

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SHENZHEN TUOZHU TECHNOLOGY CO., LTD.,
Petitioner,

v.

STRATASYS, INC.,
Patent Owner.

IPR2025-00531
Patent 9,168,698 B2

Before HYUN J. JUNG, CHRISTOPHER L. OGDEN, and LILAN REN,
Administrative Patent Judges.

JUNG, *Administrative Patent Judge.*

JUDGMENT
Final Written Decision
Determining Some Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

We have jurisdiction under 35 U.S.C. § 6 (2026). This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73 (2025). For the reasons that follow, we determine that Shenzhen TuoZhu Technology Co., Ltd. (“Petitioner”) has shown by a preponderance of the evidence that claims 1–11 and 13–15, but not claim 12, of U.S. Patent No. 9,168,698 B2 (Ex. 1001, “the ’698 patent”) are unpatentable.

A. Background and Summary

Petitioner filed a Petition (Paper 2, “Pet.”) requesting institution of an *inter partes* review of claims 1–15 of the ’698 patent. Discretionary denial of institution was determined to be not appropriate in this proceeding, and the proceeding was referred to the Board. Paper 10. Pursuant to 35 U.S.C. § 314, we instituted an *inter partes* review of claims 1–15 of the ’698 patent on all presented challenges. Paper 11 (“Inst. Dec.”), 15.

After institution, Patent Owner filed a Response (Paper 19, “PO Resp.”), to which Petitioner filed a Reply (Paper 26, “Pet. Reply”), and Patent Owner, thereafter, filed a Sur-reply (Paper 34, “PO Sur-reply”). An oral hearing in this proceeding was held on July 14, 2026; a transcript of the hearing is included in the record. Paper 38 (“Tr.”).

B. Real Parties in Interest

Petitioner identifies Shenzhen TuoZhu Technology Co., Ltd., Bambulab Limited, Shanghai Lunkuo Technology Co. Ltd., TuoZhu Technology Limited, and Bambulab USA Inc. as the real parties in interest. Pet. 77. Patent Owner identifies Stratasys, Inc. and Stratasys Ltd. as the real parties in interest. Paper 3 (Patent Owner’s Mandatory Notices), 2.

C. Related Matters

The parties identify *Stratasys, Inc. v. Shenzhen TuoZhu Technology Co. Ltd.*, 2-24-cv-00644 (E.D. Tex.) and *BambuLab USA, Inc. v. Stratasys, Inc.*, 1-24-cv-01511 (W.D. Tex.) as related matters. Pet. 77; Paper 3, 2. Patent Owner also identifies IPR2025-00257, IPR2025-00311, IPR2025-00321, IPR2025-00354, IPR2025-00438, IPR2025-00532, IPR2025-00585, and IPR2025-00611. *Id.*

The parties jointly filed a “Verdict Form” (Ex. 2030) and “Defendants’ Disclosure of Final Invalidity Theories, Final Prior Art References/Combinations, and Final Equitable Defenses” (Ex. 2029) from *Stratasys, Inc. v. Shenzhen TuoZhu Technology Co. Ltd.*, 2-24-cv-00644 (E.D. Tex.). The “Verdict Form” indicates that claim 10 of the ’698 patent was not proven to be invalid by the Defendants. Ex. 2030, 5; *see also id.* at 2 (“The ‘’698 Patent’ refers to U.S. Patent No. 9,168,698.”); Ex. 2029, 1–2 (Defendants’ “final invalidity theories” including “[t]he combination of MakerBot Replicator, Bukkapatnam,[□] and Igasaki[□] render[ing] Claim 10 obvious under 35 U.S.C. § 103.”).

For the reasons explained below, in this proceeding, Petitioner shows by a preponderance of the evidence that Calderon and RepRap20208 would have rendered obvious claim 10 but fails to show that Warren would have rendered obvious the same claim. Petitioner also filed a stipulation that “they will not pursue in the 2:24-cv-00644 case or the 1:24-cv-01511 case, against the ’698 Patent, the specific grounds asserted in IPR2025-00531 or any other ground that was raised or could have been reasonably raised in an IPR.” Ex. 1027. The Decision Referring Petitions to the Board found that “Petitioner has also filed a broad stipulation” in reaching its determination

that “Petitioner’s arguments . . . against discretionary denial are persuasive.”
Paper 10, 3.

In view of the above and the facts and circumstances of this proceeding (particularly the different combination of prior art references presented to us), we do not consider our determination for claim 10 of the ’698 patent in this proceeding to be inconsistent with the determination from related litigation.

D. The ’698 Patent (Ex. 1001)

The ’698 patent issued on October 27, 2015 from an application filed on October 29, 2013 and claims priority to a provisional application filed on October 29, 2012. Ex. 1001, codes (22), (45), (60). Figure 1 of the ’698 patent is reproduced below.

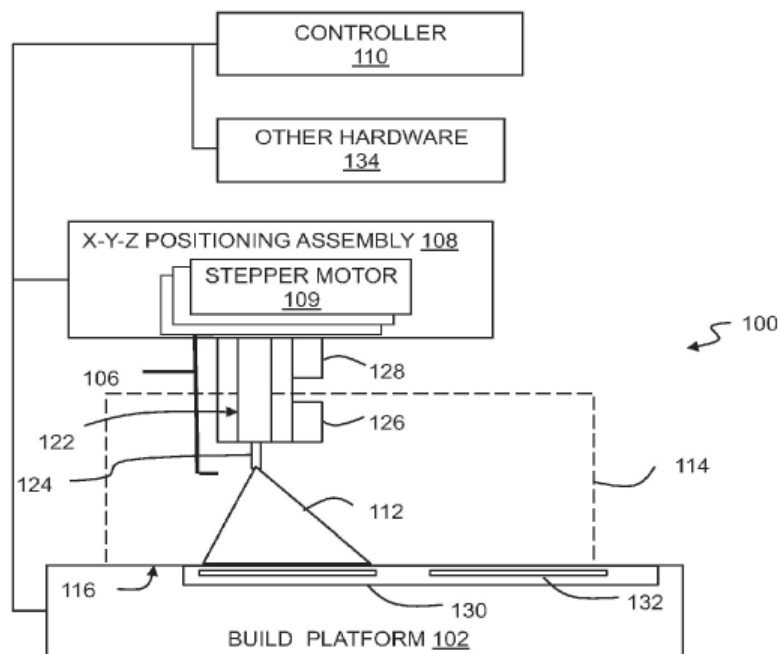


Fig. 1

Figure 1 shows “a block diagram of a three-dimensional printer.”
Ex. 1001, 1:37, 2:7. “In general, the printer 100 may include a build

platform 102, an extruder 106, an x-y-z positioning assembly 108, and a controller 110 that cooperate[s] to fabricate an object 112 within a working volume 114 of the printer 100.” *Id.* at 2:7–11.

The ’698 patent explains that “components of the three-dimensional printer may degrade with time” and “become dented, warped, misaligned, etc.,” leading to “errors [that] may disadvantageously affect the ability of the three-dimensional printer to accurately fabricate objects.” Ex. 1001, 1:14–18. Thus, according to the ’698 patent, there is “a need for pressure-sensing extruders and methods for using same.” *Id.* at 1:18-19.

Figure 6 of the ’698 patent is reproduced below.

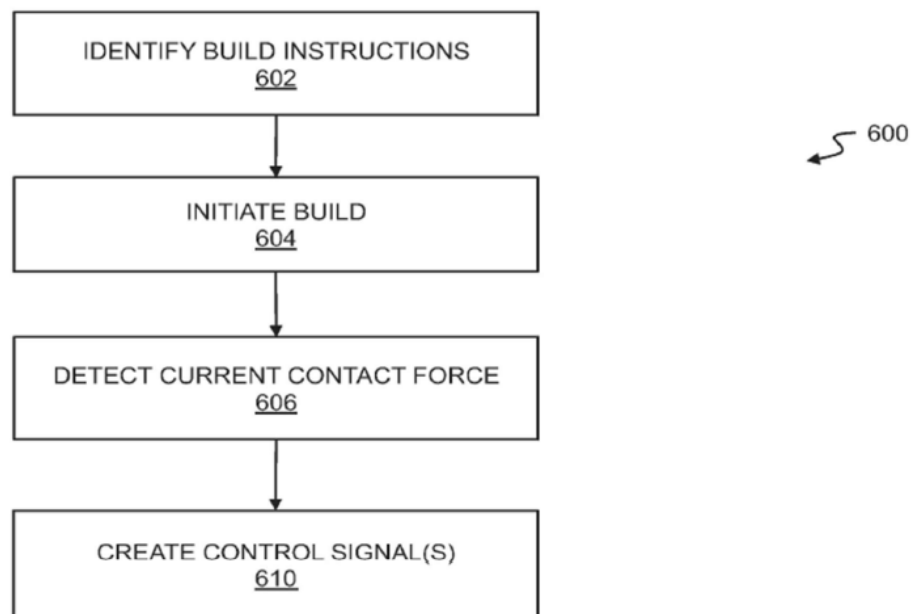


Fig. 6

Figure 6 shows “a flowchart of a process for fabricating an object.” Ex. 1001, 1:44, 10:28. The ’698 patent explains that an “extruder or other tool head” may be instrumented to detect contact force against the extruder, such as by a build platform or an object being fabricated” and “to detect deflection forces and the like acting on the tool that might indicate an

operating error.” Ex. 1001, 1:23–28. “The resulting feedback data” may be used “to control operation of the three-dimensional printer during fabrication or diagnostics.” *Id.* at 1:28-30.

“The three-dimensional printer . . . may for example include a fabrication tool such as an extruder and one or more sensors such as strain gauges mechanically coupled to the fabrication tool.” Ex. 1001, 10:39–44. “The one or more sensors may be configured to detect a current contact force between the fabrication tool and the separate structure, and to provide corresponding data to a controller of the three-dimensional printer for use during fabrication.” *Id.* at 10:44–48. “The current contact force may be used directly as an input to a control program executing on the controller for the three-dimensional printer, or the current contact force may be compared to other data such as a previous contact force or an expected contact force in order to determine an appropriate response.” *Id.* at 10:50–55.

E. Illustrative Claim

The ’698 patent includes 15 claims, all of which Petitioner challenges. Reproduced below is claim 1, the only independent claim.

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.

Ex. 1001, 12:37–49.

F. Asserted Prior Art and Proffered Testimonial Evidence

Petitioner identifies the following references as prior art in the asserted grounds of unpatentability:

Name	Reference	Exhibit
Calderon	US 6,629,011 B1, issued Sept. 30, 2003	1009
Napadensky	US 9,031,680 B2, issued May 12, 2015	1005
Warren	US 2003/0100824 A1, published May 29, 2003	1004
Eshed	US 2007/0179656 A1, published Aug. 2, 2007	1008
RepRap20208	Discussion Thread “ <i>Genetic Algorithms</i> ” (available at https://reprap.org/forum/read.php?1,20208,page=1)	1010

Petitioner contends that Warren, Eshed, Calderon, and RepRap20208 are prior art under § 102(b) and that Napadensky is prior art under § 102(e).¹ Pet. 1–2. Petitioner also provides a Declaration of Andrew Wolfe, Ph.D. Ex. 1003. Petitioner further provides a Declaration of Dr. Adrian Bowyer (Ex. 1014) to support that RepRap20208 is a printed publication, a Declaration of June Munford (Ex. 1015) to support that Exhibit 1013 is a true and correct copy, and a Declaration of Lynn Berthusen (Ex. 1022) to support that RepRap20208 was visited and printed out on December 31, 2024.

Patent Owner provides a Declaration of Dr. Tim A. Osswald. Ex. 2027. Deposition transcripts for Dr. Wolfe (Ex. 2020) and Dr. Osswald (Ex. 1042) were filed.

¹ The relevant sections of the Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112–29, 125 Stat. 284 (Sept. 16, 2011), took effect on March 16, 2013. Because the ’698 patent issued from an application that claims priority to an application filed before that date, our citations to 35 U.S.C. §§ 102 and 103 in this Decision are to their pre-AIA versions. *See also* Pet. 1 (identifying that “the ’698 Patent’s earliest effective date” is October 29, 2012).

G. Asserted Grounds

Petitioner asserts that claims 1–15 are unpatentable on the following grounds:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1–6, 8–15	103	Warren
3, 7, 9	103	Warren, Eshed
1–5, 7–10, 12–15	103	Calderon, RepRap20208
11	103	Calderon, RepRap20208, Napadensky

Pet. 1.

II. ANALYSIS

A. Legal Standards

“In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent [claim] it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016). This burden of persuasion never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail in an *inter partes* review, the petitioner must support its challenges by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

Petitioner contends that the challenged claims of the ’698 patent are unpatentable under § 103. Pet. 1. A claim is unpatentable under § 103 if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying

factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) where in evidence, so-called secondary considerations. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966). When evaluating a combination of teachings, we must also “determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR*, 550 U.S. at 418 (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

B. Level of Ordinary Skill in the Art

Petitioner argues that one of ordinary skill in the art would have had “a bachelor’s degree in Mechanical Engineering, Computer Engineering, Electrical Engineering, or a comparable field and at least two years of experience working with 3D printers” and that “[a]dditional years of experience could substitute for a formal degree (and vice versa).” Pet. 5 (citing Ex. 1003 ¶¶ 20–23). Petitioner also argues that one of ordinary skill in the art “would have possessed background knowledge and understanding of the pertinent technologies employed by the ’698 patent, including implementing sensor-based systems.” *Id.* (citing Ex. 1003 ¶¶ 7–19, 21–23, Appx. A).

Patent Owner responds that one of ordinary skill in the art “would have had a bachelor’s degree in Mechanical Engineering, Computer Engineering, Electrical Engineering, Chemical Engineering, Materials Science, or a comparable field and at least two years of experience related to 3D printing, with additional experience potentially being a substitute for a formal degree or training (and vice versa).” PO Resp. 8 (citing Ex. 2027 ¶¶ 22–26). Patent Owner also argues that “the Petition has failed to show

that the claims of the '698 Patent are unpatentable irrespective of the level of skill of a skilled artisan.” *Id.*

The parties’ proposals for the level of ordinary skill in the art are substantially the same. Pet. 5; PO Resp. 8. Based on the full record, we adopt Petitioner’s proposal. We find that Petitioner’s proposed level of ordinary skill in the art is consistent with the '698 patent and the asserted prior art. Our analysis below would not change if we had adopted Patent Owner’s proposal.

C. Claim Construction

In an *inter partes* review, the claims are construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. [§] 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

37 C.F.R. § 42.100(b); *see Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc).

According to Petitioner, “the Challenged Claims are obvious under any reasonable *Phillips* interpretation,” and “Petitioner submits that the Board need not resolve any express constructions.” Pet. 5. At institution, we did not need to construe expressly any claim language. Inst. Dec. 6. “Patent Owner submits that the Board does not need to construe any claim terms in any particular way to conclude that the challenged claims are not unpatentable.” PO Resp. 8.

In view of the full record, we do not need to interpret expressly any claim term to resolve the parties’ dispute. *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019) (“The Board is required to construe ‘only

those terms that . . . are in controversy, and only to the extent necessary to resolve the controversy.”) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

D. Asserted Obviousness Based on Warren

1. Warren (Ex. 1004)

Warren “relates generally to tools and methods for depositing materials accurately on a selected substrate.” Ex. 1004 ¶ 3. Warren describes 3D printing called “direct-write deposition technology” (“DWDT”), which can be used “for dispensing uniform lines of viscous solutions, suspensions, sols, or pastes to create exact replicas of stored patterns.” *Id.* ¶¶ 10, 11. When a DWDT 3D printing apparatus is employed for “biological, medical, bioengineering, and tissue-engineering,” Warren uses the label “human architecture tool” (“HAT”). *Id.* ¶ 14. “The 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.* ¶ 93.

Warren describes “a system and method for controlling the position of one or more elements of a dispensing system to maintain a desired contact force between the elements.” Ex. 1004 ¶ 288. According to Warren, “vibration of particular amplitude (A) is imparted to one or more of the elements of the dispensing system,” such as “the dispenser, the substrate, or both the dispenser and the substrate.” *Id.* ¶ 289.

“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.” Ex. 1004 ¶ 289. “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.” *Id.*

According to Warren, “the system is sensitive enough to maintain a desired contact force between the dispenser and the substrate.” *Id.* ¶ 290.

Figure 18 of Warren is reproduced below.

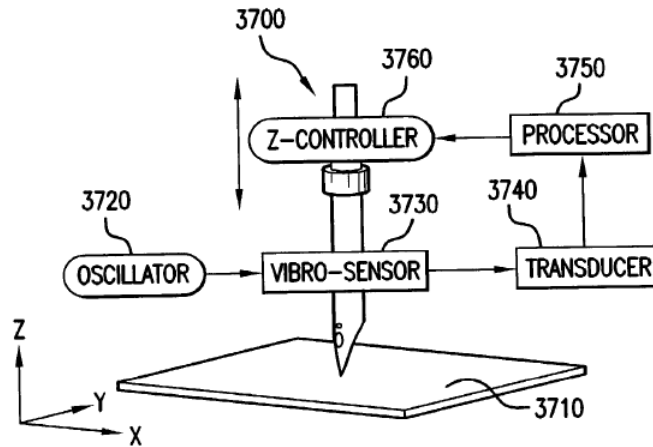


FIG. 18

Figure 18 “is a schematic illustration of an exemplary system for dispensing materials using feedback to control the position of a dispenser according to one embodiment.” Ex. 1004 ¶ 35. Warren’s “vibration oscillator 3720 is attached to the dispenser 3700 for imparting vibration to the dispenser 3700,” and “[a] vibration sensor 3730 and a transducer 3740 are attached to the dispenser 3700 for sensing the A and f of vibration of the dispenser 3700.” *Id.* ¶ 300.

“The vibration imposed on the dispenser 3700 is changed, e.g., modulated, by the contact of the 3700 dispenser with the substrate 3710.” Ex. 1004 ¶ 302. “The transducer 3740 senses and transfers the changed vibration signal to an amplifier (not shown), which then creates a feedback signal that is generally proportional to the intensity of the physical contact of the dispenser 3700 with the substrate 3710.” *Id.* “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.” *Id.*

Figure 22A of Warren is reproduced below.

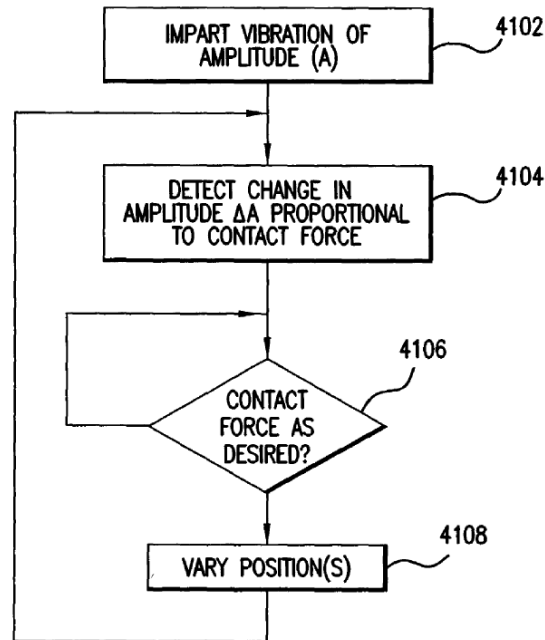


FIG.22A

Figure 22A “is a flow chart of an exemplary method of controlling the position of the elements of a dispensing system.” Ex. 1004 ¶ 39. Warren states that “[a]t step 4104, a change in the amplitude of vibration of the dispenser and/or the substrate is detected,” and that “[t]his change in amplitude is proportional to the force of contact between the dispenser and the substrate.” *Id.* ¶ 313.

2. *Claim 1*

a) “*A method comprising:*”

Petitioner argues that, to the extent the preamble is limiting, Warren discloses it. Pet. 16 (citing Ex. 1003 ¶¶ 74, 75; Ex. 1004 ¶¶ 7–14, 58–63, 93, 230–324, 390–446).

We find that a portion of Warren cited by Petitioner discloses “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” and “*also include the use of the several embodiments of the technologies as an integrated apparatus or tool.*” Ex. 1004 ¶ 93 (emphasis added). We credit Petitioner’s testimonial evidence regarding the preamble, because the cited portions of Warren support it. Ex. 1003 ¶ 74; Ex. 1004 ¶¶ 7–14, 58–63, 93, 230–324, 390–446. Patent Owner does not present a response for the preamble of claim 1. *See* PO Resp. 10–43.

Based on the full record, Petitioner persuades us, and we find, that Warren teaches or suggests the preamble of claim 1. In view of our finding, we do not need to determine if the preamble is limiting.

b) “identifying build instructions for fabricating an object”

Petitioner argues that Warren discloses the above-quoted limitation. Pet. 16–17 (citing Ex. 1003 ¶¶ 76–78; Ex. 1004 ¶¶ 392, 393, 402, 403). Petitioner also argues that ’698 patent indicates that the claim language “is intended to be construed broadly” so that it would include Warren’s asserted teaching. *Id.* at 17 (citing Ex. 1001, 10:28–37; Ex. 1003 ¶¶ 77, 78).

