

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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SHENZHEN TUOZHU TECHNOLOGY CO., LTD.,  
Petitioner

v.

STRATASYS, INC.  
Patent Owner.

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IPR2025-00531  
U.S. PATENT NO. 9,168,698

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**EXHIBIT LIST**

<b>Exhibit No.</b>	<b>Description</b>
2001	Docket Navigator – Judge Rodney Gilstrap Motion Success for Stay Pending IPR and Time to Milestones
2002	United States District Courts — Judicial Caseload Profiles for Eastern District of Texas (Sept. 30, 2024 and Dec. 31, 2024), available at <a href="https://www.uscourts.gov/data-news/reports/statistical-reports/federal-court-management-statistics">https://www.uscourts.gov/data-news/reports/statistical-reports/federal-court-management-statistics</a>
2003	Minute Entry for proceedings held before District Judge Gilstrap on Nov. 7, 2024, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG (E.D. Tex. Nov. 14, 2024)
2004	Discovery Order, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 35 (E.D. Tex. Dec. 2, 2024)
2005	Protective Order, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 36 (E.D. Tex. Dec. 3, 2024)
2006	e-Discovery Order, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 41 (E.D. Tex. Dec. 19, 2024)
2007	Invalidity and Ineligibility Contentions, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, (E.D. Tex. Jan. 30, 2025)
2008	Transcript of Hearing on the Nomination of Howard Lutnick, of New York, to be Secretary of Commerce (Jan. 29, 2025)
2009	Order Denying Defendants' Motion to Dismiss for Failure to Join Indispensable Party, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt. No. 53 (E.D. Tex. May 29, 2025)
2010	Plaintiff's Unopposed Motion to Consolidate Case No. 2:25-cv-00465-JRG with Case Nos. 2:24-cv-00644-JRG and 2:24-cv-00645-JRG, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt. No. 54 (E.D. Tex. May 30, 2025)
2011	Lex Machina, Patent Litigation Report 2024 (Feb. 2024)
2012	U.S. District Court, Eastern District of Texas [Live] Calendar Events Set for 6/1/2026-8/1/2026
2013-2019	Reserved

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.
2027	Declaration of Dr. Tim A. Osswald

**I. INTRODUCTION**

Pursuant to 35 U.S.C. §§ 313 and 316, and 37 C.F.R. § 42.120, Stratasys, Inc. (“Stratasys” or “Patent Owner”) hereby submits this Response to the Petition for *inter partes* review (“Petition” or “Pet.”) filed by Shenzhen Tuozhu Technology Co., Ltd. (“Petitioner”), challenging claims 1-15 (“challenged claims”) of U.S. Patent No. 9,168,698 (“the ’698 Patent”) (EX1001).

Petitioner alleges that the challenged claims are invalid based on four grounds (1A, 1B, 2A, 2B). Petitioner argues that independent claim 1 is obvious over U.S. Patent No. 6,986,739 (“Warren”) (EX1004) in Ground 1A and U.S. Patent No. 6,629,011 (“Calderon”) (EX1009) in view of RepRap20208 (EX1010) in Ground 2A. Petitioner argues in Ground 1B that claims 3, 7, and 9 are obvious over Warren in view of U.S. Patent Publication No. 2007/0179656 (“Eshed”). Further, Petitioner argues in Ground 2B that claim 11 is obvious over Calderon, RepRap20208, and U.S. Patent No. 9,031,680 (“Napadensky”).

Petitioner has failed to meet its burden to show unpatentability with respect to any of the challenged claims. The challenged claims of the ’698 Patent are directed to solutions that include identifying build instructions for fabricating an object, one or more sensors mechanically coupled to the fabrication tool that are 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 sensor(s), 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.

Petitioner proposes flawed motivations to combine for both grounds challenging independent claim 1. For Ground 1A, there is no motivation to combine differing embodiments of Warren in the manner that Petitioner proposes. And for Ground 2A, there is no motivation to combine Calderon with RepRap20208. Petitioner routinely ignores the disclosures of the references themselves and makes unsupported assertions contrary to the teachings of the references themselves. Additionally, each of Grounds 1A and 2A fail to teach multiple elements of independent claim 1. Further, for Ground 1B there is no motivation to combine Warren with Eshed and the combination does not teach the elements of the challenged claims. Similarly, for Ground 2B there is no motivation to combine Calderon and RepRap20208 with Napadensky and the combination does not teach the elements of claim 11.

In summary, Petitioner has failed to carry its burden to show that the challenged claims are unpatentable under any of the asserted grounds.

## II. THE '698 PATENT AND THE CHALLENGED CLAIMS

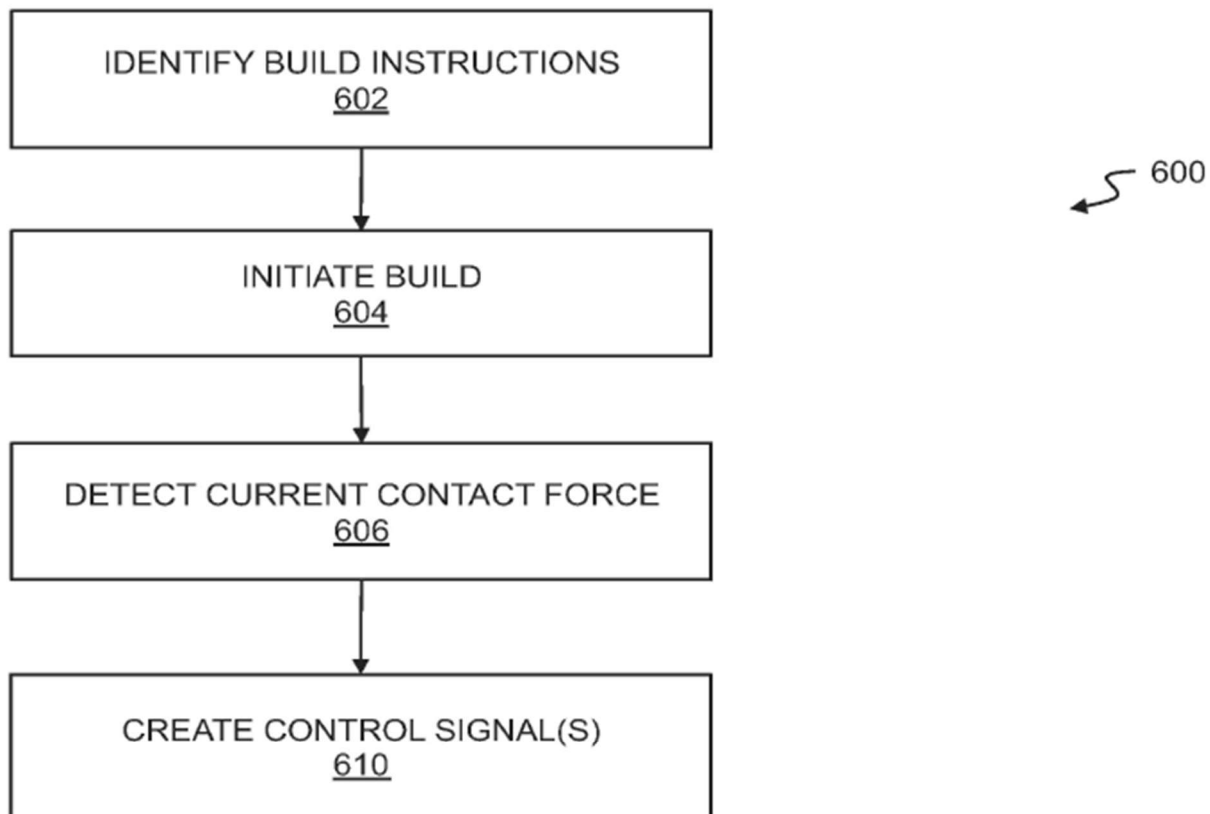
### A. Summary of the '698 Patent (EX1001)

The '698 Patent 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. As the patent explains, “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.

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.

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



**Fig. 6**

*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.

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.

Thereafter, a current contact force is detected at step 606. *See id.* at 10:49-50. “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.” *See id.* at 10:50-55. 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 next step in the process (step 610) creates a control signal in response to the current 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. 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 current contact force. *See id.* at 10:66-11:4. 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. Other actions may be taken when the detected current 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.

The '698 Patent also discloses a method in Figure 4 to detect planarity of a surface and responsively make corrections. A number of contact force measurements may be made across the surface, such as 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.

Numerous claims embody these solutions, including independent claim 1. For instance, claim 1 recites “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” “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.”

*Id.* at 12:39-49.

As explained below, the asserted grounds fail to teach the elements of claim 1, as well as elements of other dependent claims. Further, because claims 2-15, depend from claim 1, the asserted grounds also fail to teach the elements of dependent claims 2-15 for at least the same reasons given for claim 1. In addition, the asserted grounds fail to teach certain elements of the dependent claims as discussed below.

