TSR in that location because Yabe teaches both electrothermal converting devices H1103 and its own temperature sensing means 102 on the same silicon base plate (H1110), thereby allowing the TSR to be positioned *substantially* planar to the heater arrays (electrothermal converting devices H1103) within each region, particularly given that the ’823 Patent treats “substantially planar” to mean “the temperature sensing element is not positioned directly above the first or second heater arrays.” Ex.1001 at 3:11-13. Alternatively, it would be obvious to a PHOSITA to position the temperature sensing element in substantially the same plane as the first and second

heater arrays as doing so would reduce manufacturing costs and time required to manufacture the printhead die.

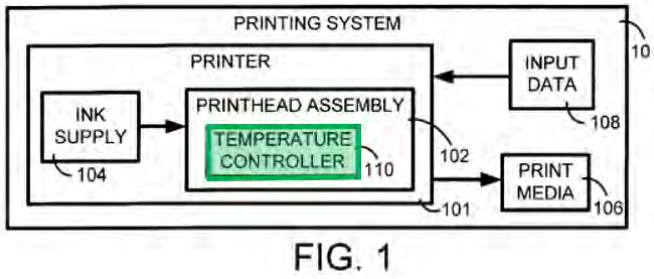
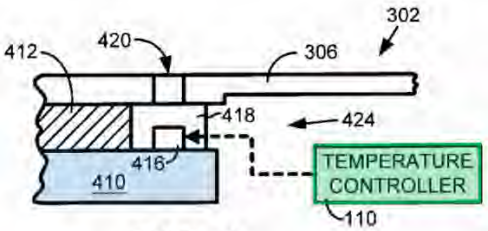
536. Therefore, it is my opinion that the Yabe-Giere673 combination further discloses that "the temperature sensing element [*i.e.*, TSR 510] is positioned substantially planar to each of the first heater array [e.g., Heater Array B] and the second heater array [e.g., Heater Array C]."

F. Claim 7

537. Claim 7 of the '823 patent depends from Claim 1. The Yabe-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 7 further adds: "at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array." In my opinion, the Yabe-Giere673 Combination discloses this limitation.

538. According to Giere673, the printing system 100 includes "a temperature control system 110 (*green*) for predicting dynamic thermal conditions of the printhead assembly 102," including "the substrate" (*blue*) Ex.1005 at 2:48-52; *see below id.* at Figs. 1 and 4. To control[] the temperature of the substrate and the temperature of each ejection chamber or nozzle chamber, Giere673 discloses that "[t]he temperature controller 110 is coupled to multiple temperature sensors (not shown)," which "determine, at a given time, a mean or ***average temperature of the***

substrate and an actual local temperature profile near designated ink ejection elements. Ex.1005 at 2:57-62. Thereafter, "[t]he temperature controller 110 uses the input data 108 [supplied by the temperature sensors] to predict thermal conditions of particular ejection chambers for selectively firing the associated heating elements." Ex.1005 at 3:1-6.

Ex.1005, Fig. 1	Ex.1005, Fig. 4
 FIG. 1	 FIG. 4

Ex.1005 at 2:62-65 ("The temperature controller 110 can be an integrated circuit, firmware, a software printer driver or the like which controls the mean temperature of the substrate of the printhead through a feedback loop (discussed in detail below).").

539. Figure 5 of Giere673 is "a top view of the substrate" and, when viewed together with Figure 4, confirms that that "the temperature controller 110 of FIG. 1 is coupled to at least one measurement sensor, such as "a thermal sense resistor (TSR) 510" that "provide[s] an approximation of the mean temperature of the substrate" to "the temperature controller 110," and the temperature controller 110

uses the mean temperature sensed by the TSR 510 "to control the temperature." Ex.1005 at 4:49-5:5.

540. Therefore, it is my opinion that the Yabe-Giere673 combination discloses that the heater chip further comprises "at least one control element [*i.e.*, temperature controller 110] operable to receive a temperature measured by the temperature sensing element [*i.e.*, TSR 510]."

G. Claim 8

541. Claim 8 of the '823 patent depends from Claim 1. The Yabe-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 8 further adds: "wherein the temperature sensing element positioned between the first heater array and the second heater array is different than the second temperature sensing element positioned between the third heater array and the fourth heater array." In my opinion, the Yabe-Giere673 Combination discloses this limitation

542. As discussed above in Section XIV.A.5 and incorporated here, the Yabe-Giere673 combination includes a single temperature sense resistor (TSR, green) in the region (Region 2) between the Heater Array B disposed along the right side of yellow ink feed slot H1102 and Heater Array C disposed along the left side of the magenta ink feed slot H1102, which the TSR senses to provides a temperature value for the second region. As discussed above in Section XIV.A.10 and incorporated here, the Yabe-Giere673 combination also includes a single

temperature sense resistor (TSR, green) in the region (Region 3) between the Heater Array D disposed along the right side of the magenta ink feed slot H1102 and Heater Array E disposed along the left side of the cyan ink feed slot H1102, which the TSR senses to provides a temperature value for the second region. As such, a PHOSITA would understand that the Yabe-Giere673 combination provides an independent TSR in each region of the Yabe printhead die. A PHOSITA would also understand that these TSRs are different than each other because they are in different regions of the printhead die, associated with different heater arrays, have different electrical connections, and produce different temperature measurements. A PHOSITA would also understand that that because ink vias act as temperature insulators they would independent temperature sensors in each region to measure and regulate each set of arrays.

543. Therefore, it is my opinion that the Yabe-Giere673 combination discloses that the heater chip further comprises that "the temperature sensing element positioned between the first heater array and the second heater array is different than the second temperature sensing element positioned between the third heater array and the fourth heater array."

H. Claim 9

544. Claim 9 of the '823 patent depends from Claim 1. The Yabe-Giere673 Combination discloses Claim 1 for the reasons discussed above. Claim 9 further

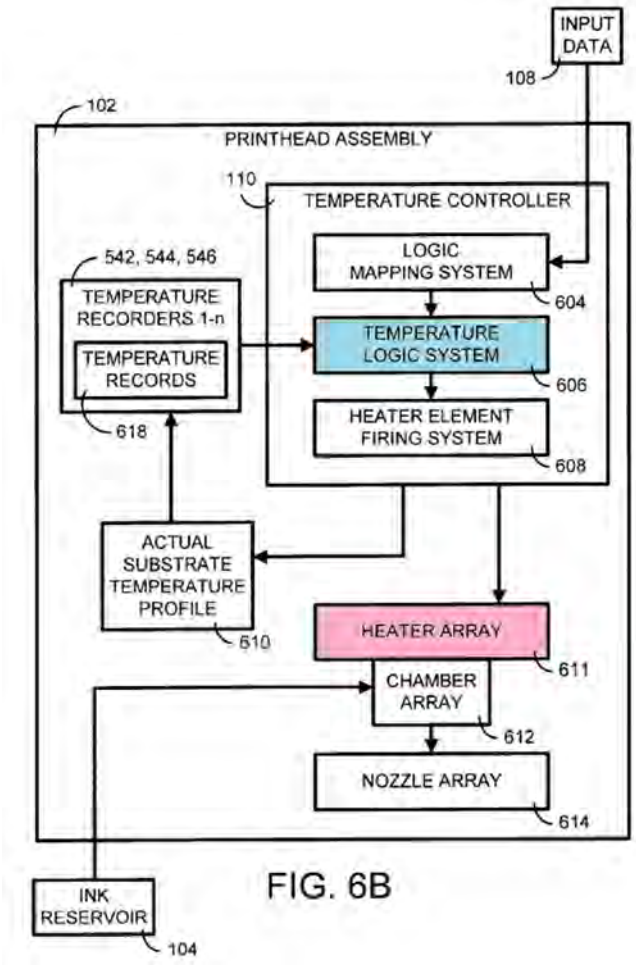
adds: “wherein the first heater array and the second heater array are operable to receive non-nucleating heating responsive to the temperature of the region sensed by the temperature sensing element.” It is my opinion that Yabe-Giere673 discloses this limitation.

