

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SHENZHEN TUOZHU TECHNOLOGY CO., LTD.,

Petitioner

v.

STRATASYS, INC.

Patent Owner.

PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 9,168,698

Case No. IPR2025-00531

DECLARATION OF DR. TIM A. OSSWALD

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EXHIBIT LIST

Exhibit	Description
2020	Transcript of the Deposition of Dr. Andrew Wolfe
2021	Reserved
2022	U.S. Patent No. 6,129,872 to Jang (“Jang”)
2023	U.S. Patent No. 7,625,198 to Lipson, et al. (“Lipson”)
2024	Ashby, M. F. (2011). Chapter 4: Material Property Charts, <i>Materials Selection in Mechanical Design</i> (pp.57–96). Elsevier Inc.
2025	TIM A. OSSWALD & GEORG MENGES, MATERIALS SCIENCE OF POLYMERS FOR ENGINEERS (3d ed. 2010), excerpted.
2026	TIM A. OSSWALD & NATALIE RUDOLPH, POLYMER RHEOLOGY (2015), excerpted.

I. INTRODUCTION

1. My name is Tim A. Osswald, and I declare as follows:

2. I am a citizen of the United States and am over 18 years of age. I have personal knowledge of the matters stated in this declaration.

3. I have been asked to provide technical assistance in the *inter partes* review of U.S. Patent No. 9,168,698, which I may abbreviate as “the ’698 Patent” or refer to as the “Challenged Patent.” I understand that this patent is owned by Stratasy, Inc. (“Stratasy”). This declaration is a statement of my opinions on issues related to the patentability of claims of the Challenged Patent.

A. Qualifications and Experience

4. I am a Professor Emeritus at the University of Wisconsin-Madison in the Department of Mechanical Engineering, where I was the Co-Director of the Polymer Engineering Center. I am also an Honorary Professor of Plastics Technology at the University of Erlangen-Nuremberg in Germany and the National University of Colombia.

5. I earned both a Bachelor of Science degree (1981) and a Master of Science degree (1982) in Mechanical Engineering from the South Dakota School of Mines & Technology. I also earned a Ph.D. (1987) in Mechanical Engineering from the University of Illinois at Urbana-Champaign. My Ph.D. research was in the field of polymer processing.

6. From 1987 to the present, I have held a variety of professional and academic positions. I was a consultant for the Dynamit Nobel Research Center in Leverkusen, Germany, as well as a Humboldt Fellow at the Institute for Plastics Processing at the Technical University of Aachen, Germany between 1987 and 1989. In 1989, I joined the Mechanical Engineering Department at the University of Wisconsin-Madison as an Assistant Professor. I became a Full Professor in 1999.

7. I have extensive experience with polymer part manufacturing processes and extensive experience with behavior and characterization of polymeric materials, including thermoplastics, thermosets, and rubber. I have in-depth knowledge in various polymer processing techniques, such as extrusion and molding processes, as well as composites manufacturing and additive manufacturing (also known as 3-D printing). I have in-depth knowledge of additive manufacturing and additive manufacturing patent history.

8. I am a member of numerous professional societies and organizations. For example, I am a member of the Society of Plastics Engineers, the Scientific Alliance of the University Professors of Polymer Technology, the Polymer Processing Society (where I currently serve as Treasurer), and the German Technical Journalists Organization (DFJV).

9. For over 30 years, I have conducted research and taught classes in the field of mechanical engineering, and more specifically regarding polymer and

composite materials and polymer and composite processing. My research has focused on polymer and polymer composites processing, polymer and polymer composites materials science, and engineering design with polymers and polymer composites. Furthermore, I regularly serve as a consultant to the plastics industry and have extensive experience dealing with additive manufacturing and design and manufacture of additive manufacturing equipment. I am currently part of the Scientific Advisory Board for SABIC Specialties, and the Scientific Advisory Council of SABIC, a large chemical company. I also served on the Technical Advisory Board of Teel Plastics, a pipe extrusion company, and the Madison Group, a plastics consulting firm.

10. Since February of 2019, I have served as an Advisory to the Colombian President on matters regarding science and technology, and the creation of a new Ministry of Science, Technology, and Innovation.

11. At the University of Wisconsin-Madison, I developed and taught a variety of courses, including Polymer Manufacturing Processes, Introduction to Transport Phenomena in Polymer Engineering, Engineering Design with Polymers, Modeling and Simulation in Polymer Processing, Introduction to Polymer Additive Manufacturing and Introduction to Polymer Composites Processing. My courses include units on fundamental aspects of polymer engineering, such as melting, solidification, and flow, as well as processing techniques such as injection molding,

extrusion processes, additive manufacturing, composites processes and secondary operations such as thermoforming, blow molding, film casting, film blowing, joining, and welding. In my additive manufacturing course, I teach a whole unit on intellectual property in additive manufacturing, as well as the underlying physics that govern the various additive manufacturing processes.

12. In addition to my teaching and research duties at the University of Wisconsin-Madison, twice a year I taught a Modeling and Simulation in Polymer Processing course at the University of Nuremberg-Erlangen in Germany. Since 2020 I teach the course Simulation of Polymer Additive Manufacturing Processes at the University of Nuremberg-Erlangen in Germany. I have also taught the Materials Science of Polymers for Engineers and Polymer Processing courses at the EAFIT University and the National University in Colombia, and the course Polymer Additive Manufacturing at the Universidad de Los Andes in Bogotá, Colombia.

13. Over the years, my research and teaching have led to the issuance of seven patents, including patents in the field of additive manufacturing, as well as several honors, and awards. For example, in 2001 I was the recipient of the VDI-K (German Engineering Society – Plastics) Dr. Richard Escales Prize; in 2006, I was named Honorary Professor at the University of Erlangen-Nuremberg in Germany, and in 2010 I was named Honorary Professor at the National University of Colombia; in 2016, I was named Educator of the Year by the Society of Plastics Engineers

(SPE); and in 2017, the same organization named me Educator of the Year in the Field of Composites.

14. I have also published over 400 papers in the field of polymer engineering and have authored 11 books in the area: Polymer Materials Science for Engineers (Hanser Publishers, 1st Edition 1996, 2nd Edition 2003, 3rd Edition 2012), Polymer Processing Fundamentals (Hanser Publishers, 1998), Injection Molding Handbook (Hanser Publishers, 1st Edition 2001, 2nd Edition 2006), Compression Molding (Hanser Publishers, 2003), Polymer Processing – Modeling and Simulation (Hanser Publishers, 2006), Plastics Handbook (Hanser Publishers 2006, 2019), Kunststoff-Taschenbuch (Hanser Publishers 2006, 2013, 2022), Plastics Testing and Characterization (Hanser Publishers, 2007), Understanding Polymer Processing (Hanser Publishers, 1st Edition 2010, 2nd Edition 2017, 3rd Edition 2025), and Discontinuous Fiber-Reinforced Composites – Fundamentals and Applications (Hanser Publishers, 2020). Some of my books have been translated into Chinese, Japanese, Spanish, Italian, Farsi, and Russian. I am also the series editor for the Plastics Pocket Power Series of Hanser Publishers. I am one of the authors of the “Plastics Handbook – The Resource for Plastics Engineers,” (“Plastics Handbook”) published by Hanser Publishers, which came out in its 5th edition in 2019. I am also one of the co-authors of the German version of the Plastics Handbook, which was published in its 32nd edition in 2022. The Plastics Handbook is a complete

compendium of polymer materials, polymer processes and polymer characterization techniques. The processing chapter presents the major additive manufacturing techniques. While the Plastics Handbook is a book for practitioners and engineers, some of my other books are polymer engineering textbooks that are used in courses taken by undergraduate and graduate students throughout the world. One such book is Understanding Polymer Processing, which contains a chapter on additive manufacturing. Other books are more advanced, and are used by researchers at universities and in the industry to acquire in-depth knowledge in polymer engineering. I have also conducted collaborative research at the interface of polymer engineering and biomaterials/biosystems, resulting in publications in journals such as Acta Biomaterialia and AIMS Bioengineering, and presentations at bioengineering-focused conferences

15. My academic and professional background and qualifications are further elaborated in my curriculum vitae (Appendix A).

B. Compensation

16. I am being compensated at my normal rate of \$700 per hour for my analysis, plus reimbursement for expenses. My compensation does not depend on the content of my opinions or the outcome of this proceeding.

C. Scope of Work and Materials Considered

17. This declaration is based on my education, personal knowledge, and professional and academic experience in the area of three-dimensional printing.

18. I have been asked to review the Challenged Patent and its prosecution history, to provide an understanding of the technology relevant to the Challenged Patent, to review certain prior-art references, and to analyze whether or not those references disclose or teach limitations of claims from the Challenged Patent.

19. The opinions stated in this declaration are from the perspective of a Person of Skill in the Art (POSITA) as of October 29, 2012, whose qualifications and abilities are described below.

20. In forming my opinions, I have reviewed the Challenged Patent, its prosecution history, the materials cited in the List of Exhibits, and the materials cited throughout my declaration. I have also relied on my academic and professional experience in reaching the opinions expressed in this declaration.

II. THE CHALLENGED CLAIMS OF THE '698 PATENT

21. I understand that Petitioner has challenged claims 1–16 of the '698 Patent (the “Challenged Claims”). The Challenged Claims are set forth below, with some claim elements further sub-divided for ease of reference:

Claim Element	Claim Language from '698 Patent
1.pre (preamble)	A method comprising:
1.a	identifying build instructions for fabricating an object;

Claim Element	Claim Language from '698 Patent
1.b	initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;
1.c	detecting the current contact force based on a sensor signal from the one or more sensors; and
1.d	creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build.
2	The method of claim 1, wherein the fabrication tool includes an extruder.
3	The method of claim 2, wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.
4	The method of claim 2, wherein the at least one component of the three-dimensional printer controls a z-distance between the extruder and a build platform of the three-dimensional printer.
5	The method of claim 2 further comprising comparing the current contact force to an expected contact force.
6	The method of claim 5 further comprising adjusting at least one parameter of the three-dimensional printer to reduce a difference between the current contact force and the expected contact force.
7	The method of claim 5 further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.
8	The method of claim 1 wherein the control signal includes a signal to the three-dimensional printer to change a distance between the fabrication tool and the separate structure.
9	The method of claim 2 wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.

Claim Element	Claim Language from '698 Patent
10	The method of claim 2 further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.
11	The method of claim 10 further comprising fabricating a layer on the surface of the separate structure that decreases one or more irregularities in the surface of the separate structure.
12a	The method of claim 1, wherein the build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure, and
12b	wherein the control signal controls the at least one component of the three-dimensional printer to achieve the specified contact force.
13	The method of claim 1 wherein the one or more sensors include a strain gauge.
14	The method of claim 1 wherein the one or more sensors include a piezoelectric sensor.
15	The method of claim 1 wherein the one or more sensors include at least one of a capacitive sensor, an optical sensor, an electromechanical sensor, an electromagnetic sensor, and an acoustical sensor.

III. LEVEL OF ORDINARY SKILL IN THE ART

22. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to the Challenged Patent as well as the level of ordinary skill in that art at the time of the claimed invention. The “art” is the field of technology to which the patent is related.

23. I have been instructed by counsel that the person of ordinary skill in the art (“**POSITA**”) is a hypothetical person who is presumed to know the relevant prior

art. I understand that the actual inventor's skill is not determinative of the level of ordinary skill. I further understand that a person of ordinary skill in the art is determined by looking at (1) the type of problems encountered in the art; (2) the prior-art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the educational level of active workers in the field.

24. In my opinion, a person of ordinary skill in the art with respect to the '698 Patent is someone with bachelor's degree in Mechanical Engineering, Computer Engineering, Electrical Engineering, Chemical Engineering, Materials Science, or a comparable field and at least two years of experience related to 3D printing, with additional experience potentially being a substitute for a formal degree or training (and vice versa).

25. I understand that Petitioner and Petitioner's expert, Dr. Wolfe, have proposed a somewhat different level of ordinary skill in the art. Specifically, they assert that a person of ordinary skill in the art "would have included a bachelor's degree in Mechanical Engineering, Electrical Engineering, Computer Engineering, or a comparable field and at least two years of experience (e.g., research or industry experience) related to 3D printing." EX1003 (Declaration of Dr. Wolfe), ¶21; Petition at 5. My opinions in this declaration would not change under this proposed level of ordinary skill in the art.

26. As of at least October 29, 2012, which I understand is the priority filing date of the '698 Patent, I had at least the level of skill required under either my or Dr. Wolfe's definitions of a person of ordinary skill in the art and, in rendering my opinions, have viewed the '698 Patent from the perspective of a person of ordinary skill in the art.

IV. LEGAL STANDARDS

27. I am not a legal expert. In presenting my opinions, I have applied the legal standards provided to me by counsel in arriving at the opinions set forth in this declaration.

28. I understand that in this *inter partes* review proceeding, the Petitioner has the burden of proving that the claims of a Challenged Patent are unpatentable in light of the prior art by a preponderance of the evidence. I understand that a preponderance of the evidence is evidence sufficient to show that a fact is more likely true than not true.

A. Legal Standard for Claim Construction

29. I understand that the first step in determining whether a patent claim would have been anticipated or obvious is to ascertain how a POSITA would have understood the claim terms.

30. I have been instructed by counsel on the law regarding claim construction and patent claims. I understand that a patent may include two types of

claims: independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim, or it can further depend from another dependent claim. I understand that a dependent claim includes all the limitations that it recites, as well as all the limitations recited in the claim(s) from which it depends.

31. It is my understanding that in proceedings before the PTAB, the claims of a patent are to be construed under what is referred to as the “*Phillips* standard.” I understand that this means that claim terms of a patent are given the meaning the terms would have to a POSITA, in view of the description provided in the patent itself and the patent’s file history.

32. I understand that to determine how a person of ordinary skill would understand a claim term, one should look to those sources available that show what a person of skill in the art would have understood the disputed claim language to mean. These sources include the words of the claims themselves, the rest of the patent’s description, the prosecution history of the patent (all of which considered “intrinsic” evidence), and “extrinsic” evidence concerning relevant scientific principles, the meaning of technical terms, the technical literature on established and emerging relevant technologies, and the state of the art at the time of the invention.

33. I understand that, in construing a claim term, one looks primarily to the intrinsic evidence, including the words of the claims themselves, the remainder of the patent, and the patent's prosecution history.

34. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient.

35. I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else. In making this determination, the claims, the remainder of the patent, and the prosecution history are of principal importance. Additionally, the patent and its prosecution history must be consulted to confirm whether the patentee has acted as its own lexicographer (i.e., provided its own special meaning to any disputed terms), or intentionally disclaimed, disavowed, or surrendered any claim scope.

36. I understand that the claims of a patent define the scope of the rights conferred by the patent. The claims particularly point out and distinctly claim the subject matter which the patentee regards as his invention. Because the patentee is required to define precisely what he claims his invention to be, it is not proper to construe claims in a manner different from the plain import of the terms as used in the patent. Accordingly, a claim construction analysis must begin and remain centered on the claim language itself. Additionally, the context in which a term is

used in the asserted claim can be highly instructive. Likewise, other claims of the patent in question, both challenged and un-challenged, can inform the meaning of a claim term. For example, because claim terms are normally used consistently throughout the patent, the usage of a term in one claim can often illuminate the meaning of the same term in other claims. Differences among claims can also be a useful guide in understanding the meaning of particular claim terms.

37. I understand that a person of ordinary skill in the art is deemed to read a claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the remaining text and figures. For this reason, the words of the claim must be interpreted in view of the entirety of the patent specification (i.e., the claims, remaining text, and figures). The written description (figures and remaining text) is the primary basis for construing the claims and provides a safeguard such that correct constructions closely align with the patent.

38. In addition to consulting the patent itself, I understand that one should also consider the patent's prosecution history. The prosecution history provides evidence of how both the Patent Office and the inventors understood the terms of the patent, particularly in light of what was known in the prior art.

39. I understand that while intrinsic evidence is of primary importance, extrinsic evidence, e.g., all evidence external to the patent and prosecution history,

including expert and inventor testimony, dictionaries, and learned treatises, can also be considered. Extrinsic evidence should not be considered, however, divorced from the context of the intrinsic evidence. Furthermore, while extrinsic evidence can shed useful light on the relevant art, it is less significant than the intrinsic record in determining the legally operative meaning of claim language.

B. Legal Standard for Prior Art

40. I understand that a patent or other publication must first qualify as prior art before it can be used to invalidate a patent claim.

41. I understand that to qualify as prior art, a reference must contain an enabling disclosure that allows one of ordinary skill to practice the claims of the Challenged Patent without undue experimentation. I understand that a patent issued by the United States Patent and Trademark Office is presumed to provide an enabling disclosure. Factors to consider in determining whether undue experimentation is needed are: (1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims.

42. I understand that for a prior-art reference to be considered for obviousness, the reference must be “analogous.” I understand that the comparison

for purposes of determining “analogous” is between the asserted prior-art reference and the Challenged Patent. I have been further informed that for a prior-art reference to be considered “analogous” to the Challenged Patent and thus available as prior art for obviousness, at least one of the following conditions must be met: (1) the reference is from the same field of endeavor as the Challenged Patent, even if it addresses a different problem; or (2) the reference is reasonably pertinent to the particular problem the Challenged Patent is concerned with, even if it is not within the same field of endeavor.

C. Legal Standard for Patentability

43. I understand that for an invention claimed in a patent to be found patentable, it must be (among other things) new and not obvious based on what was known before the invention was made.

44. I understand that, once the claims of a patent have been properly construed, the second step in determining patentable of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

45. I understand that for purposes of this declaration, there are two ways to demonstrate that a patent claim is not patentable. A patent claim can be anticipated, or a patent claim can be obvious. I address each of these below.

1. Anticipation and Inherency

46. I understand that prior art can “anticipate” the claims of an asserted patent. It is my understanding that in order for a claim to be anticipated by the prior art, every element of that claim must be found, explicitly or inherently, in a single prior art reference. In other words, to determine whether a single prior art reference anticipates a patent claim, one should consider not only what is expressly disclosed in that reference, but also what inherently occurred as a natural result of the practice of the system or method disclosed in that prior art reference.

47. It is further my understanding that to establish such inherency, the missing descriptive matter must be necessarily present in the item of prior art and that it would be so recognized by persons of ordinary skill in the art. It is also my understanding that such inherency may be shown through extrinsic evidence.

2. Obviousness

48. I understand that the prior art may render a patent claim “obvious.” I understand that two or more prior art references (e.g., prior art articles, patents, or publications) that each disclose fewer than all elements of a patent claim may nevertheless be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in the art at the time would have been motivated to combine the prior art in such a way with a reasonable expectation of success.

49. I understand that this motivation to combine need not be explicit in any of the prior art, but it may be inferred from the knowledge of one of ordinary skill in the art at the time the patent was filed. I also understand that one of ordinary skill in the art is not an automaton but is a person having ordinary creativity. I further understand that an obviousness analysis recognizes that market demand often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace. I further understand that one or more prior art references, articles, patents or publications that disclose fewer than all of the elements of a patent claim may render a patent claim obvious if including the missing element would have been obvious to one of skill in the art (e.g., the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system).

50. I understand that a person of ordinary skill in the art provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents a person of ordinary skill from using hindsight in deciding whether a claim is obvious.

51. I also understand that an obviousness determination includes the consideration of various factors such as (1) the scope and content of the prior art, (2) the differences between the prior art and the challenged claims, (3) the level of ordinary skill in the pertinent art, and (4) when in evidence, the existence of

secondary considerations (such as commercial success, long-felt but unresolved needs, failure of others, etc.) to the extent they exist and have a nexus to the claimed invention.

52. I am informed that secondary indicia of non-obviousness (also known as secondary considerations) may include (1) a long felt but unmet need in the prior art that was satisfied by the invention of the patent; (2) commercial success or lack of commercial success of processes covered by the patent; (3) unexpected results achieved by the invention; (4) praise of the invention by others skilled in the art; (5) taking of licenses under the patent by others; and (6) deliberate copying of the invention. I also understand that there must be a relationship between any such secondary indicia and the invention. I further understand that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination. I also understand that secondary considerations are given less weight when the alleged invention represents a relatively small advance in a crowded field with predictable results. I further understand that the patentee has the burden of coming forward with evidence of the relationship between any secondary consideration of non-obviousness and the claimed invention (also known as the “nexus”).

53. It is also my understanding that there are additional considerations that may be used as further guidance as to when the above factors will result in a finding that a claim is obvious, including the following:

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;
- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;
- there is known work in one field of endeavor that may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to a POSITA;
- there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims; and
- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

54. I understand that a particular combination may be proven obvious by showing that it was obvious to try the combination. For example, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp because the result is likely the product not of innovation but of ordinary skill and common sense.

55. I further understand that a claim may be deemed invalid for obviousness in light of a single prior art reference, without the need to combine references, if the elements of the claim that are not found in the reference can be supplied by the knowledge or common sense of one of ordinary skill in the relevant art.

56. I also understand that practical and common-sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I further understand that a person of ordinary skill in the art looking to overcome a problem will often be able to fit the teachings of multiple publications together like pieces of a puzzle, although the prior art need not be like two puzzle pieces that must fit perfectly together. I understand that an obviousness analysis therefore considers the inferences and creative steps that a person of ordinary skill in the art would employ under the circumstances.

57. I understand that a person of ordinary skill could have combined two pieces of prior art or substituted one prior art element for another if the substitution can be made with predictable results, even if the swapped-in element is different from the swapped-out element. I understand that the relevant question is whether prior art techniques are interoperable with respect to one another, such that a person of skill would view them as a design choice, or whether a person of skill could apply prior art techniques into a new combined system.

58. In sum, my understanding is that prior art teachings are properly combined where a person of ordinary skill in the art having the understanding and knowledge reflected in the prior art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

V. THE '698 PATENT AND THE CHALLENGED CLAIMS

A. Summary of the '698 Patent (EX1001)

59. I have reviewed the '698 Patent, which relates to “three-dimensional printers” that “can be used to fabricate various desired objects based on computer models of those objects.” EX1001 at 1:12-14.