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

During prosecution, the applicant explained that unlike the cited art, the 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. The applicant explained that the examiner correctly noted that U.S. Patent No. 6,129,872 to Jang (“*Jang*”) (EX2022) did not disclose detecting a contact force between the fabrication tool and a separate structure. EX1002 at 32. The examiner had rejected the claims over *Jang* in view of U.S. Patent No. 7,625,198 to Lipson, et al. (“*Lipson*”) (EX2023). *See* EX1002 at 42-44. But 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. In particular, the feedback is used to control print parameters during a build. *Id.* Thus, 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. *Id.* In response to the applicant's arguments, the examiner allowed the claims explaining that the prior art fails to teach or suggest the claimed method. *See id.* at 20-27.

### **III. LEVEL OF ORDINARY SKILL**

For the purpose of this Response, a person of ordinary skill in the art (a "POSITA") in relation to the subject matter of the '698 Patent would have had a 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). *See EX2027 at ¶¶22-26.*

As explained below, the Petition has failed to show that the claims of the '698 Patent are unpatentable irrespective of the level of skill of a skilled artisan.

### **IV. CLAIM CONSTRUCTION**

For the purposes of this Response, Patent Owner submits that the Board does not need to construe any claim terms in any particular way to conclude that the challenged claims are not unpatentable. *See Wellman, Inc. v. Eastman Chem.*

Co., 642 F.3d 1355, 1361 (Fed. Cir. 2011) (“need only be construed ‘to the extent necessary to resolve the controversy’”).

## V. APPLICABLE LEGAL STANDARDS

Each of Petitioner's grounds relies on obviousness under 35 U.S.C. § 103. A claim cannot be considered obvious if even one element of the claim is absent from the prior art. *See CFMT, Inc. v. YieldUp Int'l Corp.*, 349 F.3d 1333, 1342 (Fed. Cir. 2003) (“Obviousness requires a suggestion of all limitations in a claim.”) (citing *In re Royka*, 490 F.2d 981, 985 (C.C.P.A. 1974)); *In re Rijckaert*, 9 F.3d 1531, 1534 (Fed. Cir. 1993) (reversing obviousness rejection as not all claim elements were taught or suggested); *Garmin Int'l, Inc. v. Patent of Cuozzo Speed Techs. LLC*, IPR2012-00001, Paper 15 at 15 (PTAB Jan. 9, 2013) (denying institution of IPR in part as prior art did not disclose all claim limitations in obviousness challenge).

Obviousness is resolved based on several factual determinations including the scope and content of the prior art, any differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art. *See Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966). IPR petitions “must address the *Graham* factors.” *Eizo Corp. v. Barco N.V.*, IPR2014-00358, Paper 11 at 29-30 (PTAB July 23, 2014) (citing *Graham*, 383 U.S. at 17-18) (faulting Petitioner for its failure to identify differences between the claimed subject matter and the prior

art and its conclusory assertions about the teachings of the prior art); *see also Moses Lake Indus., Inc. v. Enthone, Inc.*, IPR2014-00243, Paper 6 at 18 (PTAB June 18, 2014); *Moses Lake Indus., Inc. v. Enthone, Inc.*, IPR2014-00246, Paper 6 at 17 (PTAB June 18, 2014); *eBay, Inc. v. Paid, Inc.*, CBM2014-00125, Paper 15 at 21 (PTAB Sept. 30, 2014).

The conclusion of obviousness based on the combination of references must be supported by an explicit analysis of a reason to combine such references. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007). Mere conclusory statements are insufficient. Instead, "there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006); *see also LG Elecs., Inc. v. Cellular Commc'ns Equip. LLC*, IPR2016-00197, Paper 7 at 7-11 (PTAB Apr. 29, 2016) (petition's conclusion of obviousness lacked sufficient articulated reasons with rational underpinnings for modifying references to achieve specific elements of the claims).

## **VI. THE PETITION DOES NOT SHOW THAT THE CHALLENGED CLAIMS ARE UNPATENTABLE UNDER GROUND 1A**

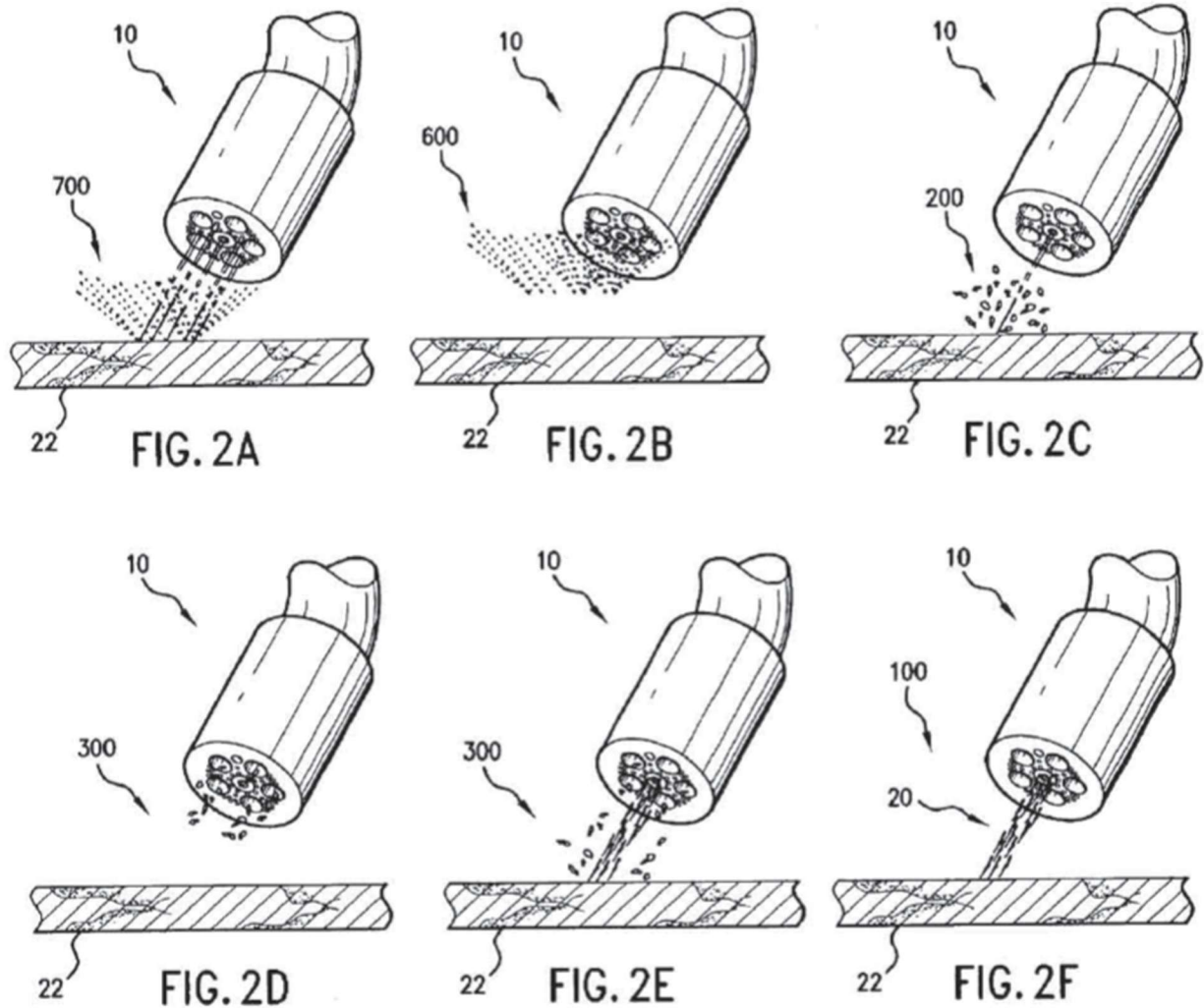
### **A. Overview of Warren (EX1004)**

Warren 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. 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].

As Warren explains there are four purported unique aspects to the HAT that uses DWDT technology. *See id.* at ¶[0059]. First, the HAT permits navigation among internal cavities and structural elements (e.g., bones), as well as arteries and veins, with the body. *See id.* at ¶[0059]. Second, it can add and/or subtract unwanted tissues and materials in a seamless and facile fashion. *See id.* at ¶[0060]. Third, it combines fabrication and assembly processes to form, for example, 3D engineered tissue constructs (ETC). *See id.* at ¶[0061]. Fourth, its processes can be performed outside of and within the body. *See id.* at ¶[0062].

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



*Id.* at Figs. 2A-2F. Figure 2A shows therapeutic emitter 700 (*id.* at ¶¶[0138]-[0141]), Figure 2B shows detector 600 for laser-induced fluorescence (LIF) (*id.* at ¶¶[0109]-[0117]), Figure 2C shows material destroyer 200 to separate cells or tissue from their endogenous position in the body (*id.* at ¶¶[0147]-[0154]), Figures 2D and 2E show material remover 300 with suction channels (*id.* at ¶¶[0205]-[0210]), and Figure 2F shows a material dispenser 100 to deposit material on a substrate 22 (*id.* at ¶¶[0220]-[0229]).