We find that a portion of Warren cited by Petitioner discloses “acquiring an image scan of a selected tissue” and “transforming information obtained from the image scan into computer-aided design and manufacturing (CAD/CAM) data.” Ex. 1004 ¶ 393. Petitioner’s cited portions also disclose that “[o]perators can then compile the data obtained from the various sources to create virtual images of . . . the engineered tissue construct (ETC) to be installed” (*id.* ¶ 402), “operators will then transform the image information obtained in the previous step into computer-aided

design and manufacturing (CAD/CAM) program data” (*id.* ¶ 403), and “[t]his transformation of images into machine language allows the images to be constructed by the HAT computer automation” (*id.*). *See also* Ex. 1001, 10:28–37 (“As shown in step, 602, the process 600 may begin with identifying build instructions for fabricating an object. It will be understood that in this context, the term ‘identifying’ is intended to be construed broadly, and may include retrieving instructions from storage, generating machine-ready code from a three-dimensional model, or modifying other machine-ready code prior to fabrication.”). We credit Petitioner’s testimonial evidence regarding “identifying build instructions for fabricating an object,” because the cited portions of Warren support it. Ex. 1003 ¶¶ 76, 77; Ex. 1004 ¶¶ 392, 393, 402, 403.

Patent Owner does not present a response for the above-quoted step of claim 1. *See* PO Resp. 10–43. Based on the full record, Petitioner persuades us, and we find, that Warren teaches or suggests “identifying build instructions for fabricating an object.”

- 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”*

Petitioner argues that Warren teaches the above-quoted limitations. Pet. 17–20 (citing Ex. 1003 ¶¶ 79–85; Ex. 1004 ¶¶ 63, 93, 288–290, 293–321, 397, 404–415, Figs. 18, 22A, 23A–23C). Petitioner also argues that one of ordinary skill in the art would have understood or found obvious that contact force is calculated from a detected change in the amplitude. *Id.* at 20 (citing Ex. 1003 ¶ 86; Ex. 1004 ¶¶ 301–307, 313). Petitioner further argues that Warren’s vibration sensor and transducer align with the ’698 patent’s

description of its sensors. *Id.* at 20–21 (citing Ex. 1001, 8:49–61; Ex. 1003 ¶¶ 86–87).

(1) Patent Owner’s Response

Patent Owner responds that Warren does not teach the above-quoted step of claim 1, because “Warren does not teach or suggest detecting a current contact force based on the sensor signal” and, instead, “repeatedly refers to detecting a change in amplitude of a vibration, not detecting or calculating a current contact force.” PO Resp. 25–26. Patent Owner argues that Warren detects a change in amplitude of vibration to (1) determine whether there is desired contact force, (2) vary the position of its dispenser or substrate, and (3) use as feedback to control the contact force between the dispenser and substrate. *Id.* at 26–27 (citing Ex. 1004 ¶¶ 289, 313, 315).

Patent Owner also argues that there is no teaching or suggestion to detect or calculate a current contact force. PO Resp. 27 (citing Ex. 2025, 62, Fig. 3.16; Ex. 2026, 47–56, Fig. 2.32; Ex. 2027 ¶¶ 161–167). Patent Owner further argues that “Petitioner concedes that Warren detects a change in amplitude of vibration and not a current contact force.” *Id.* at 25–26 (citing Pet. 20; Ex. 1004 ¶ 313). According to Patent Owner, Petitioner resorts to impermissible hindsight. *Id.* at 26.

Patent Owner also responds that it would not have been obvious to detect or calculate the current contact force from the detected change in amplitude, because Warren does not explain how to detect current contact force from a change in amplitude and simply states that current contact force and the change in amplitude are proportional. PO Resp. 27 (citing Pet. 20–21; Ex. 1003 ¶¶ 86–87; Ex. 1004 ¶ 315; Ex. 2027 ¶¶ 170–189). Patent Owner argues by reference to Warren’s Figure 21 that “Warren fails to teach how to detect the current contact force from the change in amplitude or

provide a motivation for doing so.” *Id.* at 27–29 (citing Ex. 1004 ¶ 306, Fig. 21; Ex. 2020, 77:5–20; Ex. 2027 ¶¶ 168, 170–173, 175, 181).

Patent Owner also argues that Petitioner fails to provide evidence that detecting current contact force from Warren’s change in amplitude was known. PO Resp. 29 (citing Ex. 2027 ¶¶ 176–188). According to Patent Owner, there were many challenges in detecting current contact force from Warren’s change in amplitude, including selection of the appropriate frequency and compensating for the composition of the substrate. *Id.* at 29–32 (citing Ex. 1004 ¶¶ 293, 295, 316; Ex. 2020, 72:13–73:16, 89:2–21; Ex. 2024, Fig. 4.1; Ex. 2027 ¶¶ 166, 179–183, 185–188).

Patent Owner further responds that there would have been no motivation to detect current contact force from Warren’s change in amplitude, because there is no comparison between current contact force and desired contact force, as asserted by Petitioner. PO Resp. 32 (citing Pet. 27–28). In Patent Owner’s view, Warren determines desired contact force by detecting a change in amplitude, and, thus, one of ordinary skill in the art would have understood that the change itself is used to indicate desired contact force. *Id.* (citing Ex. 1004 ¶¶ 302, 306, 311, 313, Figs. 21, 22A; Ex. 2027 ¶ 189).

Patent Owner also argues that the ’698 patent does not describe obtaining the current contact force from Warren’s change in amplitude. PO Resp. 32–33 (citing Ex. 1001, 8:56–61; Ex. 1004 ¶ 306, Fig. 21; Ex. 2027 ¶ 190). Patent Owner, thus, argues that Warren would not have rendered obvious claim 1. *Id.* at 33 (citing Ex. 2027 ¶¶ 156–191).

(2) Reply Arguments

Petitioner replies that the ’698 patent uses sensors broadly to encompass many things, including Warren’s vibration sensors. Pet. Reply 3

(citing Ex. 1001, 8:49–9:8; Ex. 1003 ¶¶ 90, 91). Petitioner argues that Warren teaches detecting contact force from a change in amplitude, and that the claims do not require calculating contact force, only detecting it. *Id.* at 3–4 (citing Pet. 20–21; PO Resp. 25–33; Ex. 1001, claim 1; Ex. 1003 ¶¶ 46–48, 80–87, 90, 91; Ex. 1004 ¶¶ 287, 302, 313–316).

Petitioner also replies that Warren maintains a desired contact force, as acknowledged by Patent Owner, and that Warren addresses a need for accurately determining contact force intensity that is built into its operating principles. Pet. Reply 4–6 (citing Pet. 21–22; PO Resp. 26, 27; Ex. 1003 ¶ 91; Ex. 1004 ¶¶ 283, 287, 289, 313–316, Fig. 22A, claims 54–56, 61, 65–67, 72). According to Petitioner, Warren teaches controlling the position of its dispenser by comparing detected and desired contact forces. *Id.* at 6 (citing Pet. 15, 19–27, 33; Ex. 1003 ¶¶ 80–89; Ex. 1004 ¶¶ 301–316, 322, 324, Fig. 22A).

Petitioner further replies that it would have also been obvious to determine contact force from Warren’s change in amplitude, because to control force intensity, it would have been understood that the difference between detected and desired forces would have to be known. Pet. Reply 6 (citing Pet. 17–21; Ex. 1003 ¶ 86; Ex. 1004 ¶¶ 301–307, 313). Petitioner argues that Warren provides an express motivation. *Id.* at 6–7 (citing Pet. 9, 15, 19–21, 31; Ex. 1003 ¶¶ 46, 71, 85–91; Ex. 1004 ¶¶ 285, 301–307, 313–316). Petitioner also argues that Patent Owner’s assertions support that determining contact force is feasible. *Id.* at 8–9 (citing Pet. 23; PO Resp. 32; Ex. 1003 ¶ 95; Ex. 1042, 80:2–81:6, 100:13–104:14; Ex. 2024, 6–8; Ex. 2027 ¶ 182).

Patent Owner replies that Petitioner does not address its argument that contact force is not detectable from a change in amplitude. PO Sur-reply 4

(citing PO Resp. 25–33; Pet. Reply 3–9). Patent Owner argues again that detecting a change in amplitude is not detecting contact force, and that Petitioner misreads Warren as comparing vibrating force to desired force. *Id.* at 5–6 (citing PO Resp. 15–16, 18–19, 21–22, 24–25, 26–27; Pet. Reply 5–7; Ex. 1004 ¶¶ 278, 279, 289, 312, 313, 315, 316, 317, 361; Ex. 2027 ¶¶ 126–134, 163–170).

Patent Owner further replies that Petitioner presents an improper, new theory about the necessity of detecting contact force. PO Sur-reply 6–7 (citing Pet. Reply 5–6). Patent Owner reiterates that Warren detects substrate contact by change in amplitude and contact is maintained if the feedback signal based on the amplitude change is at a constant level. *Id.* at 6 (citing PO Resp. 26–27; Ex. 1004 ¶¶ 289, 312, 313, Fig. 22A).

Patent Owner argues that the alternative obviousness theory is based on the flawed necessity argument, that Petitioner presents attorney argument about force intensity being a component of a force vector, and that obviousness requires more than just the ability to be determined. PO Sur-reply 6–8 (citing Pet. Reply 6–9). According to Patent Owner, it would not have been obvious to detect a contact force from Warren’s amplitude change. *Id.* at 8 (citing PO Resp. 27–33; Ex. 2027 ¶¶ 156–191). Patent Owner also argues that its declarant explained that determining contact force from amplitude changes is more than looking up material properties and that there is no support that the calculation was commonplace. *Id.* at 8–9 (citing Pet. 23; Pet. Reply 8–9; Ex. 1003 ¶ 95; Ex. 1004 ¶¶ 168, 181, Fig. 21; Ex. 2027 ¶¶ 178–181).

(3) *Petitioner Persuades Us that Warren Teaches or Suggests the Limitations*

(a) *“initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool”*

We find that a portion of Warren cited by Petitioner discloses that “a tool capable of producing a modeled structure through 3D direct construction of various materials into complex shapes” and “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.” Ex. 1004 ¶ 93. We also find that cited Figures 23A–23C show “a fabrication tool.” *See also id.* ¶ 278 (stating that “[o]ne specific embodiment of the tabletop in vitro tool design is . . . illustrated in FIGS. 23A-23C” and that “this embodiment includes four material dispensers, one through-nozzle dispenser and three capillary-based dispensers”). We further find that Warren discloses vibration sensor 3730 and transducer 3740 are attached to dispenser 3700. *Id.* ¶¶ 300, 315, Fig. 18.

We credit Petitioner’s testimonial evidence regarding “initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool,” because the cited portions of Warren support it. Ex. 1003 ¶¶ 79–84; Ex. 1004 ¶¶ 63, 93, 288–290, 293–321, 397, 404–415, Figs. 18, 21, 23A–23C. Patent Owner does not dispute that Warren discloses the above-quoted limitations. *See* PO Resp. 25–33.

(b) *“the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure”*

Patent Owner, instead, disputes that Warren teaches, suggests, or would have rendered obvious “one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure.” See PO Resp. 25–33. Turning to Petitioner’s arguments and evidence regarding the detection of current contact force, we find that Petitioner cites a portion of Warren that discloses it “is directed to a system and method for controlling the position of one or more elements of a dispensing system to maintain a desired contact force between the elements.” Ex. 1004 ¶ 288. Petitioner also cites a portion that discloses “vibration of particular amplitude (A) . . . may be imparted to the dispenser, the substrate, or both the dispenser and the substrate” and that “[a] change in the amplitude of vibration (ΔA) of the dispenser, the substrate, or both the dispenser and the substrate upon contact with each other, is detected by the system.” *Id.* ¶ 289.

Another cited portion of Warren discloses that “a change in the amplitude of vibration of the dispenser and/or the substrate is detected,” and that “this change in amplitude is proportional to the force of contact between the dispenser and the substrate.” Ex. 1004 ¶ 313; *see also id.* Fig. 22A (showing “detect change in amplitude ΔA proportional to contact force” at block 4104). “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,” and “[t]he positions of the dispenser, the substrate, or the dispenser and the substrate may be controlled in this manner.” *Id.* ¶ 289; *see also id.* ¶¶ 293–318 (describing embodiments with such control in Figs. 18, 19, 20A, 20B, 22, 22A, 40).

We credit Petitioner’s testimonial evidence that Warren teaches, suggests, or would have rendered obvious, detecting the current contact force between a fabrication tool and a separate structure, because the cited portions of Warren support it. Ex. 1003 ¶¶ 85, 86; Ex. 1004 ¶¶ 31–307, 313, Fig. 18, 19, 22A. We agree with Petitioner’s declarant that Warren’s vibration sensor and transducer would be “sensors that are collectively operable to sense any force . . . of the fabrication tool and separate structure” and so “may be used as sensors 302,” as described by the ’698 patent. Ex. 1001, 8:56–59; Ex. 1003 ¶ 86.

Turning to Patent Owner’s responsive arguments, Patent Owner does not dispute that Warren discloses detecting a change in amplitude of vibration and determining whether there is desired contact force “based on the detected change in amplitude.” PO Resp. 26 (citing Ex. 1004 ¶¶ 289, 313). Because Warren also discloses that the “change in amplitude is proportional to the force of contact between the dispenser and the substrate,” we find that one of ordinary skill in the art would have understood that Warren teaches or suggests detecting a current contact force by detecting “a change in the amplitude of vibration of the dispenser and/or the substrate.” Ex. 1004 ¶ 313.

Thus, even if Warren does not directly detect current contact force, as argued by Patent Owner, Warren discloses detecting the change in amplitude to detect whether the current contact force is the desired contact force “based on the detected change in amplitude.” Ex. 1004 ¶ 313, Fig. 22A. In other words, Warren teaches or suggests using the change in amplitude as an indirect way to detect the contact force, because Warren expressly teaches that the two are proportional. *Id.* ¶ 313, Fig. 22A. Because Warren further discloses that 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,” Warren teaches or suggests that the “detected ΔA ” represents the current contact force. *Id.* ¶ 289. We agree with Patent Owner that one of ordinary skill in the art “would have understood from Warren’s teachings that the change in amplitude itself is used to indicate desired contact.” PO Resp. 32; Ex. 2027 ¶ 189.

In view of our findings, we determine that these teachings are well within the scope of the claim language “one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure.” Patent Owner’s arguments appear to limit the claim language to direct detection of current contact force, but such a claim interpretation was not presented and finds no support in the record. *See* PO Resp. 8 (“Patent Owner submits that the Board does not need to construe any claim terms in any particular way to conclude that the challenged claims are not unpatentable”). Also, in view of our findings, we do not agree with Patent Owner that Petitioner is resorting to impermissible hindsight. *Id.* at 26.

As for Patent Owner’s arguments regarding the calculation of current contact force, the claim only requires “one or more *sensors configured to detect a current contact force* between the fabrication tool and a separate structure,” not configured to calculate the current contact force. Also, in view of our findings and the claim language in dispute, we do not need to reach Petitioner’s theory that the ordinarily skilled artisan “would have understood or found it obvious that the *contact force* can be readily calculated from the detected ‘change in the amplitude.’” Pet. 20–21.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests “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.”

d) “detecting the current contact force based on a sensor signal from the one or more sensors”

Petitioner argues that Warren teaches the above-quoted limitations. Pet. 21 (citing Ex. 1003 ¶¶ 88, 89; Ex. 1004 ¶¶ 302, 313). For the reasons given above for “the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure,” we find that Warren teaches or suggests “detecting the current contact force based on a sensor signal from the one or more sensors.” We also credit Petitioner’s testimonial evidence regarding the above-quoted step of claim 1, because the cited portions of Warren support it. Ex. 1003 ¶ 88; Ex. 1004 ¶¶ 302, 313.

Patent Owner responds with the same arguments summarized above that Warren does not disclose and would not have rendered obvious detecting the current contact force. PO Resp. 25–33. Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests “detecting the current contact force based on a sensor signal from the one or more sensors.”

e) “creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build”

Petitioner argues that Warren teaches the above-quoted limitations. Pet. 21–23 (citing Ex. 1003 ¶¶ 90, 91; Ex. 1004 ¶¶ 286, 287, 293, 301–304, 309, 313, 316, Figs. 18, 22A).

We find that a portion of Warren cited by Petitioner discloses that “[t]he transducer 3740 senses and transfers the changed vibration signal to an amplifier (not shown), which then creates a feedback signal that is

generally proportional to the intensity of the physical contact of the dispenser 3700 with the substrate 3710” and “[t]he 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.” Ex. 1004 ¶ 302. Another cited portion of Warren describes “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.” *Id.* ¶ 313.

The method includes detecting “a change in the amplitude of vibration of the dispenser and/or the substrate” and that “[t]his change in amplitude is proportional to the force of contact between the dispenser and the substrate.” Ex. 1004 ¶ 313. Then, “a determination is made whether the contact force is that which is desired, based on the detected change in amplitude.” *Id.* If it is not, then the position of the dispenser or the substrate is varied. *Id.* We credit Petitioner’s testimonial evidence regarding the above-quoted step of claim 1, because the cited portions of Warren support it. Ex. 1003 ¶¶ 90, 91; Ex. 1004 ¶¶ 293, 301–304, 309, 313, 316, Figs. 18, 22A.

Patent Owner responds with the same arguments summarized above that Warren does not disclose and would not have rendered obvious detecting the current contact force. PO Resp. 25–33. Based on the full record and for the reasons discussed above, Petitioner persuades us, and we find, that Warren teaches or suggests “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.”

f) Reason to Modify

Petitioner argues that Warren suggests combining aspects of its disclosure. Pet. 13 (citing Ex. 1004 ¶¶ 93, 230–252, 283–318). Petitioner also argues that one of ordinary skill in the art would have been motivated to

apply Warren’s through-nozzle dispenser as the dispenser in the vibrating force sensor configuration. *Id.* (citing Ex. 1003 ¶ 67; Ex. 1004 ¶¶ 226–252, 283–318). Petitioner provides several motivations in support. *Id.* at 13–16.

Patent Owner responds to the asserted motivations. PO Resp. 16–25. The parties also provide reply arguments. Pet. Reply 1–3; PO Sur-reply 1–4. During oral argument, Petitioner’s counsel indicated that the proposed modification is not necessary for the challenge to claim 1. *See* Tr. 40:24–41:24. Petitioner proposes the modification to reach certain dependent claims. *See id.* at 41:12–21.

We, therefore, analyze the parties’ dispute regarding the proposed modification below in our discussion of dependent claims 3 and 9.

g) Objective Evidence of Nonobviousness

Patent Owner does not present any objective evidence of nonobviousness in connection with any claim of the ’698 patent. *See* PO Resp.

h) Petitioner Shows that Claim 1 is Unpatentable over Warren

“Once all relevant facts are found, the ultimate legal determination [of obviousness] involves weighing of the fact findings to conclude whether the claimed combination would have been obvious to an ordinary artisan.”

Arctic Cat Inc. v. Bombardier Recreational Prods. Inc., 876 F.3d 1350, 1361 (Fed. Cir. 2017) (quoting *In re Cyclobenzaprine Hydrochloride Extended-Release Capsule Patent Litig.*, 676 F.3d 1063, 1068–69 (Fed. Cir. 2012)).

Above, based on the full record before us, we provide our factual findings regarding (1) the level of ordinary skill in the art, (2) the scope and content

of the prior art, (3) any differences between the claimed subject matter and the prior art, and (4) objective evidence of nonobviousness.

In particular, we find that (1) Petitioner’s proposed level of ordinary skill in the art is consistent with the prior art of record, (2) Warren teaches or suggests all the limitations of claim 1, and (3) no objective evidence of nonobviousness has been asserted in connection with any claim.

Weighing these underlying factual determinations, a preponderance of the evidence persuades us that claim 1 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

3. Claim 2

Claim 2 depends from claim 1 and recites “wherein the fabrication tool includes an extruder.” Ex. 1001, 12:50–51. Petitioner argues that Warren teaches the subject matter of claim 2. Pet. 23–25 (citing Ex. 1003 ¶¶ 93–96; Ex. 1004 ¶¶ 230–252, 295, 299, Figs. 18–20B, 23A–23C).

We find that the cited portions of Warren disclose apparatus 10 with dispensers 100 and that capillary vibro-sensor dispenser “forces, e.g., fluid or paste, in a reservoir 3850 through the tip 3840 of a syringe using air pressure applied from a source 3810.” Ex. 1004 ¶ 295, Figs. 18–20B, 23A–23C. We also credit Petitioner’s cited testimonial evidence because Warren supports it. Ex. 1003 ¶¶ 94, 96; Ex. 1004 ¶¶ 295, 299, Figs. 18–20B, 23A–23C. We agree that Warren’s teachings parallel an embodiment of the ’698 patent. Pet. 24–25; Ex. 1001, 2:45–47; Ex. 1003 ¶ 97; Ex. 1021, 3:14–38.

Patent Owner argues that Warren would not have rendered obvious claim 2 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192).

Based on the full record, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 2. Weighing

our underlying factual determinations, a preponderance of the evidence persuades us that claim 2 of the '698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

4. Claim 3

Claim 3 depends from claim 2 and recites “wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.” Ex. 1001, 12:52–54.