545. It is my understanding that non-nucleating heating (NNH) can refer to a technique of applying short pulses to heater resistors, i.e., too short to eject an ink drop (nucleation), but sufficient to warm the substrate and ensure the heater chip operates at a desired temperature range. *See, e.g.*, Ex.1001 at 3:33-39. As discussed above in Section XIV.A.6 and incorporated here, Giere673’s “**temperature controller 110 aids in controlling the temperature of the substrate** and the temperature of each ejection chamber or nozzle chamber” which “results in improved print quality and printhead life because the printhead 102 will consequently operate closer to its optimum temperature.” Ex.1005 at 3:7-12. Specifically, Giere673 discloses that temperature controller 110 uses a closed loop method wherein in response to the temperature of the region sensed by the temperature sensing elements generating “printing parameters,” including pulse widths to heaters and warming using non-ejecting devices, that are used to regulate the substrate temperature. As illustrated in Fig. 6A (below), temperature controller 110 includes “**temperature logic system 606** (*teal*)” that generates various printing parameters. Ex.1005 at 6:21-28. According to Giere673, during operation of the

printhead, an actual temperature profile is created that includes the current temperature of the substrate. Giere673 discloses that the "temperature logic system uses these temperature and printing inputs…to generate printing parameters and then output them in a closed loop system to the actual substrate temperature profile 610." Ex.1005 at 6:46-52. Giere673 further explains that the "printing parameters can include **pulse widths, pulse rates, ink ejection chambers 418 to be fired and when they will be fired, warming using non-ejecting devices, and firing voltages** that act as the inputs for the actual substrate temperature profile 610." Ex.1005 at 6:52-57; *see also* Ex.1005 at 9:33-38 ("since the firing system limits the rate, voltage or pulse width of firing of heater elements, less energy will be used"). Giere673 then states that "**[t]his rate, width and order of firing are programmed, and if necessary, adjusted in the programming, so that the temperature of the heater array 611 [*pink, below*], and therefore the temperature of the ink in the chamber array 612, are maintained at an optimum temperature for the formation of ink droplets**." Ex.1005 at 9:13-18.

546. Thus, in my opinion, Giere673 discloses that the heaters receive non-nucleating heating (e.g., adjustments to pulse width) responsive to the sensed temperature.

Ex.1005, Fig. 6A



547. Moreover, like the ’823 Patent, Giere673 also discloses using a non-nucleating heating method to control its heating elements: “The temperature logic system also generates firing voltages 814 and **activates heater elements that do not eject ink 816**.” Ex.1005 at 9:18-20; *see also id*. at 6:52-57 (“**warming using non-ejecting devices**”).

548. Accordingly, based on the above, it is my opinion that Giere678 discloses wherein the first heater array (e.g., Heater Array B) and the second heater

array (e.g., Heater Array C) are operable to receive non-nucleating heating (e.g., adjustments to firing rate, firing voltage, or pulse width) responsive to the temperature of the region sensed by the temperature sensing element (TSR). Thus, it is my opinion that the Yabe-Giere673 Combination discloses Claim 9.

I. Claim 10

549. Claim 10 of the ’823 patent depends from Claim 9. The Yabe-Giere673 Combination discloses Claim 9 for the reasons discussed above. Claim 10 further adds: “wherein the non-nucleating heating is of a short duration such that ink will not be ejected from the first via or the second via during the non-nucleating heating.”

550. As discussed above in Sections XIV.A.6 and XIV.H and incorporated here, Giere673’s temperature controller 110 aids in controlling the temperature of the substrate by, for example, adjusting the pulse width to the heater arrays. As such, in my opinion, the first heater array (e.g., Heater Array B) and the second heater array (e.g., Heater Array C) are operable to receive non-nucleating heating (e.g., adjustments to firing rate, firing voltage, or pulse width) responsive to the temperature of the region sensed by the temperature sensing element (TSR).

551. It is further my opinion that the pulse width adjustments will be of a short duration such that ink will not be ejected from the heater arrays. For example, Giere673 specifically states that “[t]he temperature logic system also generates firing voltages 814 and **activates heater elements that do not eject ink 816**.” Ex.1005 at

9:18-20; see also id. at 6:52-57 ("warming using non-ejecting devices"). Giere673 also describes limiting, e.g., shortening, the pulse width. Ex.1005 at 9:33-38. ("since the firing system limits the rate, voltage or pulse width of firing of heater elements, less energy will be used").

552. Accordingly, based on the above, it is my opinion that Giere678 discloses wherein the non-nucleating heating (e.g., adjustments to firing rate, firing voltage, or pulse width) is of a short duration such that ink will not be ejected from the first via or the second via during the non-nucleating heating. Thus, it is my opinion that the Yabe-Giere673 Combination discloses Claim 10.

J. Claim 11

553. As shown below, the limitations of claim 11 mirror those of claim 1 and 7.

11[p]	A method of fabricating chips for use with a printing device, comprising	**1[p]**	A chip for use with a printing device
11[a]	providing a first heater array positioned substantially adjacent a first via;	**1[a]**	a first heater array positioned substantially adjacent a first via
11[b]	providing a second heater array positioned substantially adjacent a second via;	**1[b]**	a second heater array positioned substantially adjacent a first via
11[c]	positioning a temperature sensing element in a region adjacent to and immediately between the first heater array and the second heater array and	**1[c]**	a region positioned between the first heater array and the second heater array, and also positioned substantially adjacent to the first

	substantially adjacent to both the first heater array and second heater array; wherein the temperature sensing element is operable to sense a temperature of the region, the temperature being representative of the region and wherein the temperature sensing element extends substantially the length of the first heater array and second heater array;		heater array and the second heater array
		1[d]	a temperature sensing element operable to sense a temperature of the region, the temperature being representative of the region
		1[e]	wherein the temperature sensing element is substantially centrally disposed with respect to the region and substantially adjacent to both the first heater array and second heater array, and further extends substantially the length of the first heater array and second heater array
11[d]	responsive to the temperature of the region sensed by the temperature sensing element, heating the first heater array and the second heater array to regulate the temperature of the region;	**1[f]**	wherein the first heater array and the second heater array are operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region
11[e]	providing at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array;	**7**	at least one control element operable to receive a temperature measured by the temperature sensing element and to heat the first heater array and the second heater array
11[f]	providing a third heater array substantially adjacent the second via;	**1[g]**	a third heater array[,] positioned substantially adjacent the second via
11[g]	providing a fourth heater array substantially adjacent a third via;	**1[h]**	a fourth heater array, positioned substantially adjacent a third via
11[h]	positioning a second temperature sensing element in a second region located between the third heater array	**1[i]**	a second region, positioned between the third heater array and the fourth heater array, and also positioned

	and the fourth heater array. wherein the temperature sensing element is operable to sense the temperature of the second region, and wherein the temperature sensing element is substantially centrally disposed with respect to the second region and is substantially adjacent to both the third heater array and fourth heater array.		substantially immediately adjacent to the third heater array and the fourth heater array
		1[j]	a second temperature sensing element operable to sense the temperature of the second region,
		1[k]	wherein the temperature sensing element is substantially centrally disposed with respect to the second region and substantially adjacent to both the third heater array and fourth heater array

554. Thus, for the same reasons that I provided above in Section XIV.A (Claim 1), incorporated here, it is my opinion that the Yabe-Giere673 Combination also discloses every limitation of Claim 11.

555. Accordingly, it is my opinion that Giere673 discloses this element.

K. Claim 12

556. Claim 12 of the ’823 patent depends from Claim 11. The Yabe-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 12 further adds: “wherein positioning a temperature sensing element in the region comprises positioning a temperature sensing element in substantially the center of the region.” This limitation mirrors limitation 1[D] and thus the Yabe-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 1, incorporated here.

557. Thus, it is my opinion that the Yabe-Giere673 Combination discloses the added limitation of Claim 11.

L. Claim 13

558. Claim 13 of the ’823 patent depends from Claim 11. The Yabe-Giere673 Combination discloses Claim 9 for the reasons discussed above. Claim 11 further adds: “the method of claim 11, wherein positioning a temperature sensing element in the region comprises positioning a thermal resistor in the region.” This limitation is identical to the added limitation of Claim 3 and thus the Yabe-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 3, incorporated here.

559. Thus, it is my opinion that the Yabe-Giere673 Combination discloses the added limitation of Claim 13.

M. Claim 15

560. Claim 15 of the ’823 patent depends from Claim 11. The Yabe-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 15 further adds: “wherein positioning a temperature sensing element in the region between the first heater array and the second heater array comprises positioning the temperature sensing element at least 300 microns from each of the first heater array and the second heater array.” This limitation is identical to the added limitation of

Claim 5 and thus the Yabe-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 5, incorporated here.

561. Thus, it is my opinion that the Yabe-Giere673 Combination discloses the added limitation of Claim 15.

N. Claim 16

562. Claim 16 of the ’823 patent depends from Claim 15. The Yabe-Giere673 Combination discloses claim 15 for the reasons discussed above. Claim 16 further adds: “wherein positioning a temperature sensing element in the region between the first heater array and the second heater array comprises positioning the temperature sensing element substantially planar to each of the first heater array and the second heater array.” This limitation is identical to the added limitation of Claim 6 and thus the Yabe-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 6, incorporated here.

563. Thus, it is my opinion that the Yabe-Giere673 Combination discloses the added limitation of Claim 16.

O. Claim 17

564. Claim 17 of the ’823 patent depends from Claim 11. The Yabe-Giere673 Combination discloses Claim 11 for the reasons discussed above. Claim 17 further adds: “wherein heating the first heater array and the second heater array to regulate the temperature of the region comprises heating the first heater array and

the second heater array using non-nucleating heating." This limitation is identical to the added limitation of Claim 9 and thus the Yabe-Giere673 Combination discloses this limitation for the same reasons I provided above for Claim 9, incorporated here.

