UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SHENZHEN TUOZHU TECHNOLOGY CO., LTD.,
Petitioner,

v.

STRATASYS, INC.,
Patent Owner.

Case IPR2025-00531
Patent 9,168,698

PETITIONER'S REPLY TO

PATENT OWNER'S RESPONSE TO PETITION

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I. INTRODUCTION

Patent Owner defends its patent by the simple expedient of ignoring the record. To avoid Warren, Patent Owner asks the Board to disregard the plain text of Warren's own claims. Those claims explicitly recite the exact vibrating sensor applied to the through-nozzle dispenser that Patent Owner insists is missing. Patent Owner then invents technical hurdles to calculating force from vibration amplitude, flatly ignoring Warren's express teaching that the two are proportional. Their defense against the Calderon grounds are equally detached from the evidence. Rather than confront the record, Patent Owner baselessly asserts that Calderon requires no improvement and a strain gauge offers no benefit—arguments the Petition preemptively dismantled. Reading the prior art as it is actually written, rather than as Patent Owner wishes it were written, renders the claims unpatentable.

II. WARREN'S THROUGH-NOZZLE DISPENSER USES A VIBRATING SENSOR

The Petition advanced both Warren's through-nozzle and capillary dispensers against the '698 patent. Petition, 6-21. The Board correctly recognized that Warren's capillary dispenser is the "fabrication tool" in 1[b], and the POR does not dispute that Warren's capillary dispenser uses vibrating force sensing. ID, n.8; POR, 24 (admitting Warren's capillary dispensers use "vibrating sensor capabilities"). Yet PO vigorously argues that Warren's through-nozzle dispenser does not use vibrating force sensing and that it would not have been obvious to do so. POR, 16-25.

PO overlooks Warren's claims, however, that recite "a vibration imparting device for imparting vibration of a particular amplitude to the at least one dispenser…a position controller for varying the position of the at least one dispenser…to obtain a desired force of contact…wherein the at least one dispenser includes at least one of a **<u>through-nozzle</u>**, a needle valve, a capillary pen, or a quill pen." Warren, claims 54→59 and 65→70 (corresponding method claims).[1] Thus, Warren expressly refutes PO's response, supporting the Petition's position advancing vibrating force sensing in Warren's through-nozzle dispenser. *E.g.*, Petition, 13-21; EX1003 ¶¶65-86; *Thereasense* at 1295 ("The claims of a prior art patent are part of its disclosure.")

Warren's claims support the position that "Warren invites the use of the vibrating force sensor concepts with other configurations of dispenser" and "a POSITA would have recognized the benefits of providing the through-nozzle dispenser with vibrating force sensor capabilities." Petition, 12-15; EX1003 ¶¶68-72 (benefits include improvements over inconsistent volumes and inaccurate start

[1] All emphases added, unless otherwise stated.

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

III. WARREN'S VIBRATION SENSOR SATISFIES 1[b]

As admitted by PO, the '698 patent describes its sensors broadly to encompass anything, "so long as the contact force(s)…may be calculated from the sensed physical characteristics." EX1001, 8:49-9:8; EX1003 ¶¶90-91; POR, 32-33. Thus, Warren's vibration sensors, which sense a change in amplitude (**ΔA**) of the vibration, satisfy the claims because Warren teaches that the contact force is detectable from the sensed **ΔA** physical characteristic. *E.g.*, EX1004 ¶[0302], [0313]-[0316]; Petition, 20-21; EX1003 ¶¶90-91. Specifically, Warren teaches that the contact force is proportional to **ΔA**. *E.g.*, EX1004 ¶[0302], [0313]; Petition, 19-21; EX1003 ¶¶80-87. Moreover, Warren teaches detecting the force from the **ΔA**. *E.g.*, Warren ¶¶[0287], [0313]-[0316]; *see also infra* §III. Thus, a POSITA would have immediately recognized that Warren teaches a sensor consistent with the '698 patent and claims. *E.g.*, EX1003 ¶¶46-48, 80-87.