As discussed above, Petitioner proposes modifying Warren to reach certain dependent claims. Tr. 41:12–21. In its arguments for claim 1, Petitioner contends that Warren suggests combining aspects of its disclosure. Pet. 13 (citing Ex. 1004 ¶¶ 93, 230–252, 283–318). Petitioner proposes applying Warren’s through-nozzle dispenser as dispenser 3700 in the vibrating force sensor configuration. *Id.* (citing Ex. 1003 ¶ 67; Ex. 1004 ¶¶ 226–252, 283–318).

Petitioner argues that one of ordinary skill in the art would have been motivated to do so, because Warren states that “dispenser 3700 may be implemented differently” and is not limited to the implementation described. Pet. 13–14 (citing Ex. 1004 ¶¶ 294, 299). According to Petitioner, the proposed combination would be combining known elements using known techniques to achieve predictable results. *Id.* at 14 (citing Ex. 1003 ¶ 68).

Another motivation, Petitioner argues, would be that, because of its more precise flow control capability via its linear actuator 144, the through-nozzle design would be used in dispenser 3700. Pet. 14 (citing Ex. 1003 ¶ 69; Ex. 1004 ¶ 243). Petitioner also argues that linear actuator 144 is conventional and its inclusion in dispenser 3700 would be a predictable combination suggested by Warren’s statement that aspects in some

embodiments can be combined. *Id.* at 14–15 (citing Ex. 1003 ¶ 70; Ex. 1004 ¶¶ 93, 243).

Petitioner further argues that applying vibration force sensing to the through-nozzle dispenser would avoid damage to the nozzle or substrate, facilitate control over the deposition geometry, and overcome issues with agglomeration or sticking. Pet. 15–16 (citing Ex. 1003 ¶ 71; Ex. 1004 ¶ 286). Petitioner additionally argues that the proposed combination is nothing more than integrating complementary teachings from the same reference related to the same technology. *Id.* at 16 (citing Ex. 1003 ¶ 66).

For claim 3, Petitioner argues that Warren teaches controlling the flow of material by adjusting valve 130 and synchronizing the valving mechanism with the xyz motion of the dispenser. Pet. 25 (citing Ex. 1003 ¶¶ 99, 100; Ex. 1004 ¶¶ 230–252, Figs. 11A–11D, 12A, 12B). Petitioner also argues that, “[i]n view of Warren’s teaching that the z-height be controlled based on contact force, it would have been apparent or obvious . . . that control signals to the z-controller step motor for adjusting the z-position of the dispenser based on contact force result in corresponding control signals to the linear actuator to provide synchronous adjustments to the flow of material from the dispenser.” *Id.* (citing Ex. 1003 ¶ 101).

Petitioner further argues that Warren teaches changing valve position in “trouble spots.” Pet. 25 (quoting Ex. 1004 ¶ 238). Petitioner, thus, argues that it would have been known, or found obvious, that “the same contact force sensing enabling dispensing onto conformal surfaces would identify these trouble spots” and Warren teaches closing the valve in response. *Id.* at 25–26 (citing Ex. 1003 ¶ 102; Ex. 1004 ¶ 238).

a) Patent Owner's Response

For claim 1, Patent Owner responds that Petitioner's reasons to combine are insufficient. PO Resp. 16 (citing Pet. 13–16), 25 (citing Ex. 2027 ¶¶ 117–155). In particular, Patent Owner responds that Warren does not invite using vibration sensing with its through-nozzle design. *Id.* at 17 (citing Pet. 13–14). Patent Owner argues that Warren merely states that dispenser 3700 is not limited to the implementations shown in Figures 19, 20A, and 20B, and there is no motivation to implement dispenser 3700 as a through-nozzle design. *Id.* at 17–18 (citing Ex. 1004 ¶¶ 295, 298–300, Figs. 18, 19, 20A, 20B, 23A–23C; Ex. 2027 ¶¶ 119–125).

Patent Owner also responds that Warren's capillary dispenser already provides high precision, Warren teaches switching from the through-nozzle dispenser to the capillary dispenser for higher detail and precision, and Warren teaches using a through-nozzle design for less detailed dispensing. PO Resp. 18–19 (citing Pet. 14; Ex. 1004 ¶¶ 260, 278; Ex. 2027 ¶¶ 126–134), 19–20 (citing Ex. 1004 ¶¶ 243, 260, 279, 298; Ex. 2027 ¶¶ 126–134, 145, 146, 154). Patent Owner, thus, argues there would have been no motivation to use the less-precise through-nozzle dispenser for high precision. *Id.* at 19.

Patent Owner further responds that there is no motivation to include a linear actuator in the capillary dispensers or quill-pen designs, because the suggestion to combine aspects applies only to combining tools, not adding features from one design to another. PO Resp. 20–21 (citing Pet. 14–15; Ex. 1004 ¶ 93, Figs. 2A–2F; Ex. 2027 ¶¶ 135–144). Patent Owner argues that Petitioner relies on impermissible hindsight, because there is no need for a linear actuator to open and close capillary dispensers. *Id.* at 21–22 (citing Ex. 1004 ¶¶ 231, 234, 260, 279, 298; Ex. 2027 ¶¶ 145–147).

Patent Owner also argues that there is no motivation to provide Warren's through-nozzle dispenser with vibrating force sensor capabilities, because the through-nozzle dispenser is controlled through the xyz motion of the dispenser to enable precise control of deposition geometry. PO Resp. 22–24 (citing Pet. 15–16; Ex. 1004 ¶¶ 227, 228, 234, 243, Fig. 36; Ex. 2027 ¶¶ 147–152). Patent Owner notes that the proposed combination is to apply the through-nozzle to dispenser 3700, not the other way around, as implicated by Petitioner's assertion to add vibrating force sensor capabilities to the through-nozzle dispenser. *Id.* at 22 (citing Pet. 13).

Patent Owner also responds that Warren teaches that other dispensers have a specific need for vibration control. PO Resp. 24 (citing Pet. 15–16; Ex. 1004 ¶¶ 234, 260, 278, 279, 295, 298). Patent Owner argues that the agglomeration issue is related to the quill-pen dispenser. *Id.* (citing Ex. 1004 ¶¶ 298, 331, 332). Patent Owner, thus, argues that there would be no reason to apply a solution for dispensing inks to the through-nozzle dispenser. *Id.* at 24–25 (citing Ex. 2027 ¶¶ 153, 154).

For claim 3, Patent Owner responds that Warren would not have rendered it obvious “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192). Patent Owner also responds that Petitioner resorts to hindsight bias. *Id.* at 33–34 (citing Pet. 25–26). Patent Owner further responds that there is no motivation to use Warren's vibration sensing with its through-nozzle design and no motivation to use the through-nozzle design for precise control, for which Warren uses its quill pen or capillary dispenser. *Id.* at 34 (citing Ex. 1004 ¶¶ 295–300, Figs. 11A–11D, 12A, 12B, 18–20B; Ex. 2027 ¶¶ 119–125, 197), 35 (citing Ex. 1004 ¶¶ 227–234; Ex. 2027 ¶¶ 147–155, 200).

Patent Owner also argues that there is no motivation to use a linear actuator with Warren's capillary or quill-pen designs, because "Warren simply describes a combination tool that integrates different device and explains that capillary or quill-pen designs already achieve precise control of the material flow." PO Resp. 34–35 (citing Ex. 1004 ¶¶ 93, 260, 279; Ex. 2027 ¶¶ 135–146, 199). Patent Owner further argues that "the synchronization of xyz motion of the dispenser for the linear actuator and valve of the through-nozzle design (and identified trouble spots) is not responsive to a current contact force," because the valve can be opened independently before any motion and the valve is not responsive to detected contact force. *Id.* at 35 (citing Ex. 1004 ¶ 235; Ex. 2027 ¶¶ 201–205).

According to Patent Owner, one of ordinary skill in the art would have understood that valve position changes near the end of motion or at certain trouble spots are not responsive to detected contact force and independent of contact force. PO Resp. 35–36 (citing Ex. 2027 ¶¶ 201–205). Patent Owner argues that one of ordinary skill in the art "would have understood that Warren's vibrating sensor solution would move the position of the dispenser to conform to the surface, as Warren teaches, rather than replacing Warren's teaching with a change to the valve position." *Id.* at 36 (citing Ex. 1004 ¶ 313).

Patent Owner also argues that, in volumetric invariant mode, valve position controls the amount of material dispensed per second, not in response to contact force, and that, in a combination approach, the dispenser does not vary in response to contact force. PO Resp. 36–37 (citing Ex. 1004 ¶¶ 239, 240; Ex. 2027 ¶¶ 201–205). Patent Owner, thus, argues that Petitioner's mapping for the recited "component" and "control signal" are

not “in response to the current contact force.” *Id.* at 37 (citing Ex. 2027 ¶¶ 193–205).

b) Reply Arguments

Petitioner replies that both Warren’s through-nozzle and capillary dispensers are relied upon, and that Warren’s capillary dispenser is the fabrication tool and uses vibration force sensing. Pet. Reply 1 (citing Pet. 6–21). According to Petitioner, Patent Owner does not dispute that Warren’s capillary dispenser uses vibrating force sensing. *Id.* (citing PO Resp. 24).

Petitioner points to Warren’s claims 54–59 and 65–70 to support that vibration sensing is used with the through-nozzle. Pet. Reply 2. Petitioner, thus, argues that Warren supports that vibrating force sensor concepts are used with other configurations. *Id.* (citing Pet. 12–15; Ex. 1003 ¶¶ 68–72). Petitioner also argues that Warren expressly teaches that its through-nozzle design has precise rate and speed control. *Id.* at 3 (citing Ex. 1003 ¶ 69; Ex. 1004 ¶¶ 234, 243).

Patent Owner replies that Petitioner does not contest its responsive arguments and, instead, presents a new theory. PO Sur-reply 1–2 (citing Pet. 13–16; PO Resp. 10–25; Pet. Reply 1–3). Patent Owner argues that Petitioner cites new portions of Warren and the cited claims of Warren do not support the proposed combination, because they are directed to dispensers with multiple tools. *Id.* at 2–3 (citing PO Resp. 10–25; Ex. 1004 ¶¶ 278, 318, Figs. 23A–23C). Patent Owner also argues that Warren teaches that its through-nozzle is less precise, thus undermining Petitioner’s motivation to combine. *Id.* at 3–4 (citing PO Resp. 15–16, 18–19, 24–25; Pet. Reply 2; Ex. 1004 ¶ 278, Figs. 23A–23C; Ex. 2027 ¶¶ 126–134, 153, 154).

c) Petitioner Shows that Claim 3 is Unpatentable

We find that Petitioner cites portions of Warren that disclose “dispenser 3700 may be implemented differently, depending upon the application” (Ex. 1004 ¶ 294), “[f]or example, capillary vibro-sensor dispensing units, such as that depicted in FIG. 19” (*id.* ¶ 295) and “[a]s another example, a quill-pen may be used . . . [as] shown in detail in FIGS. 20A and 20B” (*id.* ¶ 298). *See also* Pet. 13 (citing Ex. 1004 ¶¶ 226–252, 283–318). Warren describes both capillary and quill-pen dispensers as “exemplary.” Ex. 1004 ¶¶ 295, 296, 298. Warren reiterates that “[t]he material dispensers illustrated in FIGS. 19, 20A and 20B are shown by way of example only” and immediately follows that statement with the disclosure that “dispenser 3700 need not be limited to these implementations.” *Id.* ¶ 299. In view of the disclosures above, we find that Warren expressly does not limit dispenser 3700 to any particular implementation, as argued by Patent Owner. *Id.* ¶¶ 294–296, 298, 299.

We also find that Petitioner cites portions of Warren that disclose “material dispenser 100 may include a through-nozzle design” that can include “linear actuator 144 to control valve opening and closing” and “valve 130 near the point of dispensing.” Ex. 1004 ¶ 231. We further find that another cited portion discloses that “[t]he rate and degree of valve opening and closing may be dynamically controlled by using a conventional linear actuator 144 to control the valve 130, which provides a means to control precisely the rate (speed) and the degree of valve opening and closing” and that “the valving mechanism may be synchronized with the xyz motion of the dispenser.” *Id.* ¶ 234. Warren also discloses that the valve’s “position is not changed until near the end of the motion or at certain ‘trouble spots’ in the middle of a path.” *Id.* ¶ 238.

Based on our findings above, Petitioner persuades us that one of ordinary skill in the art would have applied Warren's through-nozzle dispenser as dispenser 3700 in the vibrating force sensor configuration. We credit Petitioner's testimonial evidence because its citations to Warren support the testimony. Ex. 1003 ¶¶ 66–70, 100–103; Ex. 1004, 226–252, 283–318.

We agree with Petitioner's declarant that Warren provides express motivation and suggestion for the proposed modification (Ex. 1003 ¶¶ 69, 70), and that the proposed modification would have represented combining known elements using known techniques to achieve predictable results and would have been nothing more than integrating complementary teachings from the same reference related to the same technology (*id.* ¶¶ 66, 68). Because the proposed modification involves integrating complementary teachings from the same reference, we also determine that there would have been a reasonable expectation of success.

We also agree with Petitioner's declarant that, because the valve “may be synchronized with the xyz motion of the dispenser” and z-height may be controlled based on contact force, there would have been control signals to the z-controller step motor for adjusting z-height and corresponding control signals to the linear actuator of the through-nozzle dispenser to provide synchronous adjustment of material flow from the dispenser, such as closing the valve in “trouble spots.” Ex. 1003 ¶ 101; Ex. 1004 ¶¶ 234, 238, 239, 243, 244, 302. Petitioner, thus, shows that its modification to Warren would have had “at least one component of the three-dimensional printer [that] controls a feed rate for a build material used in the build,” as required by claim 3.

Turning to Patent Owner’s responsive arguments, we find that Warren motivates or suggests using the through-nozzle design in dispenser 3700. Ex. 1003 ¶¶ 69, 70; Ex. 1004 ¶¶ 294–296, 298, 299. We, thus, disagree that there is no invitation or motivation for Petitioner’s proposed modification. PO Resp. 16–18.

Regarding Warren’s capillary dispenser already providing high-precision and, therefore, failing to provide a motivation or reason to use the through-nozzle dispenser for high-precision (PO Resp. 18–21, 22–25, 34–35), we find that Warren does provide a motivation or suggestion to use the through-nozzle dispenser, because “dispenser 3700 may be implemented differently, depending upon the application.” Ex. 1004 ¶¶ 294–296, 298, 299. We also determine that the proposed modification would have represented combining known elements using known techniques to achieve predictable results and would have been nothing more than integrating complementary teachings from the same reference related to the same technology. Ex. 1003 ¶¶ 66, 68.

Also, because we find that Warren motivates or suggests Petitioner’s proposed modification, we do not agree that Petitioner relies on impermissible hindsight or hindsight bias. PO Resp. 21–22, 33–34. Further, Patent Owner’s argument that the valve position in Petitioner’s proposed modification is not responsive to detected contact force does not address the proposed modification. PO Resp. 35–37. Petitioner’s proposed modification would have (1) control signals to the z-controller step motor for adjusting z-height *based on contact force* and (2) *corresponding control signals to the linear actuator* of the through-nozzle dispenser *to provide synchronous adjustment of material flow from the dispenser*, such as closing the valve in “trouble spots.” Pet. 25–26; Ex. 1003 ¶¶ 101, 103. In other

words, Petitioner proposes having a control signal to the linear actuator of the through-nozzle dispenser that is synchronized to z-height adjustment so that the control signal is ultimately based on the contact force. *See* Pet. 26 (“both of which are controlled based on contact force”); Ex. 1003 ¶ 103.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 3 and that one of ordinary skill in the art would have made the proposed modification with a reasonable expectation of success. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 3 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

5. Claim 4

Claim 4 depends from claim 2 and recites “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.” Ex. 1001, 12:55–58.

Petitioner argues that “Warren discloses creating a control signal ‘to control the position of the dispenser 3700.’” Pet. 26–27 (citing Ex. 1004 ¶ 302, Fig. 18). Petitioner also argues that one of ordinary skill in the art “would have found it apparent or obvious” that substrate 3710 shown in Figure 18 can be mounted on the z-stage shown in Figure 22, and, thus, the “z-controller step motor” of the material dispensing system “controls a z-distance between the extruder and a build platform of the three-dimensional printer.” *Id.* at 27 (citing Ex. 1003 ¶¶ 105–108).

We find that the cited portion of Warren discloses that “transducer 3740 senses and transfers the changed vibration signal to an amplifier” that “creates a feedback signal that is generally proportional to the

intensity of the physical contact of the dispenser 3700 with the substrate 3710” and “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.” Ex. 1004 ¶ 302. “For example, the feedback signal may be used by a z-controller processor 3750 to control the z positioning of the dispenser 3700 via a z-controller step motor 3760.” *Id.* We also credit Petitioner’s cited testimonial evidence, because Warren supports it. Ex. 1003 ¶¶ 106, 107; Ex. 1004 ¶ 302, Figs. 18, 22.

Patent Owner argues that Warren would not have rendered obvious claim 4 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192).

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 4. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 4 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

6. Claim 5

Claim 5 depends from claim 2 and recites “further comprising comparing the current contact force to an expected contact force.” Ex. 1001, 12:59–60.

Petitioner argues that Warren teaches comparing the current contact force to a desired or expected force. Pet. 27–28 (citing Ex. 1003 ¶¶ 109–111; Ex. 1004, Fig. 22A).

We find that Figure 22A of Warren shows that “[a]t step 4104, a change in the amplitude of vibration of the dispenser and/or the substrate is detected,” and that “[t]his change in amplitude is proportional to the force of contact between the dispenser and the substrate.” Ex. 1004 ¶ 313, Fig. 22A.

We also find that Warren discloses that “[a]t step 4106, a determination is made whether the contact force is that which is desired, based on the detected change in amplitude.” *Id.* ¶ 313, Fig. 22A. We credit Petitioner’s cited testimonial evidence, because Warren supports it. Ex. 1003 ¶ 110; Ex. 1004 ¶ 313, Fig. 22A.

Patent Owner responds that Warren does not measure a contact force for reasons asserted for claim 1. PO Resp. 37–38 (citing Pet. 27–29; Ex. 1004 ¶¶ 289, 305, 311, 313, 316, Fig. 22A; Ex. 2027 ¶¶ 206–211). The parties refer to their arguments for claim 1 in their subsequent briefs. Pet. Reply 10–11; PO Sur-reply 10.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 5. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 5 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

7. Claim 6

Claim 6 depends from claim 5 and recites “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.” Ex. 1001, 12:61–64.

Petitioner argues that that Warren teaches adjusting a printer parameter (position of dispenser 3700) to reduce the difference between the current contact force and desired or expected contact force. Pet. 28–29 (citing Ex. 1003 ¶¶ 112–115; Ex. 1004 ¶¶ 302, 313).

We find that the cited portions of Warren disclose that a “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”

(Ex. 1004 ¶ 302), “[i]f 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” (*id.* ¶ 313), and “[s]teps 4104, 4106 and 4108 are repeated as necessary to obtain a desired contact force between the substrate and the dispenser, e.g., to maintain contact of a desired force between the substrate and the dispenser” (*id.*). We credit Petitioner’s cited testimonial evidence, because Warren supports it. Ex. 1003 ¶¶ 113, 114; Ex. 1004 ¶¶ 302, 313.

Patent Owner responds that Warren does not measure a contact force for reasons asserted for claim 1. PO Resp. 37–38 (citing Pet. 27–29; Ex. 1004 ¶¶ 289, 305, 311, 313, 316, Fig. 22A; Ex. 2027 ¶¶ 206–211). The parties refer to their arguments for claim 1 in their subsequent briefs. Pet. Reply 10–11; PO Sur-reply 10.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 6. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 6 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

8. Claim 8

Claim 8 depends from claim 1 and recites “wherein the control signal includes a signal to the three-dimensional printer to change a distance between the fabrication tool and the separate structure.” Ex. 1001, 13:1–4.

Petitioner argues that Warren’s z-controller processor 3750 controlling the position the z-position of dispenser 3700 to vary the position of the dispenser or the substrate teaches the limitations of claim 8. Pet. 30 (citing Ex. 1003 ¶¶ 116–118; Ex. 1004 ¶¶ 302, 313, Figs. 18, 22A).

We find that the cited portions of Warren disclose that “transducer 3740 senses and transfers the changed vibration signal to an amplifier” that “creates a feedback signal” that “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.” Ex. 1004 ¶ 302. “For example, the feedback signal may be used . . . to control the z positioning of the dispenser 3700.” *Id.* We also credit Petitioner’s cited testimonial evidence, because Warren supports it. Ex. 1003 ¶ 117; Ex. 1004 ¶¶ 302, 313, Figs. 18, 22A.

Patent Owner argues that Warren would not have rendered obvious claim 8 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192).

Based on the full record and the reasons given above, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 8. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 8 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

9. Claim 9

Claim 9 depends from claim 2 and recites “wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.” Ex. 1001, 13:5–7.

