Patent Owner Stratasys, Inc.'s Presentation – July 14, 2026

IPR2025-00531 — U.S. Patent No. 9,168,698
IPR2025-00532 — U.S. Patent No. 10,556,381

Overview of Argument

I. Overview of the Challenged Patents

II. Overview of the Prior Art

III. The Challenged Claims are Patentable Under Ground 1A

IV. The Challenged Claims of the ‘698 Patent are Patentable Under Ground 1B

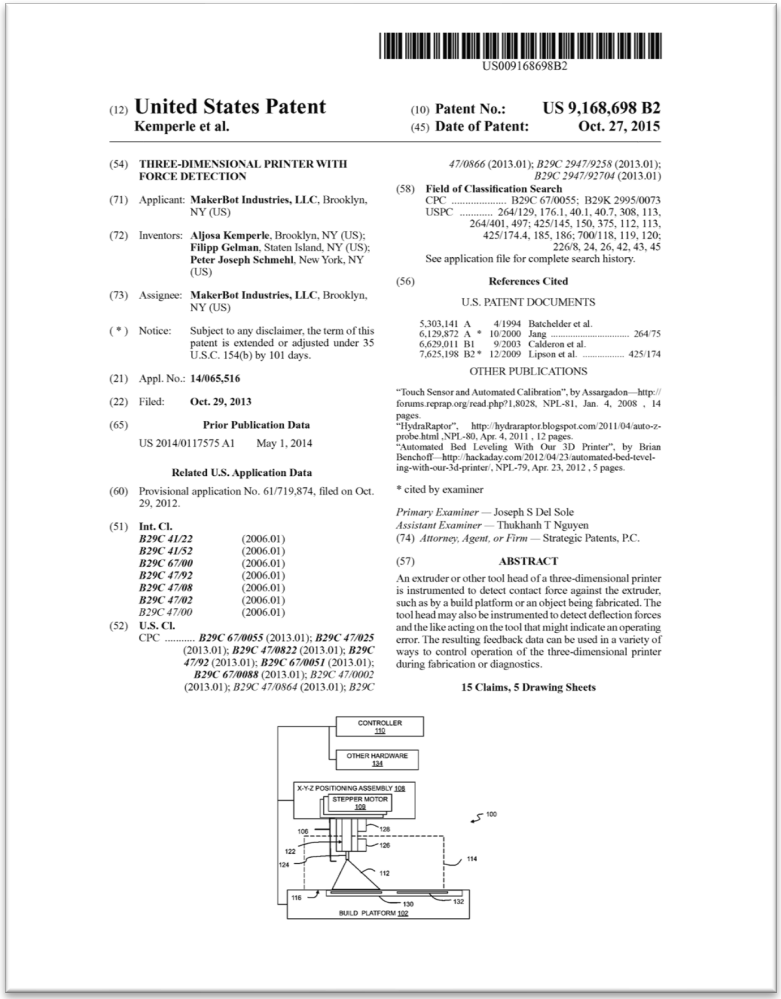
V. The Challenged Claims of the ‘381 Patent are Patentable Under Ground 1B

VI. The Challenged Claims are Patentable Under Ground 2A

VII. Claim 11 of the ‘698 Patent is Patentable Under Ground 2B

Overview of the Challenged Patents – the ’698 Patent

- The ‘698 Patent relates to force-sensing “three-dimensional printers.”
- “An extruder or other tool head of a three-dimensional printer is instrumented to detect contact force against the extruder, such as by a build platform or an object being fabricated. … The resulting feedback data can be used in a variety of ways to control operation of the three-dimensional printer during fabrication or diagnostics.”
‘698 EX1001 at 1:23-30.



US009168698B2

(12) **United States Patent**
Kemperle et al.

(10) **Patent No.: US 9,168,698 B2**
(45) **Date of Patent: Oct. 27, 2015**

(54) **THREE-DIMENSIONAL PRINTER WITH FORCE DETECTION**

(71) Applicant: **MakerBot Industries, LLC**, Brooklyn, NY (US)

(72) Inventors: **Aljosa Kemperle**, Brooklyn, NY (US); **Filipp Gelman**, Staten Island, NY (US); **Peter Joseph Schmehl**, New York, NY (US)

(73) Assignee: **MakerBot Industries, LLC**, Brooklyn, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 101 days.

(21) Appl. No.: **14/065,516**

(22) Filed: **Oct. 29, 2013**

(65) **Prior Publication Data**

US 2014/0117575 A1 May 1, 2014

Related U.S. Application Data

(60) Provisional application No. 61/719,874, filed on Oct. 29, 2012.

(51) **Int. Cl.**

B29C 41/22	(2006.01)
B29C 41/52	(2006.01)
B29C 67/00	(2006.01)
B29C 47/92	(2006.01)
B29C 47/08	(2006.01)
B29C 47/02	(2006.01)
B29C 47/00	(2006.01)

(52) **U.S. Cl.**
CPC ***B29C 67/0055*** (2013.01); ***B29C 47/025*** (2013.01); ***B29C 47/0822*** (2013.01); ***B29C 47/92*** (2013.01); ***B29C 67/0051*** (2013.01); ***B29C 67/0088*** (2013.01); *B29C 47/0002* (2013.01); *B29C 47/0864* (2013.01); *B29C 47/0866* (2013.01); *B29C 2947/9258* (2013.01); *B29C 2947/92704* (2013.01)

(58) **Field of Classification Search**
CPC B29C 67/0055; B29K 2995/0073
USPC 264/129, 176.1, 40.1, 40.7, 308, 113, 264/401, 497; 425/145, 150, 375, 112, 113, 425/174.4, 185, 186; 700/118, 119, 120; 226/8, 24, 26, 42, 43, 45
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Strategic Patents, P.C.

(57) **ABSTRACT**

An extruder or other tool head of a three-dimensional printer is instrumented to detect contact force against the extruder, such as by a build platform or an object being fabricated. The tool head may also be instrumented to detect deflection forces and the like acting on the tool that might indicate an operating error. The resulting feedback data can be used in a variety of ways to control operation of the three-dimensional printer during fabrication or diagnostics.

15 Claims, 5 Drawing Sheets

Overview of the Challenged Patents – the '698 Patent

- Petitioner challenges independent claim 1.

> **1**. A method comprising:
> identifying build instructions for fabricating an object;
> initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;
> detecting the current contact force based on a sensor signal from the one or more sensors; and
> 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.

-00531 Pet. 1-2.

Overview of the Challenged Patents – the '698 Patent

- Petitioner also challenges claims 2-15, all depending on claim 1.

2. The method of claim **1**, wherein the fabrication tool includes an extruder.

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

4. The method of claim **2**, wherein the at least one component of the three-dimensional printer controls a z-distance between the extruder and a build platform of the three-dimensional printer.

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

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

7. The method of claim **5** further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.

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

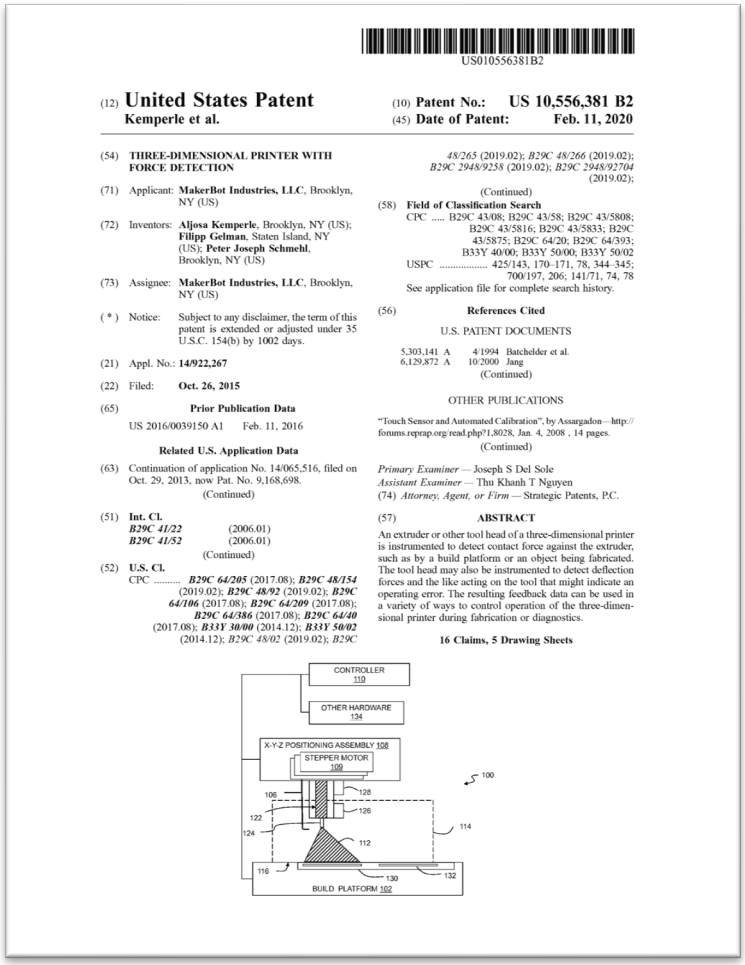
10. The method of claim **2** further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.

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

12. 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.

Overview of the Challenged Patents – the ’381 Patent

- The ‘381 Patent is a continuation of the application leading to the ‘698 Patent.
’381 EX1001 at 1:6-10.



US010556381B2

(12) **United States Patent**
Kemperle et al.

(10) **Patent No.: US 10,556,381 B2**
(45) **Date of Patent: Feb. 11, 2020**

(54) **THREE-DIMENSIONAL PRINTER WITH FORCE DETECTION**

(71) Applicant: **MakerBot Industries, LLC**, Brooklyn, NY (US)

(72) Inventors: **Aljosa Kemperle**, Brooklyn, NY (US); **Filipp Gelman**, Staten Island, NY (US); **Peter Joseph Schmehl**, Brooklyn, NY (US)

(73) Assignee: **MakerBot Industries, LLC**, Brooklyn, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1002 days.

(21) Appl. No.: **14/922,267**

(22) Filed: **Oct. 26, 2015**

(65) **Prior Publication Data**

US 2016/0039150 A1 Feb. 11, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/065,516, filed on Oct. 29, 2013, now Pat. No. 9,168,698.
(Continued)

(51) **Int. Cl.**
B29C 41/22 (2006.01)
B29C 41/52 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B29C 64/205*** (2017.08); ***B29C 48/154*** (2019.02); ***B29C 48/92*** (2019.02); ***B29C 64/106*** (2017.08); ***B29C 64/209*** (2017.08); ***B29C 64/386*** (2017.08); ***B29C 64/40*** (2017.08); ***B33Y 30/00*** (2014.12); ***B33Y 50/02*** (2014.12); *B29C 48/02* (2019.02); *B29C 48/265* (2019.02); *B29C 48/266* (2019.02); *B29C 2948/9258* (2019.02); *B29C 2948/92704* (2019.02);
(Continued)

(58) **Field of Classification Search**
CPC B29C 43/08; B29C 43/58; B29C 43/5808; B29C 43/5816; B29C 43/5833; B29C 43/5875; B29C 64/20; B29C 64/393; B33Y 40/00; B33Y 50/00; B33Y 50/02
USPC 425/143, 170-171, 78, 344-345; 700/197, 206; 141/71, 74, 78
See application file for complete search history.

(56) **References Cited**

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6,129,872 A 10/2000 Jang
(Continued)

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(Continued)

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Assistant Examiner — Thu Khanh T Nguyen
(74) *Attorney, Agent, or Firm* — Strategic Patents, P.C.

(57) **ABSTRACT**

An extruder or other tool head of a three-dimensional printer is instrumented to detect contact force against the extruder, such as by a build platform or an object being fabricated. The tool head may also be instrumented to detect deflection forces and the like acting on the tool that might indicate an operating error. The resulting feedback data can be used in a variety of ways to control operation of the three-dimensional printer during fabrication or diagnostics.

16 Claims, 5 Drawing Sheets

Overview of the Challenged Patents – the '381 Patent

- Petitioner challenges independent claim 1.

> **1**. A three-dimensional printer comprising:
> a fabrication tool including an extruder configured to extrude build material to fabricate an object during a build process;
> one or more sensors mechanically coupled to the extruder, wherein the one or more sensors are collectively operable to sense a contact force between the extruder and a separate structure distinct from the fabrication tool; and

> a controller configured to receive a signal from the one or more sensors on the extruder and to calculate the contact force between the extruder and the separate structure.

-00532 Pet. 1-2.

Overview of the Challenged Patents – the '381 Patent

- Petitioner also challenges claims 2-16, all depending on claim 1.

2. The three-dimensional printer of claim **1**, wherein the contact force is a force along an extrusion axis of the extruder.

3. The three-dimensional printer of claim **1**, wherein the contact force includes a deflection force exerted by the separate structure on a tip of the extruder.

4. The three-dimensional printer of claim **1**, wherein the separate structure includes an object being fabricated by the three-dimensional printer.

6. The three-dimensional printer of claim **1**, wherein the contact force is a force normal to a surface of the separate structure.

7. The three-dimensional printer of claim **1**, wherein the one or more sensors are collectively operable to sense a force between the fabrication tool and the separate structure along two or more non-parallel axes.

8. The three-dimensional printer of claim **7**, wherein the one or more sensors are collectively operable to sense a force between the fabrication tool and the separate structure along three or more non-parallel axes.

11. The three-dimensional printer of claim **1**, further comprising:

one or more actuators mechanically coupled to the fabrication tool, and a control circuit in data communication with the one or more actuators and the one or more sensors, the control circuit configured to control the one or more actuators to achieve a specified contact force between the one or more sensors and the separate structure.

12. The three-dimensional printer of claim **1**, wherein the controller is further configured to adjust operation of the three-dimensional printer according to one or more of the signal from the one or more sensors and the calculated contact force.

13. The three-dimensional printer of claim **12**, wherein the controller is configured to adjust a feed rate of build material from the extruder in response to the calculated contact force.

15. The three-dimensional printer of claim **12**, wherein the controller is configured to adjust a speed of movement of the extruder in response to the calculated contact force.

16. The three-dimensional printer of claim **12**, wherein the controller is configured to adjust a temperature of the extruder in response to the calculated contact force.

Overview of the Prior Art

- Petitioner asserts Warren (EX1004) in Ground 1A, and the combination of Calderon (EX1009) and RepRap20208 (EX1010) in Ground 2A against each challenged patent.
- Asserts Eshed (EX1008) in Ground 1B and Napadensky (EX1005) in Ground 2B exclusively against the '698 Patent.
- Asserts Dunn (EX1007) in Grounds 1B and 2B exclusively against the '381 Patent.