IV. WARREN DETECTS A CONTACT FORCE BASED ON A SENSOR SIGNAL

Despite PO's arguments to the contrary, Warren teaches, and renders obvious, detecting the current contact force based on a sensor signal (1[c]) and creating a control signal to control the printer in response to the current contact force while depositing material during the build (1[d]). POR, 25-33. Importantly, the '698 patent does not claim calculating a contact force—only "detecting the current contact force." EX1001, cl.1; *compare* '381 patent, cl.1 ("calculate the contact force"). And as discussed in Section III, *supra*, Warren's sensors provide **ΔA,** from which contact force is detected.

As PO correctly points out, Warren teaches varying the position of one or more elements of the dispenser "to maintain a desired force of contact between the dispenser and the substrate." POR, 26 (citing Warren ¶[0289]); *see also* Warren ¶¶[0283] (introducing controlling position of the dispensing system using force feedback"), [0313]-[0316], FIG. 22A, claims 54-56, 61, 65-67, and 72; Petition 21-22. Warren varies the position based on a comparison between a detected contact force and a desired contact force. *E.g.*, EX1004 ¶[0313], FIG. 22A ("whether the contact force is that which is desired"); Petition, 22; EX1003 ¶91.

Warren explains that its system addresses a need for "a depositing system that **<u>accurately determines the intensity of the contact force</u>** between a dispensing tip and a substrate surface." Warren ¶[0287]. Warren explains that its system controls "the contact force between the dispensing structure and the substrate surface," to maintain contact "**intensity**, accurate to a precision of **micronewtons of force**, if not smaller **units of force**." *E.g.*, Warren ¶[0316]; Petition, 23, 25-27, 33; EX1003 ¶91. Warren has "demonstrated" that the system is "sufficiently sensitive to allow for the **sensing of the contact force** as a dispenser contacts a substrate surface." Warren ¶[0316]. Contrary to PO's arguments, these passages expressly support the conclusion that Warren does indeed convert **ΔA** from its vibrating sensor into a "quantitative contact force." POR, 27.

Warren also explains that "[c]ontrol applied in this manner allows for dispensing to be accomplished onto conformal surfaces" because "the force feedback control continuously corrects the dispensing structure's Z-height position as the Z height of the substrate surface changes, either by modifying the dispenser's position, the substrate's position, or both." Warren ¶[0316]; see also *id.* ¶[0314] ("force of contact between the dispensing tip and the substrate surface applied is controlled by a feedback measurement system"); Petition, 22-33.

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

Warren consistently teaches comparing the detected contact force intensity to a desired value when determining whether or not to reposition the dispenser or substrate. Specifically, Warren teaches that if "the **contact force is** that which is **desired**," the process may stop; and if "it is determined that **the contact force is not as desired**, the position(s) of the dispenser and/or the substrate are varied." Warren ¶[0313]. So, not only does Warren teach detecting the contact force (*e.g.*, to micronewton precision), Warren teaches controlling the position of the dispenser by comparing the detected contact force to a desired intensity. Petition, 15, 19-27, 33; EX1003 ¶¶80-19; Warren ¶¶[0301]-[0316], [0322], [0324], FIG. 22A.

V. DETERMINING FORCE IS OBVIOUS

Beyond demonstrating that Warren detects contact force, the Petition further demonstrates that it was obvious that Warren determines a contact force from **ΔA**. *E.g.*, Petition, 17-21; EX1004, [0313], [0301]-[0307]; EX1003, ¶86 (explaining additional details of Warren's sensing operations). Consistent with the discussion of Warren in §IV, *supra*, a POSITA would have understood that to control to a desired force intensity, one would need to know the difference between the desired force and a detected force. *E.g.*, EX1004 ¶[0313]-[0316]; Petition, 19-21; EX1003 ¶91.

Warren provides express motivation for detecting the contact force. Warren begins by stating plainly that "for proper deposition some knowledge is **required** of the **intensity of the contact force** between the dispenser tip and the surface where deposition is desired." EX1004 ¶[0285]; Petition 15; EX1003 ¶71. Warren recognizes the quantitative (proportional) relationship between contact force and sensor output. *E.g.*, EX1004 ¶[0302]; Petition, 19-20; EX1003 ¶¶46, 85. Warren concludes by identifying the need to accurately determine "**the intensity of the contact force** between a dispensing tip and a substrate surface to maintain a desired contact force." EX1004 ¶[0287]; EX1003 ¶¶71, 91, 120; Petition, 9, 15, 31. And as discussed above, Warren compares a detected contact force intensity with a desired value for determining whether to reposition the dispenser/substrate, the force intensity being a magnitude component of the force vector quantity measured in Newtons. *E.g.*, EX1004 ¶¶[0313]-[0316] (micronewton precision).