Petitioner argues that Warren’s processor provides a control signal that drives components of the material dispensing system including a linear actuator to control the material dispensing rate. Pet. 31 (citing Ex. 1004 ¶¶ 234, 239, 243, 255, Figs. 11A–11C, 12A, 12B). Petitioner also argues that one of ordinary skill in the art “would have known that the linear actuator regulates the dispensing rate of material from the dispenser to

control the amount of material fed to the nozzle tip per second (i.e., ***feed rate of build material extruded by the extruder***) so that Warren’s dispenser ‘maintains contact of a desirable intensity.’” *Id.* (citing Ex. 1003 ¶¶ 119–121; Ex. 1004 ¶¶ 234, 238, 316).

Patent Owner responds that Warren would not have rendered obvious claim 9 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192). Patent Owner also provides its arguments for claim 9 together with its arguments for claim 3. *Id.* at 33–37. The parties also present their reply arguments for claim 9 together with claim 3. Pet. Reply 9–10; PO Sur-reply 9–10.

For the reasons given above for claim 3 and based on Petitioner’s additional citations to the record, we determine that Petitioner’s proposed modification would have had a “control signal [that] includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder,” as required by claim 9. Ex. 1004 ¶¶ 234, 239, 243, 255, Figs. 11A–11C, 12A, 12B. We also credit Petitioner’s testimonial evidence for claim 9, because the citations to Warren support it. Ex. 1003 ¶ 120; Ex. 1004 ¶¶ 234, 239, 243, 255, 316, Figs. 11A–11C, 12A, 12B.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 9 and that one of ordinary skill in the art would have made the proposed modification with a reasonable expectation of success. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 9 of the ’698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

10. Claim 10

Claim 10 depends from claim 2 and recites “further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.” Ex. 1001, 13:8–11.

Petitioner argues that Warren detects separate structures based on measuring changes in amplitude across a surface of the substrate on the build platform. Pet. 31–32 (citing Ex. 1003 ¶¶ 122–124). Petitioner points to Warren’s teaching of control based on continuously detecting contact force to correct the dispensing structure’s z-height position as the height of the substrate changes. *Id.* at 32 (citing Ex. 1004 ¶¶ 293, 301–304, 316, Fig. 22A).

Petitioner also argues that Warren teaches varying the position of the dispenser relative to the substrate so as to follow irregular or curved surfaces. Pet. 32 (citing Ex. 1004 ¶ 293). Petitioner, thus, argues that one of ordinary skill in the art would have recognized that, when Warren prints on a non-flat surface, it is detecting that the substrate is not flat by continuously measuring vibration signal amplitude changes and correcting for contact force by continuous force feedback control. *Id.* (citing Ex. 1003 ¶ 125; Ex. 1004 ¶¶ 313, 316, Fig. 22). Petitioner also argues that it would have been obvious to apply Warren’s force sensing to determine surface planarity as part of a calibration procedure before printing an object to obtain, for example, the spatial relationship between the extrusion tip and substrate to build error-free models. *Id.* at 33 (citing Ex. 1003 ¶¶ 126, 127).

a) Patent Owner’s Response

Patent Owner responds that Petitioner’s arguments are “based on a flawed interpretation of Warren.” PO Resp. 38–39 (citing Pet. 31–33).

Patent Owner argues that Warren “does not teach detecting the planarity of the surface ‘based on a number of contact force measurements across a surface,’” measuring contact force, or “making a number of contact force measurements that collectively form the basis for detecting planarity” and, instead, “teaches adjusting the height of the dispenser based on a detected change in amplitude of vibration at a given point above a substrate before moving to the next position.” *Id.* at 39 (citing Ex. 1004 ¶¶ 293, 310, 313; Ex. 2027 ¶¶ 206–211, 216).

Patent Owner also responds that “Warren does not teach detecting planarity before printing” and that Petitioner resorts to hindsight bias in asserting that it would have been obvious “to apply ‘Warren’s force sensing to determine surface planarity as part of a calibration procedure.’” PO Resp. 39 (citing Pet. 33). Patent Owner argues that “Warren does not teach any calibration procedure involving his vibration sensing solution.” *Id.* at 39–40 (citing Ex. 1004 ¶¶ 226, 227, 285, 289; Ex. 2027 ¶ 217).

Patent Owner also argues that one of ordinary skill in the art “would have understood that Warren already provides a technique to build accurate error-free models by determining the spatial relationship between a tip extruding material and a substrate,” so that there would have been “no motivation to run a calibration procedure separate from the print, as doing so does not avoid ‘a large spacing between the tip and the substrate surface’ for a substrate that has been warped or damaged from use.” PO Resp. 40 (citing Ex. 1001, 9:41–46; Ex. 1004 ¶¶ 293, 310, 313; Ex. 2027 ¶ 218). Patent Owner, thus, argues that there would have been no motivation to apply Warren’s vibration sensing as a calibration procedure and claim 10 has not been shown to be unpatentable. *Id.* at 40, 41 (citing Ex. 2027 ¶¶ 212–220).

b) Reply Arguments

Petitioner replies that the claim does not require determining level or planarity, only detecting planarity. Pet. Reply 11 (citing PO Resp. 38–41). Petitioner argues that Warren adjusts for changes in z-height using determined contact force at different positions on the substrate and corrects for z-height changes using contact force measurements. *Id.* (citing Ex. 1004 ¶¶ 313–316).

Petitioner also replies that one of ordinary skill in the art “would have been motivated to know the spatial relationship between the extrusion tip and the substrate prior to building to create error-free models.” Pet. Reply 11 (citing Ex. 1003 ¶¶ 122–132). Petitioner argues that Warren supports printing curved surfaces, and that it would have been obvious to calibrate the dispenser to follow a curved or irregular surface. *Id.* at 11–12 (citing Pet. 31–35; Ex. 1003 ¶¶ 122–132; Ex. 1004 ¶¶ 293, 316).

Patent Owner replies that “Warren does not teach: 1) detecting a planarity, much less doing so based on contact-force measurements; 2) detecting planarity before printing, as the Petition asserts; and 3) decreasing irregularities by depositing cells into porous scaffolds.” PO Sur-reply 11 (citing PO Resp. 38–41). Patent Owner also replies that Petitioner improperly introduces an implicit construction for detecting planarity in reply, not in the Petition. *Id.* (citing Pet. Reply 11–12). Patent Owner further replies Petitioner does not address its testimonial evidence that “Warren does not teach making a number of contact-force measurements *that collectively* form the basis for detecting planarity” and that “what Warren detects is for a given point and not across a surface for a plane.” *Id.* (citing PO Resp. 39; Ex. 2027 ¶ 216).

c) Petitioner Fails to Show that Claim 10 is Unpatentable

We find that the portions of Warren cited by Petitioner disclose that Warren, “by varying the position of the dispenser 3700 relative to the substrate 3710, enables the dispenser to follow irregular or curved surfaces.” Ex. 1004 ¶ 293. Petitioner cites other portions that describe imposing a vibration on dispenser 3700, sensing a change in vibration amplitude, and creating a feedback signal “to control the position of the dispenser 3700 to maintain a desired force of contact between the dispenser 3700 and the substrate 3710.” *Id.* ¶¶ 301–304, Fig. 22A.

Another cited portion states that “[c]ontrol 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.” Ex. 1004 ¶ 316. Warren’s manner of control enables “fine lines, e.g., 20 µm wide,” “placing electronic elements on a cylinder,” “seek[ing] and find[ing] contact with a surface,” and “maintain[ing] contact of a desirable intensity, accurate to a precision of micronewtons of force.” *Id.*

We find that Warren does not explicitly disclose that it detects planarity. Ex. 1004 ¶¶ 293, 301–304, 316, Fig. 22A; *see also* Ex. 1003 ¶ 123 (opining that “a planarity of the separate structure” can be “flatness of the substrate positioned on the build platform”). In particular, we find that none of the cited portions of Warren teaches or suggests “detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.” *See* Ex. 1004 ¶¶ 293, 301–304, 316, Fig. 22A. At best, Warren describes “a number of contact force measurements across a surface of the separate structure.”

Also, none of the cited portions of Warren supports Petitioner's argument that continuously detecting contact force would have been recognized as detecting a planarity of the separate structure. *See* Ex. 1004 ¶¶ 293, 301–304, 316, Fig. 22A. Warren would not have been understood to be detecting planarity, because Warren detects a change in amplitude so that the dispenser can adjust for “irregular or curved surfaces.” *See* Ex. 1004 ¶¶ 293, 301–304, 316, Fig. 22A. Warren's “force feedback control *continuously corrects* the dispensing structure's z-height position as the z height of the substrate surface changes.” *Id.* ¶ 316 (emphasis added). Continuous correction would not require additionally determining planarity, so that Warren's dispenser can follow an irregular or curved surface. *Id.* ¶ 293. Warren's dispenser can follow a surface no matter its flatness, because of its continuous correction. *See* Ex. 1004 ¶ 293.

For the reasons above, the cited portions of Warren also do not support Petitioner's testimonial evidence that one of ordinary skill in the art “would have recognized that, when printing on a non-flat (e.g., irregular or conformal) surface, Warren's dispensing system is detecting that the substrate is not flat (i.e., *detecting a planarity of the separate structure*).” Ex. 1003 ¶ 125. Based on Warren's disclosure, we give more weight to Patent Owner's testimonial evidence. Ex. 2027 ¶ 216 (“Warren also does not teach making a number of contact force measurements that collectively form the basis for detecting planarity. Rather, Warren teaches adjusting the height of the dispenser based on a detected change in amplitude of vibration at a given point above a substrate before moving to the next position”) (citing Ex. 1004 ¶¶ 293, 310, 313).

Turning to Petitioner's obviousness theory, Petitioner does not sufficiently explain why one of ordinary skill in the art would have been

motivated to “detect[] a planarity of the separate structure” as part of a calibration procedure before printing an object. Pet. 32–33. Even if we agreed that the “known benefits and advantages of the calibration procedure includ[e], e.g., obtaining ‘spatial relationship between the extrusion tip and the substrate prior to building’ in order to “build accurate error-free models,” Petitioner’s citations to the record do not support that detecting planarity of the substrate would have provided those “known benefits and advantages.”

For example, Petitioner points us to disclosures that “[t]he calibration routine includes calibrating a Z-axis tip-to-substrate offset to ensure that the system knows the spatial relationship between the extrusion tip and the substrate prior to building a model” (Ex. 1007 ¶ 6) and that adjusting a position of a platform upon which material is deposited accounts for an offset when toggling between tips (*id.* ¶ 52). Neither citation relates to detecting a planarity. Petitioner’s citations to the record relate more to determining the relative positions between tips and surfaces, not the planarity of those surfaces. *See id.* ¶¶ 6, 52–54; *see also* Ex. 1003 ¶ 123 (opining that “a planarity of the separate structure” can be “flatness of the substrate positioned on the build platform”). The record, thus, does not support one of ordinary skill in the art would have “appl[ied] Warren’s force sensing to determine surface planarity as part of a calibration procedure before printing an object.”

Based on the full record and for the reasons above, Petitioner does not persuade us by a preponderance of the evidence that claim 10 of the ’698 patent is unpatentable.

11. Claim 11

Claim 11 depends from claim 10 and recites “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.” Ex. 1001, 13:12–15.

Because claim 11 depends from claim 10, Petitioner does not persuade us by a preponderance of the evidence that claim 11 of the ’698 patent is unpatentable, for the same reasons given above for claim 10.

12. Claim 12

Claim 12 depends from claim 1 and recites “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.” Ex. 1001, 13:16–21.

Petitioner argues that Warren’s CAD/CAM data includes “***at least one instruction*** ‘to maintain a desired force of contact between the dispenser 3700 and the substrate 3710.’” Pet. 35 (citing Ex. 1003 ¶¶ 133, 134; Ex. 1004 ¶¶ 285, 290, 302, 313, 397, 404–415). Referring to arguments for claim 1, Petitioner argues that a control signal controls, at least, the z-controller step motor and linear actuator to achieve a specified contact force. *Id.* at 35–36 (citing Ex. 1003 ¶¶ 135, 136; Ex. 1004 ¶¶ 288, 289, 302, 304, 305).

Patent Owner responds that Warren does not teach or suggest any specified force and only teaches that it desires a contact force based on a change in vibration amplitude. PO Resp. 42 (citing Pet. 35; Ex. 1003 ¶¶ 133–136; Ex. 1004 ¶ 313). Patent Owner argues that, unlike the ’698 patent, “Warren does not teach or suggest specifying a target for the contact force, much less identifying a specified contact force for control,” and, thus, claim 12 has not been shown to be unpatentable. *Id.* at 42–43 (citing

Ex. 2027 ¶¶ 221–227). The parties refer to their arguments for claim 1 in their subsequent briefs. Pet. Reply 10–11; PO Sur-reply 10.

We find that none of the cited portions of Warren disclose that its “build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure.”

Ex. 1004 ¶¶ 285, 290, 302, 313, 397, 404–415. The cited portions, instead, describe maintaining a desired force of contact between the dispenser and substrate but do not describe that Warren’s “build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure.” *See id.* ¶¶ 285, 290, 302, 313. Other cited portions disclose “a number of biological and tool-operational tasks” that include operators selecting (1) the material, (2) deposition parameters (such as “volumes of materials to be dispensed, flow rates through the nozzles, temperatures, fluids to be stored, etc.”), and (3) settings for the flow rates, nozzle types, pump, and temperature. *Id.* ¶¶ 397, 404–415; *see also id.* ¶¶ 402, 403 (describing acquiring images of the tissue to be constructed and transforming those images into computer-aided design and manufacturing (“CAD/CAM”) program data).

Petitioner’s declarant opines that Warren’s CAD/CAM data executed on Warren’s printing system includes an instruction to maintain a desired force of contact between dispenser and substrate. Ex. 1003 ¶ 134.

Petitioner’s declarant, however, relies on the same portions of Warren cited by Petitioner that do not describe that Warren’s CAD/CAM data includes an “instruction for achieving a specified contact force between the fabrication tool and a separate structure.” *See* Ex. 1004 ¶¶ 285, 290, 302, 313, 397, 404–415; *see also* Tr. 51:2–53:8 (discussing claim 12). We, thus, give that insufficiently supported testimony little weight.

Based on the full record, Petitioner does not persuade us by a preponderance of the evidence that Warren teaches or suggests the additional limitations of claim 12. Petitioner, thus, does not persuade us by a preponderance of the evidence that claim 12 of the '698 patent is unpatentable.

13. Claim 13

Claim 13 depends from claim 1 and recites “wherein the one or more sensors include a strain gauge.” Ex. 1001, 13:22–23.

Petitioner argues that Warren has piezotransducers for sensing the vibration of dispenser 3700 and that piezotransducers commonly converted mechanical pressure or strain into an electrical signal. Pet. 36 (citing Ex. 1003 ¶¶ 137–139; Ex. 1004 ¶¶ 300–302). Petitioner also argues that one of ordinary skill in the art would have found it obvious to configure vibration sensor 3730 to sense the strain of dispenser 3700. *Id.* (citing Ex. 1006 ¶¶ 44, 45, Fig. 7; Ex. 1012 ¶ 34).

We find that the portions of Warren cited by Petitioner describe that oscillator 3720 and transducer 3740 may be a “piezoceramic plate” or a “piezoelectric bimorph ceramic element.” Ex. 1004 ¶ 300. We also credit Petitioner’s cited testimonial evidence that such devices were commonly configured to convert mechanical strain to an electrical output and, thus, it would have been obvious to configure vibration sensor 3700 to sense strain of dispenser 3700, because the citations to the record support the testimony. Ex. 1003 ¶ 138; Ex. 1006 ¶¶ 44, 45, Fig. 7; Ex. 1012 ¶ 34.

Patent Owner argues that Warren would not have rendered obvious claim 13 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192).

Based on the full record and for the reasons above, Petitioner persuades us, and we determine, that Warren teaches or suggests the additional limitations of claim 13 and that one of ordinary skill in the art would have made the proposed modification. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 13 of the '698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

14. Claim 14

Claim 14 depends from claim 1 and recites “wherein the one or more sensors include a piezoelectric sensor.” Ex. 1001, 13:24–25.

Petitioner argues that Warren describes a piezoelement for additional flexibility and sensitivity and that the piezoelement would have been recognized as referring to a piezoelectric sensor. Pet. 36–37 (citing Ex. 1003 ¶¶ 140, 141; Ex. 1004 ¶¶ 295, 296, 300, 304–307).

We find that the cited portions of Warren disclose a “piezomembrane” implemented with an electroceramic sensor, transducer, or oscillator” (Ex. 1004 ¶¶ 295, 296, 300), a “piezoelement” of the dispenser (*id.* ¶¶ 304, 306), and “piezotransducer” (*id.* ¶ 305). We credit Petitioner’s cited testimonial evidence, because Warren supports it. Ex. 1003 ¶ 141; Ex. 1004 ¶¶ 295, 296, 300, 304–307

Patent Owner argues that Warren would not have rendered obvious claim 14 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192).

Based on the full record, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 14. Weighing our underlying factual determinations, a preponderance of the evidence

persuades us that claim 14 of the '698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

15. Claim 15

Claim 15 depends from claim 1 and recites “wherein the one or more sensors include at least one of a capacitive sensor, and optical sensor, an electromechanical sensor, an electromagnetic sensor, and an acoustical sensor.” Ex. 1001, 13:26–29.

Petitioner argues that Warren teaches vibration sensor 3730 and transducer 3740 for sensing the amplitude and frequency of vibration of dispenser 3700. Pet. 37 (citing Ex. 1004 ¶¶ 300, 301, Fig. 18). According to Petitioner, transducer 3740 converts mechanical vibration into an electrical signal and, thus, is an electromechanical sensor and an acoustic sensor. *Id.* (citing Ex. 1003 ¶ 143). We credit Petitioner’s cited testimonial evidence that transducer 3740 is both an electromechanical and acoustic sensor, because the cited portions of Warren support it. Ex. 1003 ¶ 143; Ex. 1004 ¶¶ 300, 301, Fig. 18, claim 14.

Patent Owner argues that Warren would not have rendered obvious claim 15 “for at least the reasons provided above for claim 1.” PO Resp. 33 (citing Ex. 2027 ¶ 192).

Based on the full record, Petitioner persuades us, and we find, that Warren teaches or suggests the additional limitations of claim 15. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 15 of the '698 patent is unpatentable over Warren. *Arctic Cat*, 876 F.3d at 1361.

E. Asserted Obviousness Based on Warren and Eshed

1. Eshed (Ex. 1008)

Eshed “relates to apparatus, hereinafter ‘rapid production apparatus’, for producing a 3-dimensional object by sequentially forming thin layers of material one on top of the other responsive to data defining the object.” Ex. 1008 ¶ 2. Eshed describes a collision problem in which a shuttle that includes a print head may collide with “unwanted protuberances,” when, “during construction of an object, construction material debris may fall on a construction layer.” *Id.* ¶ 171. Eshed’s rapid production apparatus includes “a collision detection system” that “[u]pon occurrence of a collision, . . . stops production of an object and generates an alarm to alert a user that a collision has occurred and that . . . intervention is require[d].” *Id.* ¶ 180.

2. Claim 3

Claim 3 depends from claim 2 and recites “wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.” Ex. 1001, 12:52–54.

Referencing its previous arguments, Petitioner contends that Warren teaches comparing current and desired contact forces and “that an ‘improper prediction’ of contact force ‘may result in either destruction of the dispenser or the substrate as the tip crashes into the substrate material.’” Pet. 38 (citing Ex. 1004 ¶¶ 285, 288–290, 302, 313). Petitioner also contends that one of ordinary skill in the art would have understood, or found obvious, that contact force greater than desired contact force would destroy the dispenser or the substrate and would be a fabrication error. *Id.* at 38–39 (citing Ex. 1003 ¶¶ 144, 145).

Petitioner argues Warren’s comparison of current and desired contact forces would have been combined with Eshed’s termination of the build

when a collision occurs so that (1) further damage is prevented, (2) continuation of an unusable build is stopped so as to increase operational efficiency, and (3) Eshed expressly teaches shutting down the system when the tip crashes into the substrate. Pet. 39–40 (citing Ex. 1003 ¶¶ 146–148; Ex. 1008 ¶¶ 171, 172). Petitioner argues that in its proposed combination, upon a collision occurring, the controller would have stopped the feed of material, thereby creating a control signal that controls a component to stop the feed. *Id.* at 40–41 (citing Ex. 1003 ¶¶ 149–151).

Petitioner also argues that the combination would have been applying Warren’s comparison of contact forces and acknowledgement of potential destruction due to fabrication error to Eshed’s detection system to achieve a predictable result. Pet. 40 (citing Ex. 1003 ¶ 148). Petitioner further argues there would have been a reasonable expectation of success. *Id.*

a) Patent Owner’s Response

Patent Owner responds that Warren does not teach all the elements of claim 3. PO Resp. 45. Patent Owner argues that, for the reasons given for claim 5, “Warren does not teach measuring a contact force.” *Id.* at 44 (citing Pet. 38–40), 46 (citing Pet. 40–41; Ex. 1004 ¶¶ 289, 305, 313, 316; Ex. 2027 ¶¶ 206–211, 240). Patent Owner, thus, argues that “stopping production cannot be based on the measured contact force as Petitioner asserts.” *Id.* at 46.