IPR2025-00531
'698 Patent

Ground	Claims	§103 Basis
1A	1-6, 8-15	Warren
1B	3, 7, 9	Warren and Eshed
2A	1-5, 7-10, 12-15	Calderon and RepRap20208
2B	11	Calderon, RepRap20208, and Napadensky

IPR2025-00532
'381 Patent

Ground	Claims	§103 Basis
1A	1-6, 9-16	Warren
1B	3, 7, 8	Warren and Dunn
2A	1-6, 9-16	Calderon and RepRap20208
2B	3, 7, 8	Calderon, RepRap20208, and Dunn

Overview of Argument

I. Overview of the Challenged Patents

II. Overview of the Prior Art

III. The Challenged Claims are Patentable Under Ground 1A

IV. The Challenged Claims of the ‘698 Patent are Patentable Under Ground 1B

V. The Challenged Claims of the ‘381 Patent are Patentable Under Ground 1B

VI. The Challenged Claims are Patentable Under Ground 2A

VII. Claim 11 of the ‘698 Patent is Patentable Under Ground 2B

The Challenged Claims are Patentable Under Ground 1A

- In each IPR, Ground 1A asserts obviousness over Warren (EX1004).
- Petitioner asserts that Warren renders obvious claims 1-6 and 8-15 of the '698 Patent and claims 1-6 and 9-16 of the '381 Patent.

IPR2025-00531
'698 Patent

Ground	Claims	§103 Basis
1A	1-6, 8-15	Warren

IPR2025-00532
'381 Patent

Ground	Claims	§103 Basis
1A	1-6, 9-16	Warren

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- There is no motivation to combine the embodiments of Warren as Petitioner asserts. -00531 Pet. at 13; *see also* -00532 Pet. at 11-12.

shapes."). Thus, for example, although Warren discloses using vibration force sensing in connection with its capillary vibro-sensor dispenser (*id.*, [0283-0318]), a POSITA would have found it obvious to use the vibrating force sensor concepts with Warren's through-nozzle dispenser (*id.*, [0230-0252]). EX1003, ¶65.

A POSITA would have been motivated to apply Warren's through-nozzle dispenser (EX1004, [0230-0252] (describing FIGS. 11A-11D and 12A-12B)) as dispenser 3700 in Warren's vibrating force sensor configuration (*id.*, [0283-0318], [0226-0229]). *Id.*, [0239]; EX1003, ¶67. A POSITA would have been motivated to

-00531 POR, 16-25; -00532 POR, 16-25

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

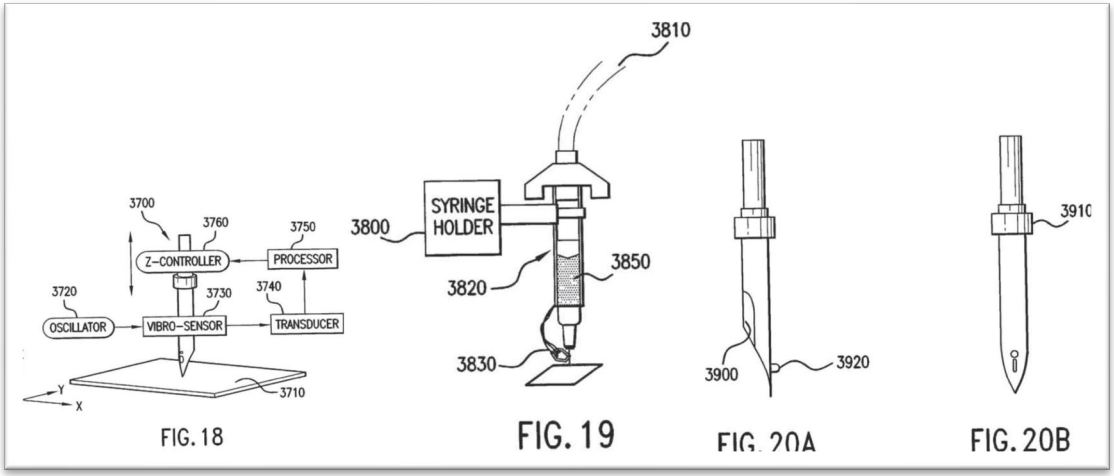
- Petition presents four deficient rationales for the combination:
  1. "Warren invites using the vibrating force sensor concepts with other dispenser configurations"
     -00531 Pet. at 13-14; -00532 Pet. at 12.
  2. "a POSITA would have been motivated by the precise flow control capability of Warren's through-nozzle design"
     -00531 Pet. at 14; -00532 Pet. at 12-13.
  3. "the predictable use of such conventional linear actuator in Warren's dispenser system 3700 … would have been obvious"
     -00531 Pet. at 14-15; -00532 Pet. at 13.
  4. "a POSITA would have recognized the benefits of providing Warren's through-nozzle dispenser with vibrating force sensor capabilities"
     -00531 Pet. at 15-16; -00532 Pet. at 13-14.

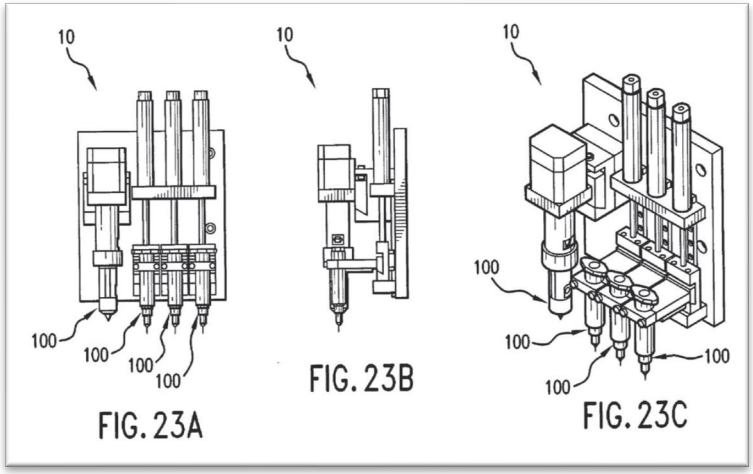
The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Petition presents four deficient rationales for the combination:
  1. **"Warren invites using the vibrating force sensor concepts with other dispenser configurations"**
     -00531 Pet. at 13-14; -00532 Pet. at 12.
  2. "a POSITA would have been motivated by the precise flow control capability of Warren's through-nozzle design"
     -00531 Pet. at 14; -00532 Pet. at 12-13.
  3. "the predictable use of such conventional linear actuator in Warren's dispenser system 3700 … would have been obvious"
     -00531 Pet. at 14-15; -00532 Pet. at 13.
  4. "a POSITA would have recognized the benefits of providing Warren's through-nozzle dispenser with vibrating force sensor capabilities"
     -00531 Pet. at 15-16; -00532 Pet. at 13-14.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Warren does not "invite[] using the vibrating force sensor concepts" with a through-nozzle design.
- Dispenser 3700 in Figure 18 is not limited to the specific implementations of Figures 19, 20A, and 20B. EX1004, ¶[0299]
- Figure 18 shows dispenser 3700 as **another** implementation of a quill-pen that is different from the one's shown in Figures 20A and 20B and the capillary dispenser of Figure 19. EX1004, Figs. 18, 19, 20A-20B, ¶¶[0295], [0298], [0300]
- Figures 23A-C show a dispenser with multiple designs. EX1004, Figs. 23A-C, ¶[0278].





-00531 POR, 17-18; -00532 POR, 17-18.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Petition presents four deficient rationales for the combination:
  1. "Warren invites using the vibrating force sensor concepts with other dispenser configurations"
     -00531 Pet. at 13-14; -00532 Pet. at 12.
  2. **"a POSITA would have been motivated by the precise flow control capability of Warren's through-nozzle design"**
     -00531 Pet. at 14; -00532 Pet. at 12-13.
  3. "the predictable use of such conventional linear actuator in Warren's dispenser system 3700 … would have been obvious"
     -00531 Pet. at 14-15; -00532 Pet. at 13.
  4. "a POSITA would have recognized the benefits of providing Warren's through-nozzle dispenser with vibrating force sensor capabilities"
     -00531 Pet. at 15-16; -00532 Pet. at 13-14.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- There is no motivation to use a through-nozzle design for the dispenser to enable precise control.
- A capillary dispenser **already** provides for high-precision, and Warren **already** teaches switching **from** the through-nozzle dispenser to a capillary dispenser when high precision is needed.
  - EX1004 at ¶[0278].

of material. In the illustrated embodiment, the larger conical through-nozzle dispenser fills and dispenses larger areas with higher-μ materials, while the smaller capillary dispensers are retracted. When smaller detail and/or less-viscous materials than those possible with the conical through-nozzle tip are required, or if a different medium is needed, then a capillary dispenser can be extended into position to do its intended high-detail and high-precision dispensing. The

-00531 POR, 18; -00532 POR 18-19.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Capillary designs are controlled by surface tension and extend on precision linear bearings, allowing for this high precision.
  - EX1004 at ¶[0279].

> **[0279]** The capillary dispensers in the illustrated embodiment may be extended via a pneumatic air cylinder with a proportional control valve controlling extension and retraction speeds. A slight positive pressure may be applied to the capillary feed channels via pneumatic tubing (not shown). However, flow from the capillary dispensers in this embodiment is primarily controlled by capillary surface tension when the tip almost touches the substrate surface. The capillary dispensers may be extended on precision linear bearings to achieve a constant, repeatable, and accurate position. The entire assembly may be mounted to high-precision linear stages to move the respective dispensers into position as needed and to provide fine height adjustments.

-00531 POR, 19; -00532 POR 19-20.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Petitioner argues that "PO mischaracterizes Warren's through-nozzle design as lacking precise deposition."
  - -00531 Reply, 2-3.
- But it is irrelevant whether the through-nozzle design has some amount of precision, as Warren expressly teaches that the through-nozzle design provides **less** detail and **less**-precision dispensing than capillary designs.

> times). PO mischaracterizes Warren's through-nozzle design as lacking precise deposition because Warren expressly teaches precise rate (speed) control resulting in "smooth, seamless, and very reproducible" start times. *E.g.*, EX1003 ¶69; EX1004 ¶¶[0234], [0243].

-00531 PO Sur-Reply, 3-4; -00532 PO Sur-Reply, 3-4.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Petition presents four deficient rationales for the combination:
  1. "Warren invites using the vibrating force sensor concepts with other dispenser configurations"
     -00531 Pet. at 13-14; -00532 Pet. at 12.
  2. "a POSITA would have been motivated by the precise flow control capability of Warren's through-nozzle design"
     -00531 Pet. at 14; -00532 Pet. at 12-13.
  3. **"the predictable use of such conventional linear actuator in Warren's dispenser system 3700 … would have been obvious"**
     -00531 Pet. at 14-15; -00532 Pet. at 13.
  4. "a POSITA would have recognized the benefits of providing Warren's through-nozzle dispenser with vibrating force sensor capabilities"
     -00531 Pet. at 15-16; -00532 Pet. at 13-14.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- There is no motivation to modify capillary/quill-pen designs to use a linear actuator.
- Petitioner argues:
  - -00531 Pet. at 15.

> Significantly, Warren explains that its "DWDT/HAT technology has a plurality of aspects that, in some embodiments, combine to make a tool capable of producing a modeled structure through 3D direct construction of various materials into complex shapes." *Id.*, [0093]. A POSITA would have recognized Warren's express suggestion to add features from its through-nozzle design (such as linear actuator 144) to Warren's dispenser system 3700 to pursue a predictable combination. EX1003, ¶70.

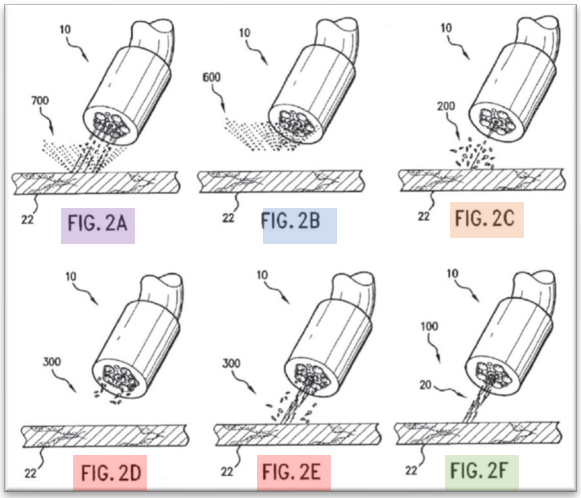
-00531 POR, 20; -00532 POR, 20.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Warren teaches a combination tool that integrates separate **devices,** not combining multiple aspects from one design to another.
  - EX1004, ¶[0093]; *see also id.* at Figs. 2A-2F.

Referring now to the drawings (FIGS. **2A-2F, 4-7, 10, 34** and **36**) the DWDT/HAT includes a material dispenser **100** for performing additive procedures by which constructs, such as engineered tissue constructs, are made from a wide range of constituent materials; a material destroyer **200** for performing subtractive procedures, such as laser-ablation; a material remover **300** for suctioning or other removal of unwanted materials; temperature controllers **400,** such as heating and cooling systems; vision and imaging devices **500,** such as cameras; detection devices **600,** for performing

processes such as optical coherence tomography infrared spectroscopy, Raman scattering, and LIF detection; therapeutic emitters **700** for performing processes such as photon therapy; location control devices **800,** such as robotic manipulation systems; and stabilization devices **900,** such as guides and stabilizers for the apparatus. Accordingly, the



-00531 POR, 20-21; -00532 POR, 20-21.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Petition presents four deficient rationales for the combination:
  1. "Warren invites using the vibrating force sensor concepts with other dispenser configurations"
     -00531 Pet. at 13-14; -00532 Pet. at 12.
  2. "a POSITA would have been motivated by the precise flow control capability of Warren's through-nozzle design"
     -00531 Pet. at 14; -00532 Pet. at 12-13.
  3. "the predictable use of such conventional linear actuator in Warren's dispenser system 3700 … would have been obvious"
     -00531 Pet. at 14-15; -00532 Pet. at 13.
  4. **"a POSITA would have recognized the benefits of providing Warren's through-nozzle dispenser with vibrating force sensor capabilities" — "avoid damage," "control over the deposition geometry," "overcome issues regarding agglomeration and/or sticking"**
     -00531 Pet. at 15-16; -00532 Pet. at 13-14.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- There is no motivation to use a through-nozzle design with a vibration solution to facilitate **control over the deposition geometry** or to **avoid damage**.
- This rationale asserts **the opposite of Petitioner's combination**
  - This rationale: use vibrating force sensor concepts with through-nozzle design
  - Petitioner's combination: apply Warren's through-nozzle dispenser as dispenser 3700 in Warren's vibrating force sensor configuration

-00531 Pet. at 13.

> shapes."). Thus, for example, although Warren discloses using vibration force sensing in connection with its capillary vibro-sensor dispenser (*id.*, [0283-0318]), a POSITA would have found it obvious to use the vibrating force sensor concepts with Warren's through-nozzle dispenser (*id.*, [0230-0252]). EX1003, ¶65.