565. Thus, it is my opinion that the Yabe-Giere673 Combination discloses the added limitation of Claim 17.

P. Ample Motivation to Combine Yabe and Giere673

566. For at least the following reasons, it is my opinion that a PHOSITA would have been motivated to arrive at the Yabe-Giere673 Combination shown below.

567. *First*, Yabe and Giere673 are analogous to the claimed subject matter in the '823 Patent because they are all within the same field of endeavour and address similar problems—namely, sensing and regulating operational temperature of a printhead die for an inkjet printing device. The '823 Patent is titled "Methods and apparatuses for Regulating the Temperature of Multi-Via Heater Chips" and purports to solve "a need in the industry for chips that can provide for monitoring and regulating the various regions of a heater chip at a desired temperature when heater arrays are placed on both sides of the ink vias." Ex.1001 at Title; *see also id.* at 2:50-54. Consistent with this, the claims are directed to a "chip for use with a printing device" comprising a plurality of ink vias substantially adjacent a plurality

of ink vias, a plurality of regions positioned between heater arrays, and "a temperature sensing element operable to sense a temperature of the region…wherein the temperature sensing element is substantially centrally disposed with respect to the region," and wherein the heater arrays are "operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region." *See e.g.*, Ex.1001, Claim 1.

568. As discussed above in Section XIV.A and incorporated here, just like the '823 Patent, the printhead heater chips of Yabe and Giere673 both include at least two adjacent ink channels for feeding ink into a chamber and at least two adjacent heater arrays for vaporizing the ink within each channel and ejecting drops of the vaporized ink through a nozzle onto a print media, such as paper. And just like the '823 Patent, Yabe and Giere673 are generally directed to sensing and regulating the temperature of the heater chip region disposed on each side of the ink channels and heater arrays.

569. Furthermore, Yabe and Giere673 address similar problems in their shared field with the '823 Patent— *viz.*, reduced print quality caused by the printhead die operating outside its optimal temperature—and both provide a similar solution to that problem— *viz.*, disposing a temperature sensors on the printhead die for

determining the temperature of the printhead die and using control means to regulate the printhead die at its optimal temperature.

570. Like the ’823 Patent, Yabe discloses a plurality of ink vias each having a heater array on either side. Ex.1008 at 8:47-51 (“Three ink supply ports H1102 are formed in parallel, and **electrothermal converting devices H1103** and ink discharge ports H1107 **are formed on both sides having each of the ink supply ports H1102 between them**.”).

571. Like the ’823 Patent, Yabe recognized the need for increase in inkjet printer recording speed and quality at the time, along with a reduction in noises (e.g., performance issues). Ex.1005 at 1:13-16 (“[i]n recent years, many recording apparatuses have been used, and for these recording apparatuses, the higher recording speed, the higher resolution, the higher quality, and the lower amount of noises are demanded, among some others.”).

572. Yabe explains that printheads having higher image quality and faster printing capability are desired. Ex.1008 at 2:23-27 (“the performance required for the ink jet recording head at present should be such as to record in the image quality in precision higher still at recording speed faster still.”). To achieve the goal of higher image quality, Yabe states that “it is required to discharge finer ink droplets under well-conditioned control.” Ex.1008 at 2:23-26. To achieve the goal of faster

print speeds, Yabe states that "it is required to increase the number of heaters for use of ink discharges." Ex.1008 at 2:31-33.

573. Thus, according to Yabe, to attain more precise images at faster recording speeds, "it is considered effective to **adopt the structure of the so-called side shooter type** where ink droplets are discharged in the direction perpendicular to the heater board which is the base plate having heat generating resistive elements for use of ink discharges formed therefor." Ex.1008 at 2:34-40. The "side shooter type" printhead, as illustrated in Yabe's Figures 5 and 14 uses a plurality of ink vias wherein "the ink supply into the head is made from the reverse side of each heat generating resistive element of the heater board by way of the through opening that penetrates the heater board [i.e., ink vias]." Ex.1008 at 2:41-43; *see also id.* at 3:16-18 ("in the mode of the side shooter recording head, a plurality of ink supply ports provided for the heater board…"). Using ink vias to pass ink from directly below allows the printhead to be more compact and thereby improve precision and speed because "it becomes unnecessary to make the distance between the discharge ports and a recording medium larger owing to the presence of a member for supplying ink to the head." Ex.1008 at 2:43-47.

574. Yabe emphasizes that using a ***plurality*** of ink supply ports on a single printhead chip can be used to form images with high precision and speed. Ex.1008 at 5:19-23 ("With the side shooter type recording head structured as described above,

it is compatible to form images in high precision and to attain a high printing speed… Conceivably, therefore, a plurality of ink supply ports are provided for one heater board."). Moreover, bidirectional printing with an even color application is achievable using a plurality of ink supply ports on a printhead die. Ex.1008 at 5:24-27. ("[t]hen, for example, it becomes possible to implement the bidirectional printing without color unevenness by arranging plural ink supply ports for one and the same color ink in the head scanning direction.")

575. Yabe further explains that there is a tendency to increase the number of ink drops, heaters, and ink supply ports on a printhead die to meet the industry necessity for higher precision of recorded images at higher recording speed. Ex.1008 at 3:35-39. ("As described above, there is a tendency that the discharge ports, the number of heaters arranged for one heater board, and the number of ink supply ports are increased to cope with the necessity of higher precision of recorded images at higher recording speed for an ink jet recording head.").

576. However, with the tendency to increase image quality in precision at high printing speed, Yabe states that it is extremely important to control the temperature of the inkjet recording head during printing to avoid performance issues. Ex.1008 at 1:43-48 ("For the ink jet recording head of the kind, thermal energy is given to ink in each nozzle to create bubbles, and by means of bubbling power, ink is discharged for recording…[and][t]herefore, it is extremely important to provide

the stabilization of ink discharges for the fulfillment of the aforesaid demands, and also, to **control the temperature of the recording head in order to stabilize the discharging amount of ink**."); *see also* Ex.1008 at 1:50-2:8.

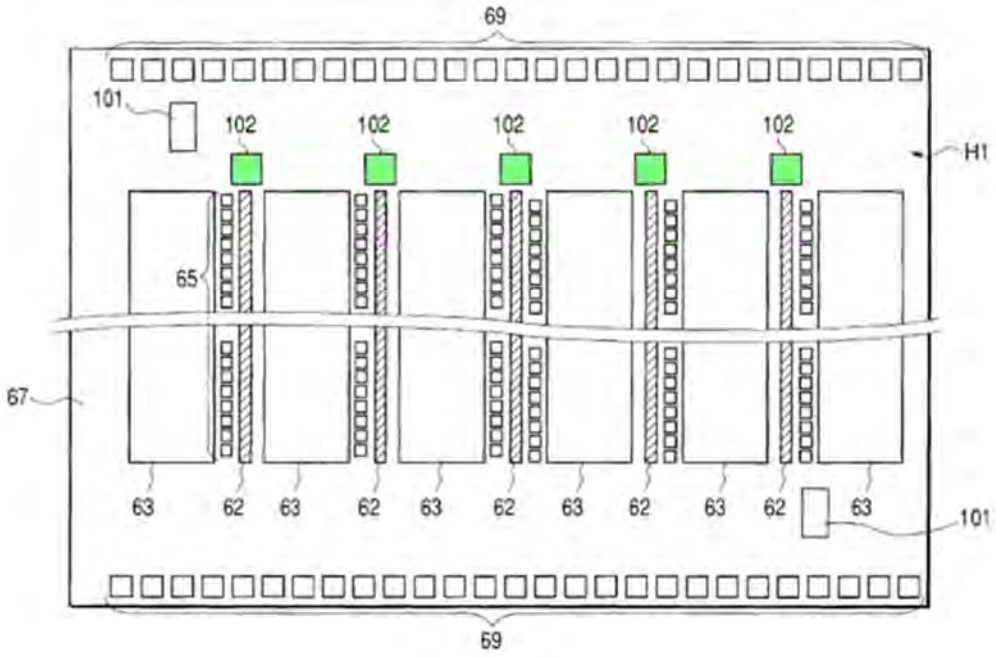
577. Thus, Yabe discloses a means for efficiently measuring and regulating the temperature of the heater board of a printhead having plural ink vias with associated heater arrays on either side so as to maintain high quality printing. Ex.1008 at 3:55-62 ("the present invention aims at the provision of an ink jet recording head of the so-called side shooter type where heater lines and ink supply ports for use of plural colors are arranged for one heater board, which has **attained the higher preciseness of the quality of recorded images at higher recording speed in a smaller size of the head itself, by arranging the layout of diode sensors and sub-heaters appropriately**."); *see also id.* at 3:45-54 ("it is necessary to prevent the 'initial discharge performance' from being deteriorated and the color tone of recorded images from becoming unstable" and, as such, "there should be **provided means for measuring the temperature of the heater board more efficiently** in accordance with the temperature characteristics obtainable by temperature detecting means, **as well as means for controlling the temperature of the heater board efficiently** in accordance with such measurement information.").