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

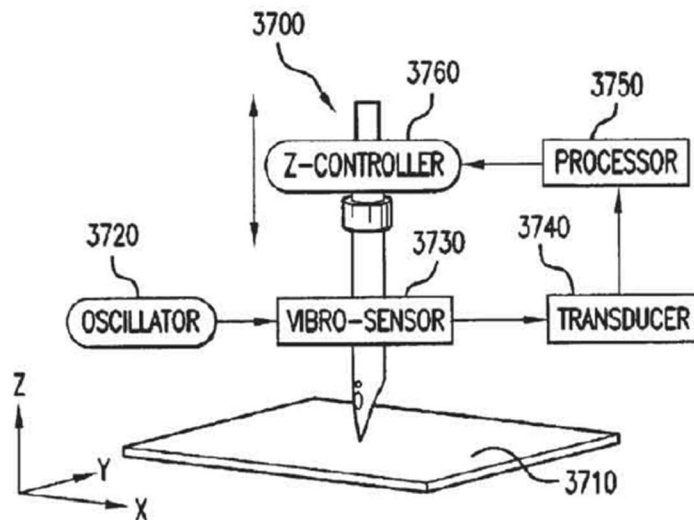


FIG. 18

*Id.* at Fig. 18, ¶[0293]. Although the substrate is shown as flat, Warren explains that this is just for the ease of illustration as 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].

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

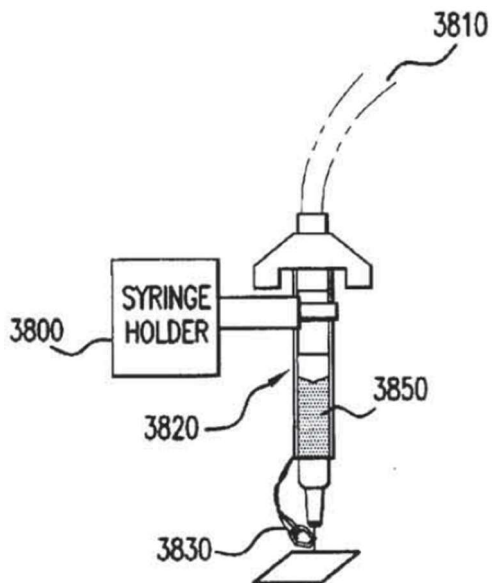
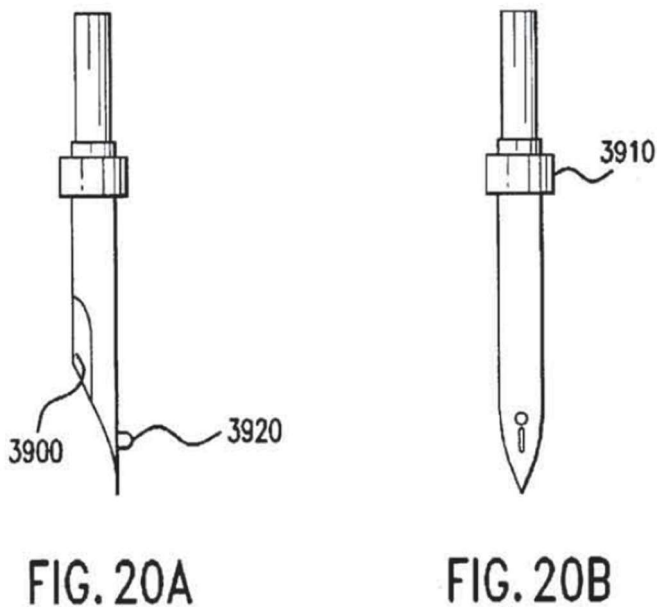


FIG. 19

*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.*

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.*

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.

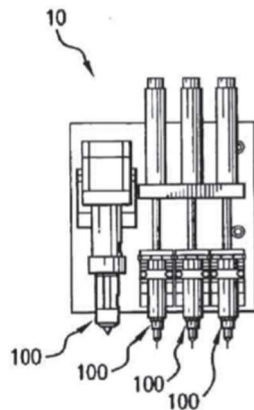


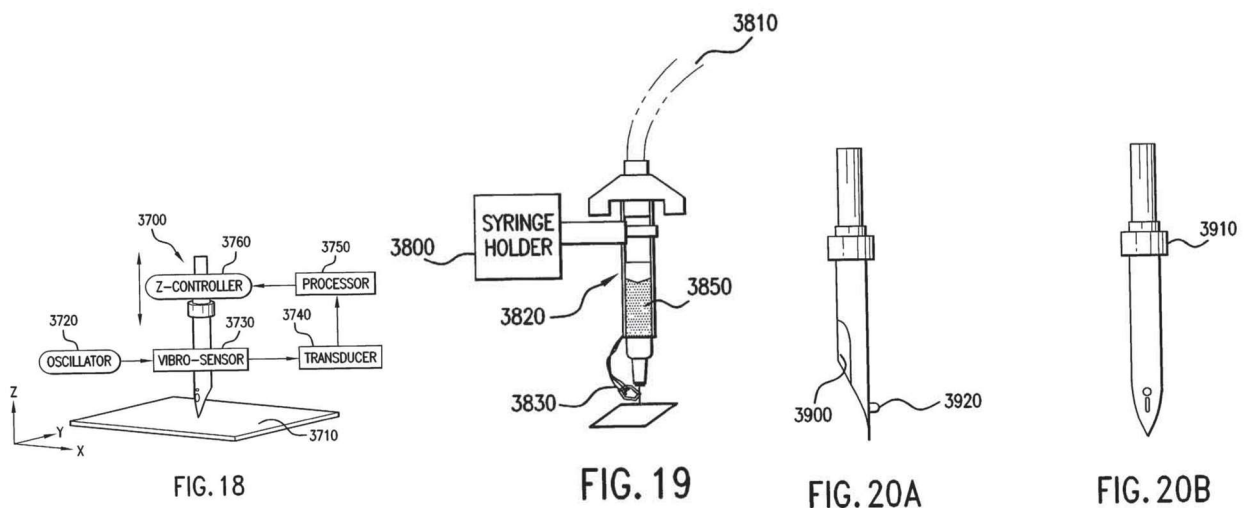
FIG. 23A

The through-nozzle dispenser is used to fill larger areas. *See id.* By contrast, the capillary dispensers are used to dispense solutions and/or cell suspensions to achieve smaller details than those possible with the through-nozzle dispenser, to provide high-detail and high-precision dispensing. *See id.*

**B. There Is No Motivation to Combine Different Embodiments of Warren**

Petitioner asserts a motivation to combine different embodiments of Warren. *See Pet.* at 13-16. Specifically, Petitioner asserts that “a POSITA would have found it obvious to use the vibrating force sensor concepts with Warren’s through-nozzle dispenser” and a “POSITA would have been motivated to apply Warren’s through-nozzle dispenser” as “dispenser 3700 in Warren’s vibrating force sensor configuration.” *Pet.* at 13. However, as explained below, none of Petitioner’s reasons or rationales for the combination is sufficient.

First, Warren does not “invite[] using the vibrating force sensor concepts” with a through-nozzle design, as Petitioner purports. *See* Pet. at 13-14 (citing EX1003, ¶68 (parroting Petitioner’s arguments without more)). Warren merely states that its dispenser 3700 is not limited to the specific implementations corresponding to Figures 19, 20A, and 20B. *See* EX1004, ¶[0299]. In fact, Figure 18 itself illustrates dispenser 3700 as another implementation of a quill-pen that is different from the one shown in Figures 20A and 20B and the capillary dispenser of Figure 19. *Compare id.* at Fig. 18 with Figs. 19, 20A-20B (reproduced below).



For instance, Figures 20A and 20B show a specific quill-pen with a vibration actuator 3910 substantially separated from the vibration transducer 3920. *Id.* at [0298]. As another example, Figure 19 shows a specific capillary syringe with a combined vibration actuator and transducer in piezomembrane 3830. *Id.* at [0295]. In contrast, Figure 18 shows another implementation of a quill-pen with a vibro-

sensor 3730 in which the separate oscillator 3720 and transducer 3740 are separate from the dispenser. *Id.* at [0300].

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]. There is no motivation or suggestion to implement dispenser 3700 as a through-nozzle design. *See id.* at ¶[0299]; EX2027, ¶¶119-125.

Second, there is no motivation to use a through-nozzle design for the dispenser to enable precise control. *See Pet.* at 14 (citing EX1003, ¶69 (again parroting Petitioner's arguments without more)). Petitioner fails to acknowledge that a capillary dispenser already provides for high-precision and that Warren teaches switching from the through-nozzle dispenser to a capillary dispenser when smaller, high-detail, high-precision dispensing is required. Namely, 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]. Similar to capillary dispensers, Warren teaches that sensoric quill-pen designs enable precise control “to sense and maintain optimum contact.” *See id.* at ¶[0260]. 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. EX2027, ¶¶126-134. 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. *See id.*

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.*; EX2027, ¶¶132-134, 145-146. Indeed, Warren 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]; *see also id.* Similarly, 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]; *see also* EX2027, ¶¶134, 146, 154. Thus, although 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] (cited by EX1003, ¶[69]); *see also* EX2027, ¶¶126-134.

Third, there is no motivation to modify Warren's capillary dispenser or quill-pen designs to use a linear actuator. *See* Pet. at 14-15 (citing EX1003, ¶[70] (again parroting Petitioner's arguments without more)). Again, there is no motivation to add such a feature. Petitioner argues 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" because the reference 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.'" Pet. at 15 (citing EX1004, [0093] (emphasis added by Petitioner)).