-00531 POR, 22; -00532 POR, 22-23.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Warren's through nozzle-design already facilitates **control over the deposition geometry** or **avoids damage** via operation micrometer or nanometer accuracy.
  - EX1004, ¶[0228]; *see also* EX2027, ¶¶147-152; EX1004, ¶¶[0234], [0243], [0227] (precision control of valve, actuator, piston), Fig. 36, ¶[0228] (location control).

> The translation system is comprised of translation stages to give motion control in the required axes. The translation stages may be of the ball-screw variety. They may have associated linear encoders to improve positional accuracy but can typically operate with 1-2 um of accuracy without them. If nanometer accuracy is required, a linear stage with linear encoders may be needed. In linear stages, the external motor is not required as it is inherent in the stage itself. For ball-screw stages, a motor and a motor driver are required. In addition, the stages must be sized to carry the desired load (weight). The motor is selected to deliver the required torque for a given speed.

-00531 POR, 22-24; -00532 POR, 22-24.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- *Other dispensers* in Warren have specific needs for a vibration solution
  - *See, e.g.*, EX1004 at ¶¶[0260], [0279].

> the constituent material. The "sensoric" feature of such quill-pens enables the tool to sense and maintain optimum contact with the deposition target while the constituent material is being dispensed from the dispenser as discussed in greater detail below.

> However, flow from the capillary dispensers in this embodiment is primarily controlled by capillary surface tension when the tip almost touches the substrate surface. The capillary dispensers may be extended on precision linear bearings to achieve a constant, repeatable, and accurate position. The entire assembly may be mounted to high-precision linear stages to move the respective dispensers into position as needed and to provide fine height adjustments.

-00531 POR, 24-25; -00532 POR, 24.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- There is no motivation to combine based on **overcoming issues regarding agglomeration and/or sticking**, which is related to implementations of a quill-pen using ink.
  - EX1004 at ¶[0298].

> **[0298]** As another example, a quill-pen may be used, in which a cell suspension or slurry functions as "ink." An exemplary quill-pen is shown in detail in **FIGS. 20A and 20B**. These dispensers include a reservoir **3900** for the "ink". Vibrating the dispenser at, for example, low f, facilitates dispensing of the ink, thus overcoming issues regarding agglomeration and/or sticking of the cells. For illustrative purposes, the quill-pen is shown in **FIGS. 20A and 20B** as being part of a dispensing unit including a vibration actuator **3910** and a vibration transducer (receiver) **3920**, as described in more detail below.

-00531, POR, 24-25; -00532 POR, 24-25.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Petitioner's Reply does not otherwise meaningfully address the four deficient rationales in the Petition. -00531 Reply 1-3
- Instead, Petitioner injects two new theories:
  - it advanced both the through-nozzle and capillary designs, and
  - Warren's claims support a motivation to combine

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- "The Combination" in the Petition did not:
  - address capillary designs beyond combining Warren's through-nozzle design with Warren's vibrating force sensor configuration
  - Refer to Warren's claims

-00531 Pet. 13-16;
see also -00532 Pet. 11-14

2. The Combination, Reasons to Combine, & Expectation of Success

A POSITA would have been motivated to apply Warren's through-nozzle dispenser (EX1004, [0230-0252] (describing FIGS. 11A-11D and 12A-12B)) as dispenser 3700 in Warren's vibrating force sensor configuration (*id.*, [0283-0318], [0226-0229]). *Id.*, [0239]; EX1003, ¶67. A POSITA would have been motivated to

* * *

relate to the same DWDT/HAT technology. EX1003, ¶66. The fundamental aspects of Warren's vibrating force sensor configuration using force feedback would remain intact, bolstered by the beneficial aspects of the through-nozzle dispenser with a reasonable expectation of success. *Id.*

-00531 PO Sur-Reply, 1-2; -00532 PO Sur-Reply, 1-2.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- *Wasica Fin. GmbH v. Cont'l Auto. Sys., Inc.*, 853 F.3d 1272, 1286–87 (Fed. Cir. 2017) (quoting *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1369 (Fed. Cir. 2016))

> It is of the utmost importance that petitioners in the IPR proceedings adhere to the requirement that the initial petition identify with particularity the evidence that supports the grounds for the challenge to each claim. . . . Unlike district court litigation—where parties have greater freedom to revise and develop their arguments over time and in response to newly discovered material—the expedited nature of IPRs bring with it an obligation for petitioners to make their case in their petition to institute.

-00531 Sur-Reply, 1-2; -00532 PO Sur-Reply, 1-2.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- *Ariosa Diagnostics, Inc. v. Verinata Health, Inc.*, 805 F.3d 1359, 1367–68 (Fed. Cir. 2015).

> *Id.* § 42.23(b). The Board must make judgments about whether a Petition identified the specific evidence relied on in a Reply and when a Reply contention crosses the line from the responsive to the new.

> We see no error in the Board's rejection of Ariosa's reliance, in its Reply submissions, on previously unidentified portions of a prior-art reference to make a meaningfully distinct contention. Ariosa's Peti-

-00531 Sur-Reply, 1-2; -00532 PO Sur-Reply, 1-2.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- *Henny Penny Corp. v. Frymaster LLC*, 938 F.3d 1324, 1330–31 (Fed. Cir. 2019)

[8, 9] We agree with Frymaster that the Board did not abuse its discretion by holding HPC to the obviousness theory in its petition. Because of the expedited nature of IPR proceedings, "[i]t is of the utmost importance that petitioners in the IPR proceedings adhere to the requirement that the initial petition identify 'with particularity' the 'evidence that supports the grounds for the challenge to each claim.'" *Id.* at 1369 (quoting 35 U.S.C. § 312(a)(3)). Accordingly, an IPR petitioner may not raise in reply "an entirely new rationale" for why a claim would have been obvious. *See id.* at 1370; 37 C.F.R. § 42.23(b). But that is what HPC did here.

-00531 Sur-Reply, 1-2; -00532 PO Sur-Reply, 1-2.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- 37 C.F.R. §§ 42.104(b)(5)

> (5) The exhibit number of the supporting evidence relied upon to support the challenge and the relevance of the evidence to the challenge raised, including identifying specific portions of the evidence that support the challenge. The Board may exclude or give no weight to the evidence where a party has failed to state its relevance or to identify specific portions of the evidence that support the challenge.

-00531 Sur-Reply, 1-2; -00532 PO Sur-Reply, 1-2.

The Challenged Claims are Patentable Under Ground 1A – No Motivation to Combine Embodiments

- Warren's claims are consistent with the lack of motivation to combine Warren's embodiments
- Claims 54, 59, 65, and 70 refer to the table-top dispenser in Warren that includes
  - multiple, separate, tool designs
  - a vibration solution with capillary designs and also a through-nozzle design

See, e.g., EX1004 at Fig. 23A

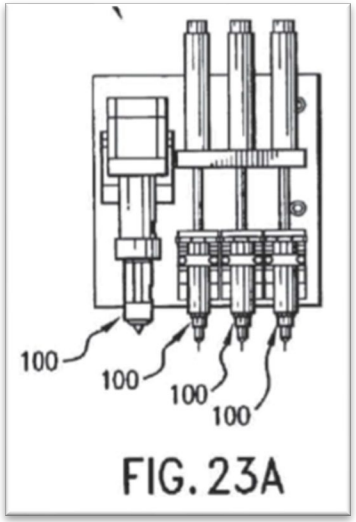


FIG. 23A

54. A system for controlling the position of at least one element of a dispensing system including at least one dispenser and at least one substrate, the system comprising:

a vibration imparting device for imparting vibration of a particular amplitude to the at least one dispenser, the at least one substrate, or both the at least one dispenser and the at least one substrate;

a detector for detecting a change in the amplitude of vibration of the at least one dispenser, the at least one substrate, or both the at least one dispenser and the at least one substrate upon contact with each other; and

a position controller for varying the position of the at least one dispenser, the at least one substrate, or both the at least one dispenser and the at least one substrate based on the detected change in amplitude of vibration to obtain a desired force of contact between the at least one dispenser and the at least one substrate.

59. The system of claim 54, wherein the at least one dispenser includes at least one of a through-nozzle, a needle valve, a capillary pen, or a quill pen.

-00531 Sur-Reply, 1-2; -00532 PO Sur-Reply, 2-3.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating Contact Force

- The '698 Patent's claims require "detecting a current contact force," while the '381 Patent claims require a "controller configured to…calculate a contact force"
  - '698 1[b]-[c]:

> 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

  - '381 1[c]:

> a controller configured to receive a signal from the one or more sensors on the extruder and to calculate the contact force between the extruder and the separate structure.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner argues "**detecting** a current contact force" ('698 Patent) based on the assertion of **calculating** a contact force.
  - -00531 Pet. at 20-21.

> In view of the proportionality, a POSITA would have understood or found it obvious that the ***contact force*** can be readily calculated from the detected "change in the amplitude." EX1004, [0313], [0301]-[0307]; EX1003, ¶86 (explaining additional details of Warren's sensing operations). Warren's vibration sensor and transducer thus align with the specification of the '698 patent, which describes its sensors broadly to sense anything, "so long as the contact force(s)…may be calculated from the sensed physical characteristics." EX1001, 8:49-61; EX1003, ¶86-87.

-00531 POR, 25-26; -00531 Sur-Reply, 4.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Warren refers to detecting a change in amplitude of a vibration, not detecting or calculating a contact force
- Amplified changed amplitude signal is fed back to control positioning
- This maintains a desired force of contact, but Warren does not teach detecting or calculating a contact force
  - EX1004 at ¶[0289], [0302].

[0289] According to exemplary embodiments, vibration of particular amplitude (A) is imparted to one or more of the elements of the dispensing system. The vibration may be imparted to the dispenser, the substrate, or both the dispenser and the substrate. A change in the amplitude of vibration (ΔA) of the dispenser, the substrate, or both the dispenser and the substrate upon contact with each other, is detected by the system. This ΔA may be a change in amplitude of the primary harmonic vibration of the dispenser or the substrate, selected secondary harmonics of either, or combinations. The position of one or more of the elements is varied, based on the detected ΔA, to maintain a desired force of contact between the dispenser and the substrate. The positions of the dispenser, the substrate, or the dispenser and the substrate may be controlled in this manner.

penser with the substrate **3710**. The transducer **3740** senses and transfers the changed vibration signal to an amplifier (not shown), which then creates a feedback signal that is

* * *

e.g., an AD621 instrumentation amplifier. The feedback signal is used to control the position of the dispenser **3700** to maintain a desired force of contact between the dispenser **3700** and the substrate **3710**. For example, the feedback

-00531 POR, 26; -00532 POR 26-27.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Thus, Warren's detected "desired contact force" is a detected **change in amplitude**.
  - EX1004 at ¶[0313].

> **[0313]** **FIG. 22A** illustrates an exemplary method for controlling the position of one or more elements of a dispensing system including at least one dispenser and at least one substrate. The method begins at step **4102** at which vibration of a particular amplitude is imparted to the dispenser and/or the substrate. At step **4104**, a change in the amplitude of vibration of the dispenser and/or the substrate is detected. This change in amplitude is proportional to the force of contact between the dispenser and the substrate. At step **4106**, a determination is made whether the contact force is that which is desired, based on the detected change in amplitude. If the contact force is that which is desired, the process may stop, or this step may be repeated to ensure the contact force remains as desired. If at step **4106** it is determined that the contact force is not as desired, the position(s) of the dispenser and/or the substrate are varied at step **4108**, causing a change in the amplitude of vibration. This change in amplitude is detected again at step **4104**.

-00531, POR 26-27; -00532 POR 26-27.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Warren describes a feedback signal but does not teach the feedback signal is then used to detect or calculate force.
  - EX1004 at ¶[0315].

> **[0315]** According to one embodiment, a source of vibration is applied to the dispenser. A vibration sensor is also attached to the dispenser to sense A or f of the applied vibration. The A of the sensed vibration is then altered, e.g., modulated by the dispenser as it contacts the substrate. The amplitude of the modulation in the signal is proportional to the force applied between the dispenser and the substrate. The modulated vibration amplitude signal is then used as feedback to control the contact force between the dispensing structure and the substrate surface.

-00531, POR 26-27; -00532 POR 26-27.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- It would not have been obvious to detect or calculate the contact force from the detected change in amplitude.
- All Warren states is that the amplitude "is proportional to the force."
  - EX1004 at ¶[0315].

> **[0315]** According to one embodiment, a source of vibration is applied to the dispenser. A vibration sensor is also attached to the dispenser to sense A or f of the applied vibration. The A of the sensed vibration is then altered, e.g., modulated by the dispenser as it contacts the substrate. The amplitude of the modulation in the signal is proportional to the force applied between the dispenser and the substrate. The modulated vibration amplitude signal is then used as feedback to control the contact force between the dispensing structure and the substrate surface.

-00531 POR, 27; -00532 POR, 27.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- 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.
- But both the "vibration signal amplitude" and "frequency" have arbitrary units.
  - EX1004 at Fig. 21.

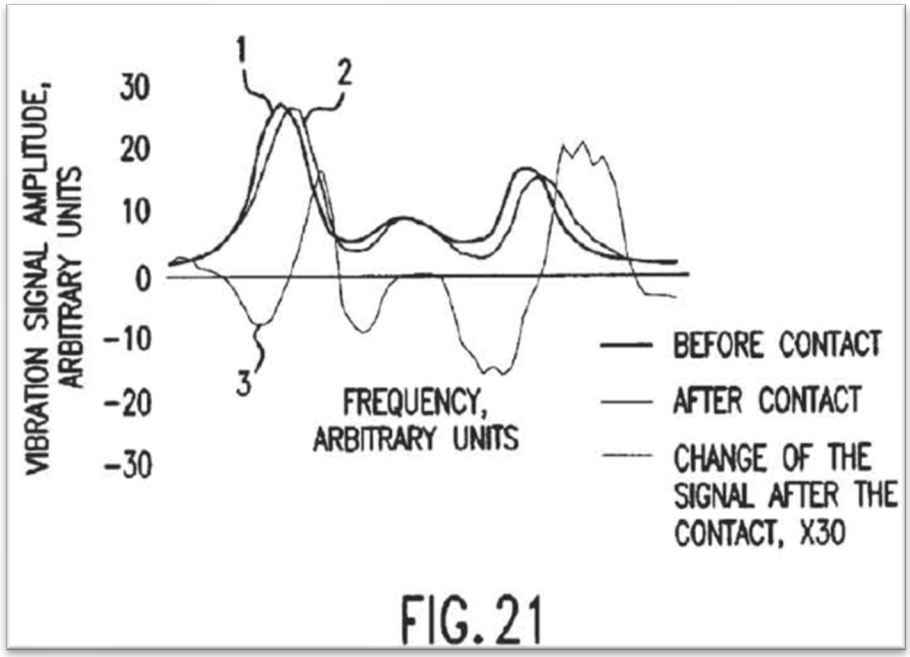


FIG. 21

-00531 POR, 27-28; -00532 POR, 27-28.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Figure 21 includes Plot 1, Plot 2, and Plot 3. Warren suggests that the user must select a frequency to measure the change in amplitude.
  - EX1004 at ¶[0306]

> **[0306]** This ΔA can be understood with reference to **FIG. 40**, which illustrates graphs of ΔA in relation to Δf at arbitrary A and f. The plots shown in **FIG. 40** represent Δf and ΔA of a complex vibration element, such as a dispensing system with a piezoelement attached. Plot 1 shows the relationship between A and f before physical contact of the vibration element with another surface, and Plot 2 shows the relationship between A and f after physical contact of the vibration element with the other surface. Plot 3 shows the absolute value of the relative ΔA. The measured ΔA are widespread throughout the vibration spectrum, often staying apart from resonance lines. This enables the selection of a working f in a desirable region not limited by the self-resonance of piezoelements.