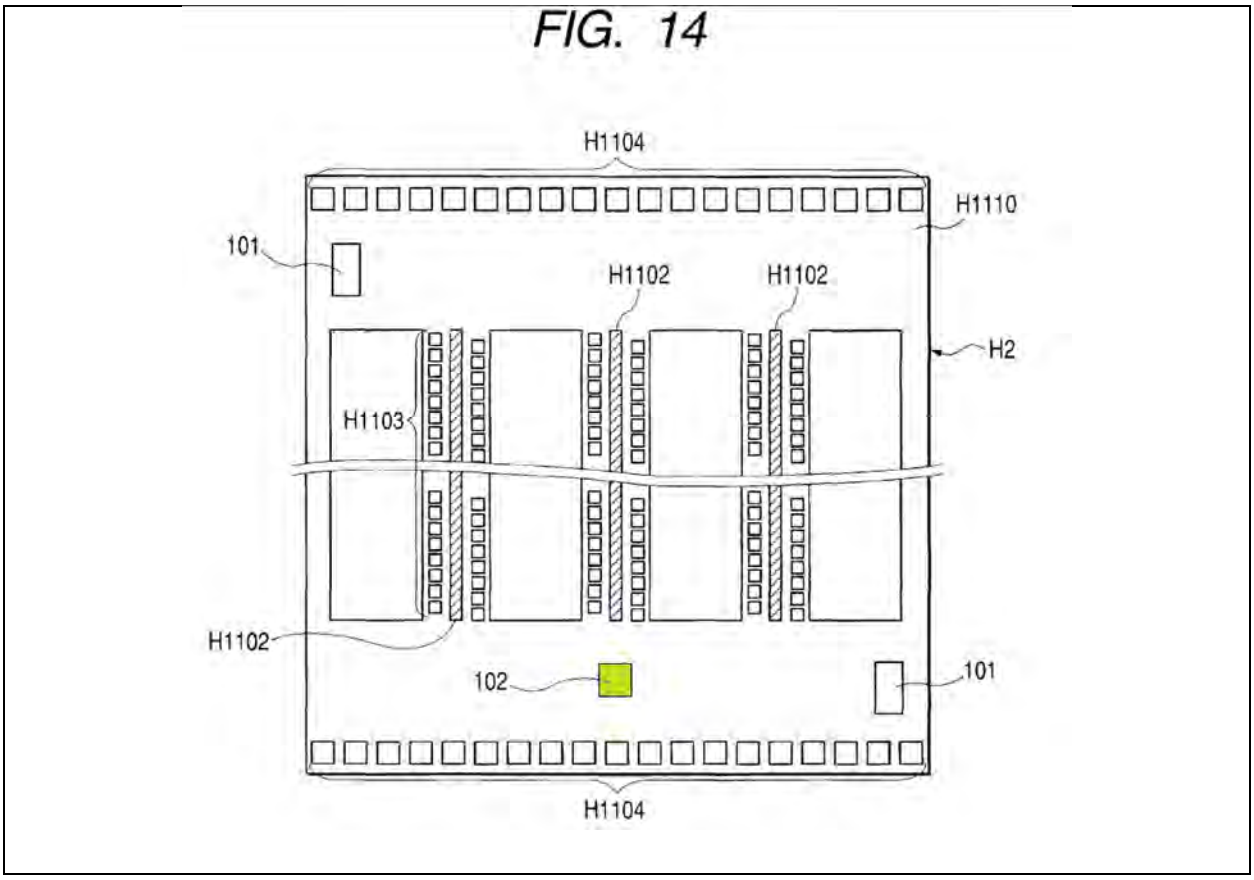
578. For example, Yabe's Figure 12 shows a plurality of "temperature detecting means 102 [green]" that are diode sensors used to detect heat at an exact

location on the heater board H1, as well as temperature control means (e.g., sub-heaters 101) to help maintain the uniformity of temperature distribution of the heater plate in accordance with the detected temperatures. Ex.1008 at 14:27-37. Similarly, Yabe's Figure 14 shows "temperature detecting means 102" and "sub-heaters 101."

Ex.1008, Fig. 12 and 14

FIG. 12





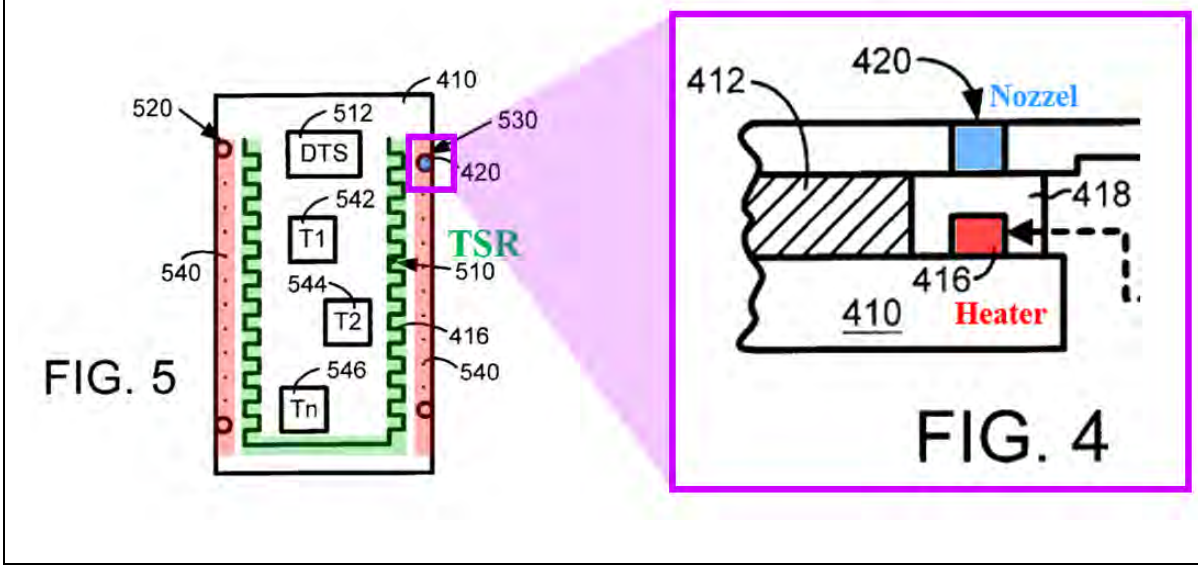
579. Yabe explains with sub-heaters 101 assisting with uniform temperature distribution on the heater board, then there is an increased degree of freedom in choosing the locations of "temperature detecting means 102 [*green*]" on its heater board (H2). Ex.1008 at 15:54-61 ("the **degree of freedom of arrangement increases for temperature detecting means to make it unnecessary to provide the temperature detecting means 102 on <u>both</u> end portions in the longitudinal direction, <u>and</u> the central portion of each ink supply port 105**."); *see also id.* at 16:49-57. A PHOSITA would understand that Yabe teaches increased freedom in choosing where to place its temperature sensors (e.g., temperature detecting means 102) on the heater board as a result of using sub-heaters because it would be

unnecessary to place temperature sensors at ***all*** portions of the heater board (e.g., **both** end portions **and** central portion) when only selected portions would suffice (e.g., in the central portion *only*). Although Yabe shows embodiments with temperature detecting means 102 on the top end portion of the heater board (Fig. 12) and temperature detecting means 102 on the bottom end portion of the heater board (Fig. 14), it does not show a figure with the temperature detecting means 102 in the central portion adjacent the ink supply ports.

580. Switching to Giere673, like the '823 Patent and Yabe, Giere673 uses "[o]ne or multiple TSRs 510 [to] provide an approximation of the mean temperature of the substrate [410]." Ex.1005 at 4:55-56. And just like the '823 Patent and Yabe, Giere673 optimizes the print quality of the inkjet printer based upon the temperature value provided by the TSR. Giere673 explicitly discloses where on the printhead die the TSR should be located for providing a sufficiently accurate temperature value to meaningfully improve print quality. Not only does Giere673 teach positioning a single temperature sensor—i.e., "temperature sensor resistor (TSR) 510 [*green* below]—between, and along the length of, two heater arrays [red], but also that the TSR 510 "preferably is not located adjacent to any particular heating elements" so that the obtained TSR value "reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005, 2:50, 4:51-56. To be sure, Giere673 teaches that "[t]he TSR 510 is located along the length of the

substrate 410" and "can have two legs that are approximately 680 µm inboard from the center of the columns of ink ejection elements 416," [red in Figs. 4 and 5]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12.