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]. For example, Warren provides examples of the individual devices in the combination tool in Figures 2A to 2F. *See* EX1004, ¶[0093], Figs. 2A-2F; *supra* § VI.A (discussing Figs. 2A-2F). Warren's combination tool does not add features from one design to another design. Rather, it integrates 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.”); EX2027, ¶¶135-144 (explaining that Warren’s DWDT/HAT integrates many different devices into one combination tool).

Moreover, Petitioner ignores Warren’s teachings and relies on impermissible hindsight. There is no need for a linear actuator to open and close a valve in Warren’s capillary designs or quill-pen designs. EX2027, ¶¶145-146 (explaining the lack of a need for a linear actuator from the through-nozzle design in the capillary and quill designs). 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]. Whereas the 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. EX2027, ¶¶145-147.

Fourth, there is no motivation to provide Warren's through-nozzle dispenser with vibrating force sensor capabilities. *See Pet.* at 15-16. As an initial matter, this rationale asserts the opposite of Petitioner's combination, which applies Warren's through-nozzle dispenser as dispenser 3700 in Warren's vibrating force sensor configuration. *See Pet.* at 13.

Moreover, there is no motivation to make this modification to facilitate control over the deposition geometry or to avoid damage (*see Pet.* at 15-16) because the through-nozzle dispenser already includes a mechanism for such control. Warren explains that, through precision control of a valve and piston opening, the material flow is “smooth, seamless, and very reproducible.” EX1004 at ¶[0243]. And, 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). 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.

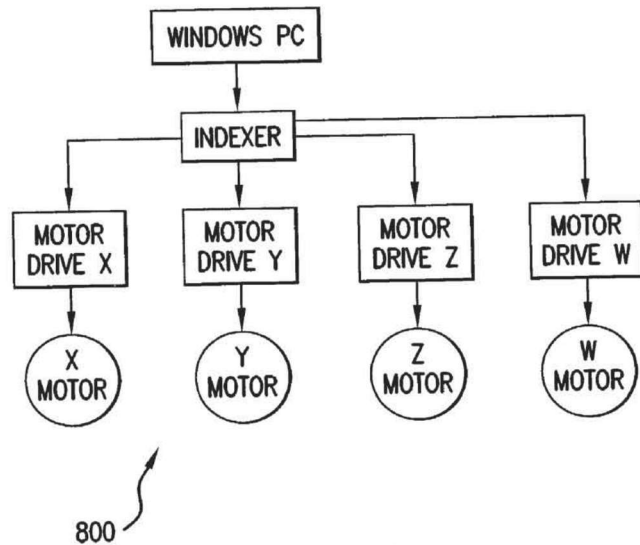


FIG. 36

*Id.* at Fig. 36. As shown, 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). Warren explains that his 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 POSITA would have understood that Warren’s 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. EX2027, ¶¶147-152.

Unlike Warren's through-nozzle dispenser, Warren discloses 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].

Further, there is no motivation based on overcoming issues regarding agglomeration and/or sticking. *See Pet.* at 15-16 (citing EX1003, ¶71 (parroting Petitioner's arguments without more)). The issue of agglomeration and/or sticking is related to implementations of a quill-pen that 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. *See* EX2027, ¶¶153-154 (explaining the agglomerates that could form within the dispenser and that a through-nozzle dispenser for depositing larger areas with less precision does not need low frequency vibrations).

Thus, there is no motivation to combine the different embodiments of Warren as Petitioner proposes. EX2027, ¶¶117-155.

### **C. Ground 1A Does Not Render Claim 1 Unpatentable**

Petitioner fails to show how Warren in Ground 1A teaches all elements of claim 1. For instance, the Petition fails to show that the reference teaches claim elements 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”), and thus 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.”).

Namely, 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. Petitioner

concedes that Warren detects a change in amplitude of vibration and not a current contact force, but it 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.’” *See* Pet. at 20 (citing EX1003, ¶86); *see also* EX1004 at ¶[0313].

Petitioner's flawed conclusion overlooks Warren's teachings and resorts to impermissible hindsight. First, Warren does not teach or suggest detecting a 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 ( $\Delta A$ ) 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.* (“The position of one or more of the elements is varied, based on the detected  $\Delta A$ , 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]. There is no teaching or suggestion to detect or calculate a current contact force. *See* EX2027, ¶¶161-169 (explaining that Warren teaches detecting a change in amplitude and thus the current amplitude is sensed to provide a change in amplitude and that Warren does not disclose how a change in vibration amplitude can be translated into a detected or quantitative contact force); EX2025 at p.62, Fig. 3.16; EX2026 at pp.47-56, Fig. 2.32.

Second, it would not have been obvious to detect or calculate the current contact force from the detected change in amplitude. *See* Pet. at 20-21 (citing EX1003, ¶¶86-87). Warren does not explain how to detect the current contact force from a change in amplitude. *See* EX2027, ¶¶170-189. It 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].

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.

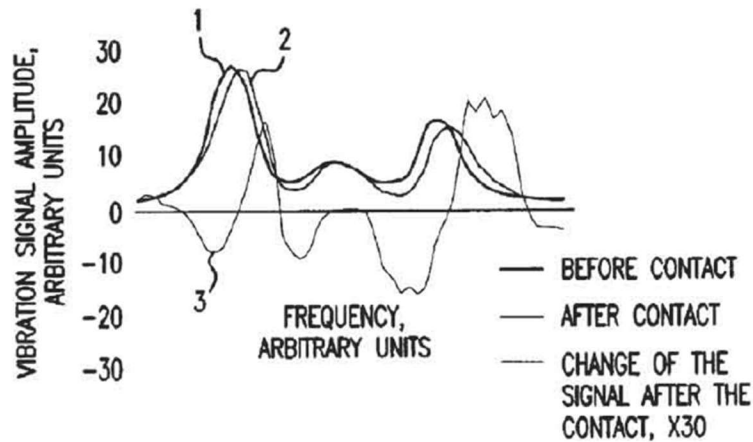


FIG. 21

See EX1004 at Fig. 21, ¶¶[0306]<sup>1</sup>. 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. EX2027, ¶¶168, 170-171, 181.

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  $\Delta A$ .” 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

<sup>1</sup> Warren’s written description incorrectly refers to Figure 21 as Figure 40.

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; EX2027, ¶¶172-173.

When asked about what Figure 21 shows, Petitioner's expert admitted that Plot 3 does not correspond to Plots 1 and 2, and that he would select one or more frequencies based on a desire to show a change in amplitude. EX2020 at 77:5-20, 79:13-80:20. But nothing in Warren tells us which frequency or frequencies to select for detecting a change in amplitude, much less to detect a current contact force. EX2027, ¶175. 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. *See id.* Thus, Warren fails to teach how to detect the current contact force from the change in amplitude or provide a motivation for doing so.

Indeed, Petitioner fails to present any evidence that detecting a current contact force from Warren's change in amplitude was known. *See* EX2027, ¶¶176-188. 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. In particular, the substrates in Warren varies in composition, which leads to differing amounts of deformation upon contact. *See* EX2027, ¶¶166, 179-183. For example, Warren's capillary

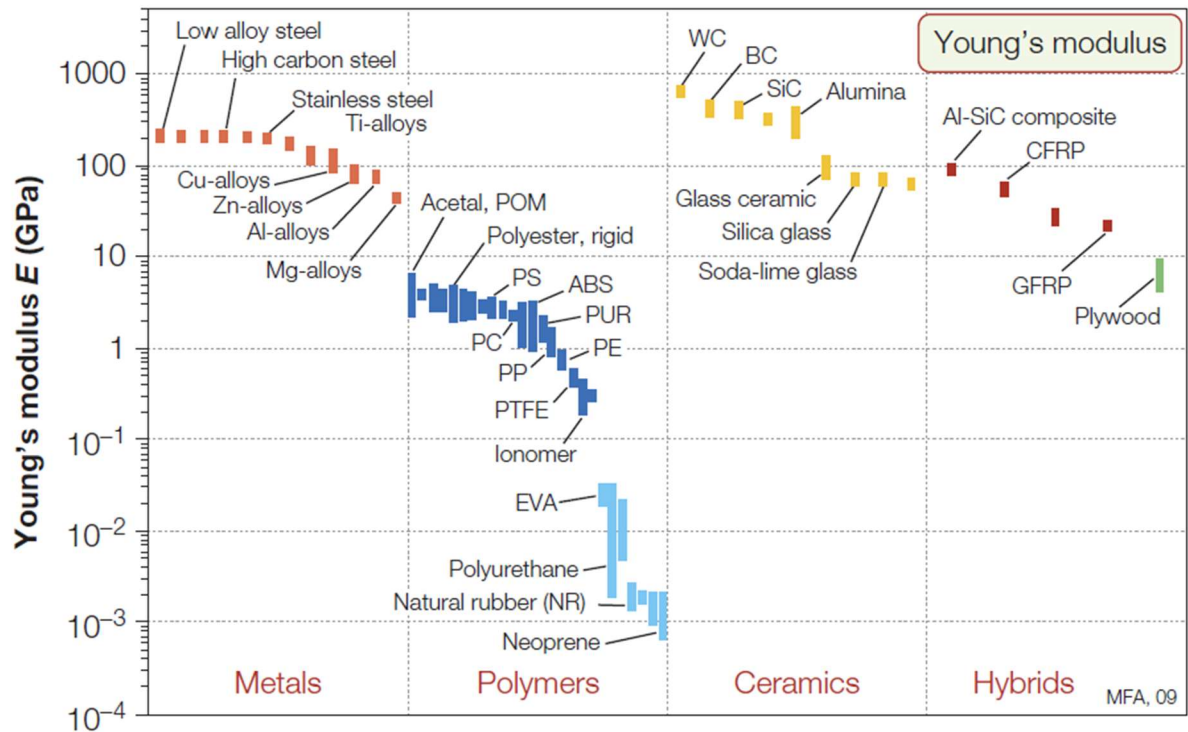
vibro-sensor dispensing units are used with “intermediate-density gelatinized slides and high-density plain and patterned slides of human white blood cells (WBC’s).”