60. The '698 Patent explains that “components of the three-dimensional printer may degrade with time.” *Id.* at 1:14-15. That is the components may “become dented, warped, misaligned, etc.” *Id.* at 1:15-16. “These errors may disadvantageously affect the ability of the three-dimensional printer to accurately fabricate objects.” *Id.* at 1:16-18. Thus, there is “a need for pressure-sensing extruders and methods for using same.” *Id.* at 1:18-19.

61. The '698 Patent explains that the three-dimensional printer includes an “extruder or other tool head” that may be instrumented to “detect contact force against the extruder, such as by a build platform or an object being fabricated” and “detect deflection forces and the like acting on the tool that might indicate an operating error.” *Id.* at 1:23-28. “The resulting feedback data” may be used “to control operation of the three-dimensional printer during fabrication or diagnostics.” *Id.* at 1:28-30.

62. Figure 6 of the '698 Patent shows a flowchart of a process for fabricating an object.

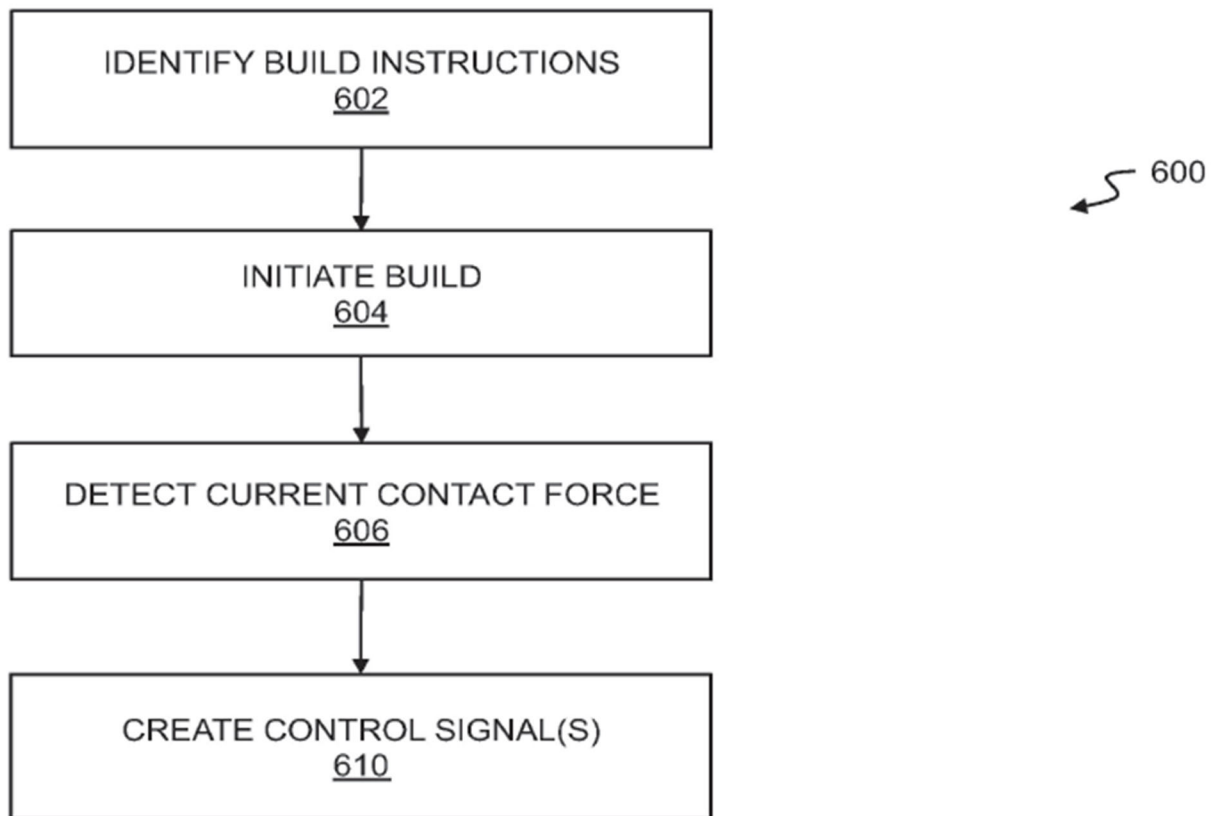


Fig. 6

63. *Id.* at Fig. 6. At step 602, the process starts by identifying build instructions for fabricating an object. *See id.* at 10:29-30. The instructions may be provided to a printer that can execute the instructions to fabricate the object. *See id.* at 10:35-37.

64. At step 604, the process continues by initiating a build. *See id.* at 10:38-39. As the '698 Patent explains, one or more sensors “may be configured to detect a current contact force between the fabrication tool and the separate structure, and to

provide corresponding data to a controller of the three-dimensional printer for use during fabrication.” *Id.* at 10:44-48.

65. Thereafter, a current contact force is detected at step 606. *See id.* at 10:49-50; *see also id.* at 8:49-61. “The current contact force may be used directly as an input to a control program executing on the controller for the three-dimensional printer, or the current contact force may be compared to other data such as a previous contact force or an expected contact force in order to determine an appropriate response.” *Id.* at 10:49-55.

66. The ’698 Patent also explains that each sensor may transmit a signal to the controller, such that the contact force(s) between the extruder and the separate structure may be calculated from the sensor signal(s). *Id.* at 8:56-61, 9:14-18.

67. Additionally, a deflection force on the fabrication tool may be measured to determine when adjustments might be made and when a process should be paused or terminated due to an inferred failure. *See id.* at 10:55-61. The deflection force may be isolated from a normal force by the use of a pair of sensors, such as strain gauges. *Id.* at 9:7-8.

68. The next step in the process (step 610) creates a control signal in response to the contact force. *See id.* at 10:62-63. The controller may generate the control signal to control a component of the three-dimensional printer during a build. *See id.* at 10:63-66; *see also id.* at 11:11-16. The control signal may be transmitted

“to various actuators or other components of the three-dimensional printer to control the three-dimensional printer in a manner responsive to the detected forces.” *Id.* 9:18-22.

69. For example, the control signal may change the feed rate of build material extruded by an extruder via a drive system or other hardware to increase or decrease the contact force. *See id.* at 10:66-11:4.

70. As another example, the control signal may vary the distance between the extruder and a separate structure to maintain steady material deposition while adjusting to surface irregularities. *See id.* at 11:4-11.

71. Other actions may be taken when the contact force exceeds a threshold or deviates from an expected value by an amount, such as terminating a build when a fabrication error is indicated by the difference between the current contact force and expected contact force. *See id.* at 11:17-22.

72. The '698 Patent also discloses a method in Figure 4 to detect planarity and responsively make corrections.

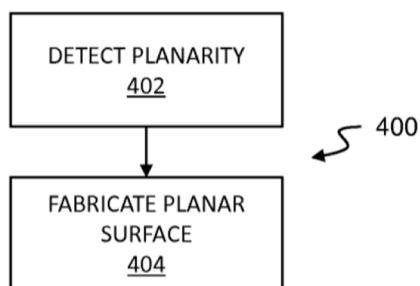


Fig. 4

73. A number of contact force measurements may be made across the surface, such as across the surface the build platform of a three-dimensional printer. *Id.* at 11:31-35. Differences among the contact force measurements may be due to warping, physical damage, misalignment in the intended mounting position, or other causes. *See id.* at 11:41-46. This leveling process may be performed concurrently with a fabrication process for an object. *See id.* at 11:34-38, Fig. 4; *see also id.* at 1:41-42, 9:24-10:19. In addition, surface contact force measurements may be stored with corresponding x and y positions on the surface and used during fabrication to compensate for the measured irregularities. *See id.* at 11:48-52. Also, a planar surface may be fabricated after detecting planarity. *See id.* at Fig. 4.

B. Summary of the Prosecution History of the '698 Patent (EX1002)

74. I reviewed the prosecution history of the '698 Patent (EX1002).

75. During prosecution, I understand that the examiner rejected pending claims 14-25 as obvious over U.S. Patent No. 6,129,872 to Jang (EX2022) in view of U.S. Patent No. 7,625,198 to Lipson (EX2023). EX1002 at 42-44 (April 9, 2015 Office Action at pp. 4-6).

76. Thereafter, I understand the applicant amended claim 14 and submitted remarks. The amendments are as follows:

14. (Currently amended) A method comprising:
identifying build instructions for fabricating an object;
initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;
detecting the current contact force based on a sensor signal from the one or more sensors; and
~~responsively~~ creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build.

EX1002 at 29.

77. In the applicant's remarks, I understand that the applicant explained that unlike the cited art, claimed method recites detecting the current contact force based on a sensor signal from one or more sensors and creating a control signal responsive to the current contact force while depositing material during a build. *See* EX1002 at 32-33.

78. In particular, the applicant explained that the examiner correctly noted that U.S. Patent No. 6,129,872 to Jang did not disclose detecting a contact force between the fabrication tool and a separate structure. *See id.* at 32.

Jang is cited for its general teaching of three-dimensional printing, and the outstanding rejection properly concedes that *Jang* "fails to disclose the step of detecting contact force between the fabrication tool and a separate structure."¹ Instead, *Lipson* is

79. Although the examiner had also relied on U.S. Patent No. 7,625,198 to Lipson, the applicant argued that Lipson fails to teach or suggest using a signal from the force sensor as feedback while depositing material during a build. *See id.* at 33.

While this passage does mention a force sensor (204), there is no suggestion here to use a signal from the force sensor as feedback *during a build*. In the device of *Lipson*, the force sensor is simply used to detect a threshold force indicating a Z axis position of a newly loaded tool tip. This may be useful, but it is significantly different than the

80. The applicant also stated that the feedback is used to control print parameters during a build. *See id.* at 33. Therefore, a control signal is created while depositing material during the build to control at least one component of the three-dimensional printer in response to the current contact force. *See id.*

newly loaded tool tip. This may be useful, but it is significantly different than the presently claimed use of a force sensor, which provides feedback to control print parameters during a build, i.e., while material is being extruded to fabricate an object. The claims have been amended to clarify this inventive concept, and to emphasize the step of creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build.

81. In response to the applicant's arguments, I understand that the examiner allowed the claims explaining that the prior art fails to teach or suggest the claimed printer. *See id.* at 20-27; *see also id.* at 21.

Allowable Subject Matter

1. Claims 14-28 are allowed over the prior art of record.
2. The following is an examiner's statement of reasons for allowance:

The prior art fails to teach or suggest an method comprising:
 - a. identifying build instructions for fabricating an object;
 - b. initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;
 - c. detecting the current contact force based on a sensor signal from the one or more sensors; and
 - d. creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build.

VI. SUMMARY OF THE PRIOR ART

82. I have reviewed the references listed below, which I understand Petitioner has cited in support of Grounds 1A-2B of their Petition:

Ground	Claims	References Cited
1A	1-6, 8-15	Warren (US 2003/0100824) (EX1004)
1B	3, 7, 9	Warren (EX1004) and Eshed (US 2007/0179656) (EX1008)
2A	1-5, 7-10, 12-15	Calderon (US 6,629,011) (EX1009) and RepRap20208 (EX1010)

Ground	Claims	References Cited
2B	11	Calderon (EX1009), RepRap20208 (EX1010), and Napadensky (US 9,031,680) (EX1005)

A. Overview of Warren (EX1004)

83. Warren (US 2003/0100824) discloses an architecture tool and methods of use, including depositing materials on a substrate, material destruction and removal, temperature control, imaging, detection, therapy and positional and locational control. EX1004 at Title, Abstract.

84. Warren explains that his tool and methods use direct-write deposition technology (DWDT) to construct inorganic and/or organic materials for fine-pattern microdispensing and/or fine-focused laser-beam writing. *See id.* at ¶¶[0010]-[0011]. The DWDT technology, as applied to biological, medical, bioengineering, and tissue-engineering, is referred to as a human architecture tool (HAT). *Id.* at ¶[0014].

85. As Warren explains there are four purported unique aspects to the HAT that uses DWDT technology. *See id.* at ¶[0059].

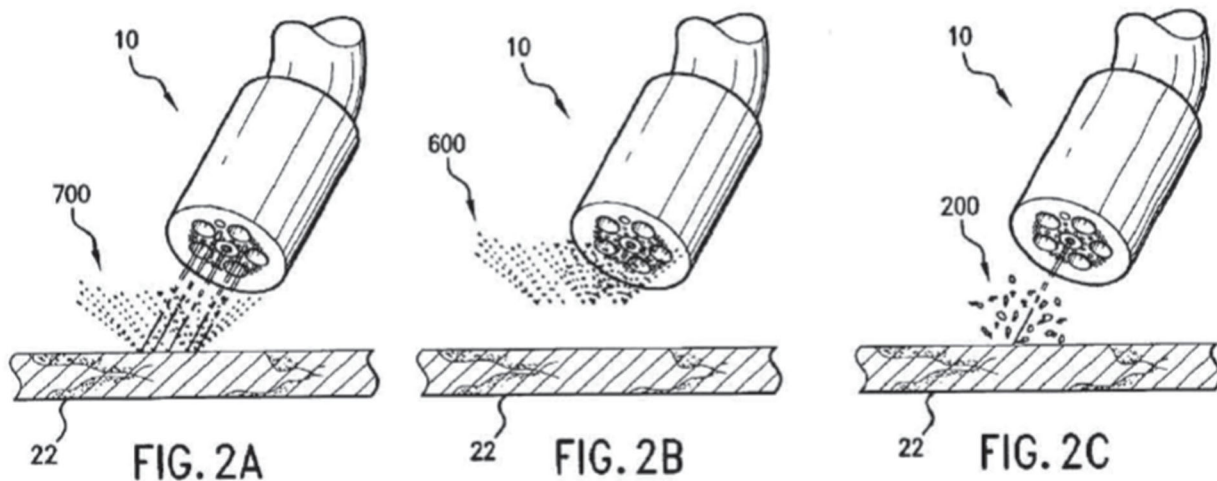
86. The first purported unique aspect to the HAT that uses DWDT technology is that it permits navigation among internal cavities and structural elements (e.g., bones), as well as arteries and veins, with the body. *See id.* at ¶[0059].

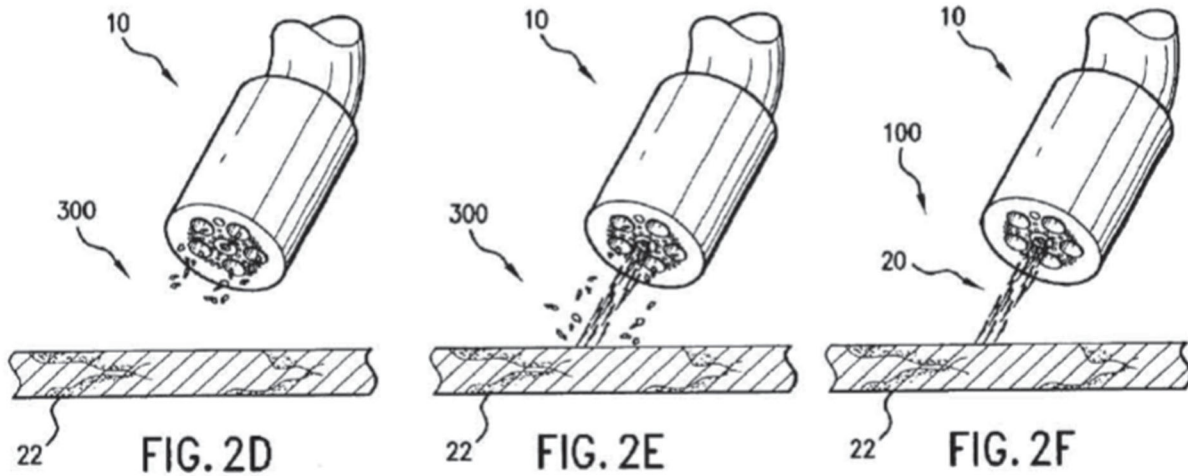
87. The second purported unique aspect to the HAT that uses DWDT technology is that it can add and/or subtract unwanted tissues and materials in a seamless and facile fashion. *See id.* at ¶[0060].

88. The third purported unique aspect to the HAT that uses DWDT technology is that it combines fabrication and assembly processes to form, for example, 3D engineered tissue constructs (ETC). *See id.* at ¶[0061].

89. The fourth purported unique aspect to the HAT that uses DWDT technology is that its processes can be performed outside of and within the body. *See id.* ¶[0062].

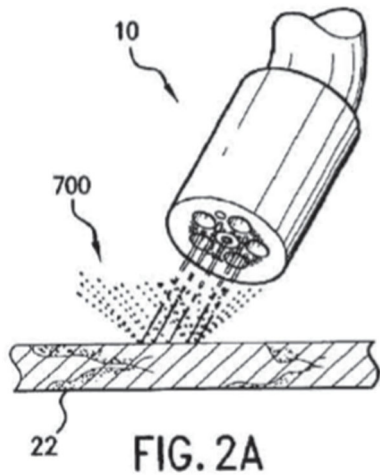
90. For example, Figures 2A through 2F of Warren show a series of perspective views using the invention in vivo.



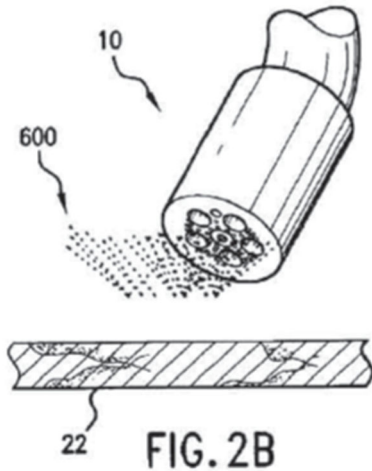


Id. at Figs. 2A-2F.

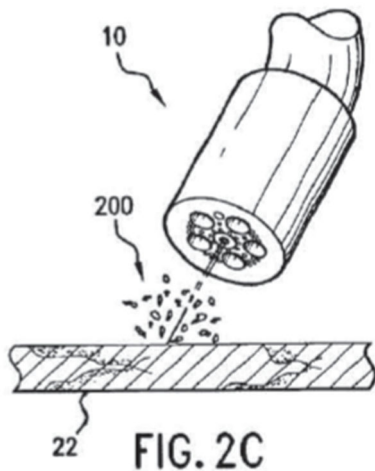
91. Figure 2A of Warren shows therapeutic emitter 700. *Id.* at ¶¶[0138]-[0141].



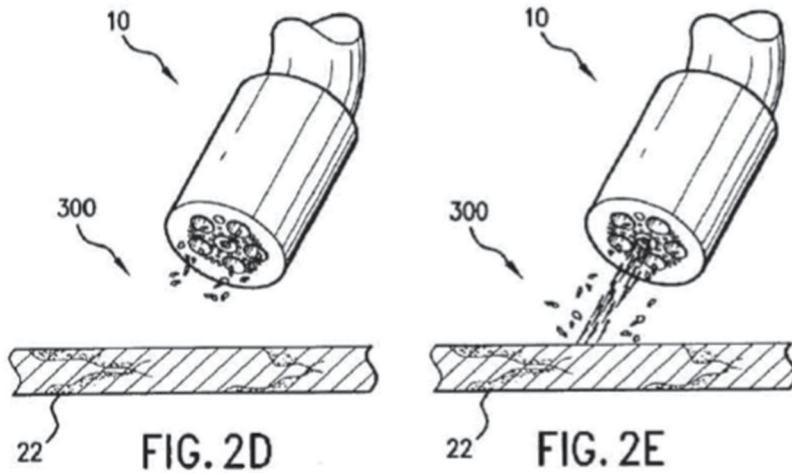
92. Figure 2B of Warren shows detector 600 for laser-induced fluorescence (LIF). *Id.* at ¶¶[0109]-[0117].



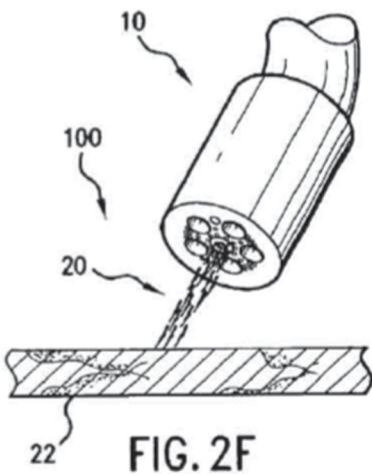
93. Figure 2C of Warren shows material destroyer 200 to separate cells or tissue from their endogenous position in the body. *Id.* at ¶¶[0147]-[0154].



94. Figures 2D and 2E of Warren show material remover 300 with suction channels. *Id.* at ¶¶[0205]-[0210].



95. Figure 2F of Warren shows a material dispenser 100 to deposit material on a substrate 22. *Id.* at ¶¶[0220]-[0229].



96. Figure 18 of Warren shows an embodiment to control the position of dispenser 3700 relative substrate 3710.

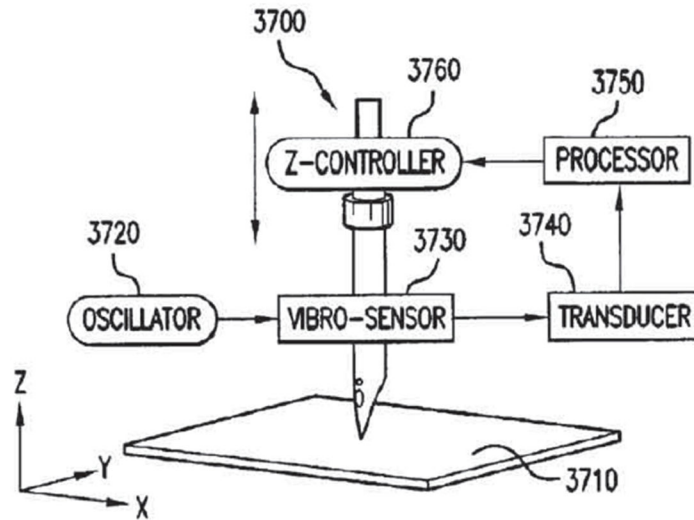


FIG. 18

Id. at Fig. 18, ¶[0293].