Ex.1005, Figs. 4 and 5

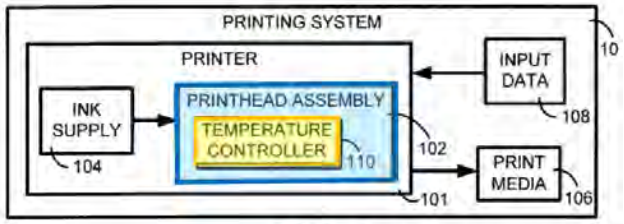
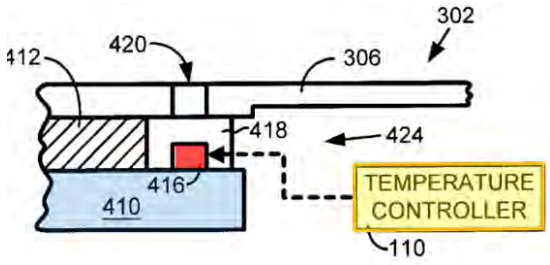


581. Put differently, Giere673 teaches disposing a single temperature sense resistor (TSR) [*i.e.*, serpentine TSR 510, *green* above] in a region on the printhead die [region of the substrate 410] adjacent, and along the length of, two heater arrays [columns of ink ejection elements 416 and 516, *red*], and positioning that TSR equidistant from the two heater arrays but no less than "approximately 680 µm inboard from the center of the [heater arrays].

582. By positioning the TSR 510 in the centre of the region between heater arrays, Giere673 teaches that the TSR value obtained by TSR 510 "reflects heating

elements firing that have already occurred," which "more accurately reflects the ***mean temperature*** of the substrate 410," as illustrated below. Ex.1005 at 4:57-59.

583. Moreover, to control[] the temperature of the substrate and the temperature of each ejection chamber or nozzle chamber, Giere673 discloses that "[t]he temperature controller 110 is coupled to multiple temperature sensors (not shown)," which "determine, at a given time, a mean or ***average temperature of the substrate*** and an actual local temperature profile near designated ink ejection elements. Ex.1005 at 2:57-62. Thereafter, "[t]he temperature controller 110 uses the input data 108 [supplied by the temperature sensors] to predict thermal conditions of particular ejection chambers for selectively firing the associated heating elements." Ex.1005 at 3:1-6; Ex.1005 at 2:62-65 ("The temperature controller 110 can be an integrated circuit, firmware, a software printer driver or the like which controls the mean temperature of the substrate of the printhead through a feedback loop (discussed in detail below).")

Ex.1005, Fig. 1	**Ex.1005, Fig. 4**
 FIG. 1	

584. Giere673 confirms that that "the temperature controller 110 of FIG. 1 is coupled to at least one measurement sensor, such as "a thermal sense resistor (TSR) 510" that "provide[s] an approximation of the mean temperature of the substrate" to "the temperature controller 110," and the temperature controller 110 uses the mean temperature sensed by the TSR 510 "to control the temperature." Ex.1005 at 4:49-5:5.

585. Not only do Yabe and Giere673 share the same field of endeavour and solve the same problem, the U.S. Patent Office also grouped the '823 Patent, Giere673, and Yabe under the same technology classification—class 347 (Incremental printing of symbolic information). Ex.1001 (U.S. Cl.); Ex.1007 (U.S. Cl.); Ex.1008 (U.S. Cl.). Giere673 and the '823 Patent also share sub-classes—347/17 (temperature or pressure of device or component thereof).

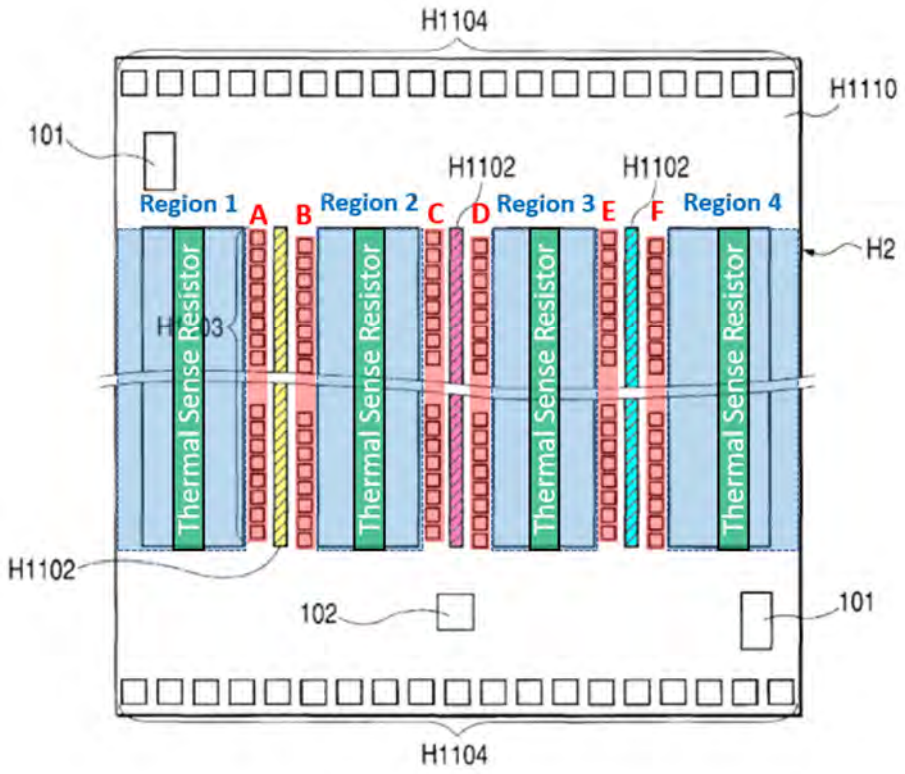
586. For at least these reasons, Giere673 and Yabe are analogous art to the '823 Patent and would have been considered by a PHOSITA attempting to solve the problem identified in the '823 Patent.

587. *Second*, in my opinion, upon considering Giere673, a PHOSITA would have applied Giere673's teachings to Yabe by (1) disposing a single TSR within the region of Yabe's printhead die formed between two adjacent heater arrays [*e.g.*, Region 2 and 3, *blue below*], and (2) positioning the TSR equidistant from both heater array within the region but no less than approximately 680 μm inboard from

the center of the heater arrays, as shown below, to ensure that the temperature value provided by the TSR reflects the mean temperature of the region.

Ex.1008, Fig. 14

FIG. 14



588. Giere673 provides express motivation for a PHOSITA to modify Yabe's printhead die to include a single TSR along the length of each region (Regions 1, 2, 3, 4) as illustrated above. For example, Giere673 explicitly discloses where on the printhead die the TSR should be located for providing a sufficiently accurate temperature value to meaningfully improve print quality. Not only does Giere673 teach positioning a single temperature sensor—i.e., "temperature sensor

resistor (TSR) 510 [*green* below]—between, and along the length of, two heater arrays [red], but also that the TSR 510 "preferably is not located adjacent to any particular heating elements" so that the obtained TSR value "reflects the temperature of the substrate 410 after heat has moved from the heating elements to the TSR 510." Ex.1005, 2:50, 4:51-56. To be sure, Giere673 teaches that "[t]he TSR 510 is located along the length of the substrate 410" and "can have two legs that are approximately 680 μm inboard from the center of the columns of ink ejection elements 416," [red in Figs. 4 and 5]," which Giere673 teaches are positioned directly below the nozzle 420 [blue in Figs. 4 and 5]. Ex.1005 at 5:5-12.

589. By positioning the TSR 510 in the centre of the region between heater arrays, Giere673 teaches that the TSR value obtained by TSR 510 "reflects heating elements firing that have already occurred," which "more accurately reflects the ***mean temperature*** of the substrate 410," as illustrated below. Ex.1005 at 4:57-59

590. Moreover, to control[] the temperature of the substrate and the temperature of each ejection chamber or nozzle chamber, Giere673 discloses that "[t]he temperature controller 110 is coupled to multiple temperature sensors (not shown)," which "determine, at a given time, a mean or ***average temperature of the substrate*** and an actual local temperature profile near designated ink ejection elements. Ex.1005 at 2:57-62. Thereafter, "[t]he temperature controller 110 uses the input data 108 [supplied by the temperature sensors] to predict thermal conditions

of particular ejection chambers for selectively firing the associated heating elements." Ex.1005 at 3:1-6; Ex.1005 at 2:62-65.