EX1004, ¶[0295]. Similarly, 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”).

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; EX2027, ¶¶185-188 (explaining that variations in frequency, temperature, time, and materials). As shown, the stiffness of materials varies by over six orders of magnitude (or 1,000,000 times) from ceramics with a Young's modulus near 1000 GPa to polyurethane and other polymers with a Young's modulus near 0.001 GPa. *Id.* Varying modulus across materials impacts the ability to detect or calculate 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. *Id.*; *see also* EX2020 at 72:13-73:16, 89:2-21 (Petitioner's expert admitting that he does not know what Young's modulus is and that he has no

experience with deposition of cells as described by Warren). Accordingly, converting Warren's change in amplitude to detect a current contact force is vastly more complicated without any reasonable expectation of success. *Id.*

Further, there is no motivation to detect the current contact force from the change in amplitude that is used in Warren's solution. There is no comparison, for example, between a detected current contact force and the "desired contact force" as Petitioner and its expert assert. *See* Pet. at 27-28 (citing EX1003, ¶¶109-11 for claim 5). Warren teaches that it 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], [0311] (explaining the details of generating the feedback signal used by the z-controller processor 3750 or PC 4140). Thus, a POSITA would have understood from Warren's teachings that the change in amplitude itself is used to indicate desired contact. EX2027, ¶189; EX1004 at Fig. 21, ¶[0306] ("Plot 3 shows the absolute value of the relative  $\Delta A$ .").

In addition, while the challenged 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 that the current contact force may be actually detected from Warren's change in amplitude. EX1001 at

8:56-61; *see also* EX2027, ¶190; EX1004 at Fig. 21, ¶[0306]. As discussed above, Warren does not teach detecting the current contact force, nor does Petitioner present any evidence that detecting the current contact force in Warren's solution was known.

Thus, Ground 1A does not render claim 1 obvious. *See* EX2027, ¶¶156-191.

**D. Ground 1A Does Not Render Claims 2-6, 8-15 Unpatentable**

Because claims 2-6 and 8-15 depend from claim 1, for at least the reasons provided above for claim 1, Ground 1A does not render claims 2-6 and 8-15 obvious. *See* EX2027, ¶192.

**E. Ground 1A Does Not Render Claims 3 and 9 Unpatentable**

Petitioner also fails to show how Warren in Ground 1A teaches all elements of claims 3 and 9. 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,” and 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.” For claim 3, Petitioner asserts that Warren's “through-nozzle dispenser includes a linear actuator . . . to adjust dispensing rate (i.e., feed rate for build material used in the build)” and that the “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.” Pet. at 26 (citing EX1004, [0234], [0236], [0238], [0239], [0243]; EX1003, ¶¶103-104); *see also* Pet. at 25-26 (citing EX1003, ¶¶99-102; EX1004, [0230-0252], FIGS. 11A-11D, 12A-12B. Similarly, for claim 9, Petitioner asserts “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 . . . so that Warren’s dispenser ‘maintains contact of a desirable intensity.’” *See* Pet. at 31 (citing EX1003, ¶¶119-121). In reaching these flawed conclusions, Petitioner and its expert resort to hindsight bias to replace Warren’s teachings.

First, as discussed above, there is no motivation to use Warren’s through-nozzle dispenser (such as those in Figures 11A-11D and 12A-12B and the associated written description) with Warren’s vibration sensing solution (such as Figure 18). *Supra* Section VI.B. Warren does not invite using the vibration sensing solution with the through-nozzle design. *See, e.g.*, EX1004, ¶¶ [0295-300], Figs. 18-20B; EX2027, ¶¶197, 119-125. There is no motivation to use the through-nozzle design for the dispenser to enable precise control. *Supra* Section VI.B. Warren describes using the quill pen or capillary dispenser to enable precise control. *See, e.g.*, EX1004 at ¶¶[0260], [0278]; EX2027, ¶¶198, 126-134. There is also no motivation to modify Warren’s capillary or quill-pen designs to use a linear actuator. *Supra* Section VI.B. Warren simply describes a combination tool that

integrates different devices and explains that capillary or quill-pen designs already achieve precise control of the material flow. *See, e.g.*, EX1004, ¶¶ [0093], [0279], [0260]; EX2027, ¶¶199, 135-146. Additionally, there is no motivation to provide Warren's through-nozzle dispenser with vibrating force sensor capabilities. *Supra* Section VI.B. Warren already contemplates a precise location control device for its through-nozzle design to control deposition geometry and avoid damage. *See, e.g.*, EX1004 at ¶¶ [0227-234]; EX2027, ¶¶200, 147-155.

Second, the synchronization of xyz motion of the dispenser for the linear actuator and valve of the through-nozzle design (and identified trouble spots) is not responsive to a current contact force. Warren describes the operation of the valve/linear actuator with the xyz motion. First, in a "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. EX2027, ¶¶201-205. Rather, a POSITA would have understood that such events are independent of the current contact force. *See id.* (explaining that the end of the motion is pre-determined by the tool path instructions as are trouble spots such as a corner and are not determined responsive

to a current contact force). Further, a POSITA would not have understood that the valve position would be adjusted responsive to Warren's vibrating sensor solution conforming to the surface. *See id.* Rather, a POSITA would have understood that Warren's vibrating sensor solution would move the position of the dispenser to conform to the surface, as Warren teaches, rather than replacing Warren's teaching with a change to the valve position. *See id.*; 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").

Second, in "volumetric invariant" mode, Warren states that the valve position is used to control the amount of material dispensed per second. EX1004, ¶[0239]. Again, a POSITA would have understood that controlling the amount of material dispensed per second does not vary in response to a current contact force in Warren. *See* EX2027, ¶¶201-205 (explaining that the amount of material dispensed is based on the distance traveled and the time taken to traverse that distance); EX1004, ¶[0239].

Third, in a "combination approach," 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]. A POSITA would have understood that the combination approach, like the two

approaches that comprise the combination approach, does not vary in response to a current contact force in Warren. *See* EX2027, ¶¶201-205. Thus, the xyz synchronization that Warren describes for a linear actuator and valve are not responsive to the 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.*; EX2027, ¶¶193-205.

**F. Ground 1A Does Not Render Claims 5 and 6 Unpatentable**

Petitioner fails to show how Warren in Ground 1A teaches all elements of claims 5 and 6. Claim 5 recites the “method of claim 2 further comprising comparing the current contact force to an expected contact force” and claim 6 recites 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.”

Petitioner asserts that Warren compares the “measured contact force” to a desired contact force for claim 5 and reduces the difference between the two to maintain a desired force of contact for claim 6. *See* Pet. at 27-29. However, Warren does not teach measuring a contact force. As explained above, Warren teaches measuring a change in amplitude of vibration and determining if contact is desired

based on this detected change in amplitude. *Supra* Section VI.B-VI.C; *see also* EX1004, Fig. 22A, ¶¶ [0289] (“The position of one or more of the elements is varied, based on the detected  $\Delta A$ , 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]; EX2027, ¶¶210 (explaining that Warren teaches looking for a change in amplitude that indicates the desired contact force). Thus, Warren does not compare a measured contact force to an expected contact force, much less reduce a difference between a measured contact force and expected contact force. *See id.*; EX2027, ¶¶206-211.

#### **G. Ground 1A Does Not Render Claims 10 and 11 Unpatentable**

Petitioner fails to show how Warren in Ground 1A teaches all elements of claims 10 and 11. 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” and 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.”

Petitioner asserts that Warren teaches detecting planarity during printing and before printing for claim 10 (*see* Pet. at 31-33) and fabricating cells to penetrate

pores of a scaffold for claim 11 (*see* Pet. at 33-35). Each of Petitioner's conclusions is based on a flawed interpretation of Warren.