97. Although the substrate is shown as flat, Warren explains that this is just for the ease of illustration—the dispenser follows irregular or curved surfaces. *Id.* Oscillator 3720 imparts vibration to dispenser 3700, and vibration sensor 3730 and transducer 3740 sense the amplitude and frequency of vibration. *See id.* at ¶[0300].

98. Warren shows one implementation of a capillary vibro-sensor dispensing unit in Figure 19.

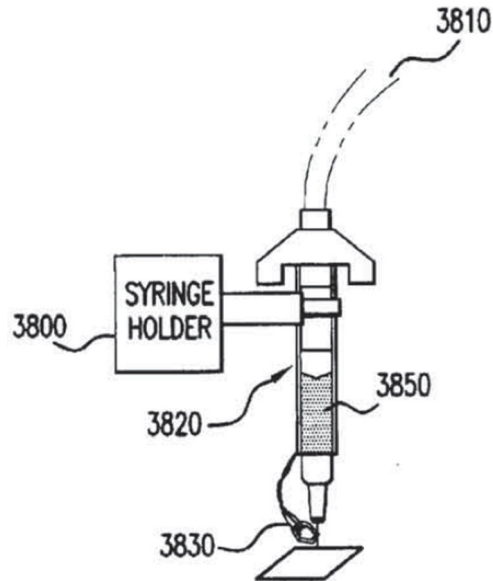
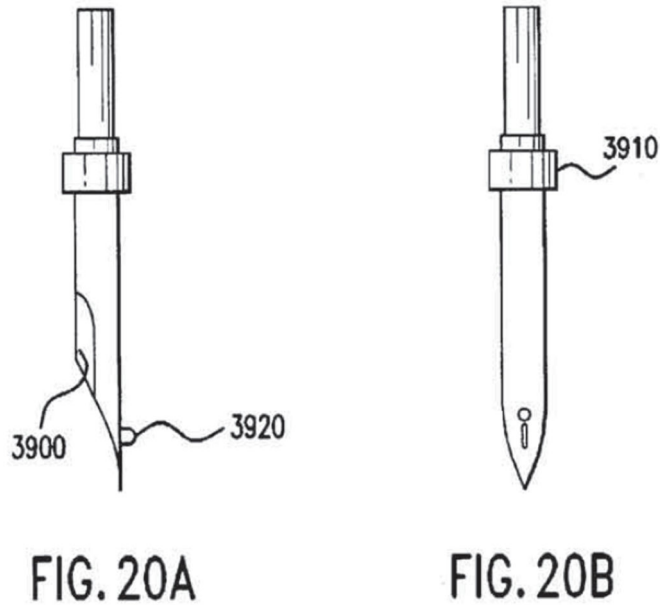


FIG. 19

See id. at ¶¶[0295]-[0297], Fig. 19. As shown, the capillary dispensing unit is held by syringe holder 3800 and the system includes a piezomembrane 3830 that may be implemented with an electroceramic sensor and include a vibration actuator and vibration transducer. *See id.*

99. Alternatively, a quill-pen may be used in which a cell suspension or slurry functions as ink. An implementation of a quill-pen is shown in Figures 20A and 20B.



See id. at ¶[0298], Figs. 20A-20B. As shown, the system includes a vibration transducer 3920. *See id.* Warren explains that vibration at a low frequency facilitates dispensing without agglomeration (e.g., clogging) and/or sticking. *See id.*

100. Warren also discloses a table-top tool can include three capillary-dispensers and another type of dispenser called a through-nozzle dispenser. *See id.* at ¶[0278], Figs. 23A-23C.

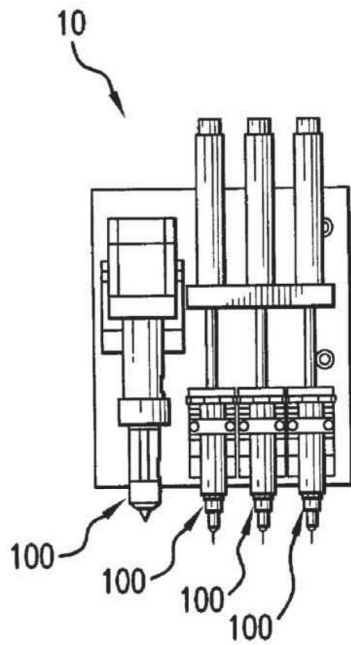


FIG. 23A

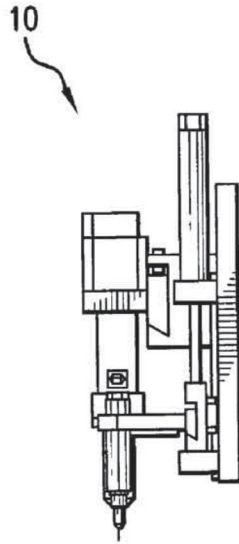


FIG. 23B

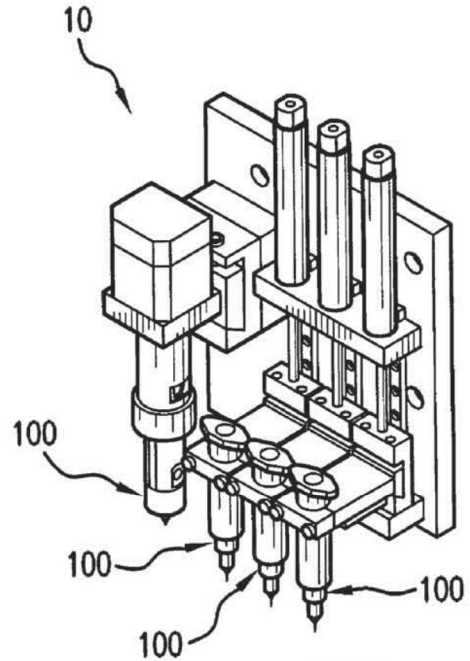


FIG. 23C

101. The through-nozzle dispenser is used to fill larger areas. *See id.* at ¶[0278], Figs. 23A-23C. By contrast, the capillary dispensers are used to dispense solutions and/or cell suspensions to achieve smaller detail than those possible with the through-nozzle dispenser, to provide high-detail and high-precision dispensing. *See id.*

B. Overview of Napadensky (EX1005)

102. Napadensky (US 9,031,680) discloses a solid freeform fabrication using a plurality of modeling materials and a plurality of dispensing heads. EX1005, Title and Abstract. Figure 1a of Napadensky shows a solid freeform fabrication system. *Id.* at Fig. 1a (shown below).

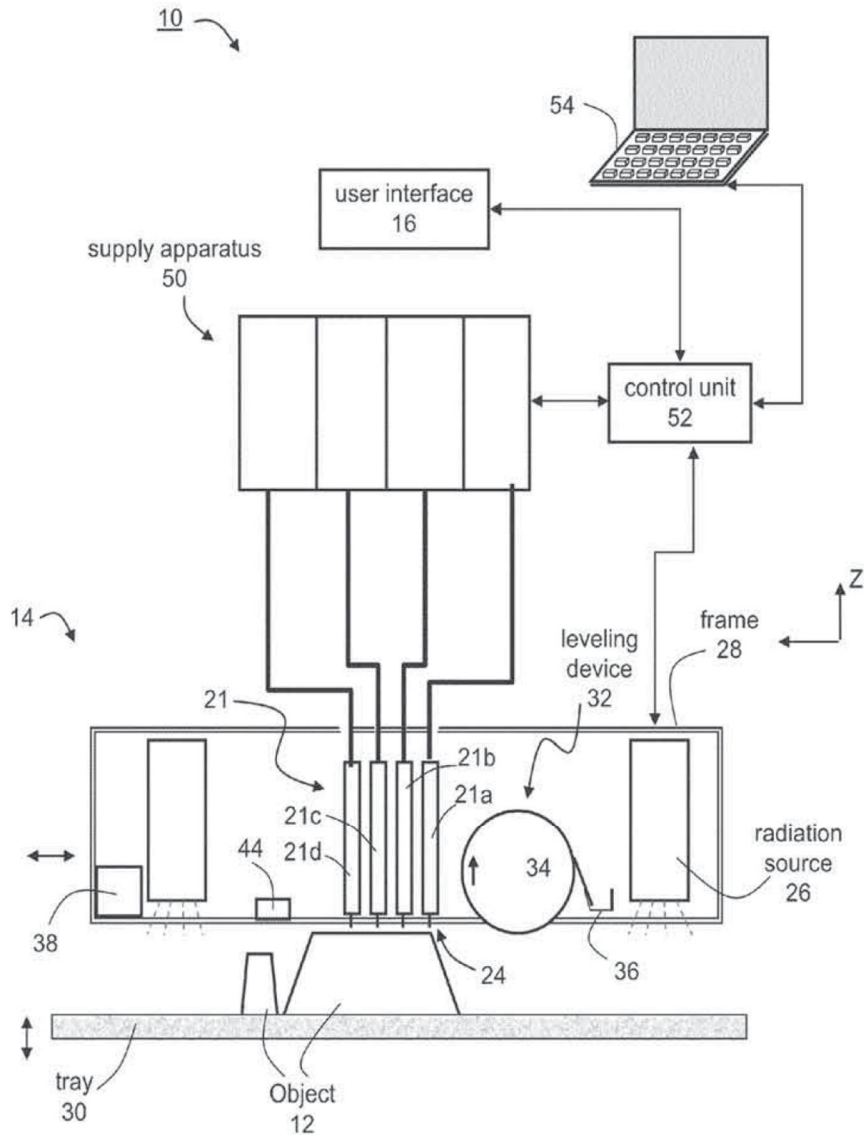


Fig. 1a

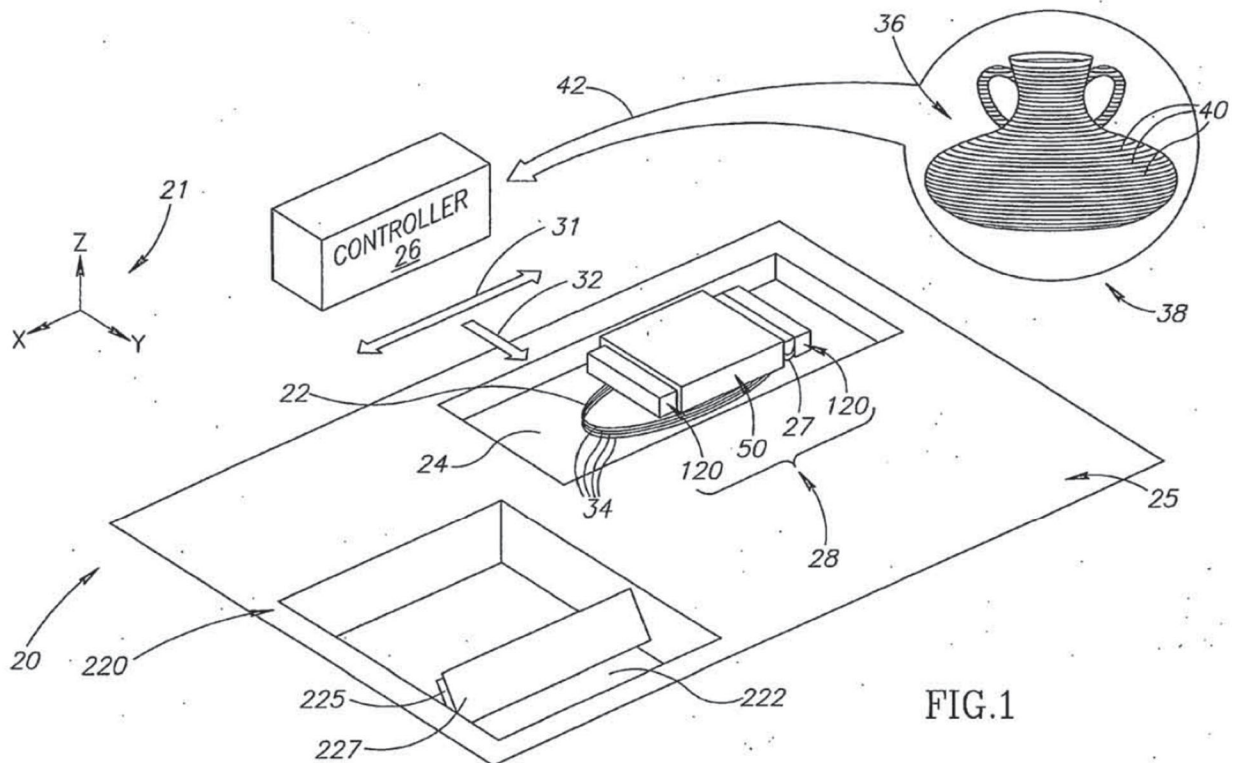
103. As shown in Figure 1a of Napadensky, the system (10) has multiple dispensing heads (21) through which building material (24) is dispensed to create object(s) (12). EX1005 at 16:32-35, Fig. 1a.

104. Also shown in Figure 1a of Napadensky is a leveling device (32), such as the roller shown in Figure 1a, that straightens a newly formed layer after the layer

is fabricated but prior to the formation of the successive layer. *See id.* at 17:62-67, Fig. 1a. In particular, the leveling device moves portions of the newly formed layer into a waste collection device (36) to collect excess material generated during leveling. *See id.* 17:67-18:4, Fig. 1a.

C. Overview of Eshed (EX1008)

105. Eshed (US 2007/0179656) relates to a rapid prototyping apparatus (RPA) for producing an object by sequentially forming thin layers of a construction material one on top of the other responsive to data defining the object. EX1008, Title and Abstract. As shown below, Figure 1 of Eshed shows his apparatus.

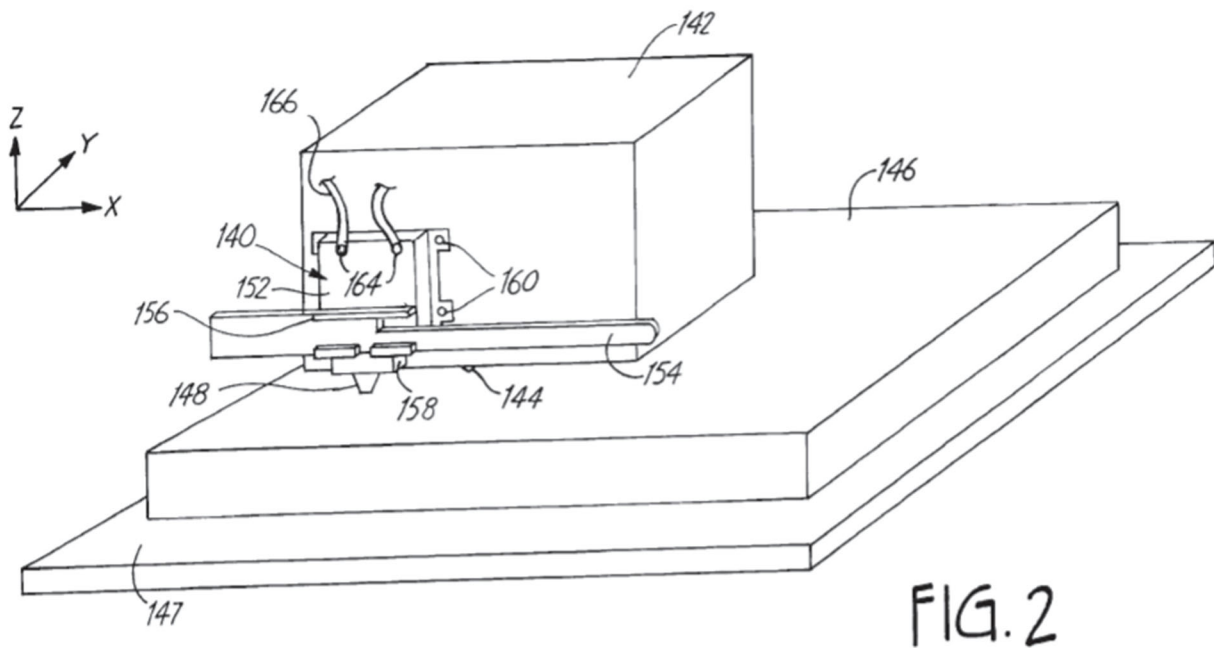


D. Overview of Calderon (EX1009)

106. Calderon (US 6,629,011) discloses a method for a three-dimensional modeling machine. EX1009 at Title.

107. Without operator intervention, Calderon senses the top surface of a substrate or other object at a variety of locations and records the Z-axis positions. *See id.* at Abstract.

108. Much of Calderon focuses on using a plunger to find z-axis positions. As shown below in Figure 2, plunger 148 is in its actuated position, protruding from the bottom of housing 152.



Id. at Fig. 2, 5:48-49. When the platform 147 is raised upward, the top surface of substrate 146 contacts plunger 148 and drives it up into housing 152. *See id.* at 5:55-

58. A sensor senses when the plunger has traveled upward by a predetermined distance and provides a signal indicating detection of the plunger. *See id.* at 5:58-61.

109. In an alternative embodiment, instead of the plunger, Calderon teaches that the tip of the nozzle and servo drive motors are used to detect contact with the substrate by monitoring a change in the servo drive current. *See id.* at 9:63-10:8.

110. Calderon explains that this alternative embodiment beneficially detects contact “without need for any special purpose sensing means.” *See id.* at 10:7-8. Calderon also explains that its autoinitialization method can also be used to ensure that the building envelope is clear or to detect partially built models. *See id.* at 10:26-31; *see also id.* at 10:50-64.

E. Overview of RepRap20208 (EX1010)

111. I understand that Petitioner has asserted that RepRap20208 is a printout dated December 31, 2024 from a “General” forum that is entitled “Genetic Algorithms.” EX1010 at 1.

112. The forum on “Genetic Algorithms” discusses using such algorithms to improve RepRap (EX1010 at 1).

 vbgraphix <u>Genetic Algorithms</u> January 11, 2009 04:35AM	Registered: 15 years ago Posts: 8
I'm wondering what applications Genetic Algorithms could have in improving RepRap. It shouldn't be too hard to use software-based optimizers that can improve our circuits, designs, etc. Thoughts?	
Reply Quote	

113. However, another forum member cast doubt on such algorithms, stating that the “question is more one of who wants to invest the man-hours to apply the method to these particular applications. It's not something I have time for.” EX1010 at 1.

 Forrest Higgs <u>Re: Genetic Algorithms</u> January 11, 2009 08:45AM	Admin Registered: 17 years ago Posts: 1,915
I've written genetic algorithms in my day job in years past. The question isn't one of whether they could improve outcomes. They definitely could. The question is more one of who wants to invest the man-hours to apply the method to these particular applications. It's not something I have time for.	

114. The RepRap20208 reference appears to focus on genetic algorithms and genetics for several pages. *See, e.g.*, EX1010 at 6 (“With generational genetic drift in a more or less homogeneous population you have some fairly well-understood statistical mechanisms”).

VII. GROUND 1A: CLAIMS 1-6, 8-15 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 1A (WARREN)

115. In Ground 1A of the Petition, Petitioner asserts that claims 1-6 and 8-15 are obvious over Warren. *See* Petition at 6-13 (Overview of Warren), 13-16 (Asserted Motivation to Combine), 16 (1.pre), 16-17 (1.a), 17-21 (1.b), 21 (1.c), 21-23 (1.d), 23-25 (claim 2), 25-26 (claim 3), 26-27 (claim 4), 27-28 (claim 5), 28-29 (claim 6), 30 (claim 8), 31 (claim 9), 31-33 (claim 10), 33-35 (claim 11), 35 (12.a), 35-36 (12.b), 36 (claim 13), 36-37 (claim 14), 37 (claim 15).

116. I have reviewed Petitioner's challenges in Ground 1A, and it is my opinion that Ground 1A fails to teach or suggest all elements of claims 1-6 and 8-15. I explain my opinions below in detail.

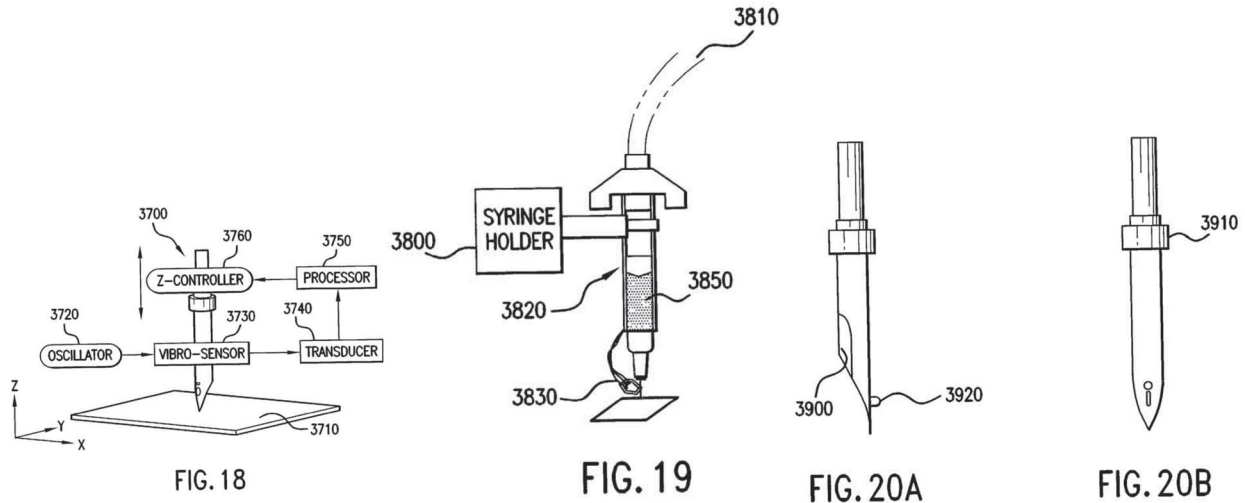
A. There is no motivation to combine different embodiments of Warren (Ground 1A)

117. I understand that Petitioner asserts a motivation to combine different embodiments of Warren. *See* Petition at 13-16. In particular, I understand that Petitioner asserts that "a POSITA would have found it obvious to use the vibrating force sensor concepts with Warren's through-nozzle dispenser." *See id.* at 13. I also understand that Petitioner asserts that a "POSITA would have been motivated to apply Warren's through-nozzle dispenser" as "dispenser 3700 in Warren's vibrating force sensor configuration." *See id.* at 13. In support of these assertions, I understand that Petitioner has provided four reasons. *See id.* at 13-16.