591. In fact, as discussed above in Section XIV.A.6 and incorporated here, Giere673's temperature controller 110 includes "temperature logic system 606" that generates various printing parameters on a **per color basis** and, based on the sensed temperature, are used to regulate the printhead die temperature. Ex.1005 at 6:21-28; *id*. at 9:8-17. For example, Giere673 states that "temperature logic system 606 then determines the firing rate and pulse width *for each color* controlled for pulse rate 802 and for pulse width 804, and forwards the firing order to the heater element firing system 608" wherein "[t]his rate, width and order of firing are programmed, and if necessary, adjusted in the programming, so that the temperature of the heater array 611, and therefore the temperature of the ink in the chamber array 612, are maintained at an optimum temperature for the formation of ink droplets."). Thus, because Giere673's "temperature controller 110 aids in controlling the temperature of the substrate and the temperature of **each ejection chamber or nozzle chamber**" its design "results in improved print quality and printhead life because the printhead 102 will consequently operate closer to its optimum temperature." Ex.1005 at 3:7-12.

592. A PHOSITA would further understand why the temperature sensor location layout illustrated above in Fig. 14 (i.e., temperature sensors centered and

throughout each region) would be advantageous. Thermal inkjet devices, like the one disclosed in Yabe, are designed to operate optimally at a nominal temperature that is chosen with the temperature management strategy in mind. Since passive cooling is the most affordable cooling method, a PHOSITA will choose an elevated temperature as the nominal temperature and use active measures to raise the ink temperature to this nominal if the ambient temperature where the printer is operating is lower. The printhead temperature will be elevated to the nominal temperature by some means, such as intermittent non-printing energy pulses to the heater resistors. Thermal inkjet devices produce acceptable printing results within a narrow range of temperatures above and below the chosen nominal operating temperature. Attempting to operate the thermal inkjet printhead somewhat outside the acceptable temperature range results in soft failure modes, such as reduced or unacceptable print quality. If the ink temperature is somewhat too low, the nucleated bubble which expels the ink may be too small which could produce visible white streaks in the image or color hue shifts as the mix of cyan, yellow, and magenta ink amounts in an image area is wrong. If the ink temperature is somewhat too large, then dark streaks or objectionable color hue shifts may be visible.

593. Hard failure modes may occur if operation is attempted well outside the acceptable ink temperature range. If the ink temperature is very low, the nucleated bubble may be too small to eject a drop at all. Visible white streaks will appear in

the image. Dribbling of ink or the firing of an ink mist may occur resulting in mist contamination of other printer components or the smearing of ink on the print media and media transport surfaces. If the ink temperature is very high, then bubble volume may be so large that the bubble breaks out through the nozzle, causing air to be ingested into the printhead. The user may have to initiate a printhead maintenance cycle whereby the nozzles are vacuumed clear of air by a maintenance station vacuum pump. Another failure can occur if a too hot ink nucleates too early in the drop firing pulse. As soon as the bubble is nucleated, the heater resistor surface can no longer transfer heat to the ink efficiently, causing the heater surface to get much hotter than designed, leading to the "burn out" of the heater resistor and, potentially, the permanent failure of that drop generator

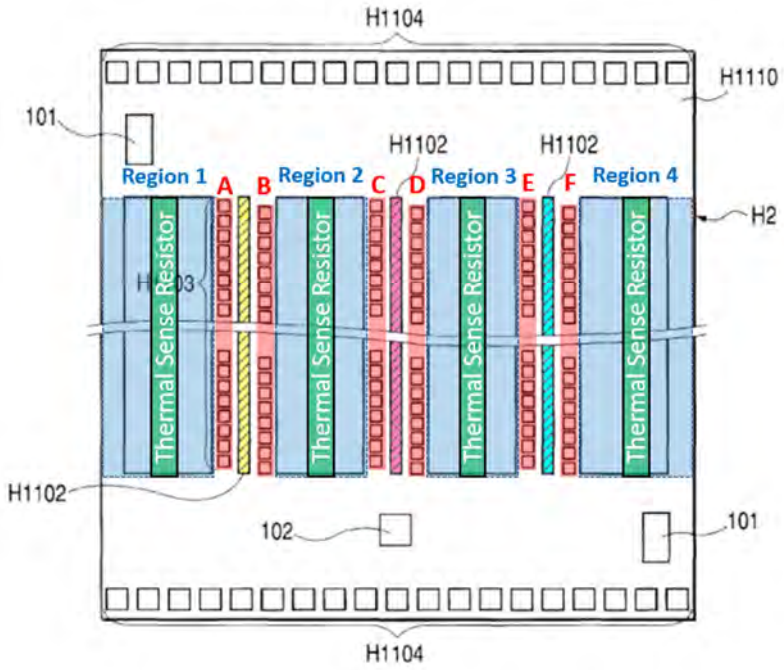
594. To optimize the printing quality of Yabe's heater board and other multi-via printhead dies with two heater arrays per ink via, a PHOSITA would know that the temperature should be measured on a per-via basis—*i.e.*, disposing a TSR adjacent each and every ink via on the printhead die. A PHOSITA would also know that a multi-via printhead die with multiple TSRs will provide more accurate temperatures values for every different-colored ink via than would a single TSR because a multi-color, multi-ink supply via thermal inkjet printhead die fabricated on a silicon substrate has thermal conduction pathways that are greatly affected by

ink via slots. This is due to the differences between the thermal conductivities of single crystal silicon.

595. The low thermal conductivity of the ink via spaces and any plastic manifold materials interfacing the silicon thermal inkjet chip causes these regions to restrict heat flow relative to the heat flow in the silicon material itself. The heat introduced by the heater resistors to fire drops will be conducted away much more rapidly into the adjacent silicon regions that into the ink supply vias or plastic printhead die components. A PHOSITA will recognize that the silicon regions between ink supply vias and between outer ink supply vias and printhead die edges achieve thermal equilibrium far more rapidly than the overall printhead die and ink supply structures. These regions are both relatively thermally isolated and quickly come to a same temperature or thermal equilibrium. These regions are therefore the most cost-effective places in which to add multiple temperature sensors to better capture the temperature conditions of the multiple color ink drop generators. Sensing the temperature in multiple regions allows the system controller to better maintain the desired ink operating temperature for all ink colors over a larger range of environmental temperatures and printing duty conditions. Thus, to further "optimize print quality" in Yabe's heater board over a larger range of conditions encountered by the user, a PHOSITA would be motivated to dispose a TSR adjacent each of the ink feed slots on substrate H1110, as shown below.

Ex.1008, Fig. 14

FIG. 14



596. Indeed, a PHOSITA would also know that excessive *localized* heating of the substrate in the regions between ink vias without compensation for the substrate temperature change can lead to degradation in print quality. Ex.1007 at 5:36-51. For example, Giere178 describes a situation where excessive printing of one color ink in one region of the printhead die, e.g., magenta ink, can increase the temperature of that color's ink ejection chambers thereby increasing the mass of the magenta ink drops beyond the desired print size. Ex.1007 at 5:52-6:3. Giere178 explains that in this situation, print quality will degrade because excessive magenta ink will alter the desired print colors. *Id*. Giere178 states that the "rate at which

signals are supplied to resistors associated with the ink ejection chambers affects the temperature of the substrate of the printhead" and "*localized heating* of the substrate can occur from firing nozzles at a greater frequency *in a particular region of the printhead*." Ex.1007 at 5:44-46. Giere178 explains that "[i]f at least some compensation is not made for these temperature changes, a perceptible degradation in print quality can result." *Id*. at 5:49-51. For example, in the magenta example described above, Giere178 states that "as a result of the excessive quantity of magenta ink applied, the hue of the region formed [in combination with cyan and yellow] will be shifted toward the magenta hue," "undesired shifts in the chroma and the luminance of [print] regions" can occur, and an "increase in the mass of ejected ink drops can reduce the sharpness of the edges when the image is formed onto paper." Ex.1007 at 5:62-6:3. Giere178 discloses a solution to the localized heating issue by placing multiple temperature sensing "resistive elements" on the substrate (between ink vias and associated heater arrays) "so that they will each assume the temperature of the local region of substrate [] on which they are placed." Ex.1007 at 8:51-54; *see also* Sections IX.B.4, XIII.A.6-7, and XIV.C. Giere178 states that its "temperature compensation system" with localized temperature sensors "may be used to control a quantity of ink deposited on a region in response to the measured temperature," or "may be used to control resistive heating elements thermally coupled to [the] substrate [] so that the temperature of [the] substrate [] is controlled

substantially at a desired temperature," or "may adjust the pulse width of the drive signals supplied to the firing resistors so that the temperature of [the] substrate [] is controlled substantially at a desired temperature." *Id*. at 9:50-60. As such, Giere178 corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere673, would have been further motivated to modify Yabe's heater board printhead die by disposing a single temperature sensor within each other region so that the TSRs collectively determine a mean temperature of Yabe's printhead die and regulate temperature on a per-color basis.