Patent Owner also responds that Warren already discloses a solution for avoiding damage to the extruder tip by sensing vibration, so there would have been no motivation to look to Eshed. PO Resp. 44 (citing Ex. 1004 ¶¶ 285, 293–295; Ex. 2027 ¶¶ 230, 231). Patent Owner further argues that there is no teaching in Warren about how to adapt the vibration sensing to Eshed’s accelerometer or audio detection system. *Id.* at 45 (citing Ex. 1004,

Fig. 18; Ex. 1008 ¶¶ 181, 182; Ex. 2027 ¶¶ 232, 233). In Patent Owner’s view, the resulting system would not have been predictable. *Id.* (citing Ex. 2027 ¶ 233). Patent Owner also argues that Warren is not concerned with terminating fabrication, and, thus, there would have been no motivation to combine Warren and Eshed. *Id.* (citing Ex. 1004 ¶ 293; Ex. 2027 ¶¶ 230–234).

b) Reply Arguments

Petitioner replies that it is not bodily incorporating Eshed into Warren and, instead, using Eshed to “enhance the combination.” Pet. Reply 12 (citing Pet. 37–42; Ex. 1003 ¶¶ 144–157; Ex. 1008 ¶ 171). Petitioner argues that destruction of the dispenser or substrate would be a fabrication error that causes termination of production and, thus, it would have been obvious to detect a fabrication error and terminate the build based ultimately on the contact force comparison of Warren. *Id.* (citing Ex. 1003 ¶¶ 144, 145).

Patent Owner replies that the ordinarily skilled artisan would not have looked to Eshed because Warren already avoids damage. PO Sur-reply 12. According to Patent Owner, Petitioner mischaracterizes its arguments as bodily incorporation. *Id.* (citing PO Resp. 44–45). Patent Owner also argues that it merely followed Petitioner’s flawed rationale and Petitioner does not address its deficiency. *Id.* (citing Pet. 38–40; PO Resp. 44–45; Ex. 2027 ¶¶ 230, 231).

c) Petitioner Shows that Claim 3 is Unpatentable

For the reasons discussed above for the challenge to claim 3 based on Warren alone, we find that Petitioner’s proposed modification of Warren would result in “at least one component of the three-dimensional printer [that] controls a feed rate for a build material used in the build,” as recited by claim 3. Ex. 1003 ¶ 144 (citing Ex. 1004 ¶¶ 288–290, 302, 313). We

agree with Petitioner's declarant that Warren's description of "[i]mproper prediction of the intensity of this force [that] may result in either destruction of the dispenser or the substrate as the tip crashes into the substrate material" would be considered a fabrication error by the ordinarily skilled artisan. Ex. 1003 ¶ 145; Ex. 1004 ¶ 285.

We also find that the portions of Eshed cited by Petitioner disclose damage may occur to Eshed's shuttle 28 as it moves over a construction layer and collides with a protuberance caused by construction material debris. Ex. 1008 ¶ 171. Petitioner also cites a portion of Eshed that discloses "an obstacle detection system" that "generates signals responsive to unwanted protuberances that may be formed on a construction layer and transmits the signals to controller 26." *Id.* ¶ 172. "The controller . . . stops production of the object and generates an alarm indicating that user intervention is required." *Id.*

In view of the cited disclosures, we determine that one of ordinary skill in the art would have combined Warren and Eshed so that, when a fabrication error occurs, such as by collision with a protuberance, production would be stopped. Ex. 1003 ¶ 146. We agree with Petitioner's declarant that such an artisan "would have known the desirability of preventing further damage to the extruder tip and the build structure being constructed" and that "once a collision has occurred, continuing the build can cause further damage to both." *Id.* ¶ 147. We also agree with Petitioner's declarant that "once a collision has occurred, the build structure can be damaged beyond repair" and "there is no point to continue the build" that may not be usable. *Id.*

Petitioner's citations to Warren and Eshed support the testimony that the proposed combination represents applying Warren's comparison of

contact forces and acknowledgement of potential destruction due to fabrication error to Eshed's detection system to achieve a predictable result. Pet. 40; Ex. 1003 ¶ 148. We also determine that there would have been a reasonable expectation of success in making the proposed combination. *Id.*

Turning to Patent Owner's responsive arguments, for the reasons discussed in the challenge based on Warren alone, we determine that Warren teaches or suggest limitations of claim 3. We also determine that combining Warren's vibration sensing with Eshed's teaching of stopping production does not undermine the proposed combination, as argued by Patent Owner. PO Resp. 44. In the proposed combination, Warren continues to detect current contact force by its vibration sensing and then stops production as taught by Eshed when the sensed contact force indicates a fabrication error. Ex. 1003 ¶ 146. Regarding the asserted lack of motivation to combine, we agree with Petitioner that its proposed combination represents applying a known technique to a known device to yield predictable results. Pet. 40; Ex. 1003 ¶ 148.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren and Eshed teach or suggest the additional limitations of claim 3 and that one of ordinary skill in the art would have made the proposed combination with a reasonable expectation of success. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 3 of the '698 patent is unpatentable over Warren and Eshed. *Arctic Cat*, 876 F.3d at 1361.

3. Claim 7

Claim 7 depends from claim 5 and recites "further comprising terminating the build when a difference between the current contact force

and the expected contact force indicates a fabrication error.” Ex. 1001, 12:65–67.

Petitioner argues that Eshed teaches stopping fabrication and Warren teaches comparing current contact force and expected contact force. Pet. 41 (citing Ex. 1003 ¶¶ 152–154). As discussed above for claim 3, Petitioner also proposes combining Warren and Eshed. *Id.* at 38–40.

Patent Owner responds that “Warren does not teach measuring a contact force, much less comparing a measured contact force to an expected contact force.” PO Resp. 46 (citing Pet. 41; Ex. 1004 ¶¶ 289, 305, 313, 316; Ex. 2027 ¶¶ 235–241). As discussed above for claim 3, Patent Owner also disputes that Warren and Eshed would have been combined. PO Resp. 44–45.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren and Eshed teach or suggest the additional limitations of claim 7, and we determine that one of ordinary skill in the art would have made the proposed combination with a reasonable expectation of success. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 7 of the ’698 patent is unpatentable over Warren and Eshed. *Arctic Cat*, 876 F.3d at 1361.

4. Claim 9

Claim 9 depends from claim 2 and recites “wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.” Ex. 1001, 13:5–7.

Petitioner argues that Eshed teaches stopping production of an object when a collision occurs, thereby teaching a control signal to the feed rate, specifically to stop the feed. Pet. 41–42 (citing Ex. 1003 ¶¶ 155–157). As

discussed above for claim 3, Petitioner also proposes combining Warren and Eshed. *Id.* at 38–40.

Patent Owner responds that Warren does not teach all the elements of claim 9. PO Resp. 45. Patent Owner argues that, for the reasons given for claim 5, “Warren does not teach measuring a contact force.” *Id.* at 46 (citing Pet. 41–42; Ex. 1004 ¶¶ 289, 305, 313, 316; Ex. 2027 ¶¶ 206–211, 240). Patent Owner, thus, argues that “stopping production cannot be based on the measured contact force as Petitioner asserts.” *Id.* As discussed above for claim 3, Patent Owner also responds that Warren and Eshed would not have been combined. PO Resp. 44–45.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Warren and Eshed teach or suggest the additional limitations of claim 9, and we determine that one of ordinary skill in the art would have made the proposed combination with a reasonable expectation of success. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 9 of the ’698 patent is unpatentable over Warren and Eshed. *Arctic Cat*, 876 F.3d at 1361.

F. Asserted Obviousness Based on Calderon and RepRap20208

1. Calderon (Ex. 1009)

Calderon discloses “modeling machines which form three-dimensional objects by depositing modeling material onto a substrate mounted to a modeling platform.” Ex. 1009, 1:5–10, Abstract. Figure 1 of Calderon is reproduced below.

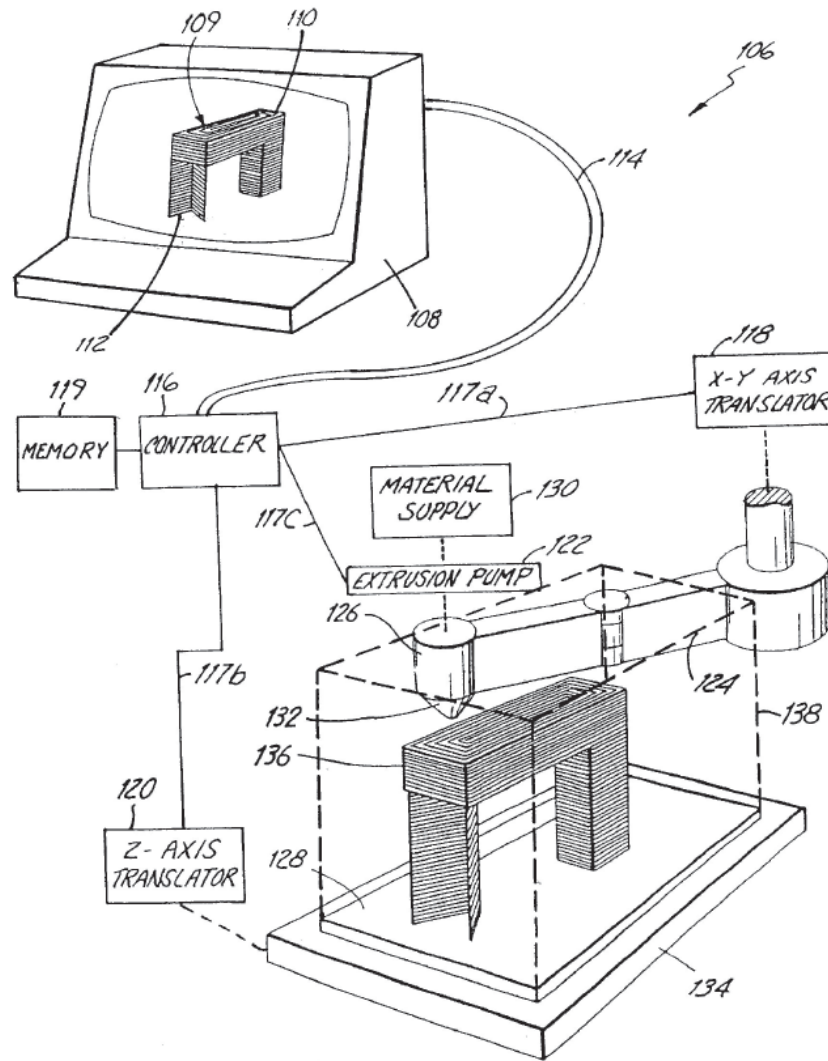


FIG. 1

Figure 1 shows “a schematic of a representative generic extrusion-based, layered modeling system.” Ex. 1009, 3:66–67. “A computer aided design (CAD) program resident in a processor 108 generates a file describing the geometry of a part 109 to be created,” and “[a] slicing program (shown as resident in processor 108 but which may alternatively be resident in a separate processor) algorithmically subdivides the file into volume elements 110 corresponding to shapes that can be extruded from a nozzle.” *Id.* at 4:21–28, Fig. 1. “[E]xtrusion-based layered modeling system 106” includes “electronic controller 116 [that], in response to receiving

three-dimensional shape data from processor 108 over line 114, controls the extrusion of modeling material in an xyz-coordinate reference frame” and “sends control signals to an xy axis translator 118, a z-axis translator 120 and an extrusion pump 122, over output signal lines 117 a, 117b and 117c, respectively.” *Id.* at 4:19–21, 4:34–37, 4:41–44, Fig. 1.

“Extrusion pump 122 synchronously provides modeling material from a material supply 130 to extrusion head 126,” and “[t]he extrusion head 126 terminates in a nozzle 132 through which the modeling material is extruded.” Ex. 1009, 4:47–52, Fig. 1. “A sensor assembly 140” is “mounted to an extrusion head 142,” and the sensor of sensor assembly 140 “may be interchanged with any sensing means which can detect and signal contact between the plunger and the substrate.” *Id.* at 5:10–11, 6:41–43.

2. *RepRap20208 (Ex. 1010)*

RepRap20208 is a discussion thread from an online public forum for developing low-cost 3D printers. A user named “Wade” states that “an accelerometer on the write head” “might be able to detect . . . [a] series of head collisions due to a bad programming job” and that a “strain gauge on the extruder mount would do that as well.” Ex. 1010, 13.

User “Wade” also states in other posts that “[c]ollision detection is a nice side [e]ffect” and strain gauges would provide “a constant measurement of the force on the head (including it[’s] weight).” Ex. 1010, 19, 20. He acknowledges that “a certain amount of backlash to take up before the sensor registers, which would prevent . . . knowing exactly when the head touches” but goes on to state that “a constant measurement of the force on the head (including it[’s] weight) would be useful” and “[t]hat points more towards strain gauges.” *Id.* at 20.

a) Whether RepRap20208 is a Printed Publication

Patent Owner argued that RepRap20208 is not a printed publication in its Preliminary Response, and the Institution Decision determined that, on the record at institution, Petitioner sufficiently showed that RepRap20208 is a printed publication but invited further development of the issue. Paper 8, 29–33; Inst. Dec. 13–15.

Petitioner argues that RepRap20208 was from a forum that was keyword searchable. Pet. Reply 26–27 (citing Pet. 2; Ex. 1010, 13–21; Ex. 1014 ¶¶ 2, 4, 6). Petitioner also notes that Patent Owner admitted the ’698 patent itself includes a link to the RepRap forum. *Id.* at 27–28 (citing Paper 8, 32; Ex. 1001, code (56); Ex. 1014 ¶ 6). Petitioner also argues that no evidence contradicts the Bowyer declaration (Ex. 1014). *Id.* at 28.

Patent Owner responds that RepRap20208 is not a printed publication and was not publicly accessible, because Petitioner does not explain how one would reach the “Generic Algorithms” thread in a general forum. PO Sur-reply 13–15 (citing Pet. Reply 26–28; Ex. 1010, 1; Ex. 1014 ¶¶ 6, 8–10, Ex. B-1). Patent Owner also faults Petitioner for raising in the reply for the first time the use of keywords and for failing to provide evidence of any search being performed and of any query before the critical date that would have led to the thread. *Id.* at 15 (citing Pet. Reply 26–27; Ex. 1014 ¶ 6). Patent Owner argues only technical accessibility has been shown, not accessibility to the particular thread. *Id.* at 16. Patent Owner also argues that the thread had different titles that did not evolve as Petitioner argued. *Id.* at 16–17 (citing Ex. 1010, 1, 15–18, 20–23).

b) Petitioner Shows that RepRap20208 is a Printed Publication

The determination of whether a reference is a “printed publication” “involves a case-by-case inquiry into the facts and circumstances

surrounding the reference’s disclosure to members of the public.” *In re Klopfenstein*, 380 F.3d 1345, 1350 (Fed. Cir. 2004). Whether a document qualifies as a printed publication is a legal conclusion based on underlying factual determinations. *Medtronic, Inc. v. Barry*, 891 F.3d 1368, 1380 (Fed. Cir. 2018).

“Because there are many ways in which a reference may be disseminated to the interested public, ‘public accessibility’ has been called the touchstone in determining whether a reference constitutes a ‘printed publication.’” *Jazz Pharmaceuticals, Inc. v. Amneal Pharmaceuticals, LLC*, 895 F.3d 1347, 1355 (Fed. Cir. 2018) (quoting *In re Hall*, 781 F.2d 897, 898–99 (Fed. Cir. 1986)). A reference is 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.” *Id.* at 1355–56 (quoting *In re Wyer*, 655 F.2d 221, 226 (CCPA 1981)).

Petitioner provides testimonial evidence from an administrator of the website that hosted the forum that includes RepRap20208. Ex. 1014 ¶¶ 3, 7. The administrator and declarant, Mr. Bowyer, avers that the forum with RepRap20208 was publicly available. *Id.* ¶ 5. The declarant also avers that people interested in 3D printing and rapid prototyping accessed the forum. *Id.* ¶ 4 (explaining that the RepRap forum directly relates to three-dimensional printing, was frequented by “around 1,000 regular monthly users” who were “interested in 3D printing [as] both professionals and hobbyists,” and was “often discussed in various print and web media and on social media” from the inception of the forum through today). Patent Owner does not dispute that RepRap20208 came from a forum that was publicly

accessible and that persons interested and ordinarily skilled in the art visited the forum. PO Sur-reply 13–17.

Mr. Bowyer further avers that the website was organized by forums and threads and could be searched by keyword or author during December 2008. Ex. 1014 ¶¶ 6–12. In particular, he states that “[i]nterested members of the public would have been able to locate the discussion thread [(RepRap20208)] by clicking through to the relevant forum or through keyword searching based on the relevant terms that appear in this thread.” *Id.* ¶ 7. Patent Owner does not dispute this testimony. Pet. Reply 28; PO Sur-reply 13–17.

Because we asked the parties to further develop the record on this issue during trial, Petitioner did so in its first available brief thereafter, and Patent Owner had an opportunity to respond and did so, Patent Owner does not show a fault in raising in the reply for the first time the use of keywords. PO Sur-reply 15. We also disagree with Patent Owner that Petitioner fails to provide evidence of any search being performed and of any query before the critical date that would have led to the thread. *Id.*

Mr. Bowyer states “[i]nterested members of the public would have been able to locate [RepRap20208] by clicking through to the relevant forum or through keyword searching based on the relevant terms that appear in this thread.” Ex. 1014 ¶ 7. Mr. Bowyer also states that “[p]ersons interested in 3D printing and rapid prototyping, both professionals and hobbyists, would have been aware of RepRap.org” and “RepRap.org had around 1,000 regular monthly users with many more users occasionally visiting or interacting with the website and public forums.” *Id.* ¶ 4. Taking these statements together, they indicate that interested people were able to (and possibly did) search for and access RepRap20208 before the critical date. RepRap20208

itself shows that posts were made by several users over a twenty-day period in January 2009, indicating that the thread was accessed before the critical date despite the changing titles. *See* Ex. 1010.

Based on the “the facts and circumstances surrounding [RepRap20208]’s disclosure to members of the public,” Petitioner persuades us, and we determine, that RepRap20208 is a printed publication. We have considered whether our determination based on the facts and circumstances of this proceeding is inconsistent with the determination in another Board proceeding involving the same parties that a video from the same forum and an article linked to the video were not sufficiently shown to be publicly accessible. *Shenzen Touzhu Technology Co., Ltd. v. Stratasys, Inc.*, IPR2025-00321, Paper 36, 13–17 (PTAB June 9, 2026) (Final Written Decision). The issue was discussed during the oral hearing, and we agree with the parties that the evidence and issue in this proceeding are different and, therefore, can lead to a different outcome. *See* Tr. 11:2–18 (discussing with Petitioner’s counsel possible inconsistencies among proceedings between the same parties), 84:8–22 (discussing with Patent Owner’s counsel that different evidence and issues may result in a different outcome). Based on the different and more persuasive evidence presented in this proceeding, our decision is not inconsistent with that in the other proceeding.

3. *Claim 1*

a) “*A method comprising:*”

Petitioner argues that Calderon teaches the preamble. Pet. 56–57 (citing Ex. 1009, 5:10–24, 6:16–18, Fig. 1). Petitioner also argues that the proposed combination would have provided a method that constantly measures force on the extrusion head. *Id.* at 57 (citing Ex. 1003 ¶ 177; Ex. 1010, 13, 19, 20).

We find that a cited portion of Calderon discloses an extrusion-based layered modeling system and that an “apparatus and method of the present invention are particularly useful in finding a z-start position when modeling on a slab substrate.” Ex. 1009, 5:11–12, 5:20–22. Patent Owner does not provide a response for the preamble of claim 1. *See* PO Resp. 48–57.

Based on the full record, Petitioner persuades us, and we find, that Calderon teaches or suggests the preamble of claim 1. In view of our finding, we do not need to determine if the preamble is limiting.

b) “identifying build instructions for fabricating an object”

Petitioner argues that Calderon teaches the above-quoted step. Pet. 57–58 (citing Ex. 1003 ¶¶ 178–180; Ex. 1009, 1:12–23, 1:33–47, 4:19–33, 4:53–65, Fig. 1, claim 5).

(1) Patent Owner’s Response

Patent Owner responds that the proposed combination does not teach “identifying build instructions for fabricating an object,” because the relied-upon file in Calderon represents the model of the object, not build instructions. PO Resp. 53–54 (citing Pet. 57, 58; Ex. 1009, Fig. 1; Ex. 2027 ¶¶ 256–260). According to Patent Owner argues, “Petitioner fails to explain why the ‘design data’ provided from the CAD system are build instructions as opposed to a model of the object itself and why depositing ‘extruded material’ in areas ‘defined from the CAD model’ teaches build instructions for fabricating an object.” *Id.* at 54 (citing Pet. 58).

(2) Reply Arguments

Petitioner replies that, as pointed out in the Petition, Calderon’s file uses a slicing program that subdivides the file describing the geometry of the part to be created into volume elements that correspond to shapes that can be extruded from a nozzle. Pet. Reply 18 (citing Ex. 1009, 4:19–33).

Petitioner argues that Calderon teaches that those volume elements are sequentially ordered so that the deposited material is appropriately supported. *Id.* (citing Ex. 1009, 4:19–33).