-00531 POR, 28-29; -00532 POR, 28-29.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner fails to present any evidence that detecting a current contact force from Warren's change in amplitude was known.
  - -00531 EX2027 (Decl. of Dr. Osswald), ¶182; *see also id.* at ¶¶176-188; -00532 EX2027, ¶185; *see also id.* at ¶¶176-191

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

-00531 POR, 29; -00532 POR 29.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- There is no motivation to detect the current contact force from the change in amplitude that is used in Warren's solution.
- Warren already teaches that it determines whether the desired contact force is obtained by detecting a change in amplitude of vibration.
  - See EX1004, ¶[0313]; *see also id.* at ¶¶[0302]; [0306]; [0311].

[0313] **FIG. 22A** illustrates an exemplary method for controlling the position of one or more elements of a dispensing system including at least one dispenser and at least one substrate. The method begins at step **4102** at which vibration of a particular amplitude is imparted to the dispenser and/or the substrate. At step **4104**, a change in the amplitude of vibration of the dispenser and/or the substrate is detected. This change in amplitude is proportional to the force of contact between the dispenser and the substrate. At

-00531 POR, 32; -00532 POR 33.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- It would not have been obvious to detect or calculate a contact force from Warren's amplitude change with a reasonable expectation of success.
- Petitioner overlooks the fact that Dr. Osswald explained Warren's system cannot rely on simple look ups or experiments
  - EX2027, ¶¶ 177-179; *see also id.* at ¶¶168, 178-181, 188.

168. As shown in the figures below, the storage and loss moduli of a polymer such as high-density polyethylene vary significantly with frequency and temperature. Warren's system, however, operates at frequencies between 90 and 100 kHz (*see, e.g.*, Warren ¶[301]), which are several orders of magnitude higher than the frequency range accessible to conventional material characterization techniques, such as dynamic mechanical analysis (DMA), which typically operate between 0.01 and 100 Hz. There is no established method or device capable of characterizing material viscoelastic properties at the frequencies and amplitudes relevant to Warren's system. Consequently, Warren's sensor cannot provide a quantitative measurement or detection of contact force and functions instead as a contact-detection device, indicating the presence of contact through a change in vibration amplitude. Warren also fails to disclose the nature of the substrate contacted by the

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

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

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

-00531 PO Sur-Reply, 8; -00532 PO Sur-Reply, 7-8.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner mistakes Warren's teaching of a system's precision (in micronewtons) with a detected contact force (which Warren does not teach).
  - EX1004, ¶[0316]; *see also* -00531 Reply, 5-7
- Precision includes many components in Warren's system, including the high precision of the capillary design that Petitioner seeks to replace in the combination.
  - *See* -00531 POR, 15-16, 18-19, 21-22, 24-25; EX1004, Figs. 23A-C, ¶¶[0278-79], [0361] (CAD file enables precision); EX2027, ¶¶126-34
  - *See also* -00532 POR, 15-16, 18-19, 21-22, 24-25; EX1004, Figs. 23A-C, ¶¶[0278-79], [0295], [0361]; EX2027, ¶¶128-35

[0316] Control applied in this manner allows for dispensing to be accomplished onto conformal surfaces as the force feedback control continuously corrects the dispensing structure's z-height position as the z height of the substrate surface changes, either by modifying the dispenser's position, the substrate's position, or both. This enables the writing of fine lines, e.g., 20 μm wide, and writing on curved surfaces, e.g., placing electronic elements on a cylinder. Control applied in this manner also enables the dispenser to seek and find contact with a surface, maintain contact of a desirable intensity, accurate to a precision of micronewtons of force, if not smaller units of force, and to break contact on command and find it again. The system has been demonstrated to be sufficiently sensitive to allow for the sensing of the contact force as a dispenser contacts a substrate surface and even as the material protruding from a nozzle on a dispenser contacts the substrate surface.

-00531 PO Sur-Reply, 5-6; -00532 PO Sur-Reply, 4-5.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner's Reply presents a new argument that "force intensity" is simply a "magnitude component" of a "force vector quantity" that is measured with "micronewton precision."
  - -00531 Reply, 7.
- This argument is fatally flawed for the same reason.

> And as discussed above, Warren compares a detected contact force intensity with a desired value for determining whether to reposition the dispenser/substrate, the force intensity being a magnitude component of the force vector quantity measured in Newtons. *E.g.*, EX1004 ¶¶[0313]-[0316] (micronewton precision).

-00531 PO Sur-Reply, 7; -00532 PO Sur-Reply, 7.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner newly introduces an argument about the "necessity" of detecting or calculating a contact force.
  - -00531 Reply, 5; *see also id.* at 6.

> The necessity of detecting contract force from the vibrating sensor output is built directly into Warren's operating principles. In order for Warren "to maintain a desired force of contact between the dispenser and the substrate," Warren must compare the vibrating force sensor's reading against the desired force. Warren ¶[0289]. To do so, the system must either convert the desired force into vibration amplitude units or convert the sensor's amplitude output into units of force. And

-00531 PO Sur-Reply, 6; -00532 PO Sur-Reply, 5-6.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- But substrate contact is detected if there is an amplitude change and contact is maintained if the "feedback signal [amplitude] is maintained at a constant level."
  - EX1004, ¶[312]
- Therefore, there is no "need" for detecting or converting to a contact force.

[0312] Using the motor driver **4150** to drive the z-axis motor **4160**, the position of the z-axis stage **4170** is changed relative to the dispenser **4100** to affect the vibration A so that A of the feedback signal is maintained at a constant level, thereby closing the feedback loop. According to one embodiment, the resolution of the system may be determined by the maximum speed and resolution of the z-axis stage **4170**, since the substrate **4110** is moved relative to a fixed dispenser **4100**.

-00531 PO Sur-Reply, 6; -00532 PO Sur-Reply, 5-6.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner's presumption of enablement does not apply, as Warren does not disclose calculating or detecting a contact force in the first place.
  - -0531 Reply, 8.

> PO's extended discussion of Young's Modulus and frequency selection to suggest that it is infeasible to calculate force from Warren's vibrating force sensor is a red herring, particularly given Warren's express teaching that the contact force is "proportional" to **ΔA** and the necessity to compare the "desired force" to the force measured by the vibrating force sensor. "Prior art disclosures are presumed enabling." *Agilent*, 139 F.4th at 1327. This rule holds true "regardless of the forum," and it means "the patentee/applicant has the burden to prove nonenablement for such prior art." *Apple*, 861 F. App'x at 449-50; *Amgen*, 314

-00531 PO Sur-Reply, 9; -00532 PO Sur-Reply, 8.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- Petitioner's Reply asserts the contact force "can be" determined or calculated.
  - -00531 Reply, 7-8; -00532 Reply, 7-8
- It is not sufficient that a contact force **could** be determined or calculated
  - *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015).

twisting of core 1. Although the Board twice stated that "board 5 *could* have been used to prevent twisting of core 1 by one with ordinary skill in the art exercising ordinary creativity," *Berk–Tek*, 2014 WL 1253012, at *13, *17 (emphasis added), it did not stop there—and properly so, because obviousness concerns whether a skilled artisan not only *could have made* but *would have been motivated to make* the combinations or modifications of prior art to arrive at the claimed invention. *See InTouch Technologies, Inc. v. VGO Communications, Inc.*, 751 F.3d 1327, 1352 (Fed.Cir.2014). The Board found that

-00531 PO Sur-Reply, 7-8; -00532 PO Sur-Reply, 7.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- *InTouch Techs., Inc. v. VGO Commc'ns, Inc.*, 751 F.3d 1327, 1352 (Fed. Cir. 2014).

> VGo's expert also succumbed to hindsight bias in her obviousness analysis. Dr. Yanco's testimony primarily consisted of conclusory references to her belief that one of ordinary skill in the art *could* combine these references, not that they *would* have been motivated to do so. *See ActiveVideo Networks, Inc. v. Verizon Commc'ns, Inc.*, 694 F.3d 1312, 1327 (Fed. Cir.2012) ("[T]he expert's testimony on obviousness was essentially a conclusory statement that a person of ordinary skill in the art would have known, based on the 'modular' nature of the claimed components, how to combine any of a number of references to achieve the claimed inventions. This is not sufficient and is fraught with hindsight bias."). Dr. Yanco also

-00531 PO Sur-Reply, 7-8; -00532 PO Sur-Reply, 7.

The Challenged Claims are Patentable Under Ground 1A – Detecting/Calculating

- *Personal Web Techs., LLC v. Apple, Inc.*, 848 F.3d 987, 993-994 (Fed. Cir. 2017).

feature." *Id.* at *8 (emphasis added). But that reasoning seems to say no more than that a skilled artisan, once presented with the two references, would have understood that they *could be* combined. And that is not enough: it does not imply a motivation

to pick out those two references and combine them to arrive at the claimed invention. *See Belden Inc. v. Berk–Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015) ("[O]bviousness concerns whether a skilled artisan not only *could have made* but *would have been motivated to make* the combinations or modifications of prior art to arrive at the claimed invention."); *InTouch Techs., Inc. v. VGO Communications, Inc.*, 751 F.3d 1327, 1352 (Fed. Cir. 2014).

-00531 PO Sur-Reply, 7-8; -00532 PO Sur-Reply, 7.

The Challenged Claims are Patentable Under Ground 1A – Controlling a Feed Rate

- Claims 3 and 9 of the '698 Patent and claim 13 of the '381 Patent are patentable for additional reasons.
- Petition relies on flawed combination of Warren's through-nozzle design and vibration sensing solution

'698 Patent:

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

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

'381 Patent:

13. The three-dimensional printer of claim **12**, wherein the controller is configured to adjust a feed rate of build material from the extruder in response to the calculated contact force.

-00531 POR, 33-37; PO Sur-Reply, 9-10; -00532 POR, 38-39; PO Sur-Reply, 12

The Challenged Claims are Patentable Under Ground 1A – Controlling a Feed Rate

Warren describes the operation of the valve/linear actuator with the xyz motion; synchronization of xyz motion is not responsive to contact force

- Distance invariant mode
  - Valve opens before motion and finishes over set distance
  - Valve changes pre-determined by tool path instructions; not by contact force
    EX1004, ¶[0235]; *see also* -00531 EX2027 (Decl. of Dr. Osswald), ¶¶201-205
  - Warren's vibration sensor solution that conforms to a surface is independent of and does not replace Warren's teaching of valve positioning. *See* EX1004, ¶[0313]
- Volumetric invariant mode
  - Valve position controls amount of material dispensed per second, which is based on distance and time; not on contact force
    EX1004, ¶[0239]; EX2027 (Decl. of Dr. Osswald), ¶¶201-205
- Cominbation approach
  - Switches between two modes as pre-determined locations; not based on contact force EX1004, ¶[0240]

-00531 POR, 35-37; PO Sur-Reply, 9-10; -00532 POR, 38-39; PO Sur-Reply, 12

The Challenged Claims are Patentable Under Ground 1A – Controlling a Feed Rate

- For claim 13 of the '381 Patent, there is no explanation why the feed rate is changed in response to the contact force.
- Petition does not even mention "contact force" for when describing feed rate, speed of movement, and temperature for claims 13, 15, and 16 of the '381 Patent.
  - Pet. 35; *see also* Pet. 36-38

Feed Rate and Speed of Movement

In the through-nozzle dispenser design, the flow of material is controlled by valve 130. EX1004, [0232], [0230-0252], FIGS. 11A-11D (annotated below), 12A-12B. Warren teaches that the actuator-controlled "valving mechanism may be synchronized with the xyz motion of the dispenser." EX1004, [0234]; EX1003, ¶134.

-00532 POR, 38-49; EX2027, ¶¶215-219; Sur-Reply, 12

The Challenged Claims are Patentable Under Ground 1A – Expected or Specified Contact Force

- Claims 5, 6, and 12 of the '698 Patent and claim 11 of the '381 Patent are also patentable for additional reasons.

'698 Patent:

2. The method of claim **1**, wherein the fabrication tool includes an extruder.

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

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

12. 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.

'381 Patent:

11. The three-dimensional printer of claim **1**, further comprising:

one or more actuators mechanically coupled to the fabrication tool, and a control circuit in data communication with the one or more actuators and the one or more sensors, the control circuit configured to control the one or more actuators to achieve a specified contact force between the one or more sensors and the separate structure.

-00531 POR, 37-38, 42-43; PO Sur-Reply, 10; -00532 POR 37-38; PO Sur-Reply, 11-12.

The Challenged Claims are Patentable Under Ground 1A – Expected or Specified Contact Force

- Warren does not teach a "measured contact force" for claim 5 and 6, because it instead detects a change in amplitude of vibration, as discussed.
  - *See, e.g.*, EX1004 ¶[0313]

[0313] **FIG. 22A** illustrates an exemplary method for controlling the position of one or more elements of a dispensing system including at least one dispenser and at least one substrate. The method begins at step **4102** at which vibration of a particular amplitude is imparted to the dispenser and/or the substrate. At step **4104**, a change in the amplitude of vibration of the dispenser and/or the substrate is detected. This change in amplitude is proportional to the

-00531 POR, 37 PO Sur-Reply, 10;

The Challenged Claims are Patentable Under Ground 1A – Expected or Specified Contact Force

- Warren does not teach a specified contact force or instruction for achieving such a force for claim 12.
- As described, Warren teaches detecting a change in amplitude of vibration that is used for control the dispenser positioning that achieves maintaining a desired contact force.
  - EX1004 at ¶¶[0289], [302], [0313]

[**0289**] According to exemplary embodiments, vibration of particular amplitude (A) is imparted to one or more of the elements of the dispensing system. The vibration may be imparted to the dispenser, the substrate, or both the dispenser and the substrate. A change in the amplitude of vibration (ΔA) of the dispenser, the substrate, or both the dispenser and the substrate upon contact with each other, is detected by the system. This ΔA may be a change in amplitude of the primary harmonic vibration of the dispenser or the substrate, selected secondary harmonics of either, or combinations. The position of one or more of the elements is varied, based on the detected ΔA, to maintain a desired force of contact between the dispenser and the substrate. The positions of the dispenser, the substrate, or the dispenser and the substrate may be controlled in this manner.