597. Moreover, the '823 Patent readily admits that, during the prior art time period, it was well known to those skilled in the art that "ink vias [] act as thermal barriers between the colors," and "without accurate temperature readings, the method of providing fire pulses to regulate thermal conditions [for a multi-via printhead die] would also be subject to error." Ex.1001 at 2:47-49. To overcome these challenges, the '823 Patent admits that prior art heater chips "provid[ed] for temperature sensing on a per-color basis" by placing "three temperature sensors 220, 222, and 224 [green below] in close proximity to each of the heater arrays, each situated on the same side of their respective vias," thereby "ensuring that there is only a small amount of thermal crosstalk between the temperature sensors." Ex.1001 at 2:13-15. Put differently, the '823 Patent corroborates my opinion that a PHOSITA, after disposing a single TSR in Region 2 or Region 3 based on Giere673,

would have been further motivated to modify Yabe's printhead die by disposing a single temperature sensor within each region so that the TSRs collectively determine a mean temperature of Yabe's printhead die because it was well known to those skilled in the art that this arrangement "provid[es] for temperature sensing on a per-color basis."

598. *Finally*, a PHOSITA would have also had a reasonable expectation of success adding the temperature controller 110 and TSRs 510 from Giere673 to the heater board H1110 of Yabe's printhead die assembly. To be sure, Giere673 recognizes that the temperature controller and thermal sensor resistors of "the present invention can be incorporated in any printhead configuration." Ex.1005 at 4:7-8; *id*. at 9:42-47 ("The above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that workers may make variations in those embodiments skilled in the art without departing from the scope of the present invention as defined by the following claims.").

599. Given the interchangeable nature of various features in the disclosed embodiments, it would have been a routine and obvious matter for a PHOSITA to combine, replace, and even modify various features from Yabe's various embodiments, as well as the embodiments of Giere673. Moreover, as I explained above, the printing system components from Yabe and Giere673 are common to all embodiments. As such, the simple, routine, and low-cost nature of adding a

temperature controller and thermal sense resistors to a printhead die assembly and printhead die, respectively, would have further motivated a person of ordinary skill in the art. Furthermore, given the simple, routine, and low-cost nature of the printhead die components disclosed in Yabe and Giere673's systems, a PHOSITA would have had a reasonable expectation of success in combining and modifying features of the embodiments together

600. Thus, in my opinion, ample motivation existed for a PHOSITA to make the Yabe-Giere673 Combination

XV. GROUND 5: YABE AND GIERE673 IN FURTHER VIEW OF PARISH RENDERS CLAIMS 4 and 14 OBVIOUS

601. In my opinion, the Yabe-Giere673 combination in view of Parish renders obvious all of the limitations of claims 4 and 14 of the '823 Patent.

A. Claim 4

602. Claim 4 of the '823 patent depends from Claim 3. The Yabe-Giere673 Combination discloses Claim 3 for the reasons discussed above. Claim 4 further adds: "wherein the temperature sensing element comprises an n-type implant donor thermal sensing resistor." Although Giere673 discloses that the temperature sensor may include a thermal sense resistor (TSR) 510, Giere673 does not explicitly say that the TSR 510 is an n-type implant donor thermal sensing resistor. However, in my opinion, Parish discloses this limitation.

603. According to Parish, the temperature sense element is or comprises a temperature sense resistor (TSR) 64," which "can include a N-type source drain (NSD) material, a N-well layer material, a P-type source drain (PSD) material, a lightly doped drain (LDD) material or another suitable material." Ex.1006 at 5:35-39.

604. Therefore, it is my opinion that the Yabe-Giere673 combination in further view of Parish discloses that "the temperature sensing element [*i.e.*, TSRs 510] comprises an n-type implant donor thermal sensing resistor."

B. Claim 14

605. Claim 14 of the '823 Patent depends from Claim 13. The Yabe-Giere673 Combination discloses Claim 13 for the reasons discussed above. Claim 14 further adds: "wherein positioning a temperature sensing element in the region comprises positioning an n-type implant donor thermal sensing resistor in the region." Although Giere673 discloses positioning a thermal sense resistor (TSR) 510 in the region, Giere673 does not explicitly say that the TSR 510 is an n-type implant donor thermal sensing resistor. However, in my opinion, Parish discloses this limitation.

606. According to Parish, the temperature sense element is or comprises a temperature sense resistor (TSR) 64," which "can include a N-type source drain (NSD) material, a N-well layer material, a P-type source drain (PSD) material, a

lightly doped drain (LDD) material or another suitable material." Ex.1006 at 5:35-39.

607. Therefore, it is my opinion that the Benjamin-Giere673 combination in further view of Parish discloses that "positioning a temperature sensing element in the region [*i.e.*, TSRs 510] comprises positioning an n-type implant donor thermal sensing resistor in the region."

C. Ample Motivation to Combine Yabe and Giere673 and Further in View of Parish

608. For at least the following reasons, it is my opinion that a PHOSITA would have been motivated to arrive at the Yabe-Giere673-Parish Combination shown below.

609. *First*, Giere673, Yabe, and Parish are analogous to the claimed subject matter in the '823 Patent because they are all within the same field of endeavour and address similar problems—namely, sensing and regulating operational temperature of a printhead die for an inkjet printing device. The '823 Patent is titled "Methods and apparatuses for Regulating the Temperature of Multi-Via Heater Chips" and purports to solve "a need in the industry for chips that can provide for monitoring and regulating the various regions of a heater chip at a desired temperature when heater arrays are placed on both sides of the ink vias." Ex.1001 at Title; *see also id.* at 2:50-54. Consistent with this, the claims are directed to a "chip for use with a printing device" comprising a plurality of ink vias substantially adjacent a plurality

of ink vias, a plurality of regions positioned between heater arrays, and "a temperature sensing element operable to sense a temperature of the region…wherein the temperature sensing element is substantially centrally disposed with respect to the region," and wherein the heater arrays are "operable to receive heating responsive to the temperature of the region sensed by the temperature sensing element, and wherein the received heating regulates the temperature of the region." *See e.g.*, Ex.1001, Claim 1

610. For the reasons explained above in Section XIV.P and incorporated here, Yabe and Giere673 are analogous to the '823 Patent because address similar problems in their shared field— *viz.*, reduced print quality caused by the printhead die operating outside its optimal temperature—and both provide a similar solution to that problem— *viz.*, disposing a temperature sensors on the printhead for determining the temperature of the printhead die and using control means to regulate the printhead die at its optimal temperature. Parish is also analogous to the '823 Patent for similar reasons.

611. For example, Parish, also like the '823 Patent, discloses a printhead chip having an ink via with heater arrays on either side. For example, with respect to Figure 3 (below), Parish discloses that "[a] portion of the inkjet print head 10, particularly the substrate (e.g., chip) 16, [includes]…heating elements 32 are arranged into a **first heating array 50** [*red*] and a **second heating array 52** [*red*]."

Ex.1006 at 4:61-65; Ex.1006 at 4:40-41 ("heating elements 32 can include any element capable of converting electrical energy into heat, such as a transducer or resistor."). Parish further states that "**the array of actuators substantially parallel the longitudinal extent of the ink via 68 [*magenta*] on either sides 71, 73 thereof**…." Ex.1006 at 6:9-11.

Ex.1006, Fig. 3

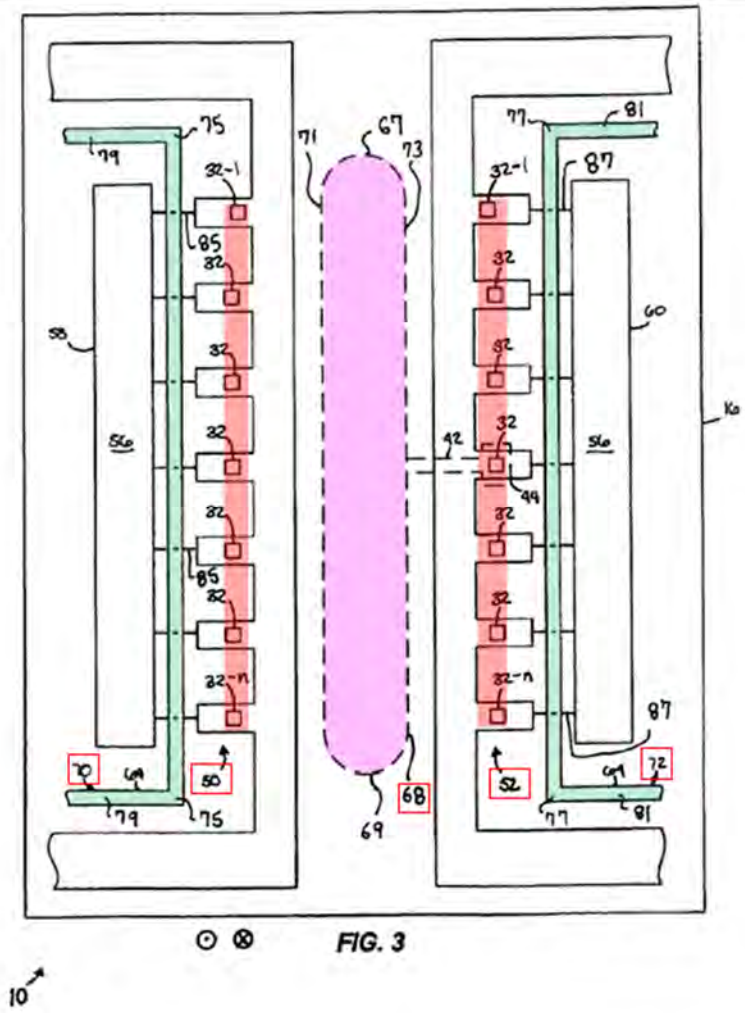


FIG. 3

612. Parish further discloses that printhead chip 16 includes temperature sense resistors (TSRs) Ex.1006 at 5:30-34 ("chip 16 further includes at least one temperature sense element positioned to sense a temperature of a location on the print head 10….the temperature sense element is or comprises a temperature sense resistor (TSR) 64."). With respect to Figure 3 (above), Parish discloses that "TSR's 70, 72 [*green*] have a longitudinal extent that is substantially parallel along and to an entire length of arrays 50, 52, [*red*] respectively, such as between individual heating elements 32-1 and 32-n." Ex.1006 at 6:5-8. As such, "each TSR is able to sense local heating per an entire array and not just a portion thereof." Ex.1006 at 6:16-18