Patent Owner replies that Calderon’s file and volume elements represent the model and are not build instructions. PO Sur-reply 22 (citing PO Resp. 53–54; Pet. Reply 18; Ex. 1009, Fig. 1; Ex. 2027 ¶¶ 256–260).

(3) Petitioner Persuades us that Calderon Teaches or Suggests the Limitation

We find that a portion of Calderon cited by Petitioner discloses that “[a] computer aided design (CAD) program resident in a processor 108 generates a file describing the geometry of a part 109 to be created” and that “[a] slicing program (shown as resident in processor 108 but which may alternatively be resident in a separate processor) algorithmically subdivides the file into volume elements 110 corresponding to shapes that can be extruded from a nozzle.” Ex. 1009, 4:21–28, Fig. 1. Calderon also discloses that “[a]dditional volume elements 112 are added as necessary to provide mechanical support to a part during its construction” and “[t]he volume elements are sequentially ordered so that deposited material is supported appropriately.” *Id.* at 4:28–33.

We also credit Petitioner’s cited testimonial evidence because the cited portions of Calderon support it. Ex. 1003 ¶¶ 178, 179; Ex. 1009, 1:12–23, 1:33–47, 4:19–33, 4:53–65, Fig. 1, claim 5. In particular, Calderon supports that its file is divided into volume elements that “can be extruded from a nozzle.” Ex. 1003 ¶ 178; Ex. 1009, 4:19–33, 4:53–65, Fig. 1.

Because Calderon describes that its slicing program “subdivides the file into volume elements 110 corresponding to shapes that can be extruded from a nozzle” and “are sequentially ordered so that deposited material is

supported appropriately” (Ex. 1009, 4:24–28, 4:31–33), the record better supports Petitioner’s position than Patent Owner’s position. Pet. 57–58; PO Resp. 53–54; Pet. Reply 18; PO Sur-reply 22.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Calderon teaches or suggests “identifying build instructions for fabricating an object.”

- 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”*

Petitioner argues that Calderon teaches initiating a build using extrusion-based layered modeling system 106 controlled by electronic controller 116. Pet. 58–59 (citing Ex. 1009, 4:19–21, 4:34–39). Petitioner also argues that extrusion-based layered modeling system 106 includes pump 122 and extrusion head 126 with nozzle 132. *Id.* at 59 (citing Ex. 1009, 4:34–5:10, Fig. 1). Petitioner further argues that a sensor assembly is mounted on the extrusion head and senses contact force of the tip against the substrate. *Id.* at 59–60 (citing Ex. 1009, 5:10–24, 6:16–18, 6:37–7:5).

Petitioner turns to RepRap20208 for strain gauges that are affixed to an extruder, as disclosed by the ’698 patent. Pet. 60 (citing Ex. 1001, 9:1–7; Ex. 1003 ¶¶ 181–183). Petitioner contends that one of ordinary skill in the art would have used RepRap20208’s strain gauges as Calderon’s sensing means, thereby teaching the recited “one or more sensors” that would detect the contact force between a fabrication tool and a separate structure. *Id.* at 60–61 (citing Ex. 1003 ¶¶ 184–186; Ex. 1009, 6:37–7:5, 9:63–10:23; Ex. 1010, 13, 19–20, Fig. 1).

(1) Patent Owner's Response

Patent Owner responds that the combination fails to teach the “current contact force” limitations, because there is no teaching of detecting a current contact force in the relied-on RepRap20208 reference and the citations to Calderon do not cure the deficiency. PO Resp. 54–55 (citing Pet. 58–63). Patent Owner argues that RepRap20208 does not mention force and merely discloses using a strain gauge on an extruder mount. *Id.* at 55–56 (citing Ex. 1010, 13).

Patent Owner also argues that RepRap20208 teaches away from using a force sensor because it does not work well and teaches away from measuring contact force because of backlash and uncertainty. PO Resp. 55–56 (citing Ex. 1010, 19, 20). Patent Owner further argues that RepRap20208 describes a constant measurement of force on the head but does not mention a contact force. *Id.* at 56 (citing Ex. 1010, 20). Patent Owner, thus, argues that RepRap20208 fails to teach detecting a current contact force. *Id.* (citing Ex. 2027 ¶¶ 268–270).

Patent Owner also responds that Petitioner's citations to Calderon fail to address the deficiency with detecting a current contact force. PO Resp. 56 (citing Ex. 1009, 3:66–67, 4:34–52, Fig. 1; Ex. 2027 ¶ 271). Patent Owner also argues there is no evidentiary support regarding Petitioner's collision detection. *Id.* at 57 (citing Pet. 62–63; Ex. 1003 ¶ 190).

(2) Reply Arguments

Petitioner replies that one of ordinary skill in the art would have been motivated to detect contact force from strain gauges, because RepRap20208 expressly teaches using strain gauges to measure force in Z-height calibration and collision detection and, thus, teaches using strain gauges to determine current contact force. Pet. Reply 18–19 (citing Pet. 48–56;

Ex. 1009, 8:14–20; Ex. 1010, 19–20). Petitioner also argues that using strain gauges to determine current contact force was well within ordinary skill in the art. *Id.* at 19 (citing Pet. 58–61; Ex. 1003 ¶¶ 181–186; Ex. 1010, 19–20; Ex. 1042, 60:1–63:7, 67:24–68:20).

Petitioner also replies that the combination would have prevented damage to the nozzle and substrate, and that Patent Owner does not address this motivation to combine. Pet. Reply 19–20 (citing Pet. 54–55, 62–63; Ex. 1003 ¶ 191; Ex. 1010, 18–19). Petitioner argues that Calderon teaches z-start positions that are not below the surface of the substrate and, even when below the surface, determining the force would have been beneficial, because it would have determined the optimal z-axis starting position. *Id.* at 20–21 (citing Pet. 54–56; PO Resp. 49–50; Ex. 1009, 2:27–34, 2:43–53).

Petitioner also argues that, in both cases, a z-axis calibration is performed that would benefit from detecting the contact force. Pet. Reply 21 (citing Pet. 54–56; Ex. 1009, 8:10–37). Petitioner further argues that RepRap20208 similarly teaches measuring upwards pressure from a calibrated touchdown. *Id.* (citing Pet. 62; Ex. 1003 ¶¶ 186–188; Ex. 1010, 19). Petitioner additionally argues that strain gauges were commonly used for force measurements, accounting for the weight of the head was not difficult, and RepRap20208 teaches using strain gauges for Z-height calibration, collision detection, and force sensing. *Id.* at 22 (citing Pet. 46–56; Ex. 1003 ¶¶ 169–173; Ex. 1010, 18–20; Ex. 1042, 60:1–63:7, 67:24–68:20).

Patent Owner replies that Petitioner did not identify a teaching and RepRap20208 teaches constant force measurement, not current contact force. PO Sur-reply 22–23 (citing PO Resp. 53–57; Pet. Reply 18–22; Ex. 1010, 19–20). Patent Owner also argues that Petitioner did not discuss

accounting for the weight of the head in its Petition and, even if it could be done, that is insufficient for obviousness. *Id.* (citing Pet. 57).

Patent Owner also replies that it explained that Calderon already protects its nozzle by monitoring the servo and provides collision detection. PO Sur-reply 23 (citing PO Resp. 48–49; Pet. Reply 19–20; Ex. 1009, 9:63–10:8, 10:26–47, 10:57–64; Ex. 2027 ¶ 247). Patent Owner also argues that Calderon’s teaching undermines Petitioner’s rationale regarding prevention of damage to the substrate. *Id.* at 23–24 (citing Pet. 54–55; PO Resp. 52).

Patent Owner contends that Petitioner presents a new theory regarding determining the force, because the Petition did not address printing below the substrate surface. PO Sur-reply 24 (citing Pet. 55; PO Resp. 52; Pet. Reply 20–21; Ex. 2027 ¶ 254). Patent Owner also contends that another new theory was presented, and that measuring force does not determine a contact force. *Id.* (citing Pet. Reply 21). Patent Owner argues that Petitioner is merely asserting that contact force could be, not would have been, determined. *Id.* Patent Owner also argues that Petitioner did not address its argument that there was no support for collision detection and no explanation why a control signal is created in response to the current contact force. *Id.* at 25 (citing PO Resp. 57).

(3) Petitioner Persuades Us that Calderon Teaches or Suggests the Limitations

(a) “initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool”

We find that the portions of Calderon cited by Petitioner disclose an “extrusion-based layered modeling system 106” with “[a]n electronic controller 116 [that], in response to receiving three-dimensional shape data from processor 108 over line 114, controls the extrusion of modeling

material in an xyz-coordinate reference frame.” Ex. 1009, 4:19–21, 4:34–39. We also find that other cited portions disclose that Calderon’s extrusion-based layered modeling system 106 includes pump 122 and extrusion head 126 with nozzle 132. *Id.* at 4:34–51, Fig. 1.

We further find that other cited portions disclose that “[a] sensor assembly 140” is “mounted to an extrusion head 142” and that the sensor of sensor assembly 140 “may be interchanged with any sensing means which can detect and signal contact between the plunger and the substrate.” Ex. 1009, 5:10–11, 6:41–43; *see also id.* at 5:25–26 (describing that sensor assembly 140 includes plunger 148 and sensor 162). We credit Petitioner’s testimonial evidence regarding the above-quoted limitations, because the citations to Calderon support it. Ex. 1003 ¶¶ 181, 182; Ex. 1009, 4:19–21, 4:34–5:24, 6:16–18, 6:37–7:5, Fig. 1. Patent Owner does not dispute that Warren discloses the above-quoted limitations. *See* PO Resp. 48–57.

(b) “the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure”

As discussed above, we find that a portion of Calderon cited by Petitioner discloses that the sensor of sensor assembly 140 “may be interchanged with any sensing means which can detect and signal contact between the plunger and the substrate.” Ex. 1009, 6:41–43. We find that another cited portion of Calderon discloses that “the tip of nozzle 132 (shown in FIG. 1) can be used as a plunging means to find z-axis positions of the platform” “by positioning the nozzle 132 above pre-selected locations of the substrate and raising the platform 134 until the nozzle tip contacts the substrate.” *Id.* at 9:63–10:1, Fig. 1. Calderon also discloses that “[c]ontact

between the tip of nozzle 132 and the substrate 128 is monitored by a sensing means.” *Id.* at 10:1–3.

We find that a portion of RepRap20208 cited by Petitioner discloses that “an accelerometer on the write head” “might be able to detect . . . [a] series of head collisions due to a bad programming job” and that a “strain gauge on the extruder mount would do that as well.” Ex. 1010, 13. We find that another cited portion discloses that “[c]ollision detection is a nice side effect” and strain gauges would provide “a constant measurement of the force on the head (including it[]s weight).” *Id.* at 19, 20; *see also* Ex. 1001, 9:1–7 (“Strain gauges are one common sensor used for such measurements, and may be suitably adapted for use with the systems and methods disclosed herein, such as by affixing one or more strain gauges to an extruder or other location along a mechanical chain that supports an extruder in an intended position during fabrication.”).

Because we find that RepRap20208 describes strain gauges as detecting collisions and providing a constant force measurement, we do not agree with Patent Owner that RepRap20208 does not mention force. PO Resp. 55–56. Also, in view of findings from RepRap20208, we determine that it would not teach away from using strain gauges to measure contact force because of backlash and uncertainty, as argued by Patent Owner. *Id.* at 55–56 (citing Ex. 1010, 19, 20).

The cited portion of RepRap20208 acknowledges that “a certain amount of backlash to take up before the sensor registers, which would prevent . . . knowing exactly when the head touches” but goes on to state that “a constant measurement of the force on the head (including it[]s weight) would be useful” and “[t]hat points more towards strain gauges.” Ex. 1010, 20. Patent Owner recognizes that RepRap20208 describes a

constant measurement of force on the head but disputes that it teaches detecting a current contact force. PO Resp. 56.

Because RepRap20208 discloses that strain gauges would provide “a constant measurement of the force on the head” that “would be useful” to address “knowing exactly when the head touches,” we find that RepRap20208 teaches or suggests detecting the current contact force on the head. Ex. 1010, 20; *see also* Ex. 1009, 6:41–43, 10:1–3 (Calderon describing sensing contact between plunger and substrate or nozzle 132 and substrate 128). Patent Owner’s argument does not explain why the cited disclosures fail to teach or suggest detecting current contact force. PO Resp. 54–55.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Calderon and RepRap20209 teach or suggest “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.” We discuss below the Petitioner’s proposed combination of Calderon and RepRap20209.

d) “detecting the current contact force based on a sensor signal from the one or more sensors”

Petitioner argues that one of ordinary skill in the art would have found it obvious to use RepRap20208’s strain gauges in Calderon to detect current contact force. Pet. 61 (citing Ex. 1010, 20). According to Petitioner, the signals from the strain gauges would “measure upwards pressure from a calibration touch” and implement collision detection during printing. *Id.* at 61–62 (citing Ex. 1003 ¶¶ 186–188; Ex. 1009, Fig. 1; Ex. 1010, 13, 19–20).

As discussed above, we find that Petitioner cites portions of RepRap20208 that disclose a “strain gauge on the extruder mount” “might be able to detect . . . [a] series of head collisions due to a bad programming job” and provide “a constant measurement of the force on the head.” Ex. 1010, 13, 20. We also find that Petitioner cites a portion of RepRap20208 that discloses “measur[ing] upwards pressure from a calibration touch down.” *Id.* at 19.

We credit Petitioner’s testimonial evidence because the citations to Calderon and RepRap20208 support it. Ex. 1003 ¶ 187; Ex. 1009, Fig. 1; Ex. 1010, 13, 19–20. As summarized above, Patent Owner responds that Calderon combined with RepRap20208 fails to teach the “current contact force” limitations. PO Resp. 53–57.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that RepRap20209 teaches or suggests “detecting the current contact force based on a sensor signal from the one or more sensors.”

- e) *“creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build”*

Petitioner argues that Calderon teaches a control signal from controller 116 that controls xy translator 118, z-axis translator 120, and extrusion pump 122. Pet. 62 (citing Ex. 1009, 4:34–52, Fig. 1). In Petitioner’s view, one of ordinary skill in the art “would have found it obvious to create the control signal *in response to the current contact force* (e.g., detected by the strain gauges on the extruder mount, as taught in RepRap20208) *while depositing material during the build* (e.g., to

implement real-time collision detection, as suggested by RepRap20208).” *Id.* (citing Ex. 1003 ¶¶ 189, 190).

Petitioner also argues that the ordinarily skilled artisan “would have known that collision detection matters whenever the extrusion head is being moved, including when build material is being deposited during printing.” Pet. 62 (citing Ex. 1003 ¶¶ 189–191). Petitioner further argues that prosecution history shows that “during a build” was equated with “while material is being extruded to fabricate an object.” *Id.* at 63 (citing Ex. 1002, 28–37; Ex. 1003 ¶¶ 177–193).

We find that the portion of Calderon cited by Petitioner discloses that “[a]n electronic controller 116, in response to receiving three-dimensional shape data from processor 108 over line 114, controls the extrusion of modeling material in an xyz-coordinate reference frame” and “sends control signals to an xy axis translator 118, a z-axis translator 120 and an extrusion pump 122, over output signal lines 117 a, 117b and 117c, respectively.” Ex. 1009, 4:34–37, 4:41–44, Fig. 1. The cited portion also discloses that “[e]xtrusion pump 122 synchronously provides modeling material from a material supply 130 to extrusion head 126,” and “[t]he extrusion head 126 terminates in a nozzle 132 through which the modeling material is extruded.” *Id.* at 4:47–52, Fig. 1.

We credit Petitioner’s testimonial evidence because the citations to Calderon support it. Ex. 1003 ¶ 189; Ex. 1009, 4:34–52, Fig. 1. As summarized above, Patent Owner responds that Calderon combined with RepRap20208 fails to teach the “current contact force” limitations. PO Resp. 53–57.

Based on the full record and for the reasons above, Petitioner persuades us, and we find, that Calderon teaches or suggests “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.”

f) Reason to Combine

Petitioner argues that Calderon describes auto-initialization of the z-axis by using the tip of nozzle 132 to find the z-axis positions of a platform. Pet. 48 (citing Ex. 1009, 9:63–10:23). Petitioner also argues that RepRap20208 complements Calderon’s disclosure by incorporating a strain gauge on an extrusion mount so that the strain gauge calibrates the z-axis and enables collision detection. *Id.* (citing Ex. 1010, 13–14, 19). Petitioner further argues that RepRap20208 discloses shutting down the machine if a collision happens. *Id.* at 48–49 (citing Ex. 1010, 19).

Because of the asserted complementary disclosures, Petitioner argues that there would have been motivation to implement collision detection using a strain gauge after initialization in Calderon and have the machine shut down, as taught by RepRap20208. Pet. 48–51 (citing Ex. 1003 ¶¶ 158–163; Ex. 1009, 9:63–10:23; Ex. 1010, 13–14), 56 (citing Ex. 1003 ¶¶ 164–174; Ex. 1009, 10:1–8). According to Petitioner, the combination would have been made to (1) shut down the machine to prevent further damage and material waste, (2) obtain real-time collision detection, (3) avoid the “slop/backlash” from Calderon’s use of servo drive motor currents, (4) overcome inaccuracies in servo drive motor currents due to dirt, wear, friction, or damage, (5) compensate better for softer or harder substrates, and (6) use known strain gauges (“predictable inclusion of a strain gauge follows the familiar pattern of merely substituting one element (a strain gauge) for another known in the field (Calderon’s teaching of monitoring servo drive

current) to obtain predictable results.”). *Id.* at 51–55 (citing Ex. 1003 ¶¶ 161, 164–172; Ex. 1009, 2:15–53; Ex. 1010, 19, 20).

Petitioner argues that the ’698 patent admits that strain gauges were commonly used for contact force measurements. Pet. 55 (citing Ex. 1001, 9:1–7). Petitioner also argues that there would have been a reasonable expectation of success in making the proposed combination. *Id.* at 56 (citing Ex. 1003 ¶ 173; Ex. 1018, 302–304).

(1) Patent Owner’s Response

Patent Owner responds that “Calderon already has his own technique for auto-initialization and collision detection to determine contact between a nozzle and the substrate by ‘monitoring a change in the servo drive current’” and discourages use of “special purpose sensing means.” PO Resp. 48–49 (citing Ex. 1009, 9:63–10:8, 10:26–47), 56–57 (citing Ex. 1009, 10:26–64; Ex. 2027 ¶¶ 247, 248, 272). Patent Owner argues that Petitioner fails to address these teachings, misrepresents and ignores the teachings of the references, and relies on impermissible hindsight. *Id.* at 49–50 (citing Pet. 51–56).

Patent Owner also argues that the proposed combination goes against Calderon’s express avoidance of special purpose sensing means. PO Resp. 50 (citing Pet. 48–52; Ex. 2027 ¶ 250). Patent Owner further argues that Calderon also has its own solution for stopping its machine, so there would have been no motivation to combine with RepRap20208. *Id.* (citing Pet. 51–52, 55–56; Ex. 1009, 10:43–45).

Patent Owner also responds that the mentions of backlash and slop are not related to Calderon’s monitoring of its servo drive motors and, instead, related to a sensor unrelated to Calderon’s solution. PO Resp. 50–51 (citing Pet. 52–53; Ex. 1009, 10:5–8; Ex. 1010, 19, 20; Ex. 2027 ¶ 251). Patent

Owner also argues that Petitioner fails to address how a strain gauge would be closer to the point of contact with platform 134 than Calderon's z-axis translator that drives platform 134. *Id.* at 51 (citing Pet. 52; Ex. 1009, Fig. 1; Ex. 2027 ¶ 252).

Patent Owner further argues that the rationale regarding accuracy and consistency is based on impermissible hindsight, because the only support comes from Petitioner's declarant and there is no supporting disclosure. PO Resp. 51–52 (citing Pet. 53–54; Ex. 1003 ¶ 170; Ex. 2027 ¶ 253). The rationale about supporting different substrates, Patent Owner argues, is flawed because the references do not mention it, and there is no teaching that strain gauges provide a benefit over Calderon's monitoring of its servo drive motors. *Id.* at 52 (citing Pet. 54–55; Ex. 1009; Ex. 1010; Ex. 2027 ¶ 254).

Patent Owner additionally argues that Calderon teaches damaging a foam substrate to extrude layers buried in the foam. PO Resp. 52 (citing Ex. 1009, 2:44–50; Ex. 2027 ¶ 254). Patent Owner, thus, argues that Petitioner has failed to show a motivation to combine. *Id.* at 52 (citing Ex. 2027 ¶¶ 243–255), 56–57 (citing Pet. 60; Ex. 2027 ¶¶ 261–273).