[0302]

penser with the substrate **3710**. The transducer **3740** senses and transfers the changed vibration signal to an amplifier (not shown), which then creates a feedback signal that is

* * *

e.g., an AD621 instrumentation amplifier. The feedback signal is used to control the position of the dispenser **3700** to maintain a desired force of contact between the dispenser **3700** and the substrate **3710**. For example, the feedback

[0313]

penser and/or the substrate. At step **4104**, a change in the amplitude of vibration of the dispenser and/or the substrate is detected. This change in amplitude is proportional to the

-00531 POR, 42-43; PO Sur-Reply, 10;

The Challenged Claims are Patentable Under Ground 1A – Expected or Specified Contact Force

- In contrast, the ***Challenged Patents*** disclose the following:
  - '698 EX1001 at 11:25-28; *see also* -00532 ('381) EX1001, 11:45-48

> In another aspect, control data may be incorporated directly into machine ready code for use during fabrication. 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. With such an instruction, a control signal may be generated during fabrication that controls one or more components of a three-dimensional printer (e.g., components that control feed rate, z-axis position, extrusion head speed, temperature) to achieve the specified contact force.

-00531 POR, 42-43; PO Sur-Reply, 10;
-00532 POR, 37-38; PO Sur-Reply, 11-12.

The Challenged Claims are Patentable Under Ground 1A – Expected or Specified Contact Force

- Additionally, Warren teaches a desire for **no change** in vibration amplitude.
  - EX1004, ¶[0312].
- Even under Petitioner's incorrect theory of calculating contact force from the amplitude change, Warren teaches targeting a constant amplitude, which corresponds to the absence of a (specified) contact force.

[0312] Using the motor driver **4150** to drive the z-axis motor **4160**, the position of the z-axis stage **4170** is changed relative to the dispenser **4100** to affect the vibration A so that A of the feedback signal is maintained at a constant level, thereby closing the feedback loop. According to one embodiment, the resolution of the system may be determined by the maximum speed and resolution of the z-axis stage **4170**, since the substrate **4110** is moved relative to a fixed dispenser **4100**.

-00531 PO Sur-Reply, 10; -00532 PO Sur-Reply, 11-12.

The Challenged Claims are Patentable Under Ground 1A – The '698 Patent and Planarity

- Claims 10 and 11 of the '698 Patent require detecting planarity based on contact force measurements.

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

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

-00531 POR, 38-41; PO Sur-Reply, 11.

The Challenged Claims are Patentable Under Ground 1A – The '698 Patent and Planarity

- Warren does not teach detecting a planarity **based on contact-force measurements**.
- As discussed, Warren does not teach measuring a contact force.
- Warren also teaches adjusting the height of the dispenser at a given point, rather than making a number of contact force measurements that form the basis for detecting planarity.
  - EX1004, ¶¶[0293], [0313]

[0293] of illustration, the substrate may have irregular surfaces. The dispensing system, by varying the position of the dispenser **3700** relative to the substrate **3710**, enables the dispenser to follow irregular or curved surfaces.

[0313] position(s) of the dispenser and/or the substrate are varied at step **4108**, causing a change in the amplitude of vibration.

-00531 POR, 39; PO Sur-Reply, 11;

The Challenged Claims are Patentable Under Ground 1A – The '698 Patent and Planarity

- Warren does not teach detecting a planarity **before printing**.
- Petitioner resorts to hindsight bias – Warren does not teach a calibration procedure
  - -00531 Pet., 33.

> A POSITA would have found it obvious to apply Warren's force sensing to determine surface planarity as part of a calibration procedure before printing an object. EX1003, ¶¶126-127. As explained Dr. Wolfe, a POSITA would have been motivated by known benefits and advantages of the calibration procedure including, e.g., obtaining "spatial relationship between the extrusion tip and the substrate prior to building" in order to "build accurate error-free models." *Id.* (citing EX1007, [0006], [0052-54]); EX1004, [0285] (discussing risk of crash and control of deposition geometry).

-00531 POR, 39-40; PO Sur-Reply, 11

The Challenged Claims are Patentable Under Ground 1A – The '698 Patent and Planarity

- Petitioner cites to another reference (EX1007, Dunn) for support
- But a POSITA would have understood that Warren already provides a technique to build accurately, and thus there is no motivation for a separate calibration procedure. *See* -00531 EX2027 (Decl. or Dr. Osswald), ¶218
- As discussed, Warren adjusts the height of its dispenser based on a change in amplitude.
  - EX1004, ¶ [0313].

> penser and/or the substrate. At step **4104,** a change in the amplitude of vibration of the dispenser and/or the substrate is detected. This change in amplitude is proportional to the

* * *

> position(s) of the dispenser and/or the substrate are varied at step **4108,** causing a change in the amplitude of vibration.

-00531 POR, 39-40; PO Sur-Reply, 11

The Challenged Claims are Patentable Under Ground 1A – The '698 Patent and Planarity

- The Reply improperly introduces an implicit claim construction for detecting planarity, without actually proposing an interpretation.
  - -00531 Reply, 11.

> The POR argues that Warren does not does not teach detecting the planarity of the surface based on a number of contact force measurements. POR, 38-41. Note that the claims do not require a determination of a level or measurement of planarity. The claims only require that planarity be detected. Warren satisfies claim 10 because Warren adjusts for changes in Z-height using the determined contact force at different positions on the substrate. Specifically, Warren "continuously

-00531 PO Sur-Reply, 11

The Challenged Claims are Patentable Under Ground 1A – The '698 Patent and Planarity

- Warren does not teach decreasing irregularities by depositing cells into porous scaffolds in accordance with claim 11 of the '398 Patent.
  - -00531 EX2027, ¶219; *see also* EX2020 (Tr. of Dr. Wolfe Dep.), 89:2-21 (admitting to have no experience with cell deposition)

EX2027, ¶219

12. Warren does not teach filling in gaps in a porous scaffold to make the resultant layer effectively planar or using a detection of planarity to fabricate a layer to decrease irregularities. Rather, Warren teaches that his solution follows "irregular or curved surfaces." EX1004, ¶[0293]. Further, flattening out extruded material with the tip does not fabricate a layer that is effectively planar as the irregularities from

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

-00531 POR, 40-41; PO Sur-Reply, 11

The Challenged Claims are Patentable Under Ground 1A – Claim 4 of '381 Patent

- Warren does not teach contact with an object.
  - EX 1004, ¶[0287];
    see also id. at ¶¶ [0287], [0289], [0302], [0313-0316]; -00532 EX2027 ¶¶206-208.

> **4**. The three-dimensional printer of claim **1**, wherein the separate structure includes an object being fabricated by the three-dimensional printer.

> [**0287**] Therefore, a need exists for a system and method for controlling the position of one or more elements of a depositing system that accurately determines the intensity of the contact force between a dispensing tip and a substrate surface to maintain a desired contact force between the dispenser and the substrate.

-00532 POR, 36-37; PO Sur-Reply, 11.

The Challenged Claims are Patentable Under Ground 1A – Claims 2, 3, 6 of '381 Patent

- Ground 1A does not teach the particular contact forces of '381 Patent claims 2, 3, and 6.
- Petition relies on same teachings of Warren for these claims. Pet. 24-25, 28-29.
- Same contact force cannot satisfy these claims
- Petition does not discuss "orthogonal directions." Reply, 10-11

> **2**. The three-dimensional printer of claim **1**, wherein the contact force is a force along an extrusion axis of the extruder.
>
> **3**. The three-dimensional printer of claim **1**, wherein the contact force includes a deflection force exerted by the separate structure on a tip of the extruder.

> **6**. The three-dimensional printer of claim **1**, wherein the contact force is a force normal to a surface of the separate structure.

-00532 POR, 35-36; PO Sur-Reply, 10.

Overview of Argument

I. Overview of the Challenged Patents

II. Overview of the Prior Art

III. The Challenged Claims are Patentable Under Ground 1A

IV. The Challenged Claims of the ‘698 Patent are Patentable Under Ground 1B

V. The Challenged Claims of the ‘381 Patent are Patentable Under Ground 1B

VI. The Challenged Claims are Patentable Under Ground 2A

VII. Claim 11 of the ‘698 Patent is Patentable Under Ground 2B

The Challenged Claims of the '698 Patent are Patentable Under Ground 1B

- Ground 1B against the '698 Patent adds Eshed (EX1004) to Warren to challenge claims 3, 7, and 9.
- Because these claims all depend on claim 1, they are patentable for at least the reasons described for Ground 1A.

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

> **7**. The method of claim **5** further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.

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

The Challenged Claims of the '698 Patent are Patentable Under Ground 1B – No Motivation

- There is no motivation to combine Warren and Eshed.
- Warren already discloses his solution for avoiding damage to the extruder. There is no motivation to prevent further damage or to look to Eshed.
  - EX1004, ¶[0293]; *see also* EX1004, ¶[0285]; EX2027 (Decl. of Dr. Osswald), ¶¶230-231

> **[0293]** In a first embodiment, the position of a dispenser relative to a substrate is controlled. For example, **FIG. 18** illustrates an exemplary system for controlling the position of a dispenser **3700** relative to a substrate **3710**. Although the substrate **3710** in **FIG. 18** is shown as being flat for ease of illustration, the substrate may have irregular surfaces. The dispensing system, by varying the position of the dispenser **3700** relative to the substrate **3710**, enables the dispenser to follow irregular or curved surfaces.

-00531 POR, 44-45; PO Sur-Reply, 12.

The Challenged Claims of the '698 Patent are Patentable Under Ground 1B – No Motivation

- No motivation to apply Warren's technique to Eshed's system, nor would the result be predictable. *See* EX2027 (Decl. of Dr. Osswald), ¶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. EX1008, ¶¶[181-182]

[0181] By way of example, RPA **300** shown in FIGS. **12A-12D** is shown comprising a collision detection system **340** optionally mounted on shuttle **28**. Optionally, collision detection system **340** comprises an accelerometer (not shown) that generates signals responsive to acceleration of shuttle **28**. A collision usually generates a force that produces an unwanted shuttle acceleration having a characteristic profile useable to identify the acceleration as resulting from a collision. For example, a collision in general results in an impulse applied to the shuttle that produces a corresponding identifiable acceleration.

[0182] Whereas in FIGS. **12A-12D** collision system **340** is shown mounted on shuttle **28**, a collision detection system, in accordance with an embodiment of the invention, may be mounted in or on other components of an RPA. For example, a collision detection system may be mounted on a component (not the shuttle) of the RPA to detect vibrations in the component characteristic of those generated by a collision. In some embodiments of the invention, a collision detection system comprises a microphone and associated algorithms for identifying sounds that typically accompany a collision.

-00531 POR, 44-45; PO Sur-Reply, 12.

The Challenged Claims of the '698 Patent are Patentable Under Ground 1B – Claims 3 and 9

- Petitioner asserts creating a control signal to stop production based on the measured contact force indicating a fabrication error.
  - -00531 Pet. at 40-41; *see also id.* at 41-42.
- But as discussed for claim 5 in Ground 1A, Warren does not teach measuring a contact force, and stopping production cannot be based on the measured contact force as Petitioner asserts for claims 3 and 9.

> In the context of claim 2, in the Warren-Eshed Combination, a POSITA would have understood or found it obvious that when "[u]pon occurrence of a collision, controller…stops production of the object" the controller would stop the feed of material as part of stopping production. EX1003, ¶¶149-150. Thus, creating a control signal to stop production based on the measured contact force indicating a

> fabrication error, e.g., collision, provides the claimed ***creating a control signal to control at least one component*** where the ***component…controls a feed rate for a build material used in the build***. EX1003, ¶150-151.

-00531 POR, 45-46; PO Sur-Reply, 12.

The Challenged Claims of the '698 Patent are Patentable Under Ground 1B – Claim 7

- Similarly, Petitioner asserts for claim 7 that the current contact force is compared to an expected contact force to terminate the build.
  - -00531 Pet. at 41.
- For the same reason, this cannot be the case.

> As described *supra* §§V.B.1-2, the Warren-Eshed combination provides ***terminating the build*** (e.g., stop the fabrication, as taught in Eshed) ***when a difference between the current contact force and the expected contact force*** (e.g., based on comparing the current contact force and the expected contact force, as taught in Warren) ***indicates a fabrication error*** (e.g., blockage by unwanted protuberances, as taught in Eshed). EX1003, ¶¶152-154.

-00531 POR, 45-46; PO Sur-Reply, 12.

Overview of Argument

I. Overview of the Challenged Patents

II. Overview of the Prior Art

III. The Challenged Claims are Patentable Under Ground 1A

IV. The Challenged Claims of the ‘698 Patent are Patentable Under Ground 1B

V. The Challenged Claims of the ‘381 Patent are Patentable Under Ground 1B

VI. The Challenged Claims are Patentable Under Ground 2A

VII. Claim 11 of the ‘698 Patent is Patentable Under Ground 2B

The Challenged Claims of the '381 Patent are Patentable Under Ground 1B

- Ground 1B against the '381 Patent adds Dunn to Warren to challenge claims 3, 7, and 8.
- Because these claims all depend on claim 1, they are patentable for at least the reasons described in Ground 1A.

> **3**. The three-dimensional printer of claim **1**, wherein the contact force includes a deflection force exerted by the separate structure on a tip of the extruder.

> **7**. The three-dimensional printer of claim **1**, wherein the one or more sensors are collectively operable to sense a force between the fabrication tool and the separate structure along two or more non-parallel axes.
>
> **8**. The three-dimensional printer of claim **7**, wherein the one or more sensors are collectively operable to sense a force between the fabrication tool and the separate structure along three or more non-parallel axes.

The Challenged Claims of the '381 Patent are Patentable Under Ground 1B – No Motivation

There is no motivation to combine Warren and Dunn and no teaching of claim 3's deflection force.

- Dunn's multi-axis sensor design is for offset calibrations, not for force sensing.
  EX1007 at ¶[0070] (breaking electrical contacts to sense material pad).
- Dunn's dedicated assembly does not sense contact with extruder tip.
  -00532 EX2027, ¶225
- Dunn's solution adds large assembly that would impede Warren's precise, "fine control." EX1004, ¶[0227]
- Adding vibration oscillators/sensors to Warren would frustrate Warren's vibration sensing capabilities with no reasonable expectation of success.
  -00532 EX2027, ¶227

Petitioner's Reply impermissibly introduces new theories regarding the combination with Dunn, relying on "other multi-axis" configurations/embodiments

-00532 PO Sur-Reply, 13-14;
see Pet. 39-41 (citing EX1007, ¶¶[0069-70], Fig. 9) and Reply, 13 (citing EX1007, ¶[0096]).