118. In my opinion, a POSITA would have understood that there is no motivation to combine the different embodiments of Warren in the manner that Petitioner proposes and that there would have been no reasonable expectation of success in doing so.

119. **First**, I understand that Petitioner asserts that “Warren invites using the vibrating force sensor concepts with other dispenser configurations when it explains that the capillary dispenser is shown with the vibrating force sensor ‘by way of example only,’ and ‘[t]he dispenser 3700 need not be limited to [the capillarity dispensing unit] implementations.’” Petition at 13-14. Dr. Wolfe makes a similar assertion. *See* EX1003, ¶68.

120. However, Warren does not “invite” the “using the vibrating force sensor concepts” with a through-nozzle design. Warren states that its dispenser 3700 is not limited to the specific implementations corresponding to Figures 19, 20A, and 20B. *See* EX1004, ¶[0299] (“The material dispensers illustrated in FIGS. 19, 20A and 20B are shown by way of example only. The dispenser **3700** need not be limited to these implementations.”). I note that Figure 18 of Warren itself illustrates a different dispenser. In Figure 18, dispenser 3700 is another implementation of a quill-pen design that is different from the quill-pen design shown in Figures 20A and 20B and from the capillary dispenser shown in Figure 19. I reproduce each of these figures from Warren below.



EX1004 at Figs. 18, 19, 20A, and 20B.

121. As shown in the figures above, Figures 20A and 20B show a specific quill-pen design with a vibration actuator 3910 substantially separated from the vibration transducer 3920. *Id.* at Figs. 20A, 20B; ¶[0298] (“For illustrative purposes, the quill-pen is shown in FIGS. 20A and 20B as being part of a dispensing unit including a vibration actuator **3910** and a vibration transducer (receiver) **3920**, as described in more detail below.”).

122. Also shown in the figures above, Figure 19 shows a specific capillary syringe with a combined vibration actuator and transducer in piezomembrane 3830. *Id.* at ¶[0295] (“FIG. 19 illustrates in detail aspects of an exemplary dispensing system including a capillary dispenser held by a syringe holder **3800** and a piezomembrane **3830**. The piezomembrane **3830** may be implemented with an electroceramic sensor and include a vibration actuator and vibration transducer, described in more detail below.”).

123. In contrast to Figures 19 and 20A-20B, Figure 18 shows another implementation of a quill-pen design with a vibro-sensor 3730 in which the separate oscillator 3720 and transducer 3740 are separate from the dispenser with vibro-sensor 3730. *Id.* at ¶[0300] (“a vibration oscillator **3720** is attached to the dispenser **3700** for imparting vibration to the dispenser **3700**. A vibration sensor **3730** and a transducer **3740** are attached to the dispenser **3700** for sensing the A and f of vibration of the dispenser **3700**. The oscillator **3720** and the transducer **3740** may be implemented with any suitable conventional devices. These elements may be spatially and physically separated ...”).

124. As additional examples, Figures 23A, 23B, and 23C illustrate multiple capillary dispensers that are individually “extended into position to do its intended high-detail and high-precision dispensing.” *Id.* at Figs. 23A-23C, ¶[0278].

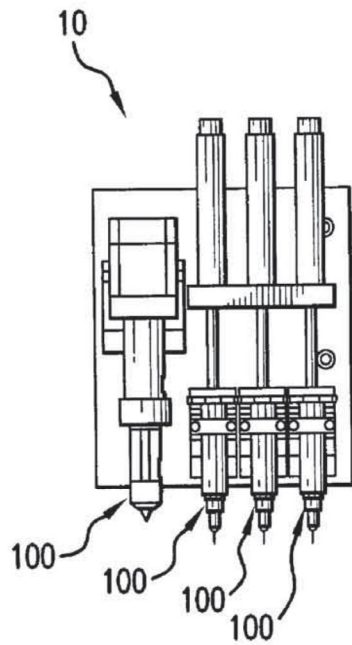


FIG. 23A

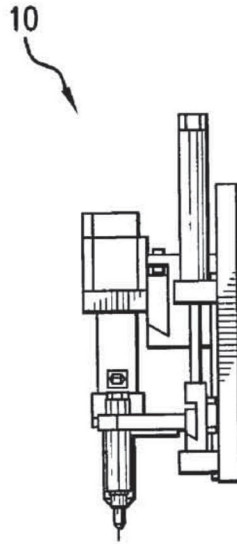


FIG. 23B

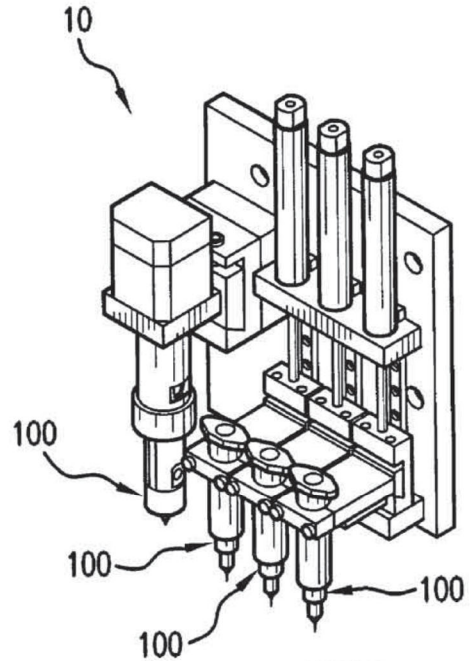


FIG. 23C

125. In my opinion, there is no motivation or suggestion to implement dispenser 3700 as a through-nozzle design. *See* EX1004, ¶[0299].

126. **Second**, I understand that Petitioner asserts that “a POSITA would have been motivated by the precise flow control capability of Warren’s through-nozzle design” and that a “POSITA would have found it advantageous to employ features from Warren’s through-nozzle design in dispenser 3700 so that ‘the initiation of material flow...can be smooth, seamless, and very reproducible.’” Petition at 14. Dr. Wolfe makes a similar assertion. EX1003, ¶69.

127. According to Warren’s teachings, the capillary dispenser already provides for high precision and a POSITA would have understood to switch from a

through-nozzle dispenser to a capillary dispenser when smaller, high-detail, high-precision dispensing is required.

128. In particular, Warren teaches that a through-nozzle design is used for less detailed dispensing to fill larger areas with higher viscosity materials, whereas capillary dispensers are used for high-detail and high-precision dispensing of lower viscosity materials to achieve smaller details. *See* EX1004 at ¶[0278] (“[T]he through-nozzle dispenser includes a 25-200- μ m conical tip attached to a suck-back spool valve, which may be used for more-viscous fluids. The capillary dispensers include >100 μ m small capillary pen tips that may be used to dispense lower- μ solutions and/or cell suspensions. Each dispenser is independently controlled to deposit a predetermined amount of material. In the illustrated embodiment, the larger conical through-nozzle dispenser fills and dispenses larger areas with higher- μ materials, while the smaller capillary dispensers are retracted. When smaller detail and/or less-viscous materials than those possible with the conical through-nozzle tip are required, or if a different medium is needed, then a capillary dispenser can be extended into position to do its intended high-detail and high-precision dispensing. The capillary dispensers are mounted in a syringe that is jacketed with aluminum to provide the maximum amount of heat transfer. The jacketed aluminum syringe may be clamped into position with an aluminum tube clamp. The dispensers in the illustrated embodiment have been designed to extend and retract, so that only one

dispenser is writing at a time; however, it is possible to have multiple dispensers writing at one time.”).

129. Similar to capillary dispensers, Warren teaches that sensoric quill-pen designs enable precise control “to sense and maintain optimum contact.” *See id.* at ¶¶ [0259-260] (“[0259] Sensoric Quill-Pen Dispensing Design [0260] In another embodiment, the at least one material dispenser **100** comprises a sensoric capillary-and/or quill-pen, in which a constituent material such as a cell suspension or slurry would function as “ink” for the dispenser. In the embodiment illustrated in FIG. 19, the capillary tube **115** communicates a material supply chamber **116**, such as a supply, reservoir, or feeder for storing a sufficient volume of the constituent material. The “sensoric” feature of such quill-pens enables the tool to sense and maintain optimum contact with the deposition target while the constituent material is being dispensed from the dispenser as discussed in greater detail below.”).

130. Thus, there is no motivation to use a through-nozzle design for the dispenser instead of a quill-pen or capillary dispenser to enable precise control.

131. Both through-nozzle designs and capillary dispensers have their respective applications, and a person of ordinary skill in the art would not be motivated to use the inherently less precise through-nozzle dispenser to deposit a low-viscosity material with high precision, given the superior control offered by capillary-based systems.

132. As Warren explains, capillary dispensers are “primarily controlled by capillary surface tension when the tip almost touches the substrate surface.” EX1004 at ¶[0279]. A POSITA would have understood that the precise start and stop of material flow would be controlled by a capillary dispenser depending on whether the dispenser was nearly in contact with the substrate surface such that the surface tension controls the precise flow of material. *See id.*

133. Warren also explains that capillary dispensers have precise control, such as linear bearings to achieve “a constant, repeatable, and accurate position” which precisely control the flow of material. EX1004 at ¶[0279].

134. Similar to capillary designs, quill pen designs maintain optimum contact with the deposition target to dispense “ink,” such as a cell suspension or slurry. EX1004 at ¶[0260]. Quill pen designs precisely control the material flow by vibrating the dispenser to overcome agglomeration and/or sticking of the ink. EX1004 at ¶[0298]. Thus, while Warren explains that through-nozzle dispensers can have “inconsistent volumes and inaccurate starting times,” there is no suggestion that such issues apply to capillary dispensers or quill pen dispensers. *See* EX1004 at ¶[0243].

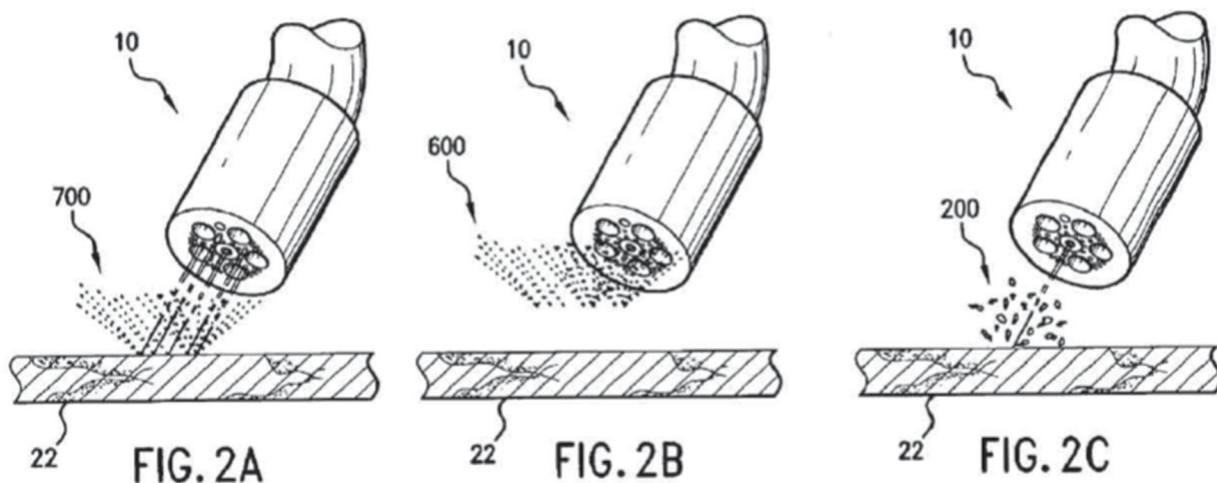
135. **Third**, I understand that Petitioner asserts that a “POSITA would have recognized Warren’s express suggestion to add features from its through-nozzle design (such as linear actuator 144) to Warren’s dispenser system 3700 to pursue a

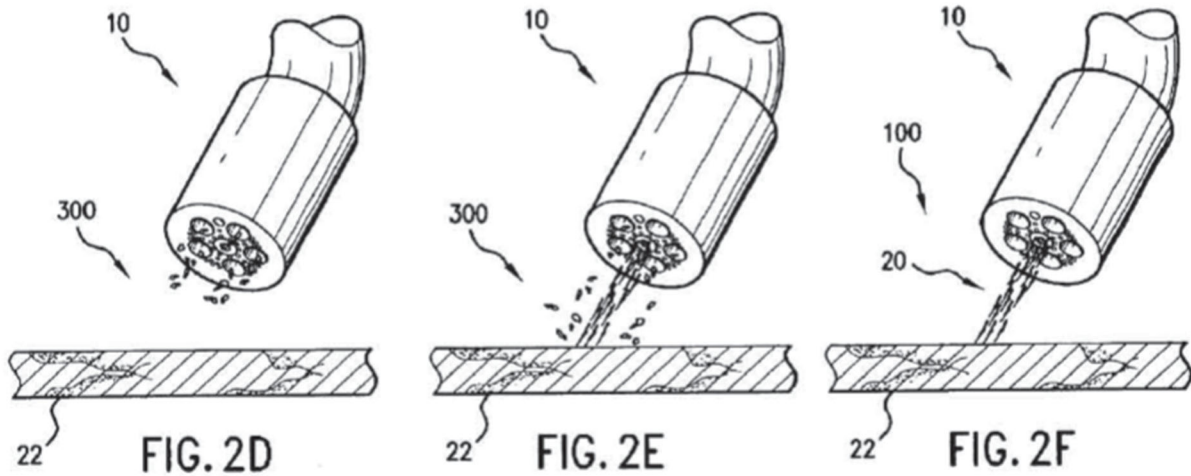
predictable combination.” Petition at 14-15. In support of its assertion, I understand that Petitioner states that Warren “explains that its ‘DWDT/HAT technology has a plurality of aspects that, in some embodiments, combine to make a tool capable of producing a modeled structure through 3D direct construction of various materials into complex shapes.’” Petition at 14-15. Dr. Wolfe makes a similar assertion. EX1003, ¶70.

136. However, Warren’s description of using multiple “aspects” that “combine” to make a tool with certain capabilities refers to a combination tool. *See* EX1004, ¶[0093].

137. For example, Warren provides examples of the individual devices in the combination tool in Figures 2A to 2F. *See* EX1004, [0093], Figs. 2A-2F.

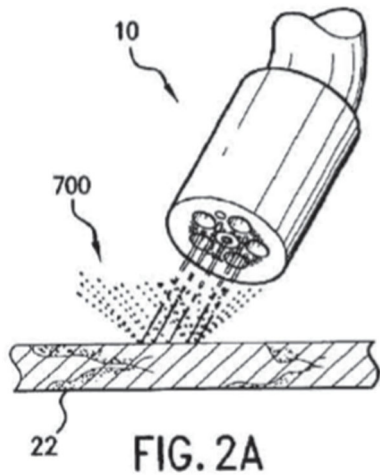
138. For example, Figures 2A through 2F of Warren show a series of perspective views using the invention in vivo.



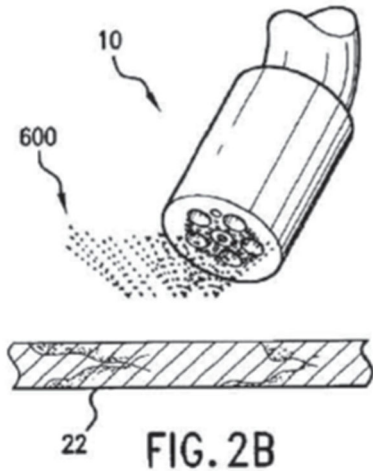


Id. at Figs. 2A-2F.

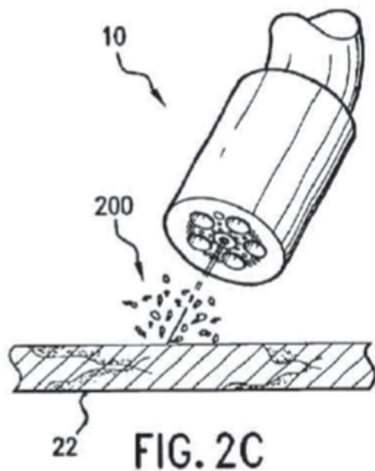
139. Figure 2A of Warren shows therapeutic emitter 700. *Id.* at ¶¶[0138]-[0141].



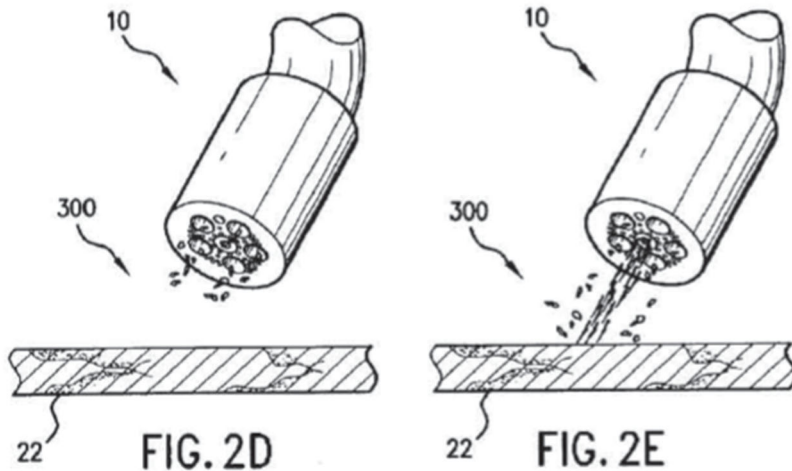
140. Figure 2B of Warren shows detector 600 for laser-induced fluorescence (LIF). *Id.* at ¶¶[0109]-[0117].



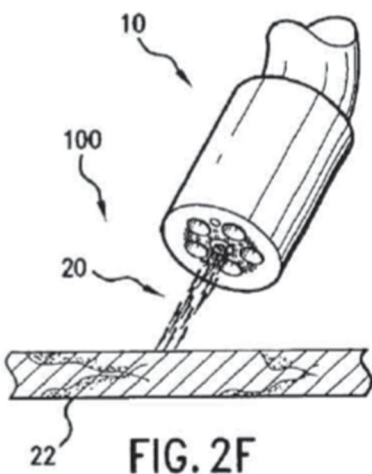
141. Figure 2C of Warren shows material destroyer 200 to separate cells or tissue from their endogenous position in the body. *Id.* at ¶¶[0147]-[0154].



142. Figures 2D and 2E of Warren show material remover 300 with suction channels. *Id.* at ¶¶[0205]-[0210].



143. Figure 2F of Warren shows a material dispenser 100 to deposit material on a substrate 22. *Id.* at ¶¶[0220]-[0229].



144. Warren's combination tool does not add features from one design to another design. Rather, a person of ordinary skill in the art would have understood that Warren integrates (i.e., combines) many devices (i.e., aspects) into one combination tool. *See id.* at ¶[0093] (“[T]he DWDT/HAT includes a material dispenser 100 . . . ; a material destroyer 200 . . . ; a material remover 300 . . . ;

temperature controllers 400 . . . ; vision and imaging devices 500 . . . ; detection devices 600 . . . ; therapeutic emitters 700 . . . ; location control devices 800 . . . ; and stabilization devices 900.”).

145. In addition, requiring a linear actuator for Warren’s capillary or quill-pen designs relies on hindsight. There is no need for a linear actuator to open and close a valve in Warren’s capillary designs or quill-pen designs. A quill pen is inherently self-regulating: ink flow is governed by capillary forces, surface tension, and wetting at the tip, rather than by an actively actuated valve. Similarly, capillary dispensers rely on passive fluid mechanics to control flow. Because material delivery in these systems is controlled by intrinsic capillary behavior, a person of ordinary skill in the art would have had no motivation to add a linear actuator for flow control, particularly given the added complexity, reduced precision, and departure from the fundamental operating principles of these designs.

146. The linear actuator in Warren’s through-nozzle designs enables control of the rate and degree that the valve opens and closes for dispensing material. *See* EX1004 at ¶¶[0231], [0234]. While Warren’s through-nozzle designs use the linear actuator to control the dispensing of material, Warren teaches that other features in his capillary dispensers and quill-pen dispensers achieve control of the material flowing out the dispenser. For example, Warren teaches that the flow of material from his capillary dispenser is “primarily controlled by capillary surface tension

when the tip almost touches the substrate surface” and that a positive pressure is applied to the feed channels. *Id.* at ¶[0279]. As another example, Warren teaches that his quill-pen dispensers enable precise control “to sense and maintain optimum contact” and are vibrated to facilitate dispensing of the ink, thus overcoming issues regarding agglomeration and/or sticking. *Id.* at ¶¶[0260], [0298]. Thus, there is no motivation to add a linear actuator to dispenser 3700.

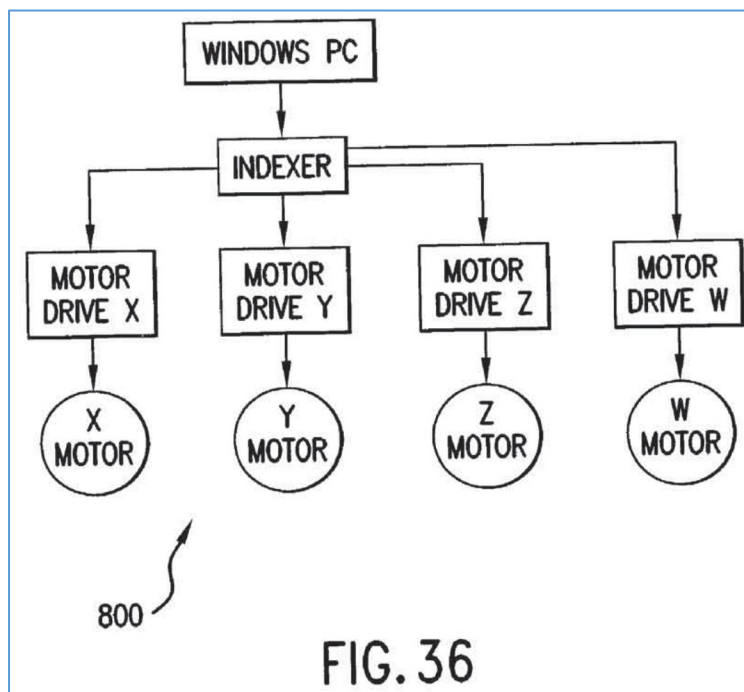
147. **Fourth**, I understand that Petitioner asserts that “a POSITA would have recognized the benefits of providing Warren’s through-nozzle dispenser with vibrating force sensor capabilities,” that “a POSITA would have sought to apply Warren’s vibration force sensing to Warren’s through-nozzle dispenser to avoid damage to the substrate or nozzle” and “to facilitate control over the deposition geometry,” and that “a POSITA would have sought ‘to overcome issues regarding agglomeration and/or sticking of the constituent material’ with the vibrating aspects.” Petition at 15-16. Dr. Wolfe makes similar assertions. EX1003, ¶71.