That Warren expresses a desire (and even demonstrates) sensing force to a high-degree of precision suggests that Warren does not rely solely on the measurement of **ΔA** in making the contact force comparison for determining whether to reposition the nozzle. *E.g.*, Warren ¶[0316]. Warren teaches that the contact force is "proportional" to **ΔA**, not equal or equivalent to it. *E.g.*, Warren ¶[0313]. And as discussed in the Petition, the proportional relationship means that the contact force can be readily determined from the detected **ΔA**. Petition, 19-21; Warren, [0313], [0301]-[0307]; EX1003, ¶¶86-91.

PO's extended discussion of Young's Modulus and frequency selection to suggest that it is infeasible to calculate force from Warren's vibrating force sensor is a red herring, particularly given Warren's express teaching that the contact force is "proportional" to **ΔA** and the necessity to compare the "desired force" to the force measured by the vibrating force sensor. "Prior art disclosures are presumed enabling." *Agilent*, 139 F.4th at 1327. This rule holds true "regardless of the forum," and it means "the patentee/applicant has the burden to prove nonenablement for such prior art." *Apple*, 861 F. App'x at 449-50; *Amgen*, 314 F.3d at 1355 ("[I]t was [the patentee] who bore the burden of proving the nonenablement[.]"). The patentee's burden requires evidence that "undue experimentation," *In re Wands*, 858 F.2d at 737, was necessary to practice even "a single embodiment," *In re Morsa*, 803 F.3d 1377, of the '698 patent based on Warren "as a whole," *Raytheon*, 993 F.3d at 1380. Patent Owner fails to surmount this high hurdle.

Even still, PO's arguments support, rather than detract from, a conclusion that determining the contact force is feasible. POR, 32 (citing EX2024, FIG. 4.1). PO's own evidence demonstrates that the properties that it says are relevant to calculating force, such as Young's Modulus, were well-known for a wide variety of materials. EX2024, 6-8 (showing Young's Modulus displayed in three different styles of graphical representation to show how material properties can be displayed); EX1042, 80:2-81:6 (can look up modulus for commonly printed materials). A POSITA would simply look up those properties, which reinforces Dr. Wolfe's testimony that "[c]alculating contact force from … a signal proportional to contact force was rudimentary engineering, commonplace and typical long before 2012." EX1003, ¶95; Petition, 23. Nothing in PO's discussion of Young's Modulus and frequency selection detracts from Warren's teaching that **ΔA** is proportional to contact force; in fact, PO's expert acquiesces that Warren so teaches. EX2027 ¶182. Moreover, PO's arguments assume first principle calculations are the only manner of correlating Warren's stated proportionality to force values, wholly ignoring that the correlation could be established by measurement and calibration. *See, e.g.,* EX1042, 102:7-103-11 (testifying a force-frequency relationship is obtainable experimentally); 100:13-104:14.

VI. GROUND 1A RENDERS DEPENDENT CLAIMS UNPATENTABLE

The Petition lays out the reasoning for how Ground 1A renders claims 2-6 and 8-15 unpatentable. Petition, 23-37. The Petition and this Reply point out how Ground 1A renders each and every element of claim 1 obvious, and POR cannot rely on claim 1 to save the dependent claims.

A. Ground 1A Renders 3 and 9 Unpatentable

Claims 3 and 9 recite changing or controlling a feed rate of build material. Warren teaches that the "valving mechanism" for extruding material "maybe synchronized with the xyz motion of the dispenser," and teaches modifying the z height based on surface changes detected by changes in force intensity." EX1004 ¶¶[0234], [0316] (teaching continuously correcting z-height). A POSITA would have understood Warren as teaching adjusting the feed rate (through the valving mechanism) with changes in z-height based on changes in calculated contact force. Petition, 25-31; EX1003 ¶¶99-104, 119-121.