(2) Reply Arguments

Petitioner replies that Calderon only monitors servo drive currents when servo drive motors are used and predominantly teaches embodiments that do not use servos, such as the one relied on for the proposed combination. Pet. Reply 12–13 (citing Pet. 42–46, 49–57; PO Resp. 48; Ex. 1009, 4:34–5:24, 6:16–18, 10:5–8). Petitioner argues that, in the relied-on embodiment, Calderon teaches z-height determination. *Id.* at 13 (citing Ex. 1009, 4:66–5:3, Fig. 1). Petitioner also argues that Calderon teaches monitoring for contact between nozzle and substrate and does not restrict the type of sensors used. *Id.* at 14 (citing Pet. 45, 48; Ex. 1003 ¶¶ 55–62;

Ex. 1009, 6:38–7:5, 9:63–10:23; Ex. 1010, 29). Petitioner further argues that Calderon also teaches nozzles tip depth at zero and above the substrate surface. *Id.* at 15 (citing PO Resp. 52; Ex. 1009, 8:45–52).

Turning to RepRap20208, Petitioner argues that it links the strain gauge to z-height determination and relates it to avoiding collision problems. Pet. Reply 14–15 (citing Pet. 48–56; Ex. 1009, 9:63–10:23; Ex. 1010, 13, 14, 18–20). Petitioner also argues that strain gauges were commonly used for force sensing, as stated by the '698 patent, and that RepRap20208 recognized strain gauges had advantages over other sensors. *Id.* at 15–16 (citing Pet. 51–55; Ex. 1001, 9:2–7; Ex. 1003 ¶¶ 165–172; Ex. 1009, 2:36–53; Ex. 1010, 14, 19, 20), 22. Petitioner, thus, argues that strain gauges would have been used in implementations without servos. *Id.* at 16 (citing Pet. 54–55; Ex. 1001, 9:2–7; Ex. 1003 ¶¶ 171, 172).

Even in implementations with servos, Petitioner argues that, in the Petition, it contends that it would have been obvious to use strain gauges for detecting extrusion head collisions and for z-axis calibration, as corroborated by RepRap20208. Pet. Reply 16–17 (citing Pet. 52–53; Ex. 1003 ¶¶ 161–167; Ex. 1010, 20). Petitioner points to RepRap20208 and its declaration for support that backlash was a problem in monitoring servo currents. *Id.* at 17 (citing Pet. 53, 54; PO Resp. 48, 49; Ex. 1003 ¶¶ 169–171; Ex. 1010, 20). Petitioner also argues that strain gauges would have improved Calderon by performing z-height calibration while performing collision detection. *Id.* at 17–18 (citing Pet. 46, 50–51; Ex. 1010, 13, 18–19).

Patent Owner replies that Petitioner is abandoning its proposal to apply a strain gauge on the extruder mount and, instead, argues that Calderon discloses monitoring more generally, not just in servo implementations. PO Sur-reply 17–18 (citing Pet. 56; Pet. Reply 13–14, 16–

17). Patent Owner argues that “Petitioner cannot cure its failure to show a motivation to combine in the Petition by changing its motivation theory in the Reply—specifically, from applying RepRap20208’s strain gauges rather than Calderon’s servo drive monitoring to merely ‘using a strain gauge with Calderon.’” *Id.* at 18 (citing Pet. 56; Pet. Reply 12).

Patent Owner also argues that Calderon does not limit its current monitoring to servo implementations. PO Sur-reply 18–19 (citing Pet. Reply 13; Ex. 1009, 9:63–10:22). Patent Owner further argues that Petitioner does not address that Calderon teaches away from special purpose sensors and so that teaching remains undisputed. *Id.* at 19 (citing PO Resp. 48–50; Pet. Reply 14, 16; Ex. 1009, 9:63–10:5, 10:7–8, 10:26–47). Patent Owner contends that Petitioner’s proposed combination ignores that teaching and introduces a special-purpose sensor. *Id.* (citing PO Resp. 47–48, 50; Ex. 1009, 10:1–8; Ex. 1018, 302–304; Ex. 2027 ¶¶ 109, 110, 250).

Patent Owner also replies that Petitioner introduces a new theory that Calderon and RepRap20208 have the same problem, whereas the Petition argued the RepRap20208 solved a problem that Calderon had. PO Sur-reply 19–20 (citing Pet. 52, 54; Pet. Reply 14). According to Patent Owner, Calderon already has a collision detection solution. *Id.* (citing PO Resp. 48–50, 56–57; Pet. Reply 14–15, 18; Ex. 1009, 9:63–10:8, 10:26–47, 10:57–64).

Patent Owner further replies that Petitioner attempts to shift the burden to Patent Owner by asserting that Patent Owner did not address printing at the surface. PO Sur-reply 20 (citing Pet. Reply 15, 20–21). Patent Owner argues that Calderon prints below the surface of some substrates and already has a solution for preventing damage to the substrate and nozzle. *Id.* at 20–21 (citing PO Resp. 48–49, 52; Pet. Reply 20–21; Ex. 1009, 2:44–50, 9:63–10:8, 10:26–47; Ex. 2027 ¶¶ 244, 247)

Patent Owner also identifies the argument that strain gauges would work over long periods of time as new analysis and unsupported attorney argument. PO Sur-reply 21 (citing Pet. Reply 15). Patent Owner contends that Petitioner fails to rebut that Calderon teaches not to use special-purpose sensors, that RepRap20208 only mentions backlash, that a strain gauge is not closer to the contact than z-axis drive motor monitoring, that RepRap20208 refers to a sensor different than Calderon's current monitoring, and that RepRap20208's context indicates reference to another sensor, not Calderon's solution. *Id.* at 21–22 (citing PO Resp. 48–51; Pet. Reply 19–20).

(3) Petitioner Shows a Persuasive Reason to Combine

We find that Petitioner cites a portion of Calderon that describes an “initialization routine” that “records the z-axis position of platform 134” by positioning nozzle 132 over locations of the substrate and raising platform 134 “until the nozzle tip contacts the substrate.” Ex. 1009, 9:63–10:5.

We also find that Petitioner cites portions of RepRap20208 that describe that a “strain gauge on the extruder mount” could detect a “series of head collisions,” the strain gauge could be used “to calibrate the Z-axis,” and “the strain gauge will tell you how much your extruder has elongated due to heating, warping, or in my special case, catastrophic failure.” Ex. 1010, 13–14. The cited portions also describe that collision detection should lead to “machine shut down,” and measuring “exactly how high my extruder head is above the bed, as height changes of 0.1 mm [can] make significant differences in raft and part adhesion.” *Id.* at 19.

Based on our findings above, we credit Petitioner's testimonial evidence that strain gauges would have been implemented in Calderon for

collision detection and shutting down the machine upon collision detection.

Ex. 1003 ¶ 163. We agree that “adding collision detection using a strain gauge described in RepRap20208 to Calderon’s three-dimensional printer would have been nothing more than applying proven elements to a system ready for improvement.” *Id.* ¶ 162; *see also* Ex. 1009, 6:41–43 (describing that the sensor of sensor assembly 140 “may be interchanged with any sensing means which can detect and signal contact between the plunger and the substrate”); Ex. 1010, 13 (describing that “a strain gauge on the extruder mount” would detect “head collisions”).

Because our findings above support it, we also credit the testimony that one of ordinary skill in the art would have been motivated to make the proposed combination for the expressly described benefits of shutting down the machine to prevent damage and collision detection provided by strain gauges. Ex. 1003 ¶¶ 165, 166. We agree with Petitioner’s declarant that the proposed combination would have been a “predictable inclusion of a strain gauge [that] follows the familiar pattern of merely substituting one element (a common strain gauge) for another known in the field (Calderon’s teaching of monitoring servo drive current) to obtain predictable results.” *Id.* ¶ 172. The record supports that there would have been a reasonable expectation of success in making the proposed combination. Ex. 1003 ¶ 173; Ex. 1018, 302–304.

Calderon states that “[i]n 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.” Ex. 1009, 10:5–8. We find that this statement “merely expresses a general preference for [simply monitoring a change in the servo drive current without need for any special purpose sensing means] but does

not ‘criticize, discredit, or otherwise discourage’ investigation into [strain gauges for collision detection and for shutting down the machine upon collision detection].” *See DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1327 (Fed. Cir. 2009) (quoting *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004)). Supporting our determination, Calderon elsewhere states that the sensor of sensor assembly 140 “may be interchanged with any sensing means which can detect and signal contact between the plunger and the substrate.” Ex. 1009, 6:41–43. Patent Owner’s argument that Calderon teaches away is therefore unsupported by the record before us.

Patent Owner argues that Calderon already has its own solution for stopping its machine because Calderon discloses that “[i]f 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.” PO Resp. 50; Ex. 1009, 10:43–45. The disclosure relates to when “a prior user builds a model but does not remove the model from the machine.” *See id.* at 10:25–47. We do not find that stopping the machine because a prior build was not removed conflicts with Petitioner’s reasons to add strain gauges for collision detection while a model is being built. Ex. 1003 ¶¶ 162, 163, 165, 166, 172; Ex. 1009, 6:41–43. As for the remaining responsive arguments (PO Resp. 50–52), they relate to Petitioner’s other reasons for combining Calderon and RepRap20208 that we do not need to reach.

Based on the full record and for the reasons above, Petitioner persuades us, and we determine, that one of ordinary skill in the art would have made the proposed combination with a reasonable expectation of success.

g) Objective Evidence of Nonobviousness

Patent Owner does not present any objective evidence of nonobviousness in connection with any claim of the '698 patent. *See* PO Resp.

h) Petitioner Shows that Claim 1 is Unpatentable over Calderon and RepRap20208

Based on the full record before us, we find that (1) Petitioner's proposed level of ordinary skill in the art is consistent with the prior art of record, (2) Calderon and RepRap20208 teach or suggest all the limitations of claim 1, (3) one of ordinary skill in the art would have combined Calderon and RepRap20208 in the manner asserted by Petitioner with a reasonable expectation of success, and (4) no objective evidence of nonobviousness has been asserted in connection with any claim.

Weighing these underlying factual determinations, a preponderance of the evidence persuades us that claim 1 of the '698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

4. Claim 2

Claim 2 depends from claim 1 and recites "wherein the fabrication tool includes an extruder." Ex. 1001, 12:50–51. Petitioner argues that Calderon teaches that extrusion head 126 has nozzle 132 through which modeling material is extruded. Pet. 63 (citing Ex. 1003 ¶¶ 194, 195; Ex. 1009, 4:48–56).

We find that the portions of Calderon cited by Petitioner teach or suggest the additional limitations of claim 2. Ex. 1009, 4:48–56. We credit Petitioner's testimonial evidence because the citations to Calderon support it. Ex. 1003 ¶ 195; Ex. 1009, 2:25–47, 4:48–56.

Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 2 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we find, that Calderon teaches or suggests the additional limitations of claim 2. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 2 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

5. *Claim 3*

Claim 3 depends from claim 2 and recites “wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.” Ex. 1001, 12:52–54.

Petitioner argues that the proposed combination would shut down the machine upon detecting a collision, as taught by RepRap20208. Pet. 63 (citing Ex. 1010, 19). Petitioner also argues that one of ordinary skill in the art “would have recognized or found obvious that shutting the 3D printer down includes stopping the feed of additional build material (i.e., ***controlling a feed rate of build material used in the build***).” *Id.* at 63–64 (citing Ex. 1003 ¶¶ 196–198). Petitioner further argues that stopping a machine when a collision has occurred was known in the art. *Id.* at 64 (citing Ex. 1008 ¶ 180). Petitioner, thus, argues that one of ordinary skill in the art “would have known, or at least found it obvious, to stop feeding of additional build material by controlling, e.g., ‘[e]xtrusion pump 122 . . . that provides modeling material from a material supply 130 to extrusion head 126,’ ” “[t]o save the machine and avoid material waste,” thereby controlling a feed rate of build material used in the build. *Id.* (citing Ex. 1003 ¶¶ 198, 199; Ex. 1009, 4:48–50).

We determine that proposed combination of Calderon and RepRap20208 would have the additional limitations of claim 3. Ex. 1009, 4:48–50; Ex. 1010, 19. We credit Petitioner’s testimonial evidence because the citations to the record support it. Ex. 1003 ¶¶ 197, 198; Ex. 1008 ¶ 180; Ex. 1009, 4:48–50; Ex. 1010, 19.

Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 3 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of claim 3. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 3 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

6. *Claim 4*

Claim 4 depends from claim 2 and recites “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.” Ex. 1001, 12:55–58.

Petitioner argues that, similar to the analysis of claim 3, when a collision is detected, the proposed combination would shut down the machine. Pet. 64. Petitioner also argues that shutting down would be recognized as, or obviously, stopping any change in the relative z-distance. *Id.* at 64–65 (citing Ex. 1003 ¶¶ 200–202; Ex. 1009, 4:56–57; Ex. 1010, 19). Petitioner further argues that such stopping was also general knowledge in 3D printing. *Id.* at 64 (citing Ex. 1008 ¶ 180).

a) Patent Owner's Response

Patent Owner responds that the combination does not teach claim 4's limitations, because there is no teaching that the z-distance needs to be changed or controlled as part of shutting down. PO Resp. 58 (citing Pet. 64–65; Ex. 2027 ¶ 277). Patent Owner argues that RepRap20208 merely describes shutting down, and that there is no teaching or suggestion that the z-distance between extruder and platform would be changed or controlled. *Id.* (citing Ex. 1010, 19; Ex. 2027 ¶ 277). Calderon, Patent Owner argues, only “stops the build and alerts the user.” *Id.* (quoting from Ex. 1009, 10:43–45). Patent Owner, thus, argues that “Petitioner has failed to show that the z-distance between the dispensing head and platform, specifically, is controlled during a machine shut down.” *Id.* (citing Ex. 2027 ¶¶ 275–278).

b) Reply Arguments

Petitioner replies that Calderon teaches stopping the build which would stop the dispenser in all directions, including the z-direction. Pet. Reply 22 (citing PO Resp. 58; Ex. 1003 ¶¶ 200, 201). Petitioner also argues that the claim only requires controlling, not changing, z-distance “which Calderon does by stopping.” *Id.* at 22–23 (citing PO Resp. 58; Ex. 1003 ¶¶ 200–202; Ex. 1009, 10:42–47; Ex. 1010, 19). Petitioner further argues that Calderon additionally teaches clearing the envelope and that would have obviously required changing the distance between the extruder and the structure. *Id.* at 23 (citing PO Resp. 58; Ex. 1003 ¶¶ 200–202; Ex. 1009, 10:42–47).

Patent Owner replies that Petitioner introduces a new argument unsupported by evidence. PO Sur-reply 25 (citing Pet. Reply 23). Patent Owner reiterates that there is no teaching or suggestion to change z-distances at shutdown. *Id.* (citing Pet. 64–65; PO Resp. 57–58; Ex. 2027 ¶ 277).

c) Petitioner Persuades Us that Claim 4 is Unpatentable

We find that the portion of Calderon cited by Petitioner discloses that “[m]odeling platform 134 moves in a z-direction under the control of z-axis translator 120.” Ex. 1009, 10:42–47. Calderon, thus, controls z-distance by preventing an undesirable change in the z-distance between the extruder and the build platform. *See id.* Petitioner also cites a portion of RepRap20208 that discloses shutting down a machine upon collision detection. Ex. 1010, 19. We agree with Petitioner that the claim only requires controlling, not necessarily affirmatively changing, z-distance “which Calderon does by stopping.” Pet. Reply 22–23.

In view of the cited disclosures, we also agree with Petitioner’s declarant that one of ordinary skill in the art would have recognized “that shutting the 3D printer down includes stopping changing any relative z-distance between the dispensing head and the platform.” Ex. 1003 ¶ 201. We credit the testimony because the citations to the record support it. Ex. 1003 ¶ 201; Ex. 1008 ¶ 180; Ex. 1009, 4:56–57.

Patent Owner’s responsive arguments do not show that Petitioner’s argument and evidence are insufficient, because they imply that the limitation “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” requires changing the z-distance. *See* PO Resp. 58. The record does not have sufficient argument and evidence to limit the scope of claim 4 in that manner. *See id.* at 8 (“Patent Owner submits that the Board does not need to construe any claim terms in any particular way to conclude that the challenged claims are not unpatentable”).

Based on the full record, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of

claim 4. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 4 of the '698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

7. Claim 5

Claim 5 depends from claim 2 and recites “further comprising comparing the current contact force to an expected contact force.” Ex. 1001, 12:59–60.

Petitioner argues that it would have been known or obvious that exceeding a threshold force indicates a collision and comparing the current contact force to that threshold force to detect the collision. Pet. 65 (citing Ex. 1003 ¶¶ 203–205).

a) Patent Owner’s Response

Patent Owner responds that Petitioner fails to show all the elements of claim 5, because there is no teaching of detecting a current contact force and, thus, no teaching of the required comparison. PO Resp. 58–59 (citing Pet. 65–66; Ex. 1009, 9:63–10:8; Ex. 1010, 13, 14; Ex. 2027 ¶¶ 279–282).

b) Reply Arguments

Petitioner replies that RepRap20208 “is concerned with collision detection and shutting down a build to protect the nozzle, substrate, and build material from damage” and the proposed combination “uses a strain gauge to determine contact force and compares the determined contact force to decide when the correct contact has occurred.” Pet. Reply 23 (citing Ex. 1009, 2:35–53, 8:35–52; Ex. 1010, 19). Petitioner, thus, argues that it would have been obvious that determining whether contact occurred would have used a comparison of known contact force and determined contact force. *Id.* (citing Ex. 1003 ¶¶ 203–205).

Patent Owner replies that Petitioner makes new improper assertions about its combination by tacitly citing to Calderon, which was not done in the Petition. PO Sur-reply 25–26 (citing Pet. 65–66; PO Resp. 58–59; Pet. Reply 23).

c) Petitioner Persuades Us that Claim 5 is Unpatentable

As discussed above for claim 1’s “current contact force,” we find that Calderon and RepRap20208 teach or suggest detecting the current contact force. Ex. 1009, 6:41–43, 10:1–3; Ex. 1010, 20. In view of those findings, we agree with Petitioner’s declarant that one of ordinary skill in the art

would have known, or found it obvious, to introduce, for example, a threshold tension indicative of collision, and ***compare the current contact force*** (e.g., obtained based on sensor signals from the strain gauge on the extruder mount, as taught in RepRap20208) ***to*** this threshold (as ***an expected contact force***) so that a collision event (i.e., “when you run into something”) can be detected.

Ex. 1003 ¶ 204.

Based on the full record, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of claim 5. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 5 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

8. Claim 7

Claim 7 depends from claim 5 and recites “further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.” Ex. 1001, 12:65–67.

Petitioner argues that its proposed combination shuts down when the threshold force is exceeded and indicates that a collision is occurring.

Pet. 65–66 (citing Ex. 1003 ¶¶ 206–208; Ex. 1010, 19). Petitioner also argues that stopping production when a collision has occurred was generally known. *Id.* at 66 (citing Ex. 1003 ¶¶ 207, 208). Petitioner, thus, argues that one of ordinary skill in the art would have known, or found it obvious, “to terminate the build once a collision is detected so that energy and material can be saved while additional damages may be prevented.” *Id.* (citing Ex. 1003 ¶¶ 207, 208).

Patent Owner presents its arguments for claim 7 together with its arguments for claim 5. PO Resp. 58–59. The parties also present their reply arguments for claim 7 together with claim 5. Pet. Reply 23; PO Sur-reply 25–26.

Based on the full record and for the reasons given above for claims 1 and 5, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of claim 7. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 7 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

9. Claim 8

Claim 8 depends from claim 1 and recites “wherein the control signal includes a signal to the three-dimensional printer to change a distance between the fabrication tool and the separate structure.” Ex. 1001, 13:1–4.

Petitioner argues that one of ordinary skill in the art “would have known, or found it obvious, to have a threshold force indicative of collision, and compare the current contact force to this threshold to detect a collision event (i.e., “when you run into something”)” to “prevent mistakenly identifying a collision and shutting down the 3D printer.” Pet. 66 (citing Ex. 1003 ¶¶ 209, 210). Petitioner also argues that, when current contact

force does not exceed the threshold, the ordinarily skilled artisan would have understood, or found obvious, that “for the 3D printer to continue to print the 3D object and for such printing to involve *a signal to the three-dimensional printer to continue to change a distance between the fabrication tool and the separate structure.*” *Id.* at 66–67 (citing Ex. 1003 ¶ 210).

Petitioner further argues its proposed combination would have “provide[d] a control signal to, e.g., z-axis translator 120, to *change a z-distance between the fabrication tool* (including, e.g., extrusion head 126) *and the separate structure* (e.g., modeling platform 134 where substrate 128 is mounted) in performing z-axis initialization, after the nozzle has contacted the substrate as taught in Calderon.” Pet. 67. Petitioner alternatively argues that the ordinarily skilled artisan “would have found it obvious to *change a distance between the fabrication tool and the separate structure* in disengaging the nozzle from the separate structure once a collision is detected during printing, as suggested by RepRap20208.” *Id.* (citing Ex. 1003 ¶¶ 211, 212; Ex. 1009, 3:1–10, 3:27–30, 4:56–57, 11:6–11; Ex. 1010, 13, 19–20).

We determine that proposed combination of Calderon and RepRap20208 would have the additional limitations of claim 8. Ex. 1009, 3:1–10, 3:27–30, 4:56–57, 11:6–11; Ex. 1010, 13, 19–20. We credit Petitioner’s testimonial evidence because the citations to the record support it. Ex. 1003 ¶¶ 210, 211; Ex. 1009, 3:1–10, 3:27–30, 4:56–57, 11:6–11; Ex. 1010, 13, 14, 19–20.

Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 8 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of claim 8. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 8 of the '698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

10. Claim 9

Claim 9 depends from claim 2 and recites “wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.” Ex. 1001, 13:5–7.

Petitioner argues that, as explained for claim 3, the 3D printer shuts down upon collision and, thus, shuts down the feed of additional build material. Pet. 67 (citing Ex. 1010, 13, 19–20). Petitioner, thus, argues that one of ordinary skill in the art would have known, or found it obvious, to send a control signal to stop feeding additional build material, thereby changing the feed rate of the extruder. *Id.* at 66–67 (citing Ex. 1003 ¶¶ 213–215; Ex. 1009, 4:48–50).

We find that the portions of RepRap20208 cited by Petitioner disclose the additional limitations of claim 9. Ex. 1010, 13, 19–20. We credit Petitioner’s testimonial evidence because the citations to the record support it. Ex. 1003 ¶ 214; Ex. 1009, 4:48–50; Ex. 1010, 13, 19–20.

Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 9 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we find, that RepRap20208 teaches or suggests the additional limitations of claim 9. Weighing our underlying factual determinations, a preponderance of the

evidence persuades us that claim 9 of the '698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

11. Claim 10

Claim 10 depends from claim 2 and recites “further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.” Ex. 1001, 13:8–11.

Petitioner argues that “Calderon teaches z-axis initialization ‘to determine whether the top surface of substrate is approximately parallel to a horizontal, xy-plane’” and positioning its nozzle to monitor contact between the tip and substrate at pre-selected locations. Pet. 68 (citing Ex. 1009, 7:65–8:5, 9:65–67). Petitioner, thus, argues that its proposed combination “includes a multi-point calibration” based on contact force measurements across a surface of a separate structure. *Id.* at 68–69 (citing Ex. 1003 ¶¶ 216–219).

a) Patent Owner’s Response

Patent Owner responds that the relied-upon portion of Calderon teaches a “Find-Z program” that skips certain steps to eliminate variables X and Y. PO Resp. 60 (citing Ex. 1009, 10:9, 10:11–15; Ex. 2027 ¶ 285). Patent Owner, thus, argues that the relied-upon portion of Calderon does not find a plane. *Id.* at 60–61 (citing Ex. 1009, 8:27, 8:34–37, 8:65–9:60, 9:62–10:22; Ex. 2027 ¶ 285). In Patent Owner’s view, one of ordinary skill in the art “would have understood that Calderon’s Example 3 finds a z-start position and does not detect the planarity of the substrate”, and “[t]hus, Petitioner has failed to show that the combination teaches claim 10.” *Id.* at 61 (citing Ex. 2027 ¶¶ 283–287).

b) Reply Arguments

Petitioner replies that Calderon's predetermined distances X and Y are respectively the distance of the sensing location above the actuated position of the plunger and the distance of the tip of the nozzle above the tip of the plunger. Pet. Reply 24 (citing Ex. 1009, 8:21–34). Petitioner also argues that those distances are not needed because a plunger is not used and, instead, the nozzle tip is used directly. *Id.* (citing Ex. 1009, 7:62–8:51, 9:63–10:15). Petitioner further argues that the X and Y distances are not related to determining whether the substrate is approximately parallel to a horizontal plane. *Id.* (citing Ex. 1009, 7:62–8:15).

Patent Owner replies that Petitioner introduces an improper, new discussion about a step not discussed in the Petition. PO Sur-reply 26 (citing Pet. 68). Patent Owner reiterates its argument from its Response. *Id.* (citing Pet. 60–61; Pet. Reply 24; Ex. 1009, 10:11–15). Patent Owner argues that, even considering that X and Y distances are removed, it would have been understood that Calderon finds a z-start position but does not detect planarity. *Id.* at 26–27 (citing Ex. 1009, 7:64–67, 9:17–19, 9:23–26; Ex. 2027 ¶ 286).

c) Petitioner Persuades Us that Claim 10 is Unpatentable

We find that a portion of Calderon cited by Petitioner discloses that “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” and that “[i]f the result of the comparison shows that the substrate top surface does not closely enough approximate a horizontal plane, that result indicates either that the substrate 146 was not mounted flush to platform 147, or that the substrate 146 has a deformity.” Ex. 1009, 7:65–8:5.

Another cited portion discloses an “initialization routine is performed by positioning the nozzle 132 above pre-selected locations of the substrate and raising the platform 134.” Ex. 1009, 9:65–67. We credit Petitioner’s testimonial evidence because the citations to Calderon support it. Ex. 1003 ¶¶ 217, 218; Ex. 1009, 7:65–8:5, 9:65–67.

In view of the cited disclosures that Calderon’s Find-Z “determine[s] whether the top surface of substrate 146 is approximately parallel to a horizontal, xy-plane,” thereby indicating that “the substrate 146 was not mounted flush to platform 147, or that the substrate 146 has a deformity” (Ex. 1009, 7:65–8:5), we do not agree with Patent Owner’s arguments that Calderon does not find a plane. PO Resp. 60–61; Ex. 1009, 8:27, 8:34–37, 8:65–9:60, 9:62–10:22. Patent Owner’s arguments addresses a specific example of the Find-Z program but not the overall determination of “whether the top surface of substrate 146 is approximately parallel to a horizontal, xy-plane.” See PO Resp. 60–61.

Based on the full record, Petitioner persuades us, and we find, that Calderon teaches or suggests the additional limitations of claim 10. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 10 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

12. Claim 12

Claim 12 depends from claim 1 and recites “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.” Ex. 1001, 13:16–21.

Petitioner refers to its arguments for claim 1 that Calderon teaches providing build instructions so that controller 116 can control extrusion of modeling material. Pet. 69 (citing Ex. 1009, 4:19–52). Petitioner argues that one of ordinary skill in the art “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.’” *Id.* (citing Ex. 1003 ¶¶ 220–222; Ex. 1010, 13–14). Petitioner, thus, argues that the ordinarily skilled artisan “would have recognized that the Calderon-RepRap20208 Combination provides *at least one build instruction for achieving a specified contact force* (e.g., one that does not exceed the threshold) *between the fabrication tool and the separate structure.*” *Id.* (citing Ex. 1003 ¶ 223).

Petitioner also argues that the control signal of claim 1 would have been understood to have been sent to control xy axis translator 118, z-axis translator 120, and extrusion pump 122 so that contact between tip of nozzle 122 and substrate 128 achieves a specified contact force not exceeding the threshold. Pet. 70 (citing Ex. 1003 ¶¶ 224, 225; Ex. 1009, 4:33–52, 9:63–10:8; Ex. 1010, 13).

a) Patent Owner’s Response

Patent Owner responds that neither of the references teaches a specified contact force and, as argued for claims 5 and 7, there is no teaching of comparing a current contact force to an expected contact force. PO Resp. 61–62 (citing Pet. 69, 70). Patent Owner argues that “Calderon teaches detecting contact by ‘monitoring a change in the servo drive current,’” and “RepRap20208 teaches watching for a ‘change in bolt tension when you run into something.’” *Id.* at 62 (citing Ex. 1009, 10:5–8;

Ex. 1010, 14). Patent Owner, thus, argues that “[t]here is no teaching of a specific contact force, much less an instruction for achieving a specific contact force” and claim 12 has not been shown to be unpatentable. *Id.* (citing Ex. 2027 ¶¶ 288–292).

b) Reply Arguments

Petitioner replies that Z-axis calibration and collision detection would need to be coded with threshold forces, as its declarant explained. Pet. Reply 24 (citing Ex. 1003 ¶¶ 220–222). Petitioner argues that it would have been obvious to perform a comparison between the threshold and determined contact force values and that to respond to collisions, the system needs instructions for achieving specific contact force. *Id.* at 24–25 (citing Ex. 1003 ¶¶ 220–222).

Patent Owner replies that “RepRap20208 teaches watching for a bolt-tension change ‘when you run into something’ and not a comparison to a threshold force.” PO Sur-reply 27 (citing PO Resp. 61–62; Pet. Reply 24–25; Ex. 2027 ¶ 290). Patent Owner, thus, argues that there is no teaching of a specified contact force or instruction for achieving it. *Id.*

c) Petitioner Fails to Show that Claim 12 is Unpatentable

We do not find that the cited portion of Calderon discloses that its “build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure.” Ex. 1009, 4:19–52.

The cited portion, instead, describes a CAD program “in a processor 108 [that] generates a file describing the geometry of a part 109 to be created” and a “slicing program” that “algorithmically subdivides the file into volume elements 110 corresponding to shapes that can be extruded from a nozzle.” Ex. 1009, 4:19–28. Calderon also discloses that “[a]dditional

volume elements 112 are added as necessary to provide mechanical support to a part during its construction” and “[t]he volume elements are sequentially ordered so that deposited material is supported appropriately.” *Id.* at 4:28–33. Calderon goes on to describe how controller 116 controls extrusion. *Id.* at 4:34–52.

Petitioner’s declarant opines that Calderon controls extrusion of modeling material and that it would have been known or obvious that the current contact force is compared to a threshold. Ex. 1003 ¶¶ 221, 222 (citing Ex. 1009, 4:19–52; Ex. 1010, 13–14). Petitioner’s declarant then concludes that one of ordinary skill in the art “would have recognized that the Calderon-RepRap20208 Combination provides *at least one build instruction for achieving a specified contact force* (e.g., one that does not exceed the threshold indicative of collision) *between the fabrication tool and the separate structure.*” *Id.* ¶ 223.

Petitioner’s declarant does not explain further why the recited “build instruction” that was mapped to Calderon’s “file describing the geometry of a part 109 to be created” in the arguments for claim 1 includes “at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure,” as required by claim 12. Pet. 57 (citing Ex. 1009, 4:19–33).

Based on the full record, Petitioner does not persuade us that Calderon or RepRap20208 teaches or suggests the additional limitations of claim 12. Petitioner, thus, does not persuade us by a preponderance of the evidence that claim 12 of the ’698 patent is unpatentable.

13. Claim 13

Claim 13 depends from claim 1 and recites “wherein the one or more sensors include a strain gauge.” Ex. 1001, 13:22–23.

Petitioner argues that RepRap20208 suggests applying strain gauges to Calderon’s sensing means. Pet. 70 (citing Ex. 1003 ¶¶ 226–228; Ex. 1009, 9:63–10:23; Ex. 1010, 19–20).

We find that the portion of RepRap20208 cited by Petitioner teaches or suggests the additional limitations of claim 13. Ex. 1010, 19–20. We credit Petitioner’s testimonial evidence because the citations to Calderon support it. Ex. 1003 ¶ 227; Ex. 1009, 9:63–10:23; Ex. 1010, 19–20.

Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 13 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we find, that RepRap20208 teaches or suggests the additional limitations of claim 13. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 13 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

14. Claim 14

Claim 14 depends from claim 1 and recites “wherein the one or more sensors include a piezoelectric sensor.” Ex. 1001, 13:24–25.

Petitioner argues that one of ordinary skill in the art would have been motivated to use piezoelectric or strain sensors on an extruder mount because they were readily available, well understood, and designed to measure mechanical pressure and strain. Pet. 70–71 (citing Ex. 1003 ¶¶ 229–231). According to Petitioner, the use of such sensors would have been a mere substitution of one known sensor for another to obtain predictable results, would not have disturbed other aspects of the system,

and would have produced substantially the same functionality described in RepRap20208. *Id.* at 66 (citing Ex. 1003 ¶ 230).

We credit Petitioner’s testimonial evidence because the citations to the record support it. Ex. 1003 ¶ 230; Ex. 1019, Abstract; Ex. 1020. Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 14 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of claim 14. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 14 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

15. Claim 15

Claim 15 depends from claim 1 and recites “wherein the one or more sensors include at least one of a capacitive sensor, and optical sensor, an electromechanical sensor, an electromagnetic sensor, and an acoustical sensor.” Ex. 1001, 13:26–29.

Petitioner argues that a strain gauge is an electromechanical sensor, because strain gauges are known to convert strain, a mechanical input, to an electrical output signal. Pet. 72 (citing Ex. 1003 ¶¶ 232, 233). Petitioner also argues that the recited list “encompasses nearly all common types of strain sensors.” *Id.* (citing Ex. 1003 ¶¶ 234, 235). In Petitioner’s view, it would have been obvious “to incorporate any of these common types of strain sensor based on RepRap20208’s general teaching of a ‘strain gauge.’” *Id.* (citing Ex. 1003 ¶¶ 234, 235).

We credit Petitioner’s testimonial evidence because the citations to the record support it. Ex. 1003 ¶¶ 234, 235; Ex. 1018, 284–290, 302–304.

Patent Owner responds that the proposed combination of Calderon and RepRap20208 would not have rendered obvious claim 15 “for at least the reasons provided above for claim [1].” PO Resp. 57 (citing Ex. 2027 ¶ 274).

Based on the full record, Petitioner persuades us, and we determine, that the proposed combination would have had the additional limitations of claim 15. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 15 of the ’698 patent is unpatentable over Calderon and RepRap20208. *Arctic Cat*, 876 F.3d at 1361.

G. Asserted Obviousness Based on Calderon, RepRap20208, and Napadensky

1. Napadensky (Ex. 1005)

Napadensky describes “solid freeform fabrication” (or “SFF”), “a technology enabling fabrication of arbitrarily shaped structures directly from computer data via additive formation steps.” Ex. 1005, 1:21–29, Abstract. Napadensky also describes potential collision with an object on the surface over which build material is being dispensed, “for example, as a result of dispensed layers being too thick and/or inconsistent in thickness, and/or because of a mechanical malfunction of the dispensing head.” *Id.* at 18:9–12. According to Napadensky, “[l]eveling device 32 serves to straighten the newly formed layer prior to the formation of the successive layer thereon” and “the layer thus formed may be straightened by leveling device 32.” *Id.* at 17:65–67, 18:36–37.

2. Claim 11

Claim 11 depends from claim 10 and recites “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.” Ex. 1001, 13:12–15.

According to Petitioner, Napadensky teaches subjecting a newly formed layer to a leveling operation to reduce surface irregularities, and Calderon teaches a surface of the platform. Pet. 74 (citing Ex. 1003 ¶¶ 239, 240; Ex. 1005, 17:56–18:4, 18:25–47).

Petitioner argues that one of ordinary skill in the art would have incorporated Napadensky’s leveling operation into the proposed combination of Calderon and RepRap20208 “to ‘straighten the newly formed layer prior to the formation of the successive layers thereon.’” Pet. 73 (citing Ex. 1005, 18:25–47). The motivation, Petitioner argues, would have been to “reduce[] surface irregularities that could cause collisions” and improve model quality. *Id.* at 73–74 (citing Ex. 1003 ¶¶ 236, 237; Ex. 1005, 18:5–18; Ex. 1009, 2:63–3:1). Petitioner also argues that there would have been a reasonable expectation of success in further combining Napadensky with Calderon and RepRap20208. *Id.* at 74 (citing Ex. 1003 ¶ 238).

a) Patent Owner’s Response

Patent Owner responds that Calderon already provides a solution that automatically calculates the z-position. PO Resp. 64–65 (citing Pet. 73–74; Ex. 1009, 2:63–3:3, 3:10–11). Patent Owner, thus, argues that there is no motivation to combine “Napadensky’s leveling device and operation when Calderon already provides a solution that automatically calculates the z-start position to avoid ‘adversely affect[ing]’ model quality with a deformed substrate.” *Id.* at 65 (citing Ex. 2027 ¶ 296).

Patent Owner also responds that Napadensky’s leveling is not similar to what the ’698 patent describes. PO Resp. 65 (citing Ex. 1003 ¶ 64; Ex. 2027 ¶ 297). Patent Owner argues that Napadensky’s leveling is done after a newly formed layer has been fabricated, not during fabrication

responsive to contact force measurements. *Id.* at 66 (citing Ex. 1001, 9:63–10:12, 10:20–27, Fig. 5; Ex. 1005, 17:62–67; Ex. 2027 ¶ 296). Patent Owner, thus, argues that claim 11 has not been shown to be unpatentable. *Id.* (citing Ex. 2027 ¶¶ 295–298).

b) Reply Arguments

Petitioner replies that it would have been recognized that depositing materials onto a porous surface would decrease irregularities by filling in the pores and stabilizing the build. Pet. Reply 25 (citing Ex. 1003 ¶¶ 236, 237; Ex. 1009, 2:26–3:1). Petitioner also replies that Calderon teaches fabricating layers to stabilize the model and reduce irregularities. *Id.* (citing Ex. 1009, 2:36–54). Petitioner argues that, for rigid substrates, Calderon would benefit from Napadensky’s leveling that straightens a layer as it is fabricated. *Id.* at 25–26 (citing Ex. 1003 ¶¶ 239, 240; Ex. 1005, 17:56–18:4, 18:25–47).

Patent Owner replies that Petitioner abandons its obviousness theory and discusses porous substrates with previously unidentified cites to Calderon. PO Sur-reply 27–28 (citing Pet. 73–74; PO Resp. 64–65; Pet. Reply 25). Patent Owner also argues that Petitioner does not address its argument that Calderon already provides its own solution, so there would have been no motivation to combine. *Id.* at 28 (citing PO Resp. 64–65). Patent Owner further argues that Petitioner relies on new arguments regarding a foam substrate and does not contest that Napadensky performs its leveling operation on an already formed layer and fails to teach fabricating a layer that decreases irregularities. *Id.* (citing PO Resp. 66; Ex. 2027 ¶¶ 299–302).

c) Petitioner Persuades Us that Claim 11 is Unpatentable

We find that the portions of Calderon cited by Petitioner disclose that “[l]eveling device 32 serves to straighten the newly formed layer prior 10

the formation of the successive layer thereon” and “the layer thus formed may be straightened by leveling device 32.” Ex. 1005, 17:65–67, 18:36–37.

Petitioner’s declarant explains that the proposed combination:

provides *fabricating a layer* (e.g., newly formed layer subject to the leveling operation, as taught in Napadensky) *on the surface of the separate structure* (e.g., surface of the platform as provided by Calderon) *that decreases one or more irregularities in the surface of the separate structure* (e.g., reduces surface irregularities, as taught in Napadensky).

Ex. 1003 ¶ 239. The testimony finds support in Napadensky. We also credit the testimony that one of ordinary skill in the art would have been motivated to combine Calderon, RepRap20208, and Napadensky with a reasonable expectation of success, because the record supports it. Ex. 1003 ¶¶ 236–238; Ex. 1005, 18:5–18, 18:25–47; Ex. 1009, 2:63–3:1.

Based on the citations to Napadensky and the asserted reason to combine, we understand Petitioner to be adding Napadensky’s leveling device 32 to Calderon combined with RepRap20208. Pet. 73–74. In particular, Petitioner contends that one of ordinary skill in the art “would further incorporate a leveling operation, as suggested by Napadensky.” *Id.* at 73 (citing Ex. 1005, 18:25–47). Petitioner’s argument indicates that the limitation “fabricating a layer on the surface of the separate structure” encompasses both extruding the layer and then subjecting that layer to Napadensky’s leveling operation. *See id.* at 73–74.

Patent Owner’s arguments, on the other hand, indicate that “fabricating a layer on the surface of the separate structure” would exclude Napadensky’s leveling operation, so that it would not “decrease[] one or more irregularities in the surface of the separate structure.” *See* PO Resp. 65–66. In view of the open-ended language of claim 11 (“further

comprising”) and because no claim interpretation for claim 11 has been proposed, we see no reason to limit the language of claim 11 so that “fabricating a layer” would not further include a leveling operation as described by Napadensky.

Patent Owner’s other argument regarding Calderon already providing a solution does not overcome Petitioner’s showing. PO Resp. 64–65. It appears to indicate that Calderon alone can meet the limitations of claim 11, because Calderon calculates z-position so that Calderon fabricates layers that avoids irregularities in the surface of the substrate, thereby decreasing irregularities. *See id.* (citing Ex. 1009, 2:63–3:3, 3:10–11).

Based on the full record, Petitioner persuades us, and we determine, that Napadensky teaches or suggests the additional limitations of claim 11 and that one of ordinary skill in the art would have combined Calderon, RepRap20208, and Napadensky in the manner asserted with a reasonable expectation of success. Weighing our underlying factual determinations, a preponderance of the evidence persuades us that claim 11 of the ’698 patent is unpatentable over Calderon, RepRap20208, and Napadensky. *Arctic Cat*, 876 F.3d at 1361.

III. CONCLUSION²

In summary:

Claim(s)	35 U.S.C. §	Reference(s)/Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–6, 8–15	103	Warren	1–6, 8, 9, 13–15	10–12
3, 7, 9	103	Warren, Eshed	3, 7, 9	
1–5, 7–10, 12–15	103	Calderon, RepRap20208	1–5, 7–10, 13–15	12
11	103	Calderon, RepRap20208, Napadensky	11	
Overall Outcome			1–11, 13–15	12

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1–11 and 13–15, but not claim 12, of U.S. Patent No. 9,168,698 B2 have been shown, by a preponderance of the evidence, to be unpatentable; and

FURTHER ORDERED that, because this is a Final Written Decision, the parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

² Should Patent Owner wish to pursue amendment of the challenged claim in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner’s attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. See 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

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