First, while Warren does teach that its dispenser “follow[s] irregular or curved surfaces” (EX1004, ¶[0293]), the reference does not teach detecting the planarity of the surface “based on a number of contact force measurements across a surface.” EX2027, ¶216. As discussed above for claims 5 and 6, Warren does not teach measuring a contact force. *Supra* Section VI.F (claims 5 and 6 for Ground 1A (Warren)); *see* EX2027, ¶¶206-211. The reference also does not teach making a number of contact force measurements that collectively form the basis for detecting planarity. EX2027, ¶216. 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]; *id.*

Second, Warren does not teach detecting planarity before printing. Petitioner and its expert resort to hindsight bias to assert it would be obvious to apply “Warren's force sensing to determine surface planarity as part of a calibration procedure.” *See* Pet. 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] (detecting

change in amplitude to avoid crashes); ¶[0226-27] (providing “fine control” via device 800 that also avoids crashes); EX2027, ¶217.

Although Petitioner cites to another reference (EX1007 to Dunn), a POSITA 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. EX2027, ¶218. As 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]; *id.* In such a solution, a POSITA would have recognized that there is no motivation to run a calibration procedure separate from the print, as doing so does not avoid “a large spacing between the tip and the substrate surface” for a substrate that has been warped or damaged from use. *Id.*; *see also* 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.

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. EX2027, ¶219. 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. EX2027, ¶219 (explaining that extruding viscous material or even flattening them out with the tip does not make the layer effectively planar); *see* Pet. at 34-35. Thus, Ground 1A does not render claims 10 and 11 unpatentable. *See* EX2027, ¶¶212-220.

## H. Ground 1A Does Not Render Claim 12 Unpatentable

Petitioner fails to show how Warren in Ground 1A teaches all elements of claim 12. 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.”

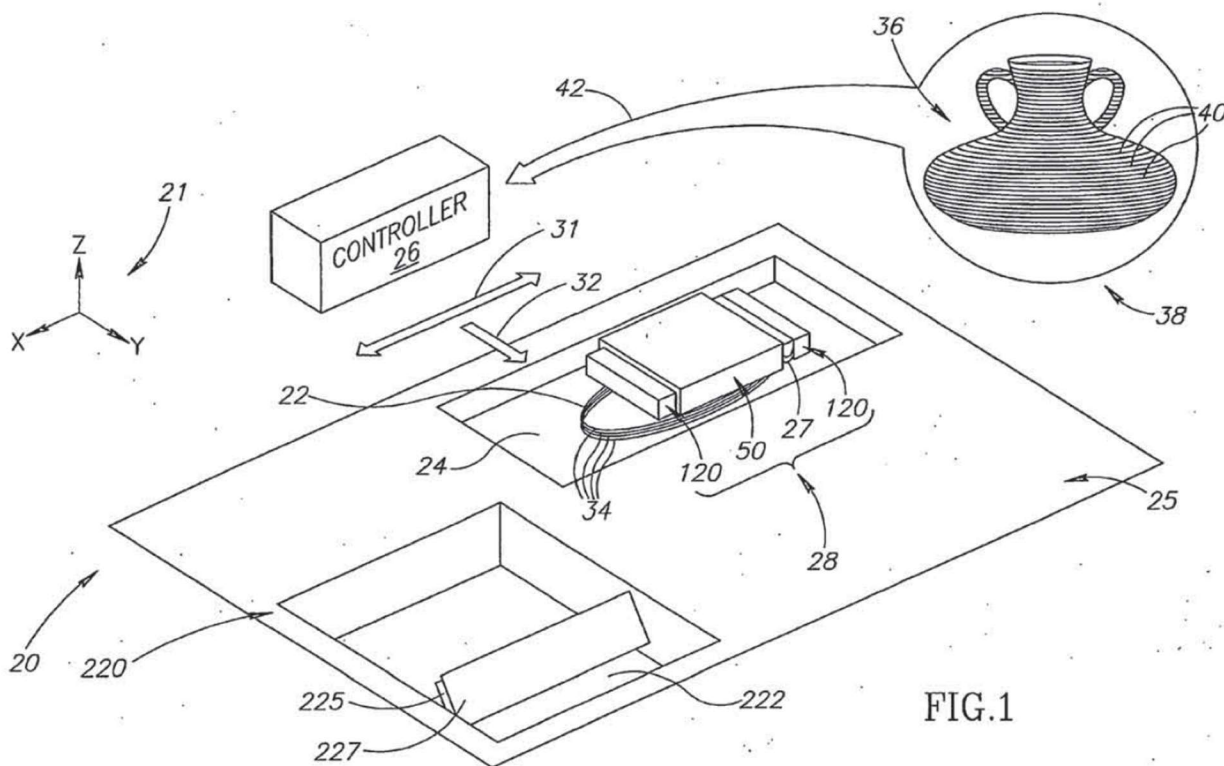
Petitioner asserts that the desire to maintain a contact force based on the change in amplitude of the vibration is a “specified contact force.” *See* Pet. at 35-36; EX1003, ¶¶133-136. However, nothing in Warren teaches or suggests a specified contact force. The reference merely states that it desires 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”); Section VI.C (claim 1). In contrast, the challenged 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. EX2027, ¶¶225-26. Thus, Ground 1A does not render claim 12 obvious. See EX2027, ¶¶221-27.

**VII. THE PETITION DOES NOT SHOW THAT THE CHALLENGED CLAIMS ARE UNPATENTABLE UNDER GROUND 1B**

**A. Overview of Eshed**

Eshed discloses 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 at Title, Abstract, Fig. 1.



**B. There Is No Motivation to Combine Warren and Eshed**

Petitioner asserts a motivation to combine Warren and Eshed. *See* Pet. 38-40 (citing 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.” Pet. 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 VI.E (claims 5 and 6 for Ground 1A). Further, as explained below, none of Petitioner’s reasons or rationales for the combination is sufficient.

First, 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). As such, a POSITA would not have desired to prevent further damage to the extruder tip. EX2027, ¶¶230-231; *see* EX1004, ¶[0285] (describing solutions without vibration sensing). Accordingly, a POSITA would not have been motivated to look for teachings from Eshed to explain collisions. *See id.*

Further, a POSITA would not have been motivated to apply Warren's technique to Eshed detection system. EX2027, ¶¶232-233. 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. 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's accelerometer or audio detection systems. EX2027, ¶233. Nor would a POSITA have understood such a resulting system to be predictable. *See id.* 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. *See* EX2027, ¶¶230-234.

### **C. Ground 1B Does Not Render Claims 3, 7, and 9 Unpatentable**

Petitioner fails to show how Warren in Ground 1A teaches all elements of claims 3 and 9. 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," 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," and 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.”

For claims 3 and 9, Petitioner asserts creating a control signal to stop production based on the measured contact force indicating a fabrication error. *See* Pet. 40-41, 41-42. However, as discussed above for claim 5, Warren does not teach measuring a contact force. *Supra* Section VI.F (claims 5 and 6 for Ground 1A (Warren)); *see also* EX1004, ¶¶[0289], [0313], [0305], [0316]; EX2027, ¶¶240, 206-211 (explaining that Warren teaches looking for a change in amplitude that indicates the desired contact force). Thus, stopping production cannot be based on the measured contact force as Petitioner asserts for claims 3 and 9.

Similarly, Petitioner asserts for claim 7 that the current contact force is compared to an expected contact force to terminate the build. *See* Pet. 41. Again, Warren does not teach measuring a contact force, much less comparing a measured contact force to an expected contact force. *Supra* Section VI.F (claims 5 and 6 for Ground 1A (Warren)); *see also* EX1004, ¶¶[0289], [0313], [0305], [0316]; EX2027, ¶¶235-241.

## **VIII. THE PETITION DOES NOT SHOW THAT THE CHALLENGED CLAIMS ARE UNPATENTABLE UNDER GROUND 2A**

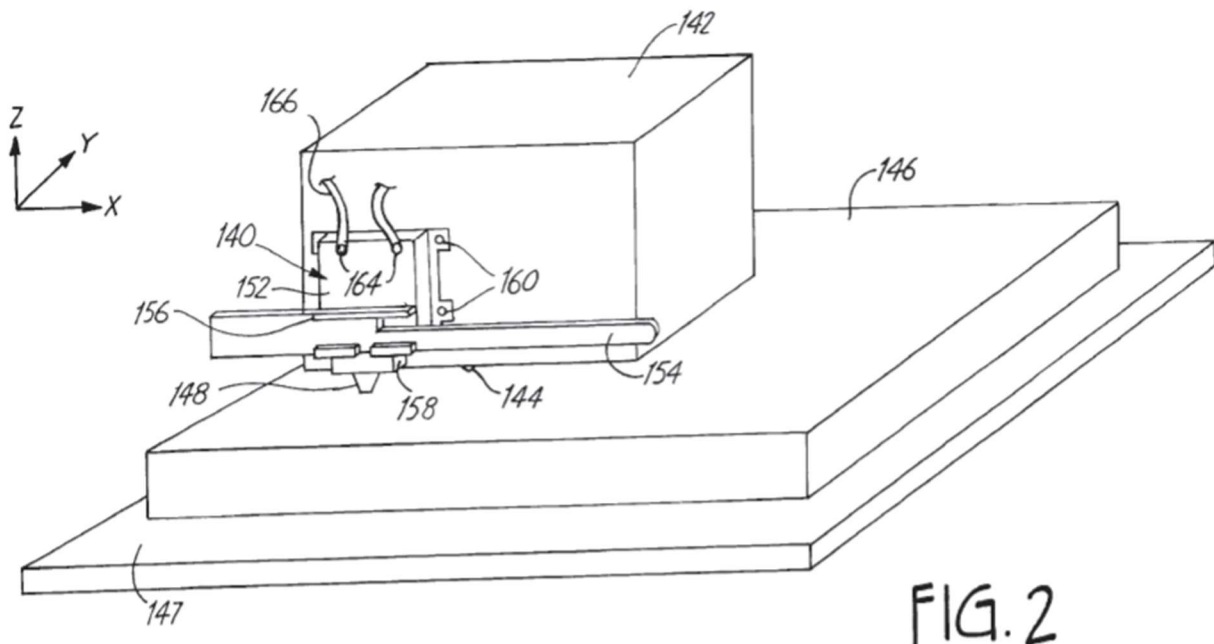
### **A. Overview of Calderon**

Calderon discloses a method for a three-dimensional modeling machine. EX1009 at Title. 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.