-00532 POR, 42-44; PO Sur-Reply, 13-14.

Overview of Argument

I. Overview of the Challenged Patents

II. Overview of the Prior Art

III. The Challenged Claims are Patentable Under Ground 1A

IV. The Challenged Claims of the ‘698 Patent are Patentable Under Ground 1B

V. The Challenged Claims of the ‘381 Patent are Patentable Under Ground 1B

VI. The Challenged Claims are Patentable Under Ground 2A

VII. Claim 11 of the ‘698 Patent is Patentable Under Ground 2B

The Challenged Claims are Patentable Under Ground 2A

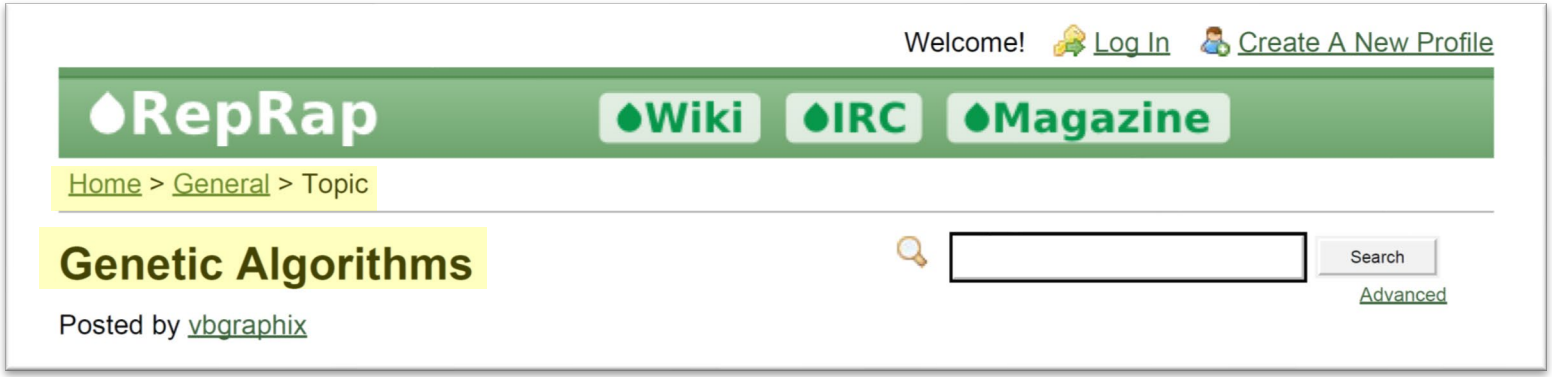
- In each IPR, Ground 2A asserts combination of Calderon (EX1009) and RepRap20208 (EX1010)
  - Petitioner challenges claims 1-5, 7-10, and 12-15 of the '698 Patent.
  - Petitioner challenges claims 1-6 and 9-16 of the '381 Patent.

2A	1-5, 7-10, 12-15	Calderon and RepRap20208

2A	1-6, 9-16	Calderon and RepRap20208

The Challenged Claims are Patentable Under Ground 2A – RepRap20208 is not a "Printed Publication"

- RepRap20208 is not a printed publication.
- RepRap20208 was printed in 2024, and is a thread entitled "Genetic Algorithms" in a general forum.
  - EX1010, 1.



-00531 Sur-Reply, 13-17; -00532 PO Sur-Reply, 14-19.

The Challenged Claims are Patentable Under Ground 2A – RepRap20208 is not a "Printed Publication"

- The question is whether the RepRap20208 thread was publicly accessible such that a POSITA "exercising reasonable diligence, can locate it."
  - *Blue Calypso, LLC v. Groupon, Inc.*, 815 F.3d 1331, 1348 (Fed. Cir. 2016).

> 99 (Fed.Cir.1986). A reference will be considered publicly accessible if it was "disseminated or otherwise made available to the extent that persons interested and ordinarily skilled in the subject matter or art exercising reasonable diligence, can locate it." *Kyocera Wireless Corp. v. Int'l Trade Comm'n*, 545 F.3d 1340, 1350 (Fed. Cir.2008). Whether a reference qualifies as a printed publication is a legal conclusion based on underlying factual determinations. *In re Lister*, 583 F.3d 1307, 1311 (Fed.Cir.2009).

-00531 Sur-Reply, 13-17; -00532 PO Sur-Reply, 14-19.

The Challenged Claims are Patentable Under Ground 2A – RepRap20208 is not a "Printed Publication"

- There is no explanation of why or how a skilled artisan would arrive at a "Genetic Algorithms" thread in a "General" forum.
  - -00531 Reply, 27-28.

> The POPR argues that EX1013 only references the RepRap wiki, without mentioning the RepRap forum. POPR, 32. But POPR admits that the face of EX1001 includes a link to the RepRap forum. EX1001, face; POPR, 32. Following

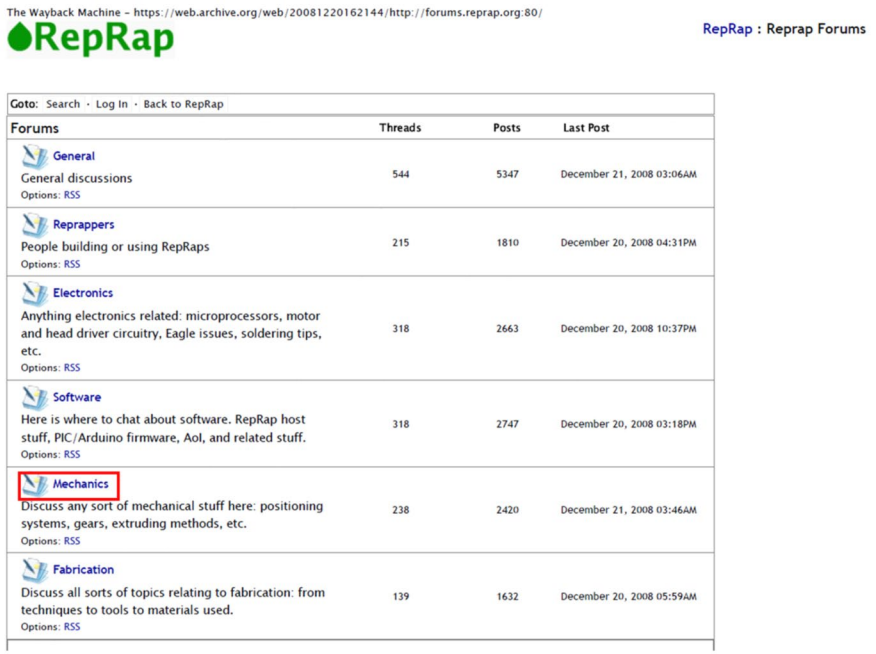
> that link would undoubtedly take a user to the RepRap forum, from which they could explore other threads of the forum, for example, through text-based searching. Bowyer testified that the "RepRap forums were (and still are) linked to the main page," and provided a screenshot of the RepRap landing page from December 16, 2008 that shows a link to "User Forums" front-and-center:

-00531 Sur-Reply, 13-17; -00532 PO Sur-Reply, 14-19.

The Challenged Claims are Patentable Under Ground 2A – RepRap20208 is not a "Printed Publication"

- Mr. Bowyer provided an example from the "Mechanics" forum to "Discuss any sort of mechanical stuff," in contrast to the "General" forum containing RepRap20208.
  - EX1014, ¶9.

specific forum by clicking on the corresponding link. For example, a user can click the "Mechanics" forum, as annotated below.


The Wayback Machine – https://web.archive.org/web/20081220162144/http://forums.reprap.org:80/

RepRap

RepRap : Reprap Forums

Goto: Search · Log In · Back to RepRap

Forums	Threads	Posts	Last Post
General General discussions Options: RSS	544	5347	December 21, 2008 03:06AM
Reprappers People building or using RepRaps Options: RSS	215	1810	December 20, 2008 04:31PM
Electronics Anything electronics related: microprocessors, motor and head driver circuitry, Eagle issues, soldering tips, etc. Options: RSS	318	2663	December 20, 2008 10:37PM
Software Here is where to chat about software. RepRap host stuff, PIC/Arduino firmware, AoI, and related stuff. Options: RSS	318	2747	December 20, 2008 03:18PM
Mechanics Discuss any sort of mechanical stuff here: positioning systems, gears, extruding methods, etc. Options: RSS	238	2420	December 21, 2008 03:46AM
Fabrication Discuss all sorts of topics relating to fabrication: from techniques to tools to materials used. Options: RSS	139	1632	December 20, 2008 05:59AM

Exhibit B-2 (forums with search button)

-00531 Sur-Reply, 13-17; -00532 PO Sur-Reply, 14-19.

The Challenged Claims are Patentable Under Ground 2A – RepRap20208 is not a "Printed Publication"

- *Blue Calypso* rejected "technical accessibility" and holds that the record must contain evidence that pre-critical-date searches (with relevant queries) would have returned the reference.
  - *Blue Calypso* at 1350.

> web address. Instead, Groupon argues that an internet search engine would have been able to locate the report. But that argument does not allow us to automatically infer that Dr. Ratsimor's webpage was "indexed . . . (through search engines or otherwise)" and thus locatable by a search engine. *See Voter Verified*, 698 F.3d at 1381. The record is devoid of any evidence that a query of a search engine before the critical date, using any combination of search words, would have led to Ratsimor appearing in the search results.

-00531 Sur-Reply, 13-17; -00532 PO Sur-Reply, 14-19.

The Challenged Claims are Patentable Under Ground 2A – RepRap20208 is not a "Printed Publication"

- All Petitioner provides (on Reply) is attorney-provided keywords, not evidence of what search a POSITA would have performed or why that search would locate the forum post.
  - -00531 Reply 26-27.

> Mr. Bowyer testified that "the forums were (and still are) fully keyword searchable, allowing users to search for and readily identify relevant discussion threads." EX1014 ¶6. Bowyer added that the "search functionality allowed users to search for posts based on…the content of the posts." EX1014 ¶6. RepRap20208, including Wade's posts, contain many relevant keywords, including "collision," "collision detection," "calibrate," "calibration," "sensor," "strain gauge," "force," and "measure," "measurement." EX1010, 13-21. In addition, the thread title "Genetic Algorithms" undoubtedly pertained to algorithms for 3D printers, like RepRap. *E.g.*, EX1010, 1; EX1014, ¶2 (RepRap project is for 3D printer

-00531 Sur-Reply, 13-17; -00532 PO Sur-Reply, 14-19.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Also, there is no motivation to combine. Petition's motivation theory:
  - -00531 Pet., 56.

> Accordingly, for at least these reasons, a POSITA would have found it obvious to apply a "strain gauge on the extruder mount" from RepRap20208 as the "sensing means" of Calderon, rather than following Calderon's suggestion of "monitoring a change in the servo drive current" (EX1009, 10:1-8) and implement collision detection using that same strain gauge. EX1003, ¶¶164-174.

-00531 Pet., 56.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- But Calderon already has its own technique for collision detection by determining contact between a nozzle and the substrate through "monitoring a change in the servo drive current."
  - EX1009 at 10:5-8.

the nozzle tip contacts the substrate. Contact between the tip of nozzle **132** and the substrate **128** is monitored by a sensing means and the controller **116** electrically records the z-axis position of platform **134** at the time contact is
5 detected. In an apparatus that uses servo drive motors, contact with the substrate **128** can be detected by simply monitoring a change in the servo drive current without need for any special purpose sensing means.

-00531 POR, 50; -00532 POR, 46-47.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- For the '698 Patent, Petitioner presents a range of deficient rationales:
  - "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).

- Petitioner presents similar deficient rationales for the '381 Patent:
  - "slop/backlash" (Pet. 50-52);
  - "force of resistance to movement" (Pet. 52);
  - "prevent damage[e to] the substrate" (Pet. 53); and
  - "strain gauges were commonly used" (Pet. 53-54).

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Calderon already teaches that "the machine stops the build and alerts the user to clear the build envelope" upon collision detection.
  - EX1009 at 10:43-45.

> a previous model. In this example, the machine looks up the x,y,z coordinates of the last features built on the previous model (stored in memory **119**), and feels for the presence or absence of those features employing the sensing techniques of the present invention. If a model is detected at the coordinates of the last features, the machine stops the build and alerts the user to clear the build envelope. The machine continues with the z-axis initialization routine when the envelope is cleared.

-00531 POR, 50; -00532 POR, 46-47.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Thus, there is no motivation to look to RepRap20208 to have the machine shut down as Petitioner proposes.
  - -00531 Pet at 51-52.

> A POSITA also would have found it obvious to implement collision detection using strain gauges on the extruder mount to shut down the 3D printer upon collision detection, as advocated by RepRap20208, to improve operation of the three-dimensional printer of the Calderon-RepRap20208 Combination. EX1003, ¶163.

-00531 POR, 50; -00532 POR, 46-47.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Petitioner's "slop/backlash" arguments is similarly deficient.
- Page 20 of RepRap20208 only mentions "backlash" and not "slop."
- Petitioner also fails to show that concern about backlash "before the sensor registers" would apply to Calderon's servo drive monitoring solution.
  - EX1010, 20.

Wade

Re: Genetic Algorithms
January 16, 2009 12:04AM

Registered: 16 years ago
Posts: 536

The upward pressure is the same thing general idea, but if you've got it truly not touching the sensor (as that datasheet reccomends), then you've got a certain amount of backlash to take up before the sensor registers, which would prevent me from knowing exactly when the head touches, which is what I'm really interested in. There's fair amount of give in the entire system when you're looking at scales of less than a mm, so I was thinking a constant measurement of the force on the head (including it's weight) would be useful. That points more towards strain gauges.

Yeah, the 4 corners calibration was what I was thinking as well. It could also pick up on a tangled plastic filament feed, which has wrecked a few builds of mine in the past as well. That would probably just trigger the head collision detection, due to the upward force on the extruder.

Mostly I just squint at the webcam feed every few hours and try and deduce if something bad has happened.