148. But applying Warren’s vibration force sensing to Warren’s through-nozzle dispenser is the opposite of Petitioner’s combination of Warren’s embodiments, which involves applying Warren’s through-nozzle dispense to Warren’s vibration force sensing configuration. *See* Petition at 13.

149. In addition, a personal of ordinary skill in the art would not have been motivated to make this modification to facilitate control over the deposition

geometry or to avoid damage. *See* Petition at 15. Warren’s through-nozzle dispenser already includes a mechanism to control the deposition geometry and to avoid damage. Warren explains that, through precision control of a valve and piston opening, the material flow is “smooth, seamless, and very reproducible.” EX1004 at ¶[0243]. In addition, control of the valve in the through-nozzle dispenser is synchronized with the xyz motion of the dispenser. *See id.* at ¶[0234]; *see also id.* at ¶[0227] (synchronizing control device 800 with the actuator).

150. In particular, the dispenser has a “location control device 800” that is “adapted to position the tool, specifically the tip orifice, at any selected position with respect to the substrate or target area.” A block diagram of the location control device is shown below.



151. *Id.* at Fig. 36. As shown in Figure 36 of Warren, the location control device includes a Windows PC, indexer, and translation system. *Id.* at ¶[0228]. “[T]he indexer accepts commands from the PC and computes the necessary commands that need to be sent to the translation system.” *Id.* The translation stages “typically operate with *1-2 um of accuracy*” and “a linear stage with linear encoders” can be used to achieve “*nanometer accuracy.*” *Id.* (emphasis added).

152. Warren explains that location control device is configured to “selectively position the tip orifice within both x and y dimensions (i.e., a plane) that is substantially parallel to the substrate or target area” in the x or y direction and “selectively position the tip orifice within the z dimension (i.e., a line) that is substantially perpendicular to that xy plane.” *Id.* Thus, a person of ordinary skill in the art would have understood that the location control device already enables the through-nozzle dispenser to precisely control deposition geometry and avoid damage by positioning the tip orifice within micrometers to nanometers of accuracy.

153. In contrast to Warren’s through-nozzle dispenser, Warren teaches other dispensers that have specific need for vibration control. For example, a capillary dispenser is “controlled by capillary surface tension when the tip almost touches the substrate surface” which may be curved. *Id.* at ¶[0279]; *see also id.* at ¶[0295]. Thus, precise control of the tip is required. As another example, certain quill-pens require a “sensoric” feature to “sense and maintain optimum contact with the deposition

target.” *Id.* at ¶[0260]. Thus, the dispensers in Warren that need vibrating sensor capabilities, such as the capillary dispenser and sensoric quill-pen, use the functionality to maintain optimum contact to prevent crashes and to control the flow of material, such as less-viscous fluids that must be dispensed close to the surface or those that function as “ink” *See id.* at ¶¶[0234], [0278], [0298].

154. Further, a person of ordinary skill in the art would not have had a motivation to combine Warren’s embodiments based on overcoming issues regarding agglomeration and/or sticking. *See* Petition at 15-16. The issue of agglomeration and/or sticking is related to implementations of a quill-pen that use ink and thus not related to a through-nozzle dispenser which does not use ink. *See* EX1004, ¶¶[0298], [0331]-[0332]. In particular, Warren explains that vibrating the quill pen at a low frequency “facilitates dispensing of the ink, thus overcoming issues regarding agglomeration and/or sticking of the cells.” *Id.* at ¶[0298]. There is no rationale for why solutions for dispensing ink would apply to a through-nozzle dispenser. The low-frequency vibrations applied to the dispenser to disperse agglomerates are unrelated to any agglomerates that may form in the ink after deposition on the substrate, which could interfere with or damage the quill. Rather, these vibrations are directed to cell or particle agglomerates that form within the dispenser itself, where dispersion is required to maintain flow of the low viscosity ink. It is well known that agglomerates are dispersed by flow-induced stresses, a

phenomenon that falls squarely within the field of dispersive mixing and would be familiar to a person of ordinary skill in the art. Furthermore, it is not necessary to use low frequency vibrations in the through-nozzle dispenser that is designed to deposit larger areas with less precision, to disperse agglomerates.

155. Thus, a person of ordinary skill in the art would not have had a motivation to combine the different embodiments of Warren as Petitioner proposes.

B. Claim 1, Elements 1.b, 1.c, and 1.d

156. Claim 1 of the '698 Patent requires, among other elements, “initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;” (claim element 1.b), “detecting the current contact force based on a sensor signal from the one or more sensors; and” (claim element 1.c), and “creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build” (claim element 1.d). *See* EX1001; *supra* Section II (“The Challenged Claims of the '698 Patent), Claim Elements 1.b, 1.c, and 1.d.

157. I understand that Petitioner contends that Warren teaches these claim elements. *See* Petition at 17-21 (1.b), 21 (1.c), 21-23 (1.d).

158. For claim element 1.b, Petitioner asserts that the “Warren also provides *one or more sensors* (e.g., vibration sensor 3730 and transducer 3740) *mechanically coupled to the fabrication tool* (e.g., apparatus 10).” Petition at 18; EX1003, ¶¶80-81. Further, Petitioner asserts that “Warren’s *sensors* are *configured to detect a current contact force* (e.g., the force of contact) *between the fabrication tool* (the capillary vibro-sensor dispenser and/or the through-nozzle dispenser) *and a separate structure* (e.g., substrate 3710).” Petition at 19-20; EX1003, ¶¶82-85. Petitioner also asserts that “In view of the proportionality [in Warren], a POSITA would have understood or found it obvious that the *contact force* can be readily calculated from the detected ‘change in the amplitude.’” Petition at 20-21; EX1003, ¶¶86-87.

159. For claim element 1.c, Petitioner asserts that the “Warren’s combined teachings provide *detecting the current contact* (e.g., ‘the force of contact between the dispenser and the substrate’) *based on a sensor signal* (e.g., ‘a change in the amplitude of vibration of the dispenser’) *from the one or more sensors* (e.g., vibration sensor 3730 and transducer 3740).” Petition at 21; EX1003, ¶¶88-89.

160. For element 1.d, Petitioner asserts that “Warren’s combined teachings provide *creating a control signal* (e.g., the signal provided by a ‘microprocessor’ or ‘personal computer (PC)’) *to control at least one component of the three-dimensional printer* (e.g., at least one of a ‘z-controller step motor’ and a ‘linear actuator’ of the material dispensing system) *in response to the current contact force*

(e.g., ‘force of contact’) *while depositing material during the build* (‘even as the material protruding from a nozzle on a dispenser contacts the substrate surface’).
Petition at 21-23; EX1003, ¶¶90-91.

161. It is my opinion that the Warren combination does not teach all portions of claim elements 1.b, 1.c, and 1.d.

162. Warren does not teach one or more sensors configured to detect a current contact force, detecting the current contact force based on a sensor signal, or in response to the current contact force, creating a control signal. In particular, Warren detects a change in amplitude of vibration and does not detect a current contact force. Petitioner asserts that “a POSITA would have understood or found it obvious that the contact force can be readily calculated from the detected ‘change in the amplitude.’” Petition at 50; EX1003, ¶86; EX1004 (Warren) at ¶¶[0313]. In my view, Petitioner’s conclusion overlooks Warren’s teachings and uses hindsight. I explain my reasons below.

163. Warren does not teach or suggest detecting the current contact force based on the sensor signal. Warren repeatedly refers to detecting a change in amplitude of a vibration, not detecting or calculating a current contact force. Warren states that a “change in the amplitude of vibration (ΔA) of the dispenser, the substrate, or both the dispenser and the substrate upon contact with each other, is detected by the system.” EX1004 at ¶¶[0289]; *see also id.* at ¶¶[0289] (“The position

of one or more of the elements is varied, based on the detected ΔA , to maintain a desired force of contact between the dispenser and the substrate.”). Similarly, when describing the method for controlling the dispensing system, Warren states that “[a]t step 4104, a change in the amplitude of vibration of the dispenser and/or the substrate is detected.” *Id.* at ¶[0313]. Further, Warren explains that the determination of whether there is a desired contact force is actually “based on the detected change in amplitude.” *Id.* Warren also explains that the position of the dispenser or substrate are varied “causing a change in the amplitude of vibration” which “is detected again at step 4104.” *Id.* Thus, Warren makes it clear that the “modulated vibration amplitude signal is then used as feedback to control the contact force between the dispensing structure and the substrate surface.” *Id.* at ¶[0315].

164. There is no teaching or suggestion to detect or calculate a current contact force. Warren does not disclose how a change in vibration amplitude can be translated into a quantitative contact force. Although he states that a “change in amplitude is proportional to the force of contact between the dispenser and the substrate” (Warren [313]), he provides no guidance regarding the proportionality constants that would relate deformation or amplitude change to a contact force. Even in hindsight, it is unclear how the signal generated by Warren’s sensor could be used to compute a contact force, and for the reasons discussed below, such a translation is not feasible based on the information provided.

165. First, the viscoelastic behavior of tissues and polymers makes their mechanical properties—such as stiffness and viscosity—strongly frequency dependent, as illustrated in the figure below. *See* EX2025 (Osswald & Menges) at p.62.

166. More generally, each material exhibits a complex mechanical (rheological) response that depends not only on frequency, but also on deformation amplitude, temperature, and time (EX2026 (Osswald & Rudolph), at pp. 47–56).

167. In addition, a strain input produced by vibration-induced excitation generates a stress response that inherently combines both elastic and viscous components. Interpreting such a response requires knowledge of both the storage modulus, which characterizes the elastic contribution, and the loss modulus, which characterizes the viscous contribution.

168. As shown in the figures below, the storage and loss moduli of a polymer such as high-density polyethylene vary significantly with frequency and temperature. Warren’s system, however, operates at frequencies between 90 and 100 kHz (*see, e.g.,* Warren ¶[301]), which are several orders of magnitude higher than the frequency range accessible to conventional material characterization techniques, such as dynamic mechanical analysis (DMA), which typically operate between 0.01 and 100 Hz. There is no established method or device capable of characterizing material viscoelastic properties at the frequencies and amplitudes relevant to

Warren's system. Consequently, Warren's sensor cannot provide a quantitative measurement or detection of contact force and functions instead as a contact-detection device, indicating the presence of contact through a change in vibration amplitude. Warren also fails to disclose the nature of the substrate contacted by the dispenser in his example. Moreover, the example shown in Figure 21 of Warren does not report frequencies or amplitudes, presenting results only in "arbitrary units," further underscoring the lack of quantitative disclosure.

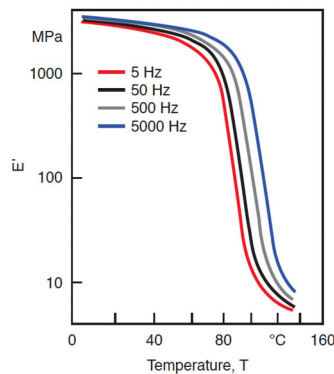


Figure 3.16 Modulus of polyvinyl chloride as a function of temperature at various test frequencies

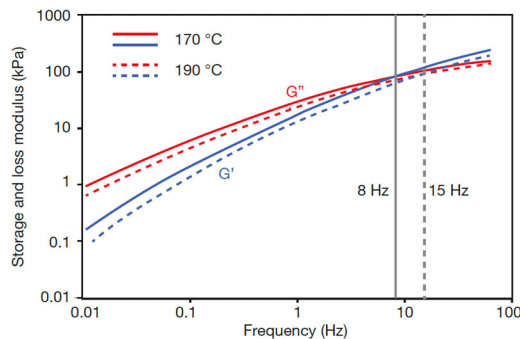


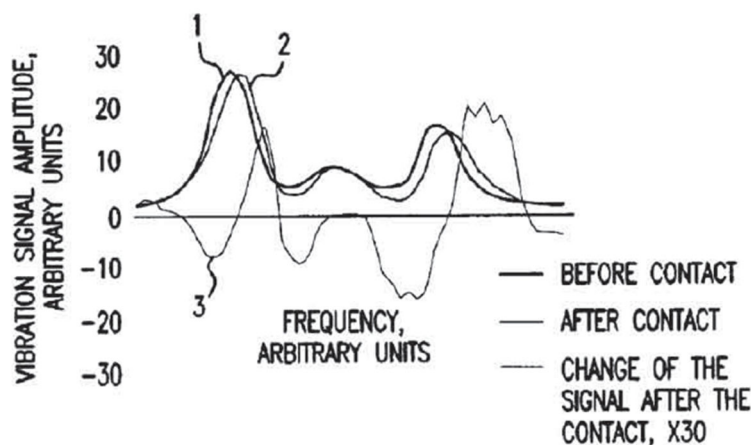
Figure 2.32 Storage and loss moduli for a blow molding grade PE-HD as functions of frequency and temperature.

EX2025 (Osswald & Menges) at Fig. 3.16 (p.62); EX2026 (Osswald & Rudolph) at Fig. 2.32 (p.53).

169. Thus, as I discussed above, Warren simply tells those skilled in the art to detect a change in amplitude and that the change in amplitude is proportional to a contact force and thus a change in amplitude indicates contact. It does not teach or suggest that the change in amplitude is converted into a detected or calculated current contact force.

170. In addition, it would not have been obvious to detect the current contact force based on the detected change in amplitude. *See* Petition at 20-21; EX1003, ¶¶86-89. As I discussed above, Warren does not explain how to detect or calculate the current contact force based on a change in amplitude. He simply states that in general the “amplitude of the modulation in the signal is proportional to the force applied between the dispenser and the substrate.” EX1004 at ¶[0315].

171. Figure 21 of Warren shows plots before and after contact, as well as the change of the signal after contact, to understand the change in amplitude.



See EX1004 at Fig. 21, ¶[0306]¹. As shown, the figure provides the “vibration signal amplitude” on the vertical axis and the “frequency” on the horizontal axis. However, as mentioned, both measures have arbitrary units, indicating that the specific magnitude of the amplitude change or frequency at which the change occurs is not relevant. As I discussed above, presenting results only in “arbitrary units” further underscores the lack of quantitative disclosure.

172. Figure 21 of Warren includes Plot 1, which “shows the relationship between A and f before physical contact of the vibration element with another surface,” Plot 2, which “shows the relationship between A and f after physical contact of the vibration element with the other surface,” and Plot 3, which shows “the absolute value of the relative ΔA .” EX1004 at ¶[0306]. Warren suggests that the user must select a frequency to measure the change in amplitude. *See id.* (“This enables the selection of a working f in a desirable region not limited by the self-resonance of piezoelements.”). As shown above in Figure 21, there is no change in the amplitude at certain frequencies where Plot 3 is at or near the horizontal axis. See EX1004 at Fig. 21. It appears that Plot 3 is at or near the horizontal axis at least seven points representing the frequencies where the amplitude curves, before and after contact or cross each other.

¹ Warren incorrectly refers to Figure 21 as Figure 40 in his text.

173. I understand that Patent Owner asked Dr. Wolfe about what Figure 21 of Warren shows. I understand that Dr. Wolfe testified that Plot 3 does not represent the difference between Plots 1 and 2:

5 Q Okay. And so we talked about element 1
6 and element 2 of figure 21. What is element 3 of
7 figure 21?

8 A It says it is the change of the signal
9 after the contact X30, so it seems to be a
10 differential. It does not seem to be the
11 difference between 1 and 2. It seems to be after
12 a different contact.

13 Q Okay. So help me understand that, the
14 difference between 1 and 2 is not what element 3
15 represents?

16 A It doesn't appear to be, if you just look
17 at it visually. And it doesn't say just change of
18 signal after contact. It says after the contact
19 X30. So I think it is a different contact that
20 was measured in figure 2.

EX2020 at 77:5-20. This assessment is incorrect, as Plot 3 with no doubt represents the difference between the curves in Plot 1 and Plot 2. Dr. Wolfe appears to have interpreted “X30” as an experimental label, whereas it in fact indicates that the plotted values were multiplied by a factor of 30 to make the difference between Plot 1 and Plot 2 visible.

174. I also understand that Dr. Wolfe testified that he would pick one or more frequencies to show “big negative difference in the signal” or “one of the top peaks.”

13 Q Okay. Okay. And so you -- you had
14 mentioned that, you know, it is as high as
15 approximately 30 units, so it is not 30 units
16 across -- I guess, you were talking about the Y
17 axes, it is not 30 units across the entire X axes?
18 A No. And again, the teaching of the patent
19 is not that you have to measure it every
20 frequency. It is that you pick one or more
21 frequencies and do your measurements at that
22 frequency, and then it might be helpful to do a

**1 graph like this to help to choose a good
2 frequency.**

**3 Q So in the example in figure 21, what
4 frequency would -- would you choose?**

**5 A I would probably choose something around
6 the extremities of figure 3. So either where
7 figure 3 goes very low showing a big negative
8 difference in the signal after contact of X30 or
9 one of the top peaks.**

10 Q Okay. And you said figure 3, are you --

11 A I'm sorry, signal 3.

12 Q Signal 3, okay.

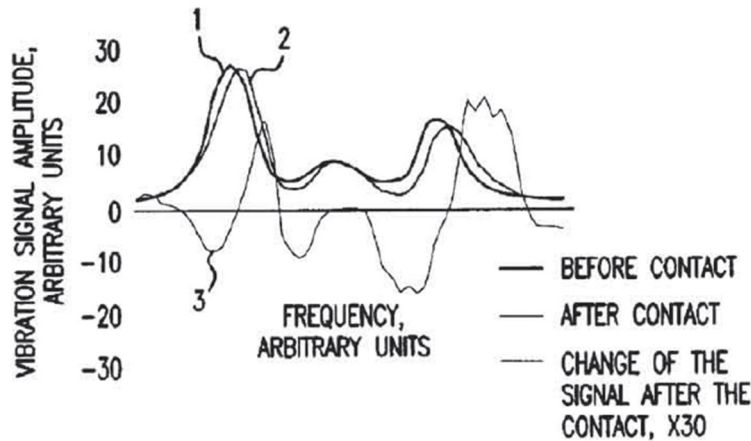
**13 So you would pick either a trough or a
14 peak of signal 3?**

**15 A Yes. Although it would work fine if I
16 picked many other -- I mean, I wouldn't want to
17 pick something where it is a zero crossing, but
18 there were many frequencies where -- where it
19 would work fine. But -- but the best ones would
20 probably be the ones that show the biggest change.**

EX2020 at 79:13-80:20.

175. However, in my view, nothing in Warren tells a person of ordinary skill in the art which frequency or frequencies to select for detecting a change in amplitude. Warren simply indicates the “frequencies are less than about 100 kHz” (Warren, [0332]) and the “selection of a working f in a desirable region [is] not limited by the self-resonance of piezoelements” (Warren, [0306]). Further, comparing Plots 1 and 2 to Plot 3 fails to indicate that any particular frequency or

set of frequencies would reliably provide a change in amplitude across different contacts.



EX1004 (Warren), at Fig. 21. Furthermore, as discussed above, the viscoelastic behavior of polymers, certain fluids, and biological tissues is frequency dependent, meaning that the shape and frequency-dependent shift of the signal observed between Plot 1 (before contact) and Plot 2 (after contact) depend on the specific material. As a result, the signal response upon contact is inherently material dependent, making it difficult to select a single operating frequency that would function reliably across a wide range of polymer substrates, tissues, or fluids. Thus, Warren fails to teach how to detect or calculate the current contact force based on the change in amplitude or provide a motivation for doing so.

176. Further, in my view, detecting a current contact force from Warren's change in amplitude was not known to those skilled in the art. Contact between a

dispenser and a substrate and any sensor measurements would have been subject to many challenges besides selecting the appropriate frequency for detecting the change in amplitude.

177. As I discussed above, a translation from a change in amplitude to a detected current contact force is not feasible based on the teachings and information provided by Warren.

178. First, the viscoelastic behavior of tissues and polymers makes their mechanical properties—such as stiffness and viscosity—strongly frequency dependent, as illustrated in the figure below (EX2025 (Osswald & Menges), at p. 62).

179. More generally, each material exhibits a complex mechanical (rheological) response that depends not only on frequency, but also on deformation amplitude, temperature, and time (EX2026 (Osswald & Rudolph), at pp. 47–56).

180. In addition, a strain input produced by vibration-induced excitation generates a stress response that inherently combines both elastic and viscous components. Interpreting such a response requires knowledge of both the storage modulus, which characterizes the elastic contribution, and the loss modulus, which characterizes the viscous contribution.

181. As shown in the figures below, the storage and loss moduli of a polymer such as high-density polyethylene vary significantly with frequency and

temperature. Warren's system, however, operates at frequencies between 90 and 100 kHz (*see, e.g.*, Warren ¶[301]), which are several orders of magnitude higher than the frequency range accessible to conventional material characterization techniques, such as dynamic mechanical analysis (DMA), which typically operate between 0.01 and 100 Hz. There is no established method or device capable of characterizing material viscoelastic properties at the frequencies and amplitudes relevant to Warren's system. Consequently, Warren's sensor cannot provide a quantitative measurement of contact force and functions instead as a contact-detection device, indicating the presence of contact through a change in vibration amplitude. Warren also fails to disclose the nature of the substrate contacted by the dispenser in his example. Moreover, the example shown in Figure 21 of Warren does not report frequencies or amplitudes, presenting results only in "arbitrary units," further underscoring the lack of quantitative disclosure.

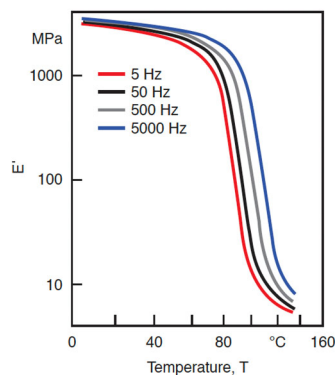


Figure 3.16 Modulus of polyvinyl chloride as a function of temperature at various test frequencies

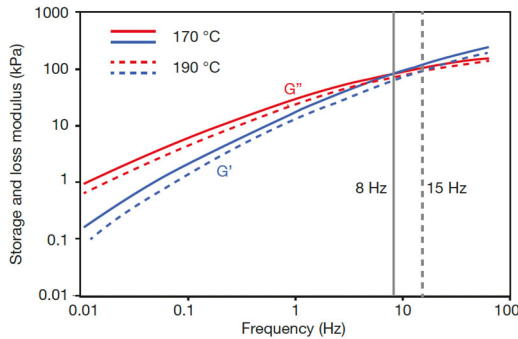


Figure 2.32 Storage and loss moduli for a blow molding grade PE-HD as functions of frequency and temperature.

EX2025 (Osswald & Menges) at Fig. 3.16 (p.62); EX2026 (Osswald & Rudolph) at Fig. 2.32 (p.53).

182. Thus, as I discussed above, Warren simply tells those skilled in the art to detect a change in amplitude, stating that the change in amplitude is proportional to a contact force, and therefore that the change in amplitude indicates contact. Warren does not teach or suggest converting the change in amplitude into a detected or quantitative current contact force.

183. Accordingly, there would have been differing amounts of deformation upon contact depending on the particular substrate Warren uses. For example, Warren’s capillary vibro-sensor dispensing units are used with “intermediate-density gelatinized slides and high-density plain and patterned slides of human white blood cells (WBC’s).” EX1004, ¶[0295].

184. Also, the dispensed material varies as well, such as “depositing a monolayer of cells; or depositing mono- or multilayered drawings of electronic elements and circuits, such as capacitors, inductors, and filters.” *Id.* Moreover, the

substrate shape itself varies. Some surfaces are curved, whereas others are flat. *See id.* (“on curved surfaces”); EX1004, ¶[0293] (“the substrate 3710 in FIG. 18 is shown as being flat” and the substrate may be an “irregular or curved surface[.]”); *see also id.* at ¶[0316] (“writing on curved surfaces”).

185. As shown in the figure below, different materials have vastly different Young’s modulus, which is a mechanical property of materials that represents stiffness when a force is applied along a length.

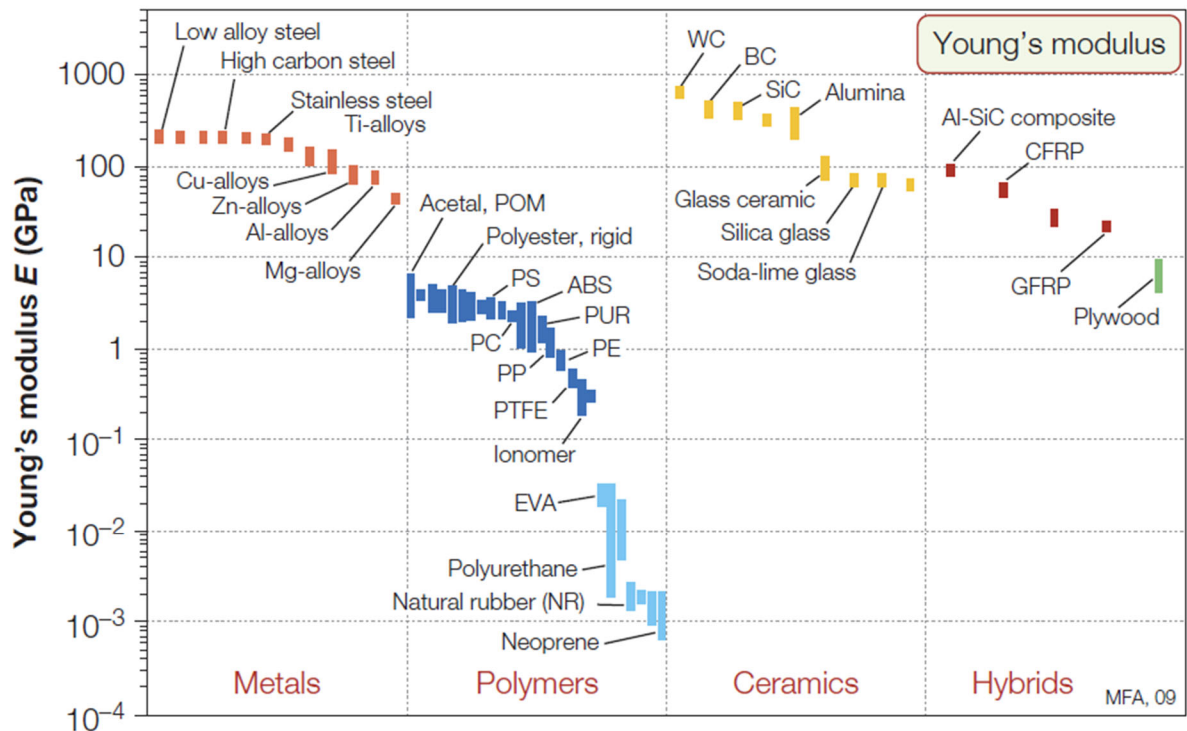


FIGURE 4.1

EX2024, at Fig. 4.1. As shown in Figure 4.1, the stiffness of materials varies by over six orders of magnitude (or 1,000,000 times) from ceramics with a Young’s modulus approaching 1000 GPa to polyurethane and other polymers with a Young’s modulus

at or below 0.001 GPa. *Id.* Varying modulus across materials impacts the ability to detect a current contact force as the force applied to a surface, such as the surface of a substrate for a three-dimensional printer or a three-dimensional printed material, because the materials have differing stiffness values and thus deformation.

186. I understand that Patent Owner asked Dr. Wolfe about Young's modulus and he testified as follows:

13 Q Okay. Are you familiar with the -- the
14 term "Young's modulus"?

15 A Yes, but I have no idea what it is.

16 Q So you have heard -- you have heard of the
17 term before?

18 A Yes. As I said, I've worked on -- on --
19 on 3D printer designs before, and I know that that
20 was an important issue, but I was able to send the
21 students off to talk to a mechanical engineering
22 specialist to figure it out. So I actually don't

1 know what the -- what the definition of a Young's
2 modulus is.

3 Q Okay. So you don't know what a Young's
4 modulus might pertain to?

5 A Not really. I think it has something to
6 do with deformation or -- or -- or
7 compressibility, but I don't -- it is not
8 something I really understand.

9 Q Okay. So for -- if it does pertain to
10 deformation, do you know the relationship between
11 Young's modulus and deformation?

12 A No.

13 Q If it pertains to compressibility, do you
14 know the relationship between Young's modulus and
15 compressibility?

16 A No.

EX2020 at 72:13-73:16.

187. I also understand that Dr. Wolfe was asked about his experience in depositing cells and he testified as follows:

2 Q What sort of industry experience do you
3 have with deposition of cells?

4 A None.

5 Q Do you have research experience related to
6 depositing cells?

7 A I don't, but Warren again, talks about a
8 lot more than that including deposition of
9 inorganic materials and specifically the
10 deposition of polymers.

11 Q How about a teaching experience? Do you
12 have teaching experience related to depositing
13 cells?

14 A No. I mean, not -- not human -- not
15 biological cells, no.

16 Q Okay. What non-biological cells do you
17 have experience with deposition on?

18 A That -- just that word might be used to
19 describe other materials. But again, I don't have
20 any -- I don't have any experience in depositing
21 biological materials.

EX2020 at 89:2-21.

188. In my view, Dr. Wolfe's lack of knowledge about Young's modulus and the deposition of cells underscores why a person of ordinary skill in the art would not have been motivated to and would not have been able to detect a current contact force based on Warren's teachings. For instance, intermediate-density gelatinized slides and high-density plain or patterned slides of human white blood cells (WBCs), as well as tissue and polymeric materials, exhibit viscoelastic behavior, with mechanical moduli that depend on frequency, temperature, and time. As illustrated

above, variations in frequency and temperature alone can result in changes in modulus of three orders of magnitude or more. Accordingly, it would not have been obvious how to convert Warren's change in amplitude to a detected current contact force.

189. Further, in my opinion there is no motivation to detect the current contact force based on the change in amplitude that is used in Warren's solution. For instance, Warren does not describe a comparison between the sensor signal and the "desired contact force" as I understand Petitioner and Dr. Wolfe assert. *See* Petition at 27-28; EX1003, ¶¶109-11. Warren teaches that he determines whether the desired contact force is obtained by detecting a change in amplitude of vibration. *See* EX1004, Fig. 22A (steps 4104-4108), ¶[0313] ("a determination is made whether the contact force is that which is desired, based on the detected change in amplitude"), ¶[0302] ("The vibration imposed on the dispenser **3700** is changed, e.g., modulated, by the contact of the **3700** dispenser with the substrate **3710**. The transducer **3740** senses and transfers the changed vibration signal to an amplifier (not shown), which then creates a feedback signal that is generally proportional to the intensity of the physical contact of the dispenser **3700** with the substrate **3710**. The amplifier may be implemented with any suitable conventional device, e.g., an AD621 instrumentation amplifier. The feedback signal is used to control the position of the dispenser **3700** to maintain a desired force of

contact between the dispenser **3700** and the substrate **3710**. For example, the feedback signal may be used by a z-controller processor **3750** to control the z positioning of the dispenser **3700** via a z-controller step motor **3760**. A personal computer (PC) may be used in conjunction with the z-controller **3750** for this purpose, in which case the feedback signal is fed directly to the PC.”), ¶[0311] (“When the substrate **4110** contacts the dispenser **4100**, the vibration f spectrum of the dispensing system is changed, and the A of the feedback signal changes. This change is sensed and processed by the electronics unit **4130** and sent, e.g., to a PC **4140**. According to one embodiment, the PC **4140**, in conjunction with the control circuitry, controls the direction and speed of the z-axis stage **4170** upon which the substrate **4110** rests. Alternatively, the control circuitry may perform this function without the use of a PC.”). Thus, a person of ordinary skill in the art would have understood from Warren’s teachings that the change in amplitude itself is used to indicate a desired contact. EX1004 at Fig. 21, ¶[0306] (“Plot 3 shows the absolute value of the relative ΔA .”). A person of ordinary skill in the art would not have understood Warren to teach or suggest detecting a current contact force based on the change in amplitude and then comparing that current contact force to another force.

190. Although the ’698 Patent describes that different sensors may be used “so long as the contact force(s) described above may be calculated from the sensed physical characteristics,” there is no teaching, whether in the ’698 Patent, Warren,

or in the references that Petitioner cited, that the current contact force may be actually detected from Warren's change in amplitude. EX1001 at 8:56-61; *see also* EX1004 at Fig. 21, ¶[0306]. As discussed above, Warren does not teach detecting the current contact force, nor do the references that Petitioner cites indicate that detecting the current contact force in Warren's system was known.

191. Thus, Ground 1A (Warren) does not show that claim 1 is obvious.

C. Claims 2-6, 8-15

192. I understand that claims 2-6 and 8-15 depend from claim 1. *Supra* Section II ("The Challenged Claims of the '698 Patent"). For at least the reasons I provided above for claim 1, it is my opinion that Petitioner has failed to show all elements of claims 2-6 and 8-15. *Supra* VII.A and VII.B. I also provide additional opinions about certain dependent claims below.

D. Claims 3 and 9

193. Claims 3 and 9 recite the following elements:

"3. The method of claim 2, wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.

9. The method of claim 2 wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder."

See EX1001; *supra* Section II ("The Challenged Claims of the '698 Patent), Claims 3 and 9.

194. I understand that Petitioner contends that Warren teaches claims 3 and 9. *See* Petition at 25-26 (claim 3), 31 (claim 9).

195. For claim 3, Petitioner asserts that “In view of Warren’s teaching that the z-height be controlled based on contact force, it would have been apparent or obvious to a POSITA that control signals to the z-controller step motor for adjusting the z-position of the dispenser based on contact force result in corresponding control signals to the linear actuator to provide synchronous adjustments to the flow of material from the dispenser.” Petition at 25; EX1003, ¶101. Petitioner also asserts that “the through-nozzle dispenser includes a linear actuator (i.e., one of the claimed *‘at least one component’*) to adjust dispensing rate (i.e., *feed rate for build material used in the build*).” Petition at 26; EX1003, ¶103. Further, Petitioner asserts “feed rate is controlled synchronously with the ‘xyz motion of the dispenser’ and in response to identified “trouble spots”...where there is too much material being deposited’ – both of which are controlled based on contact force.” Petition at 26; EX1003, ¶¶103-104.

196. For claim 9, Petitioner similarly asserts that “In the context of Warren’s ‘force feedback control’ that ‘enables the dispenser to seek and find contact with a surface,’ dispense on ‘conformal surfaces,’ and identify ‘trouble spots’ having ‘too much material,’ a POSITA would have known that the linear actuator regulates the dispensing rate of material from the dispenser to control the amount of material fed

to the nozzle tip per second (i.e., feed rate of build material extruded by the *extruder*) so that Warren's dispenser 'maintains contact of a desirable intensity.'" Petition at 31; EX1003, ¶¶119-121.

197. However, as I discussed above in Section VII.A, there is no motivation to use Warren's through-nozzle dispenser with Warren's vibration sensing solution. *Supra* Section VII.A. Warren does not invite using his vibration sensing solution with his through-nozzle design. *See* EX1004, ¶¶ [0295-300] and Figures 18, 19, 20A, and 20B.

198. Similarly, as I discussed above in Section VII.A, there is no motivation to use the through-nozzle design for the dispenser to enable precise control. *Supra* Section VII.A. Warren describes using a quill-pen or capillary design to enable precise control. *See* EX1004, ¶¶[0260], [0278].

199. Similarly, as I discussed above in Section VII.A, there is no motivation to modify Warren's capillary or quill-pen designs to use a linear actuator. *Supra* Section VII.A. Warren describes a combination tool that integrates different devices, explains that capillary and quill-pen designs already achieve precise control of the material flow. *See* EX1004 at ¶¶[0093], [0231], [0234], [0279], [0260], [0298].

200. Similarly, as I discussed above in Section VII.A, there is no motivation to provide Warren's through-nozzle dispenser with vibrating force sensor capabilities. *Supra* Section VII.A. Warren teaches that his through-nozzle dispenser

already includes a mechanism to control the deposition geometry and to avoid damage by using location control device 800. *See* EX1004, ¶[0243], [0234], [0227], [0228], Fig. 36.

201. In addition, Warren’s synchronization of xyz motion of the dispenser for the linear actuator and valve of the through-nozzle design, as well as identified trouble spots, is not responsive to a current contact force. Warren describes the operation of his valve and linear actuator in the through-nozzle design with the xyz motion.

202. First, in Warren’s “distance invariant” mode, the valve can be opened “independently before any xyz motion begins, then finish opening the valve over a set xyz distance.” EX1004, ¶[0235]. While the position of the valve can change “near the end of the motion or at certain ‘trouble spots’ in the middle of a path,” neither the end of the motion or such trouble spots (“such as at a corner where there is too much material being deposited”) is responsive to the current contact force detected. Rather, those identified trouble spots exist according to the geometry of the object to be printed and any preliminary build instructions. A person of ordinary skill in the art would have understood that such events are independent of the current contact force because they are identifiable prior to any contact force or printing operation.

203. Further, a person of ordinary skill in the art would not have understood that the valve position in Warren’s through-nozzle design would be adjusted

responsive to Warren’s vibrating sensor solution conforming to the surface. Rather, a person of ordinary skill in the art would have understood that Warren’s vibrating sensor solution would move the position of the dispenser to conform to the surface, as Warren teaches. Such an individual would not be motivated to replace Warren’s teaching with a change to the valve position. *See* EX1004, ¶[0313] (“the position(s) of the dispenser and/or the substrate are varied at step 4108, causing a change in the amplitude of vibration”).

204. Second, in Warren’s “volumetric invariant” mode, Warren states that the valve position is used to control the amount of material dispensed per second. EX1004, ¶[0239]. Again, a person of ordinary skill in the art would have understood that controlling the amount of material dispensed per second does not vary in response to a current contact force in Warren. Rather, the amount of material dispensed depends on the distance traveled by a dispenser and the time taken (or to be taken) to travel that distance. *See* EX1004, ¶[0239].

205. Third, in Warren’s “combination approach,” Warren defines “the speed at which the dispenser should move” and switches between the “distance invariant mode” that sets the valve to be reached at certain pre-determined xyz locations and a “volumetric invariant mode” based on characterization. EX1004, ¶[0240]. For the reasons I provided above, a person of ordinary skill in the art would have understood that Warren’s combination approach, like the two approaches (“distance invariant”

mode and “volumetric invariant” mode) that comprise the combination approach, does not vary in response to a current contact force in Warren. Thus, the xyz synchronization that Warren describes for a linear actuator and valve in the through-nozzle design are not responsive to a current contact force. Accordingly, Ground 1A does not render claims 3 and 9 obvious because the “component” and “signal” that Petitioner identifies for controlling or changing the feed rate of the build material is not created “in response to the current contact force” (see claim 1). *See id.*

E. Claims 5 and 6

206. Claims 5 and 6 recite the following elements:

“5. The method of claim 2 further comprising comparing the current contact force to an expected contact force.

6. The method of claim 5 further comprising adjusting at least one parameter of the three-dimensional printer to reduce a difference between the current contact force and the expected contact force.”

See EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent), Claims 5 and 6.

207. I understand that Petitioner contends that Warren teaches claims 3 and 9. *See* Petition at 27-28 (claim 5), 28-29 (claim 6).

208. For claim 5, Petitioner asserts that “Warren’s combined teachings further provide *comparing the current contact force* (e.g., measured contact force) *to an expected contact force* (e.g., desired contact force).” Petition at 27-28; EX1003, ¶¶109-111.

209. For claim 6, Petitioner asserts that “Warren’s combined teachings further provide *adjusting at least one parameter of the three-dimensional printer* (e.g., the z-position of integrated dispenser) to *reduce a difference between the current contact force and the expected contact force* (e.g., maintain a desired force of contact).” Petition at 28; EX1003, ¶¶112-113.

210. However, Warren does not teach a “measured contact force” as Petitioner asserts. As I explained above, Warren teaches measuring a change in amplitude of vibration and this change in amplitude indicates whether a desired contact has occurred. *Supra* Sections VII.A (lack of motivation for combination), VII.B (Claim 1); *see also* EX1004, Fig. 22A, ¶¶ [0289] (“The position of one or more of the elements is varied, based on the detected ΔA , to maintain a desired force of contact between the dispenser and the substrate.”), [0313] (repeatedly referring to the detected change in amplitude); [0305] (“A is inevitably altered” “when a vibrating element contacts”), [0311], [0316]. Thus, Warren does not have a measured contact force or compare a measured contact force to an expected contact force (as in Claim 5), much less reduce a difference between a measured contact force and expected contact force (as in Claim 6).

211. Thus, Ground 1A (Warren) does not show that claims 5 and 6 are obvious.

F. Claims 10 and 11

212. Claims 10 and 11 recite the following elements:

“10. The method of claim 2 further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.

11. The method of claim 10 further comprising fabricating a layer on the surface of the separate structure that decreases one or more irregularities in the surface of the separate structure.”

See EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent), Claims 10 and 11.

213. I understand that Petitioner contends that Warren teaches claims 3 and 9. *See* Petition at 31-33 (claim 10), 33-35 (claim 11).

214. For claim 10, I understand that Petitioner asserts that “Warren’s combined teachings further provide detecting a planarity of the separate structure (e.g., flatness of the substrate positioned on the build platform) based upon a number of contact force *measurements* (e.g., by measuring ΔA (changed amplitude) of a vibration signal imposed on the dispenser) *across a surface of the separate structure* (e.g., a surface of the substrate positioned on the build platform).” Petition at 31-32; EX1003, ¶¶122-124. I also understand that Petitioner asserts that Warren teaches “Detecting Planarity During Printing” and “Detecting Planarity Before Printing.” Petition at 32-33; EX1003, ¶¶125-127.

215. For claim 11, I understand that Petitioner asserts that “POSITA would understand that such porosity is an *irregularity in the surface* of the scaffold.”

Petition at 33; EX1004, [0320]; EX1003, ¶129. I also understand that Petitioner asserts that “a POSITA would understand that the deposited cells are *a layer on the separate structure* and that *decreases one or more irregularities* by attaching and penetrating the pores.” Petition at 33-34; EX1003, ¶¶128-129. In addition, Petitioner asserts that “viscous materials” that “exit the through-nozzle dispenser or the capillary dispenser, the extruded fluids would *decrease irregularities*, and certainly any smaller irregularities, *in the surface of the separate structure* when the viscous materials accumulate and fill irregularities on the surface.” Petition at 34-35; EX1003, ¶¶131-132.

216. First, while Warren does teach that its dispenser “follow[s] irregular or curved surfaces” (EX1004, ¶[0293]), he does not teach detecting the planarity of the surface “based on a number of contact force measurements across a surface.” As discussed above for claims 5 and 6, Warren does not teach measuring a contact force. *Supra* Section VII.E. Warren also does not teach making a number of contact force measurements that collectively form the basis for detecting planarity. Rather, Warren teaches adjusting the height of the dispenser based on a detected change in amplitude of vibration at a given point above a substrate before moving to the next position. *See, e.g.*, EX1004, ¶[0313], [0310], [0293].

217. Second, Warren does not teach detecting planarity before printing. Petitioner and Dr. Wolfe rely on hindsight to assert it would be obvious to apply

“Warren’s force sensing to determine surface planarity as part of a calibration procedure.” *See* Petition at 33 (EX1003, ¶¶126-27). Warren does not teach any calibration procedure involving his vibration sensing solution. *See generally* EX1004; *see also* EX1004, ¶[0285] (describing tip crashes); ¶[0289] (describing controlling the dispenser based on a detected change in amplitude that avoids crashes); ¶[0226-27] (describing location control device 800 that provides “fine control” that also avoids crashes).

218. Although Petitioner cites to another reference (EX1007 to Dunn), a person of ordinary skill in the art would have understood that Warren already provides a technique to build accurate error-free models by determining the spatial relationship between a tip extruding material and a substrate. As I discussed, Warren adjusts the height of its dispenser based on a change in amplitude of a vibration to conform to surfaces. *See, e.g.*, EX1004, ¶[0313], [0310], [0293]. In such a solution, a person of ordinary skill in the art would have recognized that there is no motivation to run a calibration procedure separate from the print. For example, a substrate that has been warped or damaged from a completed print would not be able to avoid “a large spacing between the tip and the substrate surface” for the very next print without running a process as part of the printing process. *See* EX1001 at 9:41-46 (“The differences amongst the measured contact forces may be attributed to warping of the surface, physical damage to the surface, (e.g., dents, scratches, etc.), the

surface having become skewed or misaligned with respect to its intended mounting position in the three-dimensional printer, or other causes.”). Thus, there is no motivation to apply Warren’s vibration sensing solution as a calibration procedure.

219. Third, depositing cells into porous scaffolds does not teach decreasing one or more irregularities in the surface of the separate structure (claim 11). A POSITA would have understood that the plain meaning of “fabricating a layer on the surface of the separate structure that decreases one or more irregularities in the surface of the separate structure” refers to the fabrication of a layer that mitigates the irregularities of the surface as detected by the planarity in claim 10. The specification of the ’698 Patent discloses “a technique for mitigating planar irregularities in a build surface” in Figure 4 and the associated description. EX1001 at 9:24-27. The first step is to detect the planarity of the surface based on a number of contact force measurements. *See id.* at 9:31-40. The second step is to fabricate a layer to mitigate irregularities. *See id.* at 9:63-10:12. The result of this process is that “gaps in the surface” are filled in “so that the resultant layer is effectively planar.” *Id.* at 10:10-12. Warren does not teach filling in gaps in a porous scaffold to make the resultant layer effectively planar or using a detection of planarity to fabricate a layer to decrease irregularities. Rather, Warren teaches that his solution follows “irregular or curved surfaces.” EX1004, ¶[0293]. Further, flattening out extruded material with the tip does not fabricate a layer that is effectively planar as the irregularities from

the surface underneath will impact subsequent layers on top of the surface. Similarly, Warren does not teach depositing viscous materials to make the resultant layer effectively planar or using a detection of planarity to fabricate a layer to decrease irregularities. *See id.*; *see also* Petition at 34-35.

220. Thus, Ground 1A (Warren) does not show that claims 10 and 11 are obvious.

G. Claim 12

221. Claim 12 recites two elements. Claim element 12.a states the “method of claim 1, wherein the build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure, and” and claim element 12.b states “wherein the control signal controls the at least one component of the three-dimensional printer to achieve the specified contact force.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent), Claim 12.

222. I understand that Petitioner contends that Warren teaches claim 12. *See* Petition at 35 (12.a), 35-36 (12.b).

223. For claim element 12.a, I understand that Petitioner asserts that “Warren’s combined teachings provide that the computer-aided design and manufacturing (CAD/CAM) data, capable of being executed on the integrated printing system, include *at least one instruction* “to maintain a desired force of

contact between the dispenser 3700 and the substrate 3710” (i.e., *for achieving a specified contact force between the fabrication tool and a separate structure*).”

Petition at 35; EX1003, ¶¶133-134.

224. For claim element 12.b, I understand that Petitioner asserts that “the control signal (e.g., from the processor) *controls the at least one component of the three-dimensional printer* (including, e.g., z-controller step motor and linear actuator) *to achieve the specified contact force*.” Petition at 35-36; EX1003, ¶¶ 135-136.

225. However, nothing in Warren teaches or suggests a specified contact force. As I discussed above, Warren merely states that he desires a contact force based on a change in amplitude of the vibration. *See, e.g.*, EX1004, at ¶[0313] (determining whether there is a desired contact force by actually “detect[ing] a change in amplitude”); *supra* Section VII.A (lack of motivation for combination), VII.B (claim 1).

226. In contrast to Warren’s teachings, the ’698 Patent discloses that, for example, “a build instruction in machine-ready code may directly specify a target for the contact force, e.g., as an explicit instruction to achieve or maintain a specified contact force between the fabrication tool and a separate structure.” EX1001 at 11:25-28. However, Warren does not teach or suggest specifying a target for the

contact force, much less identifying a specified contact force for control. Thus, Warren does not teach or suggest a specified contact force.

227. Thus, Ground 1A (Warren) does not show that claim 12 is obvious.

VIII. GROUND 1B: CLAIMS 3, 7, AND 9 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 1B (COMBINATION OF WARREN AND ESHED)

228. In Ground 1B of the Petition, Petitioner asserts that claims 3, 7, and 9 are obvious over Warren and Eshed. *See* Petition at 37-38 (Overview of Eshed), 38-40 (Asserted Motivation to Combine), 40-41 (claim 3), 41 (claim 7), 41-42 (claim 9).

229. I have reviewed Petitioner's challenges in Ground 1B, and it is my opinion that Ground 1B fails to teach or suggest all elements of claims 3, 7, and 9. I explain my opinions below in detail.

A. There is no motivation to combine Warren and Eshed (Ground 1B)

230. I understand that Petitioner asserts a motivation to combine Warren and Eshed. *See* Petition at 38-40; EX1003, ¶¶144-148. Specifically, Petitioner asserts that a "POSITA would have been motivated to safeguard operation of the three-dimensional printer by comparing the current contact force and the expected contact force, as taught in Warren, and stopping production when the difference indicates a fabrication error, such as a collision with unwanted protuberances, terminating the build, as suggested by Eshed." Petition at 39. As explained above for claim 5,

Petitioner's view of Warren is fundamentally flawed as the reference does not teach comparing a current contact force to an expected contact force. *Supra* Section VII.E (claims 5 and 6 for Ground 1A (Warren)).

231. In my view, there is no motivation to combine because Petitioner's rationales are insufficient to motivate a person of ordinary skill in the art to make the proposed combination. Warren already discloses his solution for avoiding damage to the extruder tip by using vibration sensing. *See, e.g.* EX1004, ¶¶ [0293-95] (following curved irregular or curved surfaces by varying the position of the dispenser and using vibration sensing). Accordingly, a person of ordinary skill in the art would not have desired to prevent even further damage to the extruder tip. Further, Warren describes other solutions to address tip crashes, such as location control device 800 that enables fine control. *See* EX1004, ¶¶[0226]-[0228], Fig. 36. Thus, a person of ordinary skill in the art would not have been motivated to look for teachings from Eshed to explain collisions.

232. In addition, a person of ordinary skill in the art would not have been motivated to apply Warren's technique to Eshed detection system. Warren describes a vibrating sensing system in which an oscillator imparts a vibration and a transducer senses the vibrations. *See, e.g.*, EX1004, at Fig. 18 (reproduced below).

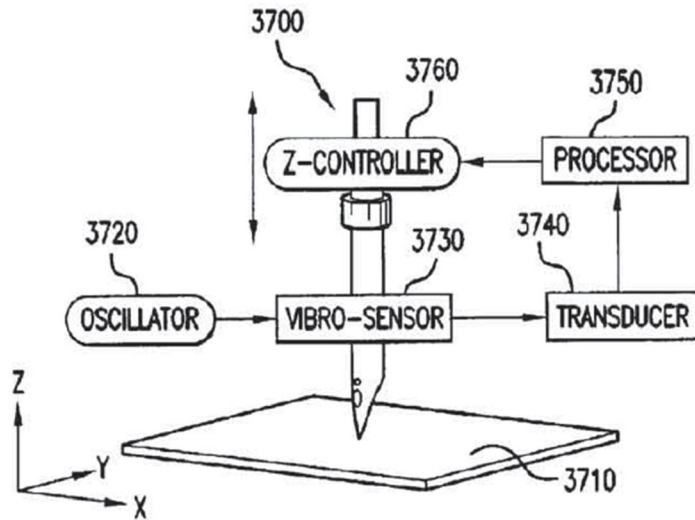


FIG. 18

233. In contrast, Eshed discloses a collision detection system that uses an accelerometer or audio detection of collisions. *See, e.g.,* EX1008, ¶¶[0181-182]. There is no teaching in Warren of how to adapt his vibration sensing teachings to Eshed accelerometer or audio detection systems. Similarly, there is no teaching in Eshed of how to adapt his accelerometer or audio detection of collisions to Warren’s vibration sensing solution. Nor would a person of ordinary skill in the art have understood such a resulting system to be predictable. Indeed, Warren was not concerned with terminating fabrication but rather conforming his dispenser to a surface, such as an “irregular or curved surface[.]” *See* EX1004, ¶[0293]. Thus, there is no motivation to combine Warren and Eshed and there would not have been a reasonable expectation of success in the combination.

234. For these reasons alone, Ground 1B (Warren and Eshed) does not show that claims 3, 7, and 9 are obvious.

B. Claims 3, 7, and 9

235. Claim 3 recites the “method of claim 2, wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent), Claim 3.

236. Claim 7 recites the “method of claim 5 further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent), Claim 7.

237. Claim 9 recites the “method of claim 2 wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent), Claim 9.

238. For claims 3 and 9, I understand that Petitioner asserts creating a control signal to stop production based on the measured contact force indicating a fabrication error. *See* Petition at 40-42.

239. Similarly, for claim 7, I understand Petitioner asserts that the current contact force is compared to an expected contact force to terminate the build. *See* Petition at 41.

240. However, as I discussed above for claim 5, Warren does not teach measuring a contact force. *Supra* Section VII.E (claims 5 and 6 for Ground 1A (Warren)); *see also* EX1004, ¶¶[0289], [0313], [0305], [0316]. Accordingly, Warren does not teach that stopping production can be based on the measured contact force, as Petitioner asserts for claims 3 and 9. Further, Warren does not teach comparing a measured contact force to an expected contact force as Petitioner asserts for claim 7. *See id.*

241. For these additional reasons, Ground 1B (Warren and Eshed) does not show that claims 3, 7, and 9 are obvious.

IX. GROUND 2A: CLAIMS 1-5, 7-10, 12-15 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 2A (COMBINATION OF CALDERON AND REPRAP20208)

242. In Ground 2A of the Petition, Petitioner asserts that claims 1-5, 7-10, and 12-15 are obvious over Calderon and RepRap 20208. *See* Petition at 42-46 (Overview of Calderon), 46-48 (Overview of RepRap20208), 48-56 (Asserted Motivation to Combine), 56-57 (1.pre), 57-58 (1.a), 58-61 (1.b), 61-62 (1.c), 62-63 (1.d), 63 (claim 2), 63-64 (claim 3), 64-65 (claim 4), 65 (claim 5), 65-66 (claim 7), 66-67 (claim 8), 67-68 (claim 9), 68-69 (claim 10), 69 (12.a), 70 (2.b), 70 (claim 13), 70-71 (claim 14), 72 (claim 15).

243. I have reviewed Petitioner’s challenges in Ground 2A, and it is my opinion that Ground 2A fails to teach or suggest all elements of claims 1-5, 7-10, and 12-15. I explain my opinions below in detail.

A. There is no motivation to combine Calderon and RepRap20208 (Ground 2A)

244. I understand that Petitioner asserts a motivation to combine Calderon with RepRap20208. *See* Petition at 48-56. I understand that Petitioner is asserting that the strain gauges from RepRap20208 would be applied and that Petitioner provides six reasons for this combination. *See id.*

245. For the strain gauges, Petitioner asserts that a “POSITA would have been motivated to apply one or more strain gauges from RepRap20208 to Calderon’s three-dimensional printer so that the printer of the [] Combination is equipped with one or more strain gauges located on the extruder mount ... to sense a contact force between nozzle 132, and substrate 128.” Petition at 49; *see also id.* at 48-56.

246. In my opinion, a person of ordinary skill in the art would have understood that there is no motivation to combine Calderon and RepRap20208 in the manner that Petitioner proposes and that there would have been no reasonable expectation of success in doing so.

247. Calderon already has his own technique for auto-initialization and collision detection to determine contact with a nozzle by “monitoring a change in the servo drive current.” EX1009 at 10:5-8; *see also id.* at 9:63-10:5, 10:26-47.

According to Calderon, his solution has a distinct advantage over discouraged solutions that need “special purpose sensing means.” *Id.* at 10:7-8; *see also id.* at 9:63-10:5, 10:26-47.

248. Calderon also teaches that his solution has collision detection to detect objects in the build envelope. *See id.* at 10:26-30. As Calderon explains, his collision detection is important when the model is being built “in a location remote from the user.” *Id.* at 10:29-31. Accordingly, his solution “feels for the presence or absence” of an object employing his sensing techniques to “stop[] the build and alert the user to clear the build envelope.” *Id.* at 10:41-45. Calderon also teaches that his solution can “feel for features of the model using [his] sensing techniques” to detect “partially built models.” *See id.* at 10:57-64.

249. In my view, Petitioner does not adequately address these teachings in Calderon and instead presents multiple, deficient rationales that ignore Calderon’s teachings. Petitioner relies on the following rationales:

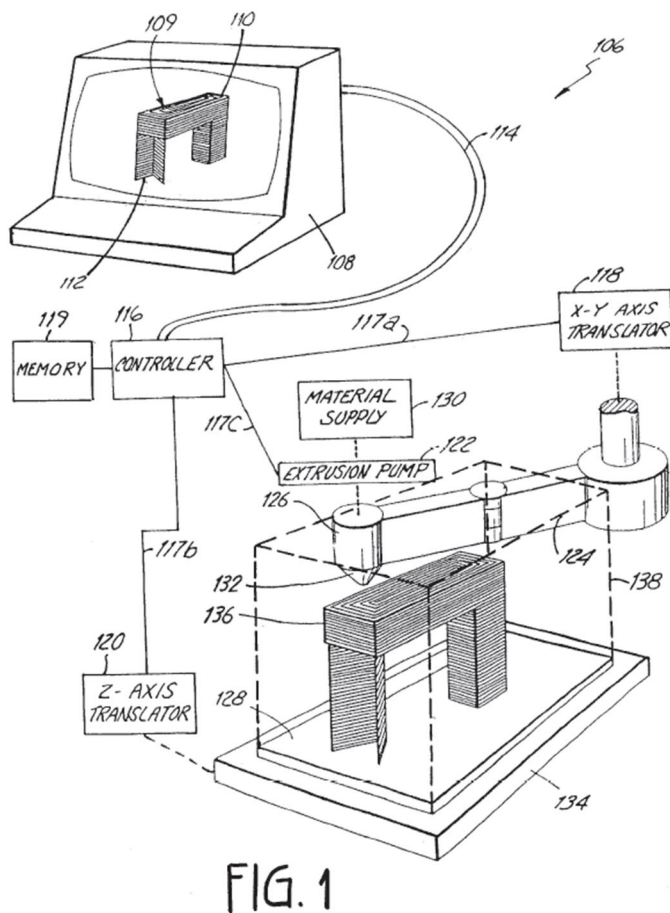
- “benefits of collision detection” (Petition 51);
- “real-time collision detection” (Petition 51-52);
- “slop/backlash” (Petition 52-53);
- “force of resistance to movement” (Petition 53-54);
- “prevent damage[e to] the substrate” (Petition 54-55); and
- “strain gauges were commonly used” (Petition 55-56).

250. In presenting these rationales, Petitioner misinterprets and ignores the teachings of Calderon and RepRap20208 and uses hindsight. RepRap20208 does not “complement[]” Calderon’s disclosure, as Petitioner asserts. *See* Petition at 48-49. Petitioner proposes *the opposite of what Calderon expressly teaches* by arguing for a combination that uses special purpose sensing means in the form of strain gauges as a substitute for Calderon’s solution that monitors changes in the servo drive current and that detects objects in the build envelop providing collision detection. *See* Petition at 50 (adding a special purpose sensing means in the form of a strain gauge “on the extruder mount”); *see also* Petition at 49, 55-56; EX1009 (Calderon), 9:63-10:5, 10:26-47. Further, Calderon already teaches his own solution to stop the machine. He teaches that “the machine stops the build and alerts the user to clear the build envelope.” *See* EX1009 at 10:43-45. Thus, a person of ordinary skill in the art would not have been motivated to look to RepRap20208 to have the “machine shut down.” *See* Petition at 51-52.

251. Similarly, Petitioner’s assertion that Calderon’s solution that monitors the current of the servo drive motors would have “slop/backlash” is deficient. *See* Petition at 52-53 (citing to RepRap20208 (EX1010), 20 and EX1003, ¶¶168-69). Page 20 of RepRap20208 (EX1010) only mentions “backlash” and not “slop” and does not indicate that the concern about backlash “before the sensor registers” relates to Calderon’s solution of constantly monitoring the current of the servo drive motors

for a change. *See* EX1010 (RepRap20208), 20; *see also* EX1009 (Calderon), 10:5-8. The surrounding context in RepRap20208 indicates that it is referring to some other sensor unrelated to Calderon's solution, such as the IESP-12 force sensor or bump sensor. *See* EX1010 (RepRap20208) at 19 ("That IESP-12 force sensor is priced right at \$7, but I'm a little skittish about the 'estimate' language in the datasheet."), 20 ("measuring contact force for a stencil cutting blade or drawing pen to get more uses out of the bot"), 20 ("if you've got it truly not touching the sensor (as that datasheet recommends [sic]), then you've got a certain amount of backlash to take up before the sensor registers"), 20 ("A cheap bump sensor is described on instructables").

252. Petitioner's assertion that RepRap20208 would measure force from a location closer to the nozzle to address slop/backlash is also incorrect. *See* Petition at 52. Petitioner incorrectly assumes that Calderon's drive current motors are only used for x-y axis translator 118. *See* Petition at 52 ("Calderon's arm, x-y axis translator"). Petitioner fails to address how a strain gauge would be closer to the point of contact with platform 134 than the z-axis translator, which directly drives modeling platform 134 involved in such contact. *See* EX1009 at Fig. 1 (reproduced below).



253. Petitioner next assertion that a strain gauge would provide “more accurate,” “consistent” force measurement is guided by hindsight. *See* Petition at 53-54 (“force of resistance to movement”); EX1003, ¶170. Although Dr. Wolfe provides a citation to Calderon (*see* EX1003, ¶170 *citing to* EX1009 at 9:63-10:23), those portions of Calderon do not support Petitioner’s conclusion that there are problems with constantly monitoring the servo drive current for a change, as Calderon teaches. In my view, there is no supporting disclosure regarding any problems with Calderon constantly monitoring the servo drive current for a change to a strain gauge.

254. Similarly, Petitioner’s assertion that a strain gauge would support different substrates without damage is fundamentally flawed. *See* Petition at 54-55. Neither Calderon nor RepRap20208 mention the term “damage” or “damaging.” *See, generally* EX1009, EX1010. There is no teaching that a strain gauge provides any benefit over Calderon’s solution of monitoring for changes in the servo drive current to prevent damage to substrate 128. Further, Calderon discloses that the extrusion nozzle should be below the top surface of some substrates, such as a foam substrate, which indicates to those skilled in the art that damage to the foam substrate is necessary to use it for extrusion, with layers “buried in the foam.” *See* EX1009 (Calderon) at 2:44-50. Thus, modifying Calderon to prevent damage to its substrate is contrary to Calderon’s express teachings.

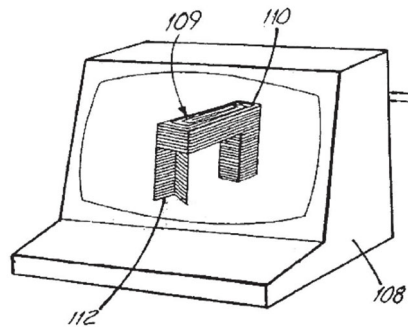
255. For these reasons, a person of ordinary skill in the art would not have been motivated combine Calderon and RepRap20208 as Petitioner asserts. Thus, Ground 1A (Warren) does not show that claim 1 is obvious.

B. Claim 1, Element 1.a

256. Claim element 1.a recites “identifying build instructions for fabricating an object.” I understand Petitioner asserts that Calderon teaches “identifying build instructions” by pointing to “a file describing the geometry of a part 109 to be created” that includes “volume elements 110.” Petition at 57. Petitioner also argues that Calderon refers to the file as “design data provided from a computer aided

design (CAD) system” where “[a] mathematical description of a physical part to be created is split into (usually) planar layers.” Petition at 58.

257. However, as shown in the excerpt of Figure 1 in Calderon below, the file and elements in the figure represent the model of the object and not build instructions for fabricating the object.



See EX1009 at Fig. 1 (excerpt).

258. Similarly, the “design data” provided from the CAD system in Calderon represent the model of the object itself. Petitioner does not explain why those are build instructions.

259. Further, Petitioner does not explain why depositing “extruded material” in areas “defined from the CAD model” teaches build instructions for fabricating an object. See Petition at 58; EX1003, ¶¶178-180

260. In my view, Petitioner has not pointed out what function identifies the build instructions and thus Ground 2A does not teach the claim element.

C. Claim 1, Elements 1.b, 1.c, and 1.d

261. Claim 1 of the '698 Patent requires, among other elements, “initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;” (claim element 1.b), “detecting the current contact force based on a sensor signal from the one or more sensors; and” (claim element 1.c), and “creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build” (claim element 1.d). *See* EX1001; *supra* Section II (“The Challenged Claims of the '698 Patent), Claim Elements 1.b, 1.c, and 1.d.

262. I understand that Petitioner contends that the Calderon-RepRap20208 combination teaches these claim elements. *See* Petition at 58-63.