PO assumes incorrectly that claims 3 and 9 require that the feed rate be controlled or changed based on the contact force. For example, claim 1 recites a control signal to control a component in response to the current contact force. EX1001, cl.1. Claim 9 merely recites that the control signal "includes" a signal to change the feed rate, without linking this signal back to the contact force. That is, the control signal of claim 1 can include other signals that are not in response to the contact force—in this case the feed rate. Generally, Warren's control signal controls both the feed rate and the xyz motion of the dispenser based on contact force, as discussed in the Petition. *E.g.*, Petition, 25-26, 31; EX1004 ¶¶[0243], [0239], [0234], [0255]; EX1003 ¶¶119-121.

B. Ground 1A Renders 5, 6, and 12 Unpatentable

As already discussed, Warren teaches comparing the contact force determined from **ΔA** against a desired value, and determining whether or not to adjust z-height based on the results of the comparison. *E.g.*, EX1004, [0303]-

[0316]; *see*, *supra*, §§IV-V. For example, Warren expressly teaches that the "force of contact between the dispensing tip and the substrate surface applied is controlled by a feedback measurement system." EX1004 ¶[0314].

C. Ground 1A Renders 10 and 11 Unpatentable

The POR argues that Warren does not does not teach detecting the planarity of the surface based on a number of contact force measurements. POR, 38-41. Note that the claims do not require a determination of a level or measurement of planarity. The claims only require that planarity be detected. Warren satisfies claim 10 because Warren adjusts for changes in Z-height using the determined contact force at different positions on the substrate. Specifically, Warren "continuously corrects the dispensing structure's Z-height **position as the Z height of the substrate surface changes**, either by modifying the dispenser's position, the substrate's position, or both." EX1004 ¶[0316]. Warren makes it clear that the z-height changes across the substrate (i.e., in the xy plane), and corrects for such changes using the contract force measurements. EX1004 ¶¶[0313]-[0316] (also discussing that continuously adjusting for changes in z-height permits printing on conformal or curved (e.g., cylindrical) surfaces). In addition, Dr. Wolfe explained that a POSITA would have been motivated to know the spatial relationship between the extrusion tip and the substrate prior to building to create error-free models. EX1003 ¶¶122-132. As mentioned above, Warren supports printing on curved surfaces, and it would have been obvious to calibrate the dispenser to following the curved or irregular surface during the build. *E.g.*, EX1003, ¶¶122-132; EX1004 ¶¶[0293], [0316]; Petition 31-35.

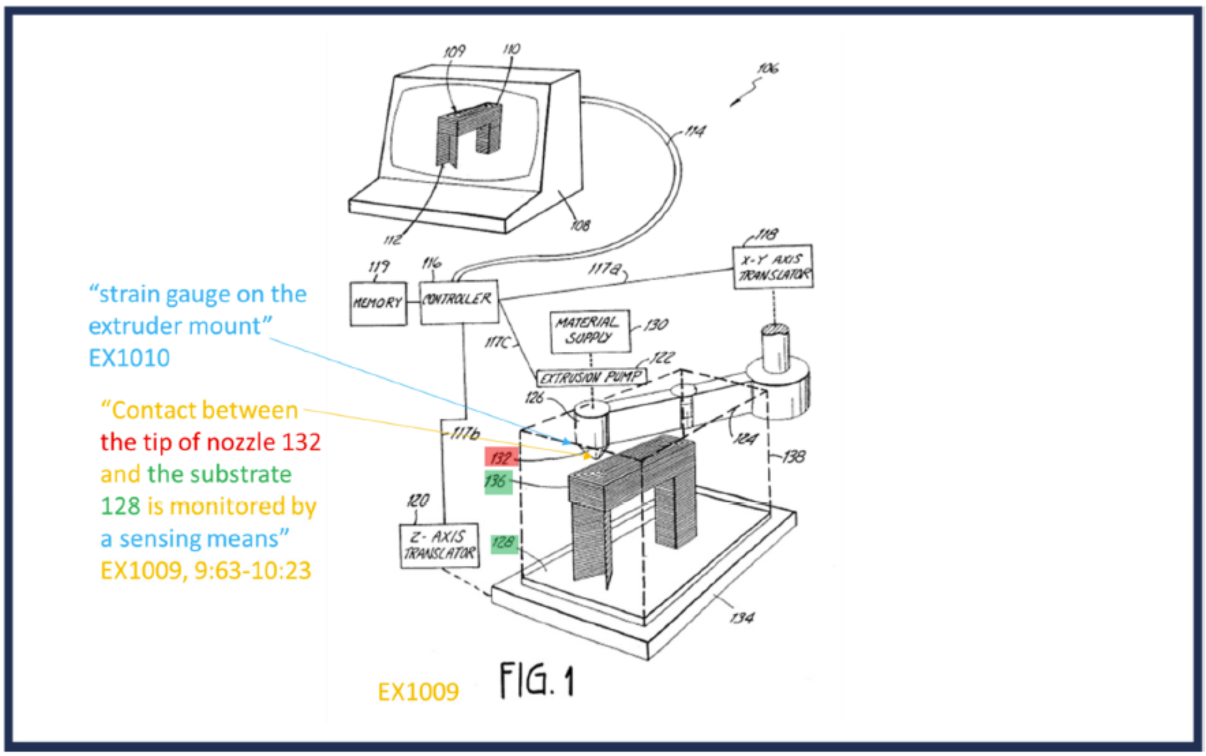
VII. GROUND 1B RENDERS 3, 7, AND 9 UNPATENTABLE

The Petition is not advancing bodily incorporation of Eshed's system into Warren's. Instead, Eshed's teachings about stopping production when a fabrication error, such as a collision, is detected enhance the combination. Petition, 37-42; EX1008 ¶[0171]; EX1003 ¶¶144-157. Dr. Wolfe explained that a POSITA would have considered destruction of the dispenser or substrate to constitute a fabrication error such that production should be terminated. EX1003 ¶¶144-145. Thus, a POSITA would have found it obvious to detect a fabrication error and terminate the build based on collisions determined from the contact force comparison technique taught by Warren. EX1003 ¶¶144-145.

Petitioner reiterates the discussion above that Warren teaches and renders obvious determining a contact force and comparing the determined contact force with a desired value. *See, supra* §§IV-V.

VIII. GROUND 2A/2B USING A STRAIN GAUGE WITH CALDERON IS OBVIOUS

PO argues that "Calderon already has his own technique for auto-initialization and collision detection to determine contact with a nozzle by 'monitoring a change in the servo drive current.'" POR 48; EX1009, 10:5-8. But Calderon monitors a change in servo drive current only in the specific use-case of "an apparatus that uses servo drive motors." EX1009, 10:5-8 (the only discussion of servos). That is, Calderon predominantly teaches embodiments that do not implement servos. *E.g.*, EX1009, 4:34-5:10, 5:10-24 6:16-18; Petition, 42-46, 49-57. For the combination, the Petition points to Calderon FIG. 1, which does not illustrate an apparatus with servo drive motors:



Petition, 60

Calderon explains that its method for determination Z-height is applicable to the three-dimensional modeling system "shown in FIG. 1." *See* EX1009, 4:66-5:3.

Before introducing the servo use-case, Calderon explains that, generally, "[c]ontact between the tip of nozzle 132 and the substrate 128 is monitored by a sensing means and the controller 116 electrically records the Z-axis position of platform 134 at the time contact is detected." EX1009, 9:63-10:5 (introducing Example 3 before mentioning servos); Petition, 48. Calderon does not restrict the type of sensor it uses, and RepRap20208's discussion of strain gauges fits with Calderon's nozzle implementation. EX1009, 6:38-7:5, 9:63-10:23; EX1010, 20 (contact force on the head). Dr. Wolfe explained that a POSITA would understand Calderon as suggesting that the mechanism for force measurement can include "any known sensing mechanism" using a conventional sensor such as a strain gauge, which was known as "a common sensor." EX1003, ¶¶55-62 (citing EX1001, 9:17-23); Petition, 45.

RepRap20208 also links the strain gauge to determining Z-height, which is the same problem Calderon is trying to solve using sensors with the nozzle tip. *E.g.*, EX1009, 9:63-10:23; EX1010, 18-19 (describing that "the frame itself warps over time, so I'd like to measure the important variable – nozzle to bed height – directly"); *see also id.*, 20 (expressing a desire for "knowing exactly when the head touches, which is what I'm really interested in"); Petition, 48-56.

Additionally, Wade introduces the discussion of strain gauges by sharing that he experienced "catastrophic failure" involving "an all-night long series of head collisions," remarking on the advantages of strain gauges to prevent this problem. EX1010, 13 (also remarking that a strain gauge could also find "bed heigh automatically"); *see also id*., 14 ("A single head collision would be more difficult to detect without a strain gauge."). A POSITA reading RepRap20208 would have immediately recognized the advantages of using a strain gauge to prevent damage to the extruder and substrate by avoiding collisions and other catastrophic failure events. Petition, 51-55; EX1009, 2:36-53; EX1003 ¶¶165-172. Note that, despite PO's argument to the contrary, Calderon does not limit its use case to being below the top surface of some substrates. POR, 52. Calderon expressly teaches use cases where the nozzle tip depth is zero or above the top surface, explaining that these specifications "can **easily** be accommodated by the algorithm." EX1009, 8:45-52.

That strain gauges were commonly used for force sensing at that time is directly supported by the '698 patent. *E.g.*, EX1001, 9:2-7 ("Strain gauges are one **common sensor** used for such [contact force] measurements."); Petition, 53-55; EX1003 ¶¶171-172. The concern of "work[ing] well over long periods of time" cited by PO refers to a specific force sensor, not strain gauges in general. EX1010, 19. Likewise, the comments about "a stencil cutting blades or drawing pen" relates to a different type of sensor. *Id*., 20. RepRap20208 also recognizes that strain gauges offer advantages over other sensors, such as addressing problems associated with heating, warping, or catastrophic failure:

> edit - the neat thing about strain gauge vs optical measurements is that the strain gauge will tell you how much your extruder has elongated due to heating, warping, or in my special case, catastrophic failure.

EX1010, 14

Thus, certainly for implementations that do not include servos, a POSITA implementing Calderon would have turned to common sensors, one of which was a strain gauge. Petition, 54-55, EX1003 ¶¶171-172, EX1001, 9:2-7. Moreover, the ’698 patent admits strain gauges were a common sensor for producing a contact force without identifying or curing any issues associated with their implementation, including issues concerning costs.

Even in the context of servo drive motors, however, the Petition addresses why it would have been obvious to modify Calderon with a strain gauge, like that described in RepRap20208, for detecting extrusion head collisions and Z-axis calibration. Petition, 52-53. For example, the Petition points out the “slop/backlash” problem that would make it difficult to accurately and precisely identify when the nozzle contacted the substrate, as is needed for Calderon’s Find-Z program. *Id.*; EX1010, 20; EX1003, ¶¶161-167. RepRap20208 corroborates the Petition’s reasoning when discussing the motivation for using a strain gauge:

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

Registered: 16 years ago
Posts: 536

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

EX1010, 20 (annotated)

Despite PO's assertion that the post concerned "some other sensor," RepRap20208 (red-underline) points to "backlash" in the "entire system" as a motivation for using strain gauges for "knowing exactly when the head touches." EX1010, 20, Petition, 53; POR, 48. Dr. Wolfe affirms that such backlash would have been present in the system when using sensors that monitor servo current. EX1003 ¶¶169-171; Petition, 53. By contrast, a strain gauge between the head and its mount will not measure arm joint and Z-drive slop/backlash, because the joints and Z-drive are outside the gauge's force path. *Id*. In the same post (blue-underline), RepRap20208 recognizes the utility of strain gauges for providing a "constant measurement of force on the head," providing express corroboration for Petitioner's assertion that a strain gauge would "produce more accurate and consistent force measurements by which to sense contact of the nozzle 132 to the substrate 128." EX1010, 20; Petition, 54; EX1003 ¶170; POR 49. Thus, as stated in the Petition, RepRap20208 contribution to Calderon results in a system that can perform Z-height calibration, while also performing collision detection. Petition, 46; EX1010, 13, 18-19 (a strain gauge for Z-height calibration, with collision detection). And, it would have improved Calderon's collision detection by enabling collision detection after initialization. Petition, 50-51.

IX. GROUND 2A RENDERS 1[a] UNPATENTABLE

The Petition points to Calderon's file "describing the geometry of the part 109 to be created" and uses a "slicing program [that] algorithmically subdivides the file into volume elements 110 corresponding to shapes that can be extruded from a nozzle." EX1009, 4:19-33. Calderon continues, "the volume elements are sequentially ordered so that **deposited material** is supported appropriately." *Id*. Thus, Calderon satisfies 1[a].

X. GROUND 2A RENDERS 1[b]-[d] UNPATENTABLE

The Petition provides a lengthy explanation for why a POSITA would have been motivated to detect contact force from the strain gauge implemented in Calderon-RepRap20208. *E.g.*, Petition, 48-56. First, as mentioned above, RepRap20208 expressly discusses using strain gauges for the specific advantage that it provides a "constant measurement of the force" in the context of Z-height calibration and collision detection between the nozzle tip and the substrate, and not just a sensor signal. EX1010, 19-20:

> Hi Wade
>
> My idea was that it would measure upwards pressure from a calibration touch down or abort if it had run into the bed.

Wade

Re: Genetic Algorithms

January 16, 2009 12:04AM

Registered: 16 years ago
Posts: 536

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

EX1010, 19-20

Petition, 55; *see also* EX1009, 8:14-20 (teaching that contact can be sensed at initial contact). *E.g.*, 8:14-20. Thus, RepRap20208 teaches a POSITA to use the strain gauges to determine a current contact force—something that was well within the skills of a POSITA at that time. EX1010, 19-20; Petition, 58-61; EX1003 ¶¶181-186; EX1042, 67:24-68:20 (sophomore engineers learn and have "hands-on experience" with strain gauges) and 60:1-63:7 (describing a commercial sensor "with strain gauges inside" that "measures the strain" which is translated to force).

Second, the Petition explains that a POSITA would have configured Calderon-RepRap20208 to control the contact force to prevent damaging the substrate or the nozzle. Petition 54-55. PO's arguments about damaging the substrate are addressed below, but notably, PO did not address the motivation in Calderon-RepRap20208 of protecting the nozzle from damage caused by collisions. Dr. Wolfe explained that collision detection matters whenever the extrusion head is being moved, including when depositing material during the build. *E.g.*, EX1003 ¶191; Petition, 62-63. This understanding is wholly consistent with the disclosure in RepRep20208, which describes using strain gauges for collision detection during the build. *E.g.*, EX1010, 18-19 (describing shutting down the machine after detecting a collision).

Regarding protecting the substrate, PO fails to recognize several aspects of Calderon's teachings. First, Calderon describes use cases where the z-start position is not below the surface of the substrate. *E.g.*, EX1009, 2:49-53. Calderon explains that, generally, the appropriate z-start position of platform "is dependent upon the particular modeling system and substrate used." EX1009, 2:49-53. For example, in some cases, the "desired nozzle tip depth may be zero" and in other cases, it may be "above the top surface of the substrate." EX1009, 2:49-53 ("These specifications can easily be accommodated by the algorithm."). Thus, Calderon supports use-cases where damage to the foam substrate is not desirable, contrary to PO's arguments. POR, 49-50.

In the use-case where the nozzle starts "below the top surface" of a foam substrate, the Petition explains why determining the force is beneficial. Petition, 54-56. Calderon explains that the "porosity and compressibility" of the foam substrate allows foundation layers to be buried into the foam. EX1009, 2:27-34.

The z-start position of the nozzle is not simply below the top surface of the foam, but starts at an "optimal" depth "so that the first two extruded layers of modeling material will be buried in the foam" to "provide a foundation to stabilize" the model. EX1009, 2:43-53. Calderon goes so far as to identify a z-axis accuracy for building on foam to be ±5-10 mils. *Id*. Thus, even in the situation where the starting z-height is below the surface of the foam, a POSITA would have benefited from knowing the contact force so as to determine the "optimal" z-axis starting position.

Additionally, Calderon explains that the z-axis starting point is determined by the z-axis calibration routine. *E.g.*, EX1009, 8:10-37. Thus, in each use-case, the z-axis calibration must first be performed. As discussed above, and in the Petition, supporting different substrate and nozzle materials benefits from detecting the contact force for that material. Petition, 54-56. A POSITA would have recognized that, among the advantages of detecting the contact force of the material in units of force from the strain gauge data when performing the z-axis calibration, included the ability to directly compare the strain gauge data to the compression strength of the substrate or nozzle. *Id*. Indeed, RepRap20208 similarly taught to "measure upwards **pressure** from a calibrated touchdown." Petition, 62; EX1010, 19; EX1003 ¶¶186-188.

Dr. Wolfe explains that strain gauges were commonly used for force measurements. *E.g.*, EX1003 ¶172; Petition 55. And obtaining contact force from a strain gauge was rudimentary engineering, commonplace and typical long before 2012. EX1042, 67:24-68:20 (sophomore engineers learn and have "hands-on experience" with strain gauges) and 60:1-63:7 (describing a commercial sensor "with strain gauges inside" that "measures the strain" which is translated to force). A POSITA would not be stymied by the simply math to account for the weight of the head. EX1003, ¶¶169-173. As discussed at length, RepRap20208 links the use of a strain gauge to Z-height calibration, collision detection, and force sensing, and is directly applicable to Calderon. *E.g.*, EX1010, 18-20; Petition, 46-56.

XI. GROUND 2A RENDERS DEPENDENT CLAIMS UNPATENTABLE

The Petition lays out the reasoning for how Ground 2A renders claims 2-6 and 9-16 unpatentable. Petition, 63-72. The Petition and this Reply point out how Ground 2A renders each and every element of claim 1 obvious, and POR cannot rely on claim 1 to save the dependent claims.

A. Claim 4 Is Unpatentable

As the POR acknowledges, Calderon teaches stopping the build, which naturally stops the motion of the dispenser in all directions, including the z-axis direction. EX1003 ¶¶200-201; POR, 58. Note that the claim does not require changing the z-distance—only controlling the z-distance—which Calderon does by stopping. EX1009, 10:42-47; EX1003 ¶¶200-202; POR, 58; see also EX1010, 19 (discussing shutting down the machine). But Calderon also teaches that the user needs to clear the envelope (EX1009, 10:42-47; POR, 58) and a POSITA would have found it obvious that, to clear the envelope, the user would need some clearance between the nozzle tip and the offending structure. Hence, as explained by Dr. Wolfe, Calderon-RepRap20208 renders obvious controlling the z-direction between the extruder and the build platform. EX1003 ¶¶200-202.

B. Claims 5 and 7 Are Unpatentable

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

C. Claim 10 Is Unpatentable

The POR confuses distances X and Y in Calderon Find-Z steps (1) and (3) with coordinates (x, y, z). In Find-Z steps (1) and (3), X is the predetermined ***distance*** of the sensing location above the actuated position of plunger, and Y is the predetermined ***distance*** of the tip of nozzle above the tip of plunger. EX1009, 8:21-34. When using a plunger, constants X and Y are needed to correlate the z-position sensed by the plunger with the actual position of the nozzle. *Id*. However, constants X and Y are not applicable to Example 3 because Example 3 does not use a plunger. It uses "the tip of the nozzle 132…as a plunging means to find z-axis positions of the platform." *Id*., 9:63-65. Example 3 is like Example 1, except that the nozzle tip is used to directly map the z-axis positions of the substrate at different x- and y-locations. *Id*., 7:62-8:51, 9:63-10:15. Nor do constants X and Y relate to step H, which performs planarization using "recorded z-axis positions" to determine whether the substrate is "approximately parallel to a horizontal xy-plane." *Id*., 7:62-8:15. Thus, planarization is achieved using recorded z-axis positions, which in Example 3, is performed without needing constants X and Y.

D. Claim 12 Is Unpatentable

In Calderon-RepRap20208, Dr. Wolfe explains that for the system perform Z-axis calibration and collision detection, the software controlling the system would need to be coded with a threshold force to determine "when you run into something." EX1003 ¶¶220-222. A POSITA would have found it obvious, in the combination, to perform a comparison with this threshold using the determined contact force values from the strain gauge. *Id*. A POSITA would have also found it obvious that to respond to collisions, the system would need to include instructions for achieving the specified contact force. *Id*.

XII. GROUND 2B RENDERS CLAIM 11 UNPATENTABLE

A. Calderon-RepRap20208-Napedensky Is Obvious

First, Calderon teaches depositing material onto a foam substrate with "porosity." *E.g.*, EX1009, 2:26-34. A POSITA would have immediately recognized that depositing material onto a porous substrate would have decreased one or more irregularities on the surface of it by filling in or smoothing the pores, which contributes to adding stability of the build. For rigid substrates, however, a POSITA would have recognized the advantages Napadensky's leveling offers to increasing the stability of the model as it is built. *E.g.*, EX1009, 2:26-3:1; EX1003 ¶¶236-237.

B. Claim 11 Is Unpatentable