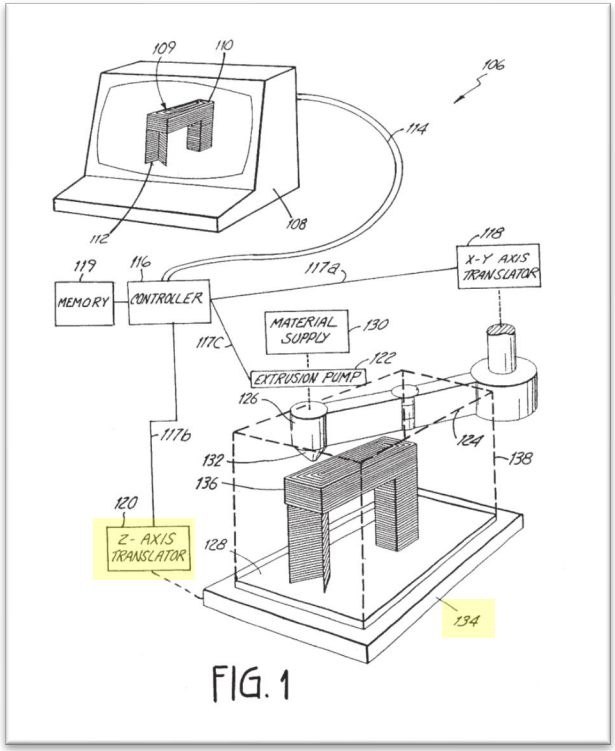
Wade

Reply Quote

-00531 POR, 50-51; -00532 POR, 48.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Petitioner's assertion that RepRap20208 would measure force from a location closer to the nozzle to address slop/backlash is also deficient.
- Petitioner fails to address how strain gauge on extruder would be closer to contact point with platform 134 than Calderon's z-axis translator, which directly drives platform 134.
  - EX1009 at Fig. 1.



-00531 POR, 51; -00532 POR. 49.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Petitioner next asserts that a strain gauge would provide "more accurate and consistent force measurements."
- No support for Petitioner's conclusory assertion (parroted by expert):
  - -00531 Pet. at 53-54

> Fourth, a POSITA would have understood that "monitoring a change in the servo drive current" measures the force of resistance to movement of the substrate 128 and platform 134 in the Z-axis, not just the contact force between the substrate 128 and nozzle 132. EX1003, ¶170. The resistance to movement of the substrate

> substrate 128. *Id*. Thus, a POSITA would seek to implement RepRap20208's strain gauge on the extrusion head as a "sensing means" in Calderon's system to produce more accurate and consistent force measurements by which to sense contact of the nozzle 132 to the substrate 128. *Id*.

-00531 POR, 51; -00532 POR, 49.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Petitioner's assertion that a strain gauge would support different substrates without damage is also flawed and hindsight.
- Neither Calderon nor RepRap20208 mention "damage" or "damaging" or that a strain gauge prevents damage.
- Instead, Calderon discloses that the extrusion nozzle should be below the top surface of some substrates ("buried in the foam"), so damage to the substrate may be necessary.
  - EX1009 at 2:44-50.

to the substrate. Nozzle tip depth is typically set at one location of the substrate. In the Stratasys FDM® machines that built the model on a foam slab substrate, the optimal position of the extrusion nozzle is below the top surface of the foam, at a depth so that the first two extruded layers of modeling material will be buried in the foam. The first two layers extruded into the foam substrate provide a foundation to stabilize a model as it is built up. The z-axis accuracy for building on the foam should be ±5–10 mils. For rigid substrates, the z-axis accuracy desired in a Stratasys FDM® modeling system is ±2–4 mils.

-00531 POR, 52; PO Sur-Reply, 20; -00532 POR 49-50; PO Sur-Reply, 25

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- In Reply, Petitioner argues that Calderon's servo drive monitoring is "only in the specific use-case of" a servo motor and that Calderon discloses monitoring more generally.
  - Reply, 13; *see also id.* at 14, 16-17.

> 'monitoring a change in the servo drive current.'" POR 48; EX1009, 10:5-8. But Calderon monitors a change in servo drive current only in the specific use-case of "an apparatus that uses servo drive motors." EX1009, 10:5-8 (the only discussion of servos). That is, Calderon predominantly teaches embodiments that do not implement servos. *E.g.*, EX1009, 4:34-5:10, 5:10-24 6:16-18; Petition, 42-46, 49-57. For the combination, the Petition points to Calderon FIG. 1, which does not illustrate an apparatus with servo drive motors:

-00531 PO Sur-Reply, 17-18; -00532 PO Sur-Reply, 19.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Reply improperly changes Petition's motivation theory and should not be considered:
  - -00531 Pet., 56.

> Accordingly, for at least these reasons, a POSITA would have found it obvious to apply a "strain gauge on the extruder mount" from RepRap20208 as the "sensing means" of Calderon, rather than following Calderon's suggestion of "monitoring a change in the servo drive current" (EX1009, 10:1-8) and implement collision detection using that same strain gauge. EX1003, ¶¶164-174.

-00531 PO Sur-Reply, 17-18; -00532 PO Sur-Reply, 19.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Rest of Calderon uses a movable plunger tripping a sensor for a binary detection of contact or no contact, not force
  - -00531 POR, 47.

> *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-

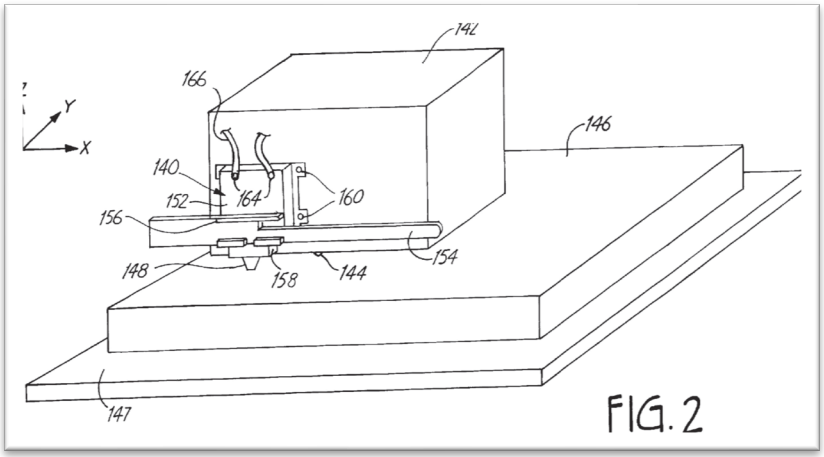


FIG. 2

-00531 PO Sur-Reply, 17-18; -00532 PO Sur-Reply, 20.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Petition relies on Calderon's alternative embodiment (Example 3)
  - -00531 Pet., 56
- Calderon's alternative embodiment:
  - Uses the tip of the nozzle instead of the plunger
  - Does not need "any special purpose sensing means" to detect contact
  - Instead monitors the drive current of a motor
    - EX1009, 9:63-10:8

EXAMPLE 3

In an alternative embodiment, the tip of nozzle **132** (shown in FIG. **1**) can be used as a plunging means to find z-axis positions of the platform. The ini performed by positioning the nozzle **13** locations of the substrate and raising th

the nozzle tip contacts the substrate. Contact between the tip of nozzle **132** and the substrate **128** is monitored by a sensing means and the controller **116** electrically records the z-axis position of platform **134** at the time contact is detected. In an apparatus that uses servo drive motors, contact with the substrate **128** can be detected by simply monitoring a change in the servo drive current without need for any special purpose sensing means.

-00531 POR, 47-48; -00531 PO Sur-Reply, 17-19;
-00532 POR, 47-48; -00532 PO Sur-Reply, 20.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- One such unneeded special-purpose sensing mean is a strain gauge
  - 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 and that detects objects in the build envelop providing collision detection. *See* Petition at 50 (adding a special purpose sensing means in the form of a strain gauge "on the extruder mount"); *see also* Petition at 49, 55-56; EX1009 (Calderon),

-00531 POR 50; PO Sur-Reply, 18-19.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Petitioner also ignores that Calderon already has a collision detection solution, so there is no advantage to adding RepRap20208's collision detection discussion.
  - EX1009, 10:1-8.

> the nozzle tip contacts the substrate. Contact between the tip of nozzle **132** and the substrate **128** is monitored by a sensing means and the controller **116** electrically records the z-axis position of platform **134** at the time contact is detected. In an apparatus that uses servo drive motors, contact with the substrate **128** can be detected by simply monitoring a change in the servo drive current without need for any special purpose sensing means.

-00531 PO Sur-Reply, 20; -00532 PO Sur-Reply, 21.

The Challenged Claims are Patentable Under Ground 2A – No Motivation to Combine

- Reply also presents attorney argument suggesting that "strain gauges" would work "well over long periods of time"—there is no evidence of that.
  - -00531 Reply, 15.

EX1003 ¶¶171-172. The concern of "work[ing] well over long periods of time" cited by PO refers to a specific force sensor, not strain gauges in general. EX1010, 19. Likewise, the comments about "a stencil cutting blades or drawing pen" relates

-00531 PO Sur-Reply, 20; -00532 PO Sur-Reply, 23.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Build Instructions

- Ground 2A does not teach claim element 1[a] of the '698 Patent.

1. A method comprising:

identifying build instructions for fabricating an object;

initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool, the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;

detecting the current contact force based on a sensor signal from the one or more sensors; and

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.

-00531 POR, 53-54.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Build Instructions

- Petitioner argues that Calderon teaches "build instructions" by pointing to "a file describing the geometry of a part 109 to be created" that includes "volume elements 110."
  - -00531 Pet. at 57.

> ***[1.a]: identifying build instructions for fabricating an object;***
>
> In the Calderon-RepRap20208 Combination, Calderon teaches ***identifying build instructions*** (e.g., "*a file* describing the geometry of a part 109 to be created," where the file includes "volume elements 110 corresponding to shapes that can be extruded from a nozzle," (EX1009, 4:19-33)) ***for fabricating an object*** (e.g., "build up model 136 layer-by-layer on the substrate 128." *Id.*, 4:53-65, claim 5 ("building an object in the coordinate system of the substrate"), FIG. 1 (below).

-00531 POR, 53-54.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Build Instructions

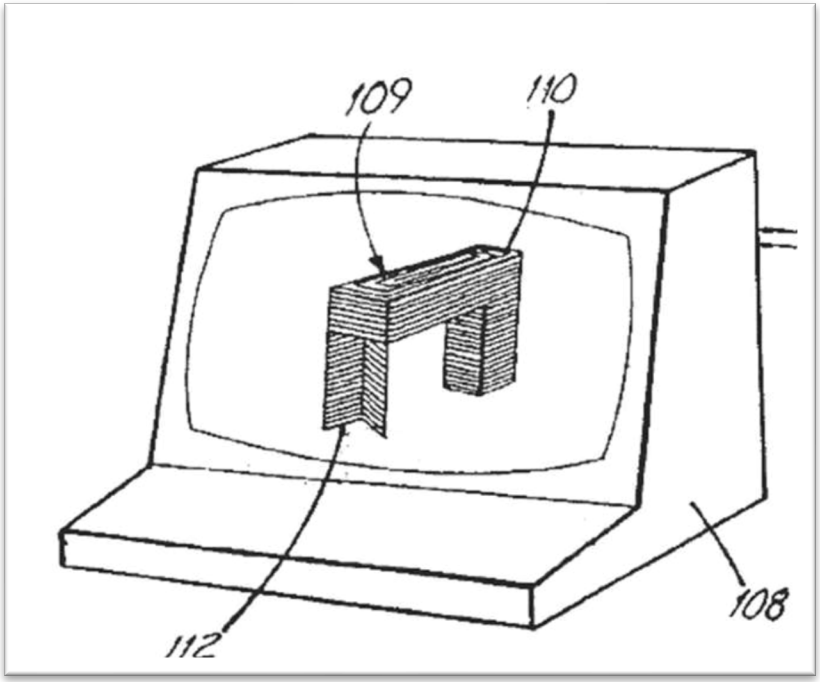
- Petitioner also argues that Calderon's file has "[a] mathematical description of a physical part to be created is split into (usually) planar layers."
  - -00531 Pet. at 58.

> Calderon also 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." *Id.*, 1:12-23 ("layered manufacturing"), 1:33-47 ("The extruded material is deposited layer-by-layer in areas *defined from the CAD model*."); §§V.C.1-3; EX1003, ¶¶178-180.

-00531 POR, 53-54.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Build Instructions

- But in Calderon, the file and elements in the file represent the 3D model of the object, not build instructions.
  - EX1009 at Fig. 1 (excerpt)



-00531 POR, 53-54; PO Sur-Reply, 22.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Detecting/Calculating Force

- Ground 2A also fails to teach "detecting the current contact force" ('698 Patent elements 1[b]-1[d]) or "calculate[ing] a contact force" ('381 Patent element 1[c]).

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.

a controller configured to receive a signal from the one or more sensors on the extruder and to calculate the contact force between the extruder and the separate structure.

-00531 POR, 54-57.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Detecting/Calculating Force

- Petitioner cites to several pages of the RepRap20208 reference.
- Page 13 does not mention a current contact force and briefly mentions using a strain gauge on the extruder mount.
  - EX1010, 13.

Wade

Re: Genetic Algorithms
January 14, 2009 04:10PM

Registered: 16 years ago
Posts: 536

Hm, I don't look forward to trying to code up a vision system from scratch....

but, an accelerometer on the write head might be useful. Keep an eye on the RMS power of the vibration the head experiences; that might be able to detect the next time I have an all-night long series of head collisions due to a bad programming job.

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. Could take some time though.

Wade

Reply Quote

-00531 POR, 54-57.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Detecting/Calculating Force

- Page 19 mentions a "force sensor" but then teaches away from using it.
  - EX1010, 19.

> Collision detection is a nice side affect; I'd have the machine shut down and flag me if it happens, as opposed to breaking something. Right now I have the Arduino shut everything off, print an error message to the serial port and go into an infinite while loop when something really bad happens, like a thermocouple malfunction. That saved my machine once already.
>
> That IESP-12 force sensor is priced right at $7, but I'm a little skittish about the "estimate" language in the datasheet. It doesn't sound like it works well over long periods of time under force though, which could be bad in our setup if it's always measuring the weight of the extruder.
>
> A metal bar with some strain gauges could work too, but the heat flow from the extruder might mess with things.

-00531 POR, 54-57.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Detecting/Calculating Force

- Page 20 mentions "measuring contact force for a stencil blade or drawing pen" but the next post also teaches away from using it.
- And mention of measuring force on the head includes weight of the head, which is not contact force (nor did Petition explain how to account for it).
  - EX1010, 20.

> The other idea that I had was measuring contact force for a stencil cutting blade or drawing pen to get more uses out of the bot.
>
> As a stencil cutter it could cut logos, labels, paper or PCB exposure or silk screen masks; other capabilitys to show off why we are into this 3D stuff.

> The upward pressure is the same thing general idea, but if you've got it truly not touching the sensor (as that datasheet reccomends), then you've got a certain amount of backlash to take up before the sensor registers, which would prevent me from knowing exactly when the head touches, which is what I'm really interested in. There's fair amount of give in the entire system when you're looking at scales of less than a mm, so I was thinking a constant measurement of the force on the head (including it's weight) would be useful. That points more towards strain gauges.

-00531 POR, 54-57; -00531 PO Sur-Reply, 23;
-00532 POR; 52-53; -00532 PO Sur-Reply, 24-25.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Detecting/Calculating Force

- The Reply refers to "measur[ing] upwards pressure" but that discussion in RepRap20208 concerns a sensor IESP-12 (which it denigrates) and not a strain gauge.
  - EX1010, 19.