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.

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.

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.

### **B. Overview of RepRap20208**

RepRap2028 appears to be a printout dated December 31, 2024 from a “General” forum that is entitled “Genetic Algorithms.” EX1010 at 1.

### **C. There Is No Motivation to Combine Calderon and RepRap20208 (Ground 2A)**

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.” Pet. at 49; *see also id.* at 48-56.

However, Calderon already has his own technique for auto-initialization and collision detection to determine contact between a nozzle and the substrate 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. 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.

Petitioner fails to adequately address these teachings in Calderon and instead presents multiple, deficient rationales that ignore Calderon's teachings:

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

In doing so, however, Petitioner misinterprets and ignores the teachings of Calderon and RepRap20208 and relies on impermissible hindsight based on

unsupported statements by its expert. *See, e.g.*, Pet. at 53-54 (citing to EX1003 at ¶170 six times for the same argument without any other support). RepRap20208 does not “complement[]” Calderon’s disclosure, as Petitioner insists. *See* Pet. at 48-49; EX2027, ¶250. 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 (*see* Pet. at 50 (adding special purpose sensing means “on the extruder mount”)) and that detects objects in the build envelope providing collision detection (*see* Pet. at 49, 51-52). Indeed, Calderon teaches that “the machine stops the build and alerts the user to clear the build envelope.” *See* EX1009 at 10:43-45. Thus, there is no motivation to look to RepRap20208 to have the “machine shut down,” as Petitioner proposes (*see* Pet. at 51-52), because Calderon already teaches his own solution to stop the machine. *See also* Pet. at 55-56 (attempting to replace Calderon’s solution with strain gauges contrary to Calderon’s teachings).

Similarly, Petitioner’s assertion that Calderon’s solution that monitors the current of the servo drive motors would have “slop/backlash” is deficient. *See* Pet. 52-53 (citing to RepRap20208 (EX1010), 20 and EX1003, ¶¶168-69). Page 20 of RepRap20208 only mentions “backlash” and not “slop” and fails to 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, 20; *see also* EX1009, 10:5-8. In fact, the surrounding context in RepRap20208 indicates that it is referring to some other sensor unrelated to Calderon's solution. *See id.* 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”); EX2027, ¶251.

Petitioner's assertion that RepRap20208 would measure force from a location closer to the nozzle to address slop/backlash is also deficient. *See* Pet. at 52. Petitioner incorrectly assumes that Calderon's drive current motors are only used for x-y axis translator 118. *See* Pet. 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. *See* EX1009 at Fig. 1; EX2027, ¶252.

Petitioner's next assertion that a strain gauge would provide “more accurate,” “consistent” force measurement is guided by impermissible hindsight. Pet. at 53-54 (discussing “force of resistance to movement”) (citing EX1003,

¶170). There is no support for Petitioner's assertion except for Petitioner's expert, who merely repeats the arguments in the Petition. EX1003, ¶170. Although the expert provides a citation to Calderon (EX1009 at 9:63-10:23), there is no supporting disclosure regarding any problems with constantly monitoring the servo drive current for a change. *See* EX2027, ¶253.

Similarly, Petitioner's assertion that a strain gauge would support different substrates without damage is fundamentally flawed. *See* Pet. at 54-55. In fact, 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 substrate 128. EX2027, ¶254. Further, Calderon discloses that the extrusion nozzle should be below the top surface of some substrates, such as a foam substrate, which indicates that damage to the foam substrate is necessary to use it for extrusion, with layers "buried in the foam." *See* EX1009 at 2:44-50. Thus, modifying Calderon to prevent damage to its substrate is contrary to Calderon's express teachings. *See* EX2027, ¶254.

For these reasons, Petitioner has failed to show a motivation to combine Calderon and RepRap20208. *See* EX2027, ¶¶243-255.

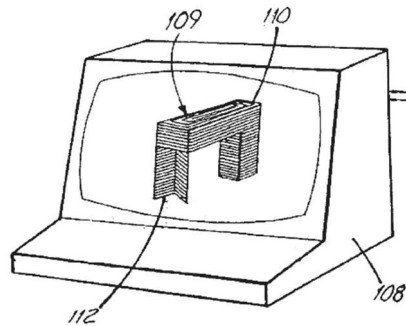
**D. Ground 2A Does Not Render Claim 1 Unpatentable**

Petitioner fails to show how the Calderon–RepRap20208 combination in Ground 2A teaches all elements of claim 1. As explained below, the combination does not teach claim elements 1[a], 1[b], 1[c], and 1[d].

**1. The Calderon and RepRap20208 combination does not teach claim element 1[a]**

The Calderon–RepRap20208 combination in Ground 2A does not teach claim element 1[a] (“identifying build instructions for fabricating an object”); EX2027, ¶¶256-260. Petitioner argues 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.” Pet. 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.” Pet. at 58.

However, Petitioner fails to explain why the file in Calderon has build instructions for fabricating the object. 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). Similarly, Petitioner fails to explain why the “design data” provided from the CAD system are build instructions as opposed to a model of the object itself and why depositing “extruded material” in areas “defined from the CAD model” teaches build instructions for fabricating an object. See Pet. at 58 (citing EX1003, ¶¶178-180 (parroting Petitioner’s assertions without any explanation)). Because Petitioner has failed to identify what are the build instructions are purportedly identified and explain its mapping for claim element 1[a], Ground 2A does not teach the claim element. See EX2027, ¶¶256-260.

## **2. The Calderon and RepRap20208 combination does not teach claim elements 1[b], 1[c], and 1[d]**

Petitioner also fails to show that the combination teaches claim elements 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”); 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”). For claim element 1[b], Petitioner argues that the strain gauge(s) of the combination operate to detect the contact force between the fabrication tool and a separate structure (substrate 128 or model 136). *See Pet.* at 58-61. And for claim element 1[c], Petitioner argues it would have been obvious to provide a constant measurement of the force on the head to detect the current contact force. *See id.* at 61-62. For claim element 1[d], Petitioner argues that the combination detects a current contact force and that it would have been obvious to create a control signal in response to the current contact force while depositing material during the build because collision detection matters when the extrusion head is being moved and there is no reason to turn off collision detection. *See id.* at 62-63.

In support of its assertions for detecting a current contact force, Petitioner cites to several pages of the RepRap20208 reference. *See Pet.* at 61-62 (citing EX1010, 13, 19-20; EX1009, Fig. 1); *supra* § VIII.C.

However, there is no teaching of detecting a current contact force. 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.”). Page 19 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. Similarly, page 20 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 its weight)”). Whether considered individually or collectively, these disclosures in RepRap20208 fail to teach detecting a current contact force. *See* EX2027, ¶¶268-270.

Petitioner’s citations to Calderon do not address the deficiencies with RepRap20208’s teachings. For example, Figure 1 of Calderon is simply a schematic of a generic system. *See* EX1009, 3:66-67, 4:34-52, FIG. 1. Thus, the combination fails to teach detecting a current contact force. *See* EX2027, ¶271.

Moreover, as explained above, there is no motivation to combine Calderon with RepRap20208. *Supra* § VIII.C. 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 (discussed in §VIII.C); EX2027, ¶¶272, 247-248. Thus, a

POSITA would not be motivated to replace Calderon's monitoring of servo drive current to detect contact with a strain gauge from RepRap20208. *See, e.g.*, Pet. at 60; *see also* EX2027, ¶¶261-273.

In addition, Petitioner's conclusions about collision detection are not supported by any evidence. *See* Pet. 62-63 (citing EX1003, ¶¶189-91). For example, Paragraph 190 of the declaration of Petitioner's expert merely cites to other sections of the declaration that simply provide an overview of Calderon (§VII.C), an overview of Eshed (a reference not part of the combination; §VII.D), and the flawed assertions on combining Calderon with RepRap20208 (§X.A). None of these sections explain why a control signal would be created in response to the current contact force.

**E. Ground 2A Does Not Render Claims 2-5, 7-10, 12-15 Unpatentable**

Because claims 2-5, 7-10, 12-15 depend from claim 1, for at least the reasons provided above for claim, Ground 2A does not render claims 2-5, 7-10, 12-15 obvious. *See* EX2027, ¶274.