613. Finally, Parish discloses that its TSR "senses the temperature of the chip 16, one or more of the heating elements 32, the ink chamber 44, or other location of the print head 10 and provides this information to the printer controller 30 or another circuit." Ex.1006 at 5:43-47. Like the '823 Patent, Parish recognizes that the ink via in the printhead chip "acts as a thermal insulator between each array 50, 52". Ex.1006 at 6:18-19; *compare with* Ex.1006 at 5:64-67 ("The ink vias 402, 404, 406, 407, on the other hand, act as thermal insulators between the thermal regions 430, 432, 434, 436, 438."). To address that problem, Parish incorporates heater arrays [50, 52, *red*] and TSRs [70, 72, *green*] along both sides of the ink via [68, *magenta*].

614. Not only do Giere673, Yabe, and Parish share the same field of endeavour and solve the same problem, the U.S. Patent Office also grouped the ’823 Patent, Giere673, Yabe, and Parish under the same technology classification—class 347 (Incremental printing of symbolic information). Ex.1001 (U.S. Cl.); Ex.1005 (U.S. Cl.); Ex.1006 (U.S. Cl.); Ex.1008 (U.S. Cl.). Giere673, Parish, and the ’823 Patent also share sub-classes—347/17 (temperature or pressure of device or component thereof).

615. For at least these reasons, Giere673, Yabe, and Parish are analogous art and would have been considered by a PHOSITA attempting to solve the problem identified in the ’823 Patent.

616. *Second*, upon considering the Yabe-Giere673 Combination, a PHOSITA would have been motived to incorporate a temperature sensing element comprising an n-type implant donor thermal sensing resistor as expressly taught by Parish to Yabe’s printhead die to arrive at the Yabe-Giere673-Parish Combination.

617. Parish provides express motivation for a PHOSITA to modify Yabe’s printhead die to include temperature sensing element comprising an n-type implant donor thermal sensing resistor. For example, Parish discloses that a broad choice of materials are suitable as a temperature sense resistor (TSR), such as “polysilicon material or another material responsive to temperature.” Parish provides several examples of suitable materials, including an n-type implant donor thermal sensing

resistor. Ex.1006 at 5:35-39 ("the TSR 64 can include a **N-type source drain (NSD) material,** a N-well layer material, a P-type source drain (PSD) material, a lightly doped drain (LDD) material **or another suitable material**.")

618. Moreover, upon considering the Yabe-Giere673 Combination, a PHOSITA would have been motivated to add an n-type implant donor thermal sensing resistor as a temperature sense resistor, as taught by Parish, because doing so would improve the effectiveness of the Yabe-Giere673 temperature compensation system as n-type implant donor thermal sensing resistors are more precise than, for example, Giere673's metal (e.g., aluminium) resistive elements.

619. A PHOSITA would understand that you could increase the fraction of the total temperature induced resistance change attributable to the resistive elements by *changing the resistive element material* to a material having a greater resistivity and thereby increasing the resistive element's resistance. A PHOSITA would understand that a temperature sense resistor made of n-type implant donor materials (NSD[11]) would have a greater resistivity than temperature sense resistors made of

[11] According to the '823 Patent, n-type implant donor thermal sensing resistors, also known as NSD sense resistors, were understood by those skilled in the art. Ex.1001 at 6:25-29 ("According to an exemplary embodiment of the present invention, the temperature sensing elements are n-type implant donor thermal sensing resistors (NSD sense resistors), as will be understood by those skilled in the art."). "NSD" refers to when an n-type implant is used for NMOS transistor source and drain areas. Ex.1014 at 4:2-3 ("NSD (n-type implant used for NMOS transistor source and drain areas)".

certain metals such as aluminum. For example, the sheet resistance of typical aluminum is 0.03 ohms/square while the sheet resistance for NSD material is 36 ohms/square Ex.1014, 4:10-18. As such, using material of a higher resistivity (sheet resistance) will also increase the resistive element resistance (because Resistance = $Resistance_{sheet}$ * (L/W)) and thus increase the fraction of temperature induced resistance change corresponding to the resistive element.

620. Accordingly, upon considering the Yabe-Giere673 Combination, a PHOSITA would have been motivated to add an n-type implant donor thermal sensing resistor as a temperature sense resistor, as taught by Parish, because doing so would improve the effectiveness of Yabe-Giere673 temperature compensation system by improving the system's precision i.e., by reducing the number of inaccuracies contributed by the metal traces.

621. It is therefore my opinion that a PHOSITA would have been motivated to modify Yabe-Giere673 printhead die to accommodate n-type implant donor thermal sensing resistors as thermal sensing elements.

622. A PHOSITA would also have had a reasonable expectation of success of adding n-type implant donor thermal sensing resistors as thermal sensing elements. The '823 Patent admits that using n-type implant donor thermal sensing resistors were well-known in the art. Ex.1001 at 6:25-29 ("According to an exemplary embodiment of the present invention, the temperature sensing elements

are n-type implant donor thermal sensing resistors (NSD sense resistors), as will be understood by those skilled in the art."). Moreover, the advantages of using NSD materials for temperature sense resistors on thermal inkjet printhead die (over metal temperature sense resistors, for example, were also well-known. Ex.1014 at 1:25-28 ("Previous designs include a temperature sense resistor (TSR) integrated into the heater chip to monitor the substrate temperature."); Ex.1014 at 4:37-42 ("While N-Well is the preferred implant for TSRs, **many implants** (**such as NSD**, LDD, and PSD) used in the geometry shown in FIG. 2 **will provide the same advantages over metal TSRs**, and are included in the scope of the present invention."); Ex.1014 at 3:17-19 ("The **temperature sense resistors** preferably comprise N-Well material, but could also **comprise NSD material**, LDD material, or PSD material, for example.").

623. It is therefore my opinion that a PHOSITA would also have had a reasonable expectation of success of adding n-type implant donor thermal sensing resistors (as taught by Parish) as Giere673's thermal sensing elements. To be sure, Giere673 recognizes that the temperature controller and thermal sensor resistors of "the present invention can be incorporated in any printhead configuration." Ex.1005 at 4:7-8; *id*. at 9:42-47 ("The above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that workers may

make variations in those embodiments skilled in the art without departing from the scope of the present invention as defined by the following claims.").

624. *Finally*, it would have been a routine and obvious matter for a PHOSITA to combine, replace, and even modify various features from Yabe and Giere673 to incorporate the features of Parish. As I explained above, the printing system components from Yabe, Parish and Giere673 are common. As such, the simple and routine nature of adding n-type implant donor thermal sensing resistors (as taught by Parish) to Yabe-Giere673 would have further motivated a person of ordinary skill in the art. Furthermore, given that Giere673 expressly articulates the interchangeability and modification of the disclosed embodiments, a PHOSITA would have had a reasonable expectation of success in combining and modifying features of the embodiments together.

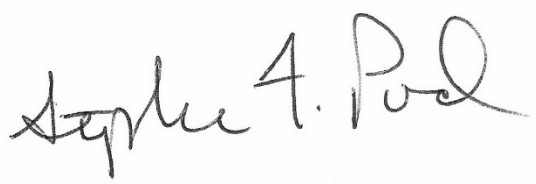
625. Thus, in my opinion, ample motivation existed for a PHOSITA to make the Giere178-Yabe-Parish Combination.

XVI. CONCLUSION

626. For the reasons set forth above, in my opinion, all of the limitations of claims 1-17 of the '823 Patent are disclosed by the above cited combinations of prior art.

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

Executed on January 23, 2023.



Dr. Stephen F. Pond, Ph.D.