> >
> > That IESP-12 force sensor is priced right at $7,
> > but I'm a little skittish about the "estimate"
> > language in the datasheet. It doesn't sound like
> > it works well over long periods of time under
> > force though, which could be bad in our setup if
> > it's always measuring the weight of the extruder.
> >
> > Wade
>
> Hi Wade
>
> My idea was that it would measure upwards pressure from a calibration touch down or abort if it had run into the bed.

-00531 POR, 54; -00531 PO Sur-Reply, 24;
-00532 POR; 52-53; -00532 PO Sur-Reply, 26.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Dependent Claims

- Because the remaining claims depend on claim 1, they are patentable for at least the foregoing reasons.
  - '698 Patent:

2A	1-5, 7-10, 12-15	Calderon and RepRap20208

  - '381 Patent:

2A	1-6, 9-16	Calderon and RepRap20208

-00531 POR, 57; -00532 POR, 54.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 4

- Further, there is no teaching of controlling z-distances in response to the contact force as in **claim 4** of the '698 Patent.
- 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."
  - -00531 Pet. 64-65 (citing EX1009, 4:56-57).

> detection. A POSITA would have recognized, or found obvious, that shutting the 3D printer down includes stopping any change the relative z-distance between the dispensing head and the platform to prevent damage. EX1003, ¶¶200-201.

-00531 POR, 57-58.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 4

- But RepRap20208 simply states to "have the machine shut down" upon collision.
  - EX1010, 19.

> Collision detection is a nice side affect; I'd have the machine shut down and flag me if it happens, as opposed to breaking something. Right now I have the Arduino shut everything off, print an error message to the serial port and go into an infinite while loop when something really bad happens, like a thermocouple malfunction. That saved my machine once already.

-00531 POR, 57-58.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 4

- Similarly, Calderon simply "stops the build and alerts the user to clear the build envelope."
  - EX1009 at 10:43-45.

> of the present invention. If a model is detected at the coordinates of the last features, the machine stops the build and alerts the user to clear the build envelope. The machine continues with the z-axis initialization routine when the envelope is cleared.

-00531 POR, 57-58.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 4

- The Reply improperly introduces attorney argument that controlling the z-direction is necessary to have "some clearance" to clear Calderon's build envelope.
  - -00531 Reply, 23.

> (discussing shutting down the machine). But Calderon also teaches that the user needs to clear the envelope (EX1009, 10:42-47; POR, 58) and a POSITA would have found it obvious that, to clear the envelope, the user would need some clearance between the nozzle tip and the offending structure. Hence, as explained by Dr. Wolfe, Calderon-RepRap20208 renders obvious controlling the z-direction between the extruder and the build platform. EX1003 ¶¶200-202.

-00531 PO Sur-Reply, 25.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claims 5 and 7

- There is also no teaching of a comparison to an expected force as in **claims 5 and 7** of the '698 Patent.

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

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

7. The method of claim **5** further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.

-00531 POR, 58-59.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claims 5 and 7

- Petitioner asserts with hindsight that a POSITA would have ***introduced*** an undisclosed threshold force to compare to the current contact force.
  - -00531 Pet. 65.

> ***5. The method of claim 2 further comprising comparing the current contact force to an expected contact force.***
>
> In the Calderon-RepRap20208 Combination, a POSITA would have known, or found it obvious, to introduce a threshold force (***an expected contact force***) that, when exceeded, indicates collision and ***compare the current contact force*** (e.g., obtained based on sensor signals from the strain gauges on the extruder mount, as taught in RepRap20208) to the threshold so a collision event (i.e., "when you run into something") can be detected. *Id.*; EX1003, ¶¶203-205 (explaining ubiquitous use of a trigger condition).

-00531 POR, 58-59.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claims 5 and 7

- The Reply improperly introduces new argument citing to Calderon, a reference the Petition did not cite when addressing claims 5 and 7.
  - Reply, 23.

> RepRap20208 is concerned with collision detection and shutting down a build to protect the nozzle, substrate, and build material from damage. *E.g.*, EX1010, 19. As discussed already, Calderon-RepRap20208 uses a strain gauge to determine contact force and compares the determined contact force to decide when the correct contact has occurred. *E.g.*, EX1009, 2:35-53, 8:35-52 (discussing different z-axis accuracy for different build materials and requiring contact force sensitivity for accurate z-start positions above and below the surface of the substrate). A POSITA would have found it obvious that the determination about whether contact has occurred correctly used a comparison of a known force contact value against determined values. EX1003 ¶¶203-205.

-00531 POR, 58-59.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- There is no teaching of planarity detection as in **claim 10** of the '698 Patent.

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

-00531 POR, 59-61.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- Petition asserts that Calderon's ***Example 3***, which describes "positioning the nozzle above pre-selected locations of the substrate" at "pre-selected locations" discloses determining planarity.
  - -00531 Pet. 68.

(reference numbers omitted). In 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." *Id.*, 9:65-67 (reference numbers omitted). The method of the Calderon-RepRap20208 Combination, thus further includes a multi-point calibration (i.e., ***detecting a planarity of the separate structure*** (such as the substrate) ***based upon a number of contact force measurements across a***

-00531 POR, 59-61.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- Calderon's ***Example 2*** requires variables X and Y to find a plane.
  - *See, e.g.*, EX1009; 8:23-28.

> Specifically, the analysis may be performed by finding a plane which is the linear least squares fit to the data points (X_j, Y_j, Z_j) corresponding to a set of i sensed z-axis positions. The plane is defined by the equation:
>
> $ax+by+cz=1$ Eq. (1)

-00531 POR, 59-61.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- And Example 3 ***eliminates those variables*** and thus cannot adhere to Example 2.
  - EX1009, 10:9-15.

> The Find-Z program works much the same in the present example as described with respect to Examples, 1 or 2 above. 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.

-00531 POR, 59-61.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- Petitioner asserts in Reply that "Example 3 is like Example 1, except that the nozzle tip is used."
  - -00531 Reply, 24.

position sensed by the plunger with the actual position of the nozzle. *Id.* However, constants X and Y are not applicable to Example 3 because Example 3 does not use a plunger. It uses "the tip of the nozzle 132…as a plunging means to find z-axis positions of the platform." *Id.*, 9:63-65. Example 3 is like Example 1, except that the nozzle tip is used to directly map the z-axis positions of the substrate at different x- and y-locations. *Id.*, 7:62-8:51, 9:63-10:15. Nor do constants X and Y relate to step H, which performs planarization using "recorded z-axis positions" to determine whether the substrate is "approximately parallel to a horizontal xy-plane." *Id.*, 7:62-8:15. Thus, planarization is achieved using recorded z-axis positions, which in Example 3, is performed without needing constants X and Y.

-00531 PO Sur-Reply, 26-27.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- But Calderon teaches that two steps of the algorithm are skipped in Example 3, not merely that the nozzle tip is used instead of a plunger.
  - EX1009, 10:9-15;

> The Find-Z program works much the same in the present example as described with respect to Examples, 1 or 2 above. 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.

-00531 POR, 59-61.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- Reply also introduced a new argument about Calderon's "step H."
- Calderon acknowledges that step H for Example 1 is replaced with a self-correct in Example 2 based on a "linear least squares fit" to X and Y, which are removed in Example 3.
  - EX1009, 9:17-26.

horizontal. This embodiment performs a self-correct of substrate surface planarity that can replace the operator correct instruction of step (H) in Example 1. Building the model in the coordinate system of the substrate further provides a nozzle tip depth that is optimized over the substrate as a whole and not just at a single x,y coordinate.

Specifically, the analysis may be performed by finding a plane which is the linear least squares fit to the data points (X_j, Y_j, Z_j) corresponding to a set of i sensed z-axis positions. The plane is defined by the equation:

-00531 PO Sur-Reply, 26-27.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of '698 Patent Claim 10

- And Step H in Example 1 "compares the recorded z-axis positions" (of a plunger) and thus is not "based upon a number of contact force measurements."
  - *See* EX1009, 7:64-67.

> When a z-axis position has been recorded for each pre-selected x, y location, step (H) is performed. In step (H), a "Find-Z" software program loaded into controller. **116** compares the recorded z-axis positions to determine whether the top surface of substrate **146** is approximately parallel to a horizontal, xy-plane. Step (H) is particularly useful for a

-00531 PO Sur-Reply, 26-27.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Achieving Specified Force

- There is no teaching of achieving a specified contact force as in **claim 12 of the '698 Patent** and **claim 11 of the '381 Patent**.

> **12**. 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.

> **11**. The three-dimensional printer of claim **1**, further comprising:
>
> one or more actuators mechanically coupled to the fabrication tool, and a control circuit in data communication with the one or more actuators and the one or more sensors, the control circuit configured to control the one or more actuators to achieve a specified contact force between the one or more sensors and the separate structure.

-00531 POR, 61-62; -00532 POR 54-55.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Achieving Specified Force

- As with claims 5 and 7, Petition improperly applies hindsight to provide a comparison:
  - Pet., 69.

> As explained *supra* §V.C.1, Calderon provides build instructions for electronic controller 116 to "control[] the extrusion of modeling material in an xyz-coordinate reference frame so that beads of modeling material are extruded layer-by-layer." EX1009, 4:19-52. A POSITA would have known, or found it obvious, to compare the current contact force (e.g., obtained based on sensor signals from the strain gauges on the extruder mount, as taught in RepRap20208) to a threshold indicative of, e.g., "when you run into something." EX1010, 13-14; EX1003, ¶¶220-222 (explaining ubiquitous use of a trigger condition for comparison, as discussed under claims 5, 7, 8).

-00531 POR, 61-62; -00532 POR 54-55.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Achieving Specified Force

- References do not teach comparison to a threshold force (see Claims 5 and 7), much less ***achieving a specified force***.
- Calderon merely teaches detecting contact by "monitoring a change in the servo drive current."
  - EX1009, 10:1-8.

> the nozzle tip contacts the substrate. Contact between the tip of nozzle **132** and the substrate **128** is monitored by a sensing means and the controller **116** electrically records the z-axis position of platform **134** at the time contact is detected. In an apparatus that uses servo drive motors, contact with the substrate **128** can be detected by simply monitoring a change in the servo drive current without need for any special purpose sensing means.

-00531 POR, 61-62; -00532 POR 54-55.

The Challenged Claims are Patentable Under Ground 2A – No Disclosure of Achieving Specified Force

- RepRap20208 just teaches watching for a "change in bolt tension when you run into something."
  - EX1010, 14.

> I wonder, does anyone make a sort of instrumented bolt for a reasonable price? The extruder mount could use a pair of bolts with strain gauges, and you could watch the change in bolt tension when you run into something. Probably cost as much as the RepRap. 

-00531 POR, 61-62; -00532 POR 54-55.

Overview of Argument

I. Overview of the Challenged Patents

II. Overview of the Prior Art

III. The Challenged Claims are Patentable Under Ground 1A

IV. The Challenged Claims of the ‘698 Patent are Patentable Under Ground 1B

V. The Challenged Claims of the ‘381 Patent are Patentable Under Ground 1B

VI. The Challenged Claims are Patentable Under Ground 2A

VII. Claim 11 of the ‘698 Patent is Patentable Under Ground 2B

Claim 11 of the '698 Patent is Patentable Under Ground 2B

- Ground 2B adds Napadensky (EX1005) to the combination of Calderon and RepRap20208 to challenge **'698 Patent claim 11**.
- Because claim 11 depends on claim 1, it is patentable for at least the reasons described for Ground 2A.

> **10**. The method of claim **2** further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.
>
> **11**. The method of claim **10** further comprising fabricating a layer on the surface of the separate structure that decreases one or more irregularities in the surface of the separate structure.

Claim 11 of the '698 Patent is Patentable Under Ground 2B – No Motivation to Combine

- There is no motivation to combine Napadensky with Calderon and RepRap20208.
- Petitioner asserts that Napadensky's leveling device reduces surface irregularities that cause collisions and "adversely affect[]" model quality.
  - -00531 Pet., 73-74

> A POSITA would have been motivated to pursue the Calderon-RepRap20208-Napadensky Combination because the leveling reduces surface irregularities that could cause collisions (e.g., "dispensed layers being too thick and/or inconsistent in thickness," "material spill or faulty material dispensing"). EX1005, 18:5-18. As explained *supra* (e.g., §V.C.1-3, claim 10), "if the substrate is deformed [and] lacks a horizontal planar surface, the model quality will be adversely affected." EX1009, 2:63-3:1; EX1003, ¶¶236-237.

-00531 POR, 64-65; PO Sur-Reply, 27-28.

Claim 11 of the '698 Patent is Patentable Under Ground 2B – No Motivation to Combine

- But Calderon already discloses a solution to this concern:
  - EX1009, 2:63-3:14.

An incorrect z-start position can result in failure in forming a model. Additionally, if the substrate is not mounted flat to the platform, or if the substrate is deformed or improperly mounted so that it lacks a horizontal planar surface, the model quality will be adversely affected regard-

less of the z-start position selected. There exists a need for a z-axis initialization routine that does not require operator intervention or judgment.

The present invention is an automated apparatus and method for initialization of a computer-controlled modeling machine that builds up three-dimensional objects on a substrate supported by a modeling platform.

An autoinitialization method of the present invention will calculate a z-start position for the platform based upon z-axis positions of the platform obtained by sensing the substrate surface at multiple x, y positions. A method for

-00531 POR, 64-65; PO Sur-Reply, 27-28.

Claim 11 of the '698 Patent is Patentable Under Ground 2B – No Disclosure of Claim 11

- And Napadensky teaches forming a layer **and then** leveling the formed layer as a separate step—not fabricating a layer to decrease irregularities.
  - EX1005, 17:62-67,

> Dispensing head **21** and radiation source **26** are preferably mounted in a frame or block **28** which is preferably operative to reciprocally move over a tray **30**, which serves as the working surface. According to the common conventions, tray **30** is positioned in the X-Y plane. Tray **30** is preferably configured to move vertically (along the Z direction), typically downward. In various exemplary embodiments of the invention, apparatus **14** further comprises one or more leveling devices **32** which can be manufactured as a roller **34** or a blade. Leveling device **32** serves to straighten the newly formed layer prior to the formation of the successive layer thereon. Leveling device **32** preferably comprises a waste

-00531, POR 66.

Claim 11 of the '698 Patent is Patentable Under Ground 2B – No Motivation to Combine

- The Reply abandons the Petition's obviousness theory and discusses applying a layer to a porous substrate in Calderon alone.
  - *Compare* Reply, 25, *with* Petition, 73-74.
- Petitioner cannot cure its failure to show a motivation to combine via new arguments that cite previously unidentified portions of Calderon.

-00531 PO Sur-Reply, 27-28.