263. For claim element 1.b, Petitioner contends that the strain gauge(s) of the combination operate to sense the contact force between the extruder and a separate structure (substrate 128 or model 136). *See* Petition at 58-61.

264. For claim element 1.c, Petitioner contends it would have been obvious to provide a constant measurement of the force on the head to detect the current contact force. *See* Petition at 61-62.

265. For claim element 1.d, Petitioner contends that the combination detects a current contact force. *See* Petition at 62-63.

266. In support of Petitioner's assertions for detecting a current contact force, Petitioner cites to several pages (pages 13 and 20) of the RepRap20208 reference and Figure 1 of Calderon. *See* Petition at 61-62 (citing EX1010, 13, 19-20; EX1009, Fig. 1).

267. It is my opinion that the combination does not teach all portions of claim elements 1.b, 1.c, and 1.d.

268. There is no teaching of one or more sensors configured to detect a current contact force, detecting the current contact force based on a sensor signal, or in response to the current contact force, creating a control signal. Page 13 of RepRap20208 does not mention a "force." *See* EX1010, 13. Rather, it merely discloses using a strain gauge on the extruder mount. *See id.* ("A strain gauge on the extruder mount would do that as well, and it could do a few other things as well, like finding the bed height automatically.").

269. Page 19 of RepRap20208 mentions a "force sensor" but teaches away from using it because it "doesn't sound like it works well over long periods of time under force." *See id.* at 19.

270. Similarly, page 20 of RepRap20208 describes "measuring contact force for a stencil cutting blade or drawing pen" but the next post teaches away from that

solution due to “backlash” and uncertainty as to “exactly when the head touches.” *See id.* at 20. It also describes a constant measurement of the force on the head, including its weight, but it does not mention a contact force. *See id.* (“a constant measurement of the force on the head (including it’s weight)”). Whether a person of ordinary skill considered these disclosures in RepRap20208 individually or collectively they fail to teach detecting a current contact force.

271. Petitioner’s citations to Calderon are also deficient. For example, Figure 1 of Calderon is simply a schematic of his generic system. *See* EX1009, 3:66-67, 4:34-52, FIG. 1. As I discussed above, Calderon monitors a change in the servo drive current. *Supra* Section VI.D (Overview of Calderon); *see* EX1009 at 10:5-8. He does not calculate a contact force. *See id.* Thus, the combination does not teach one or more sensors configured to detect a current contact force, detecting the current contact force based on a sensor signal, or in response to the current contact force, creating a control signal.

272. Moreover, as I explained above, there is no motivation to combine Calderon with RepRap20208. *Supra* Section IX.A. Among many other reasons, there is no motivation to look to RepRap20208 for Petitioner’s coined “real-time collision detection” as Calderon already has his own solution for collision detection. *See* EX1009, at 10:26-64. Accordingly, a person of ordinary skill in the art would not have been motivated to replace Calderon’s monitoring of servo drive current to

detect a current contact force with a strain gauge from RepRap20208 that provides a special purpose sensing means. *See, e.g.*, Petition at 60.

273. Thus, Ground 2A (Calderon and RepRap20208) does not show that claim 1 is obvious.

D. Claims 2-5, 7-10, 12-15

274. I understand that claims 2-5, 7-10, 12-15 depend from claim 1. *Supra* Section II (“The Challenged Claims of the ’698 Patent”). For at least the reasons I provided above for claim 1, it is my opinion that Petitioner has failed to show all elements of claims 2- 5, 7-10, 12-15. *Supra* Sections IX.A, IX.B, IX.C. I also provide additional opinions about dependent claims 4, 5, 7, 10, and 12 below.

E. Claim 4

275. Claim 4 recites “The method of claim 2, wherein the at least one component of the three-dimensional printer controls a z-distance between the extruder and a build platform of the three-dimensional printer.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent”).

276. I understand Petitioner asserts that “shutting the 3D printer down includes stopping any change the relative z-distance between the dispensing head and the platform to prevent damage.” Petition at 64-65; EX1009, 4:56-57.

277. I disagree with Petitioner’s assertion. The combination of Calderon and RepRap20208 does not teach changing the z-distance as part of shutting down the

3D printer. RepRap20208 simply includes a forum poster who would “have the machine shut down.” EX1010, 19. There is no teaching or suggestion that the z-distances between the extruder and build platform would need to be changed or controlled, much less to do so as part of machine shut down. Similarly, Calderon simply “stops the build and alerts the user to clear the build envelope.” EX1009 at 10:43-45. Accordingly, there is no rationale for controlling the z-distance between the dispensing head and platform, specifically, during a machine shut down.

278. Thus, Ground 2A (Calderon and RepRap20208) does not show that claim 4 is obvious.

F. Claims 5 and 7

279. Claim 5 recites the “method of claim 2 further comprising comparing the current contact force to an expected contact force” and claim 7 recites the “method of claim 5 further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent”).

280. I understand Petitioner asserts that a POSITA would have introduced a threshold force to compare to the current contact force to detect a collision. *See* Petition at 65; EX1003, ¶¶203-205. I also understand Petitioner asserts that the build

is terminated when the difference between the current contact force and expected contact force indicates a collision. *See* Petition at 65-66; EX1003, ¶¶206-208.

281. However, Petitioner’s flawed conclusion ignores the teachings of the references themselves. As I discussed above, there is no teaching of detecting a current contact force in the combination. *Supra* Section IX.C (claim 1). For instance, RepRap20208 says it watches “the change in bolt tension” for strain gauge. EX1010, 14; *see also id.* at 13, 19, 20. Calderon teaches that it determines contact by “monitoring a change in the servo drive current.” EX1009, 9:63-10:8. Accordingly, there is no teaching of comparing a current contact force to an expected contact force, much less terminating the build when the difference indicates a fabrication error or introducing an expected contact force that is not taught by the combination.

282. Thus, Ground 2A (Calderon and RepRap20208) does not show that claims 5 and 7 are obvious.

G. Claim 10

283. Claim 10 recites the “method of claim 2 further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent”).

284. I understand Petitioner asserts that “[i]n Calderon’s Example 3, Calderon describes ‘positioning the nozzle above pre-selected locations of the

substrate’ so that ‘[c]ontact between the tip of nozzle and the substrate is monitored’ with a ‘sensing means’ at these ‘pre-selected locations.’” Petition at 68. On this basis, I understand Petitioner concludes that the combination includes “a multi-point calibration . . . based upon a number of contact force measurements across a surface of the separate structure.” Petition at 68-69; EX1003, ¶¶216-219.

285. However, in my view, Petitioner ignores the claim language itself and Calderon’s teaching about Example 3, the very example that Petitioner relies upon to support its conclusion. In Calderon’s Example 3, a “Find-Z program” is run. *See* EX1009, 10:9. The program records the actual z-axis positions of the platform and refers to the steps of the algorithm, as described by the prior examples, except that “Steps (1) and (3) of the algorithm above can be skipped, however, as the recorded z-positions in the present embodiment are the actual z-axis positions of the platform. In other words, this approach eliminates the variables X and Y.” *Id.* at 10:11-15. Thus, a POSITA would have understood that the steps for Example 3 are as follows:

“(2) Select the lowest of the actual z-axis positions.” (*id.* at 8:27); and

“(4) Add a constant value Z, representing the desired depth of the tip of nozzle 144 below the top surface of substrate 146, to the result of step (3), to arrive at the z-start position.” (*id.* at 8:34-37).

286. Although Calderon discloses specific analysis to find a plane in Example 2, that analysis requires variables X and Y, which are expressly eliminated

in Example 3 (i.e., the example that Petitioner relies upon). *See id.* at 8:65-9:60 (Example 2), 9:62-10:22 (Example 3), 10:14-15 (“In other words, this approach [for Example 3] eliminates the variables X and Y.”). Thus, a POSITA would have understood that Calderon’s Example 3 finds a z-start position and does not detect the planarity of the substrate. Accordingly, Petitioner has failed to show that the combination teaches claim 10.

287. Thus, Ground 2A (Calderon and RepRap20208) does not show that claim 10 is obvious.

H. Claim 12

288. Claim 12 recites the “method of claim 1, wherein the build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure, and wherein the control signal controls the at least one component of the three-dimensional printer to achieve the specified contact force.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent”).

289. I understand Petitioner asserts that a POSITA would have “known, or found it obvious, to compare the current contact force . . . to a threshold indicative of, e.g., ‘when you run into something’” and “recognized that the Calderon-RepRap20208 Combination provides at least one build instruction for achieving a specified contact force (e.g., one that does not exceed the threshold) between the

fabrication tool and the separate structure.” Petition at 69. Petitioner also points to claims 5 and 7 to assert that the control signal achieves the specified contact force. *See* Petition at 70.

290. However, the combination does not teach a specified contact force or an instruction for achieving a specified contact force. Nothing in Calderon and RepRap20208, whether considered alone or in combination, teaches a “specified contact force.” Calderon teaches detecting contact by “monitoring a change in the servo drive current.” EX1009, 10:5-8. Similarly, RepRap20208 teaches watching for a “change in bolt tension when you run into something.” EX1010, 14. There is no teaching of a specific contact force, much less an instruction for achieving a specific contact force.

291. Further, as I explained above for claims 5 and 7, there is no teaching of comparing a current contact force to an expected contact force. *Supra* Section IX.F (claims 5 and 7).

292. Thus, Ground 2A (Calderon and RepRap20208) does not show that claim 12 is obvious.

X. GROUND 2B: CLAIM 11 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 2B (COMBINATION OF CALDERON AND REPRAP20208 WITH NAPADENSKY)

293. In Ground 2B of the Petition, Petitioner asserts that claim 11 is obvious over Calderon, RepRap20208, and Napadensky. *See* Petition at 72-73 (Overview of Napadensky); 73-74 (Asserted Motivation to Combine), 74 (claim 11).

294. I have reviewed Petitioner’s challenges in Ground 2B, and it is my opinion that Ground 2B fails to teach or suggest all elements of claim 11. I explain my opinions below in detail.

A. There is no motivation to combine Calderon and RepRap20208 with Napadensky (Ground 2B)

295. I understand that Petitioner asserts a motivation to combine Calderon and RepRap20208 with Napadensky. *See* Petition at 73-74; EX1003, ¶¶236-238. In particular, Petitioner asserts that the leveling device in Napadensky reduces surface irregularities that cause collisions and that would “adversely affect” model quality. *See id.* (citing EX1005 (Napadensky), 18:25-47; EX1009 (Calderon), 2:63-3:1).

296. However, Petitioner’s conclusion ignores Calderon’s own teachings in the combination. In particular, Calderon already discloses a solution to his concern that “if the substrate is deformed [and] lacks a horizontal planar surface, the model quality will be adversely affected.” EX1009, 2:63-3:1. In particular, Calderon therefore recognized there is “a need for a z-axis initialization routine that does not require operator intervention or judgment” (*id.* at 3:1-3) and provides an “autoinitialization method” that “will calculate the z-start position” (*id.* at 3:10-11). Thus, a person of ordinary skill in the art would not have been motivated to pursue using Napadensky’s leveling device and its operation when Calderon already provides a solution that automatically calculates the z-start position to avoid “adversely affect[ing]” model quality with a deformed substrate.

297. Further, I disagree with Dr. Wolfe's conclusion that Napadensky's leveling process with its leveling device is similar to the description of the '698 Patent. *See* EX1003, ¶64. The '698 Patent explains that "a layer may be fabricated on the surface that mitigates one or more irregularities in the surface" responsive to the contact force measurements "so that the resultant layer is effectively planar." EX1001 at 9:63-10-12; *see also id.* at 10:20-27 (describing result of leveling), Fig. 5. Thus, the leveling operation described by the '698 Patent changes the way the layer is fabricated responsive to contact force measurements. *See id.* In contrast, Napadensky's leveling process with its leveling device is performed after a newly formed layer is fabricated but prior to the formation of the successive layer. EX1005, 17:62-67, Fig. 1a (reproduced below).

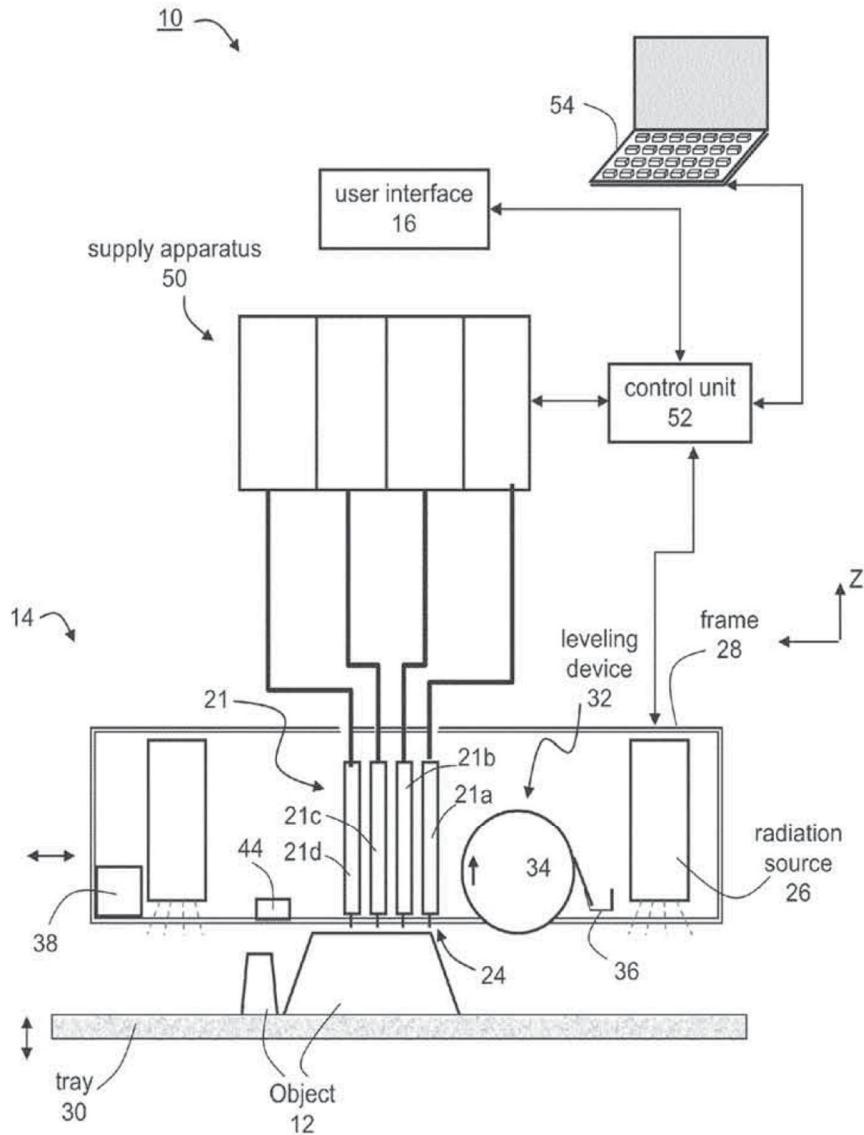


Fig. 1a

Accordingly, the proposed leveling operation in Napadensky is not similar to the leveling operation described by the '698 Patent as it is performed after a new layer is formed. Thus, there is no motivation to combine in Ground 2B.

298. For these reasons alone, Ground 2B (Calderon, RepRap20208, and Napadensky) does not show that claim 11 is obvious.

B. Claim 11

299. Claim 11 recites the “method of claim 10 further comprising fabricating a layer on the surface of the separate structure that decreases one or more irregularities in the surface of the separate structure.” *See* EX1001; *supra* Section II (“The Challenged Claims of the ’698 Patent”).

300. I understand Petitioner asserts that the Calderon-RepRap20208-Napadensky combination teaches claim 11 because the leveling operation (from Napadensky) decreases one or more irregularities in the surface of the separate structure. *See* Petition at 74.

301. However, as I explained above, Napadensky’s leveling operation is performed on a newly formed layer that has already been fabricated. EX1005, 17:62-67, Fig. 1a; *supra* Section X.A. Napadensky’s leveling operation is not performed to fabricate the layer itself, which is what the ’698 Patent discloses. Thus, in the combination, there is no teaching of fabricating a layer that decreases one or more irregularities in the surface of the separate structure.

302. For this additional reason, Ground 2B (Calderon, RepRap20208, and Napadensky) does not show that claim 11 is obvious.

XI. CONCLUSION

303. For the reasons set forth above, it is my opinion that claims 1-15 of U.S. Patent No. 9,168,698 would not have been obvious to a person of ordinary skill in the art at the relevant time.

304. In signing this Declaration, I understand it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I understand I may be subject to cross-examination in this case, and that any cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

305. I declare that all statements made herein of my 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 knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

306. I declare under penalty of perjury under the laws of the United State that the forgoing is true and correct.

Executed on this 30th day of January, 2026.



Dr. Tim A. Osswald

APPENDIX A

Professor Tim A. Osswald

Professor Emeritus - University of Wisconsin-Madison

Honorary Professor at the Friedrich-Alexander University, Erlangen, Germany

Honorary Professor at the National University, Bogotá, Colombia

co-Director of the Polymer Engineering Center

EDUCATION:

PhD	1987	University of Illinois-Urbana, Mechanical Engineering
MS	1982	South Dakota School of Mines & Tech., Mechanical Engineering
BS	1981	South Dakota School of Mines & Tech., Mechanical Engineering
H.S.	1975	S.D.S.J.C, Cúcuta, Colombia

POSITION HELD:

2008-2009	Interim Chair of Plastics Technology, University of Erlangen-Nuremberg (from August 1, 2008 to February 28, 2009)
1999-2024	Professor, Department of Mechanical Engineering, and co-Director of the Polymer Engineering Center, UW
1995-1999	Associate Professor, Department of Mechanical Engineering, UW
1989-1995	Assistant Professor, Department of Mechanical Engineering, UW
1987-89	Humboldt Fellow: Institute for Plastics Processing (IKV), Technical University of Aachen (RWTH), West Germany
1987-89	Consultant: Dynamit Nobel, Leverkusen, Germany
1986	College Graduate in Training: GM Research Labs
1982-83	Instructor: Mechanical Engineering, SDSM & T, SD

HONORS AND AWARDS:

- Journal of Polymer Composites, Editor (2021-present)
- Advisor to the Colombian President on Science and Technology (2019-present)
- Member of the 2019 Commission to create a Science Ministry in Colombia
- Sabic Educator of the Year - SPE Composites Division (2017)
- Fred E. Schwab Education Award - National SPE Educator Award (2016)
- SPE Educator of the Year Award - Milwaukee, Wisconsin (2016)
- Honorary Professor - National University of Colombia (2010)
- Fellow of the Society of Plastics Engineers (2008)
- Honorary Professor - University of Erlangen-Nuremberg (2006)
- Chaired Professorship: K.K. and Cindy Wang Professor (2005-2015)
- Journal of Polymer Technology, Editor (2004-present)
- Nominated as the first American member of the International Alliance of Polymer Technology Professors (2002)
- Recipient of the VDI-K Dr.-Richard-Escales-Prize (2001)
- Journal of Polymer Engineering, Editor for the Americas, (1999-present)
- Hanser Publishers, Advisory Board, (1998-present)
- Journal of Society of Manufacturing Engineers, Editor -- Plastics
- NSF Presidential Young Investigator Award (1991-96)
- Alexander von Humboldt Fellow (1987-89)

PERSONAL INFORMATION:

Married, two children. Born in Bogotá, Colombia, US Citizen,
Fluent in English, German and Spanish. Communicates in French,
Italian and Portuguese

BOOKS

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Professor Tim A. Osswald

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COURSES DEVELOPED

ME 310 Manufacturing: Polymer Processing and Engineering

Introduction to all important aspects of polymer processing and engineering including polymeric materials, material properties, design and manufacturing considerations, processing methods, part performance, post-consumer recycling and upcycling, societal responsibilities and ethics, and various techniques for modeling in materials processing like dimensional analysis, design of experiments, analytical solutions, and computer simulation.

ME417 Transport Phenomena in Polymer Processing

A course that focuses on the application of transport phenomena principles to the processing of polymeric materials. This course delves into the intricacies of heat transfer, fluid mechanics, and mass transfer as they relate to the manufacturing of polymers.

ME418 Engineering Design with Polymers

A course intended to acquaint the student with a polymers' unique behavior and its relation to design, covering molecular structure, basic properties, the relation between processing and properties of the final part, mixing, anisotropy, and residual stresses during solidification.

ME514 Polymer Additive Manufacturing

A quantitative and qualitative study of additive manufacturing processes. Emphasis on proper additive manufacturing technique selection for optimized final product design and properties, as well as presentation of emerging additive manufacturing techniques.

ME 718 Modeling and Simulation Polymer Processing.

A course designed to acquaint the student with computer simulation technology used for the engineering of polymer processes, such as compression molding, injection molding, extrusion, blow molding, and many others.

PATENTS

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|-----------------|--|
| 1. US 5,971,603 | Static Mixer Head |
| 2. US 6,136,246 | Screw extruder with improved dispersive mixing elements |
| 3. US 7,314,363 | Device to visualize in-line and quantify the polymer melting in plasticating screw machines without significantly affecting its thermal regime |
| 4. US 9,321,207 | Polymer Pelletization Via Melt Fracture |

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5. US 9,205,590 Micropelletizer Using Rayleigh Disturbances
6. US 9,895,844 System for Use with Three Dimensional Printer and Method for
Using the Same (applied 2015, granted 2018)
7. WO2015126733 System for Use with Three Dimensional Printer and Method for Using the Same
8. US11,207,799 B2 Pelletization Gas Guide
9. United States Patent Application 20230339155, METHOD FOR SIMULATING A FIBER ORIENTATION
IN AN INJECTION-MOLDED PART MADE OF A FIBER-REINFORCED PLASTIC, AND DESIGN
METHOD FOR DESIGNING AN INJECTION-MOLDED PART MADE OF A FIBER-REINFORCED PLAS-
TIC
10. WO2023144631 Ammonia-Free Latex Compositions
11. US 11,911,949 Rotating Nozzle Structure and Method