**F. Ground 2A Does Not Render Claim 4 Unpatentable**

Petitioner also fails to show how the Calderon–RepRap20208 combination in Ground 2A teaches all elements of claim 4. 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.”

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.” Pet. 64-65 (citing EX1009, 4:56-57).

However, the combination of Calderon and RepRap20208 does not teach changing the z-distance as part of shutting down the 3D printer. EX2027, ¶277. 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 shut down. *See* EX2027, ¶277. Similarly, Calderon simply “stops the build and alerts the user to clear the build envelope.” EX1009 at 10:43-45. Thus, Petitioner has failed to show that the z-distance between the dispensing head and platform, specifically, is controlled during a machine shut down. *See* EX2027, ¶¶275-278.

#### **G. Ground 2A Does Not Render Claims 5 and 7 Unpatentable**

Petitioner fails to show how the Calderon–RepRap20208 combination in Ground 2A teaches all elements of claims 5 and 7. Claim 5 recites the “method of claim 2 further comprising comparing the current contact force to an expected contact force,” and claim 7 recites “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.”

Petitioner asserts that a POSITA would have introduced a threshold force to compare to the current contact force to detect a collision. *See* Pet. 65 (citing EX1003, ¶¶203-205). Petitioner also asserts that the build is terminated when the difference between the current contact force and expected contact force indicates a collision. *See* Pet. 65-66 (citing EX1003, ¶¶206-208). However, Petitioner's flawed conclusion ignores the teachings of the references themselves. As discussed above, there is no teaching of detecting a current contact force. *Supra* Section VIII.D.2; EX1010, 13, 14 (watching “the change in bolt tension” for strain gauge), 19, 20; EX1009, 9:63-10:8 (determining contact by “monitoring a change in the servo drive current”); EX2027, ¶281. 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. *See* EX2027, ¶¶279-282.

#### **H. Ground 2A Does Not Render Claim 10 Unpatentable**

Petitioner fails to show how the Calderon–RepRap20208 combination in Ground 2A teaches all elements of claim 10. 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.”

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.’” Pet. 68. On this basis, 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.” Pet. 68-69 (EX1003, ¶¶216-219 (parroting Petitioner’s arguments without further explanation)). However, Petitioner ignores the claim language itself and Calderon’s teaching about Example 3, the very example that Petitioner relies upon to support its flawed conclusion.

In Calderon’s Example 3, a “Find-Z program” is run. *See* EX1009, 10:9. It 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). *See* EX2027, ¶285.

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. *See* EX2027, ¶286. Thus, Petitioner has failed to show that the combination teaches claim 10. *See* EX2027, ¶¶283-287.

### **I. Ground 2A Does Not Render Claim 12 Unpatentable**

Petitioner fails to show how the Calderon–RepRap20208 combination in Ground 2A teaches all elements of claim 12. 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.”

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.” Pet. 69. Petitioner also points to claims 5 and 7 to assert that the control signal achieves the specified contact force. *See* Pet. 70. But Petitioner fails to appreciate that the combination does not teach a specified contact force, much less 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. *See* EX2027, ¶290.

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

Thus, Petitioner has failed to show that the Calderon-RepRap20208 combination tends claim 12 is obvious. *See* EX2027, ¶¶288-292.

**IX. THE PETITION DOES NOT SHOW THAT THE CHALLENGED CLAIMS ARE UNPATENTABLE UNDER GROUND 2B**

**A. Overview of Napadensky**

Napadensky discloses a solid freeform fabrication using a plurality of modeling materials and a plurality of dispensing heads. EX1005 at Title, Abstract.

Figure 1a shows a solid freeform fabrication system. *Id.* at Fig. 1a.

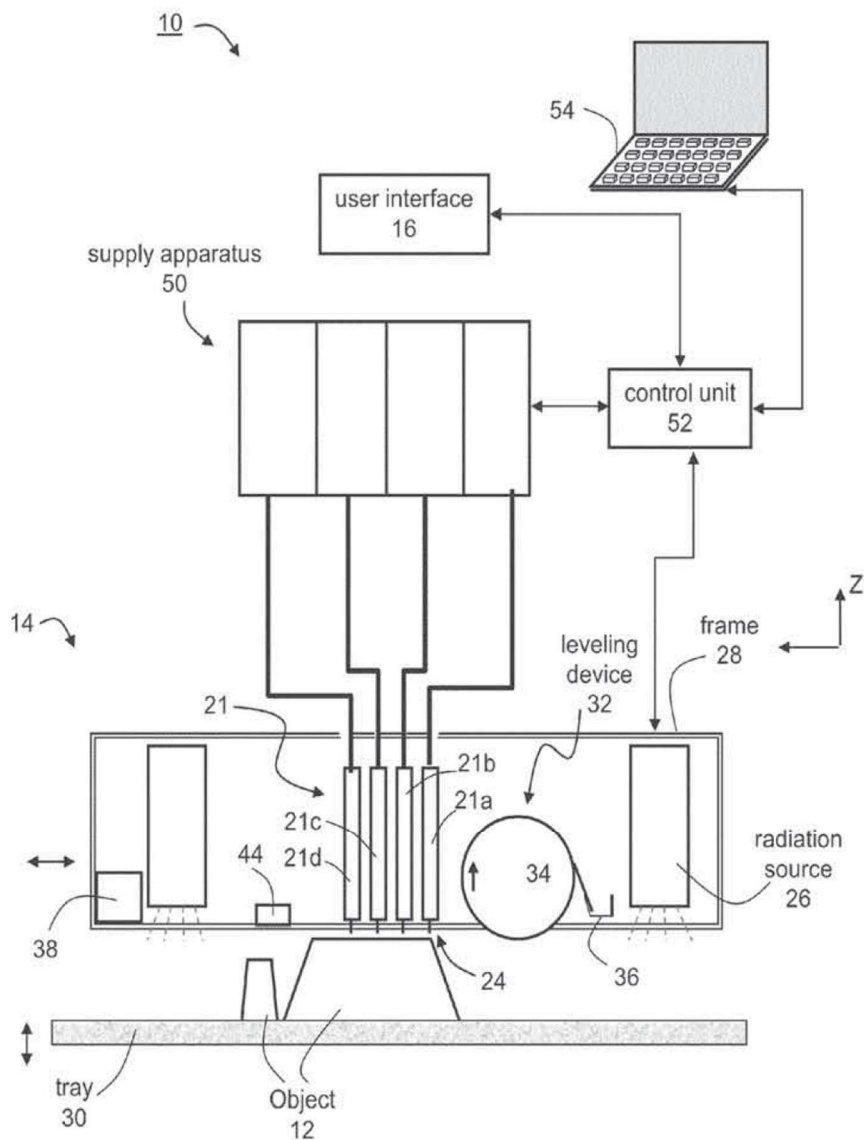


Fig. 1a

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. In addition, a leveling device (32), such as the roller shown in Figure 1a, 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.

**B. There Is No Motivation to Combine Calderon and RepRap20208 with Napadensky**

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

However, Petitioner ignores Calderon's own teachings in the combination to support its flawed conclusion. 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, there is no motivation to pursue Napadensky’s leveling device and 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. *See* EX2027, ¶296.

Further, Petitioner’s expert incorrectly observes that Napadensky’s leveling process with its leveling device is similar to the description of the ’698 Patent. *See* EX1003, ¶64 (cited by Pet. 73); EX2027, ¶297. 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. *See* EX2027, ¶296; EX1005, 17:62-67, Fig. 1a. Thus, the proposed leveling operation from Napadensky is not similar to the leveling operation described by the ’698 Patent. *See id.*

Thus, there is no motivation to combine in Ground 2B. *See* EX2027, ¶¶295-298.

### C. Ground 2B Does Not Render Claim 11 Unpatentable

Petitioner asserts that the Calderon-RepRap20208-Napadensky combination teaches claim 11 (“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”) because the leveling operation (from Napadensky) decreases one or more irregularities in the surface of the separate structure. *See* Pet 74. However, as explained above, Napadensky’s leveling operation is performed on a newly formed layer that has already been fabricated. *See* EX2027, ¶¶301, 297; EX1005, 17:62-67, Fig. 1a. 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. *See* EX2027, ¶¶299-302.

### X. CONCLUSION

For the foregoing reasons, Petitioner has failed to show by a preponderance of the evidence that any of the asserted grounds render any of the challenged claims obvious. The Board should find in favor of Patent Owner and uphold the validity of the challenged claims.

Respectfully submitted,

Dated: January 30, 2026

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**CERTIFICATE OF COMPLIANCE**

Pursuant to 37 C.F.R. § 42.24(d), I certify that this Response complies with the type-volume limits of 37 C.F.R. § 42.24(b)(1) because it contains 13,265 words, excluding the parts that are exempted by 37 C.F.R. § 42.24(a), according to the word processing system used in preparation of this Response.

Dated: January 30, 2026

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**CERTIFICATE OF SERVICE**

Pursuant to 37 CFR § 42.6(e)(4), the undersigned certifies that on January 30, 2026, a complete copy of the foregoing Patent Owner's Response was served on Lead and Back-up Counsel for Petitioner at the service address provided in Petitioner's Mandatory Notices:

Email: IPR56224-0008IP1@fr.com

Dated: January 30, 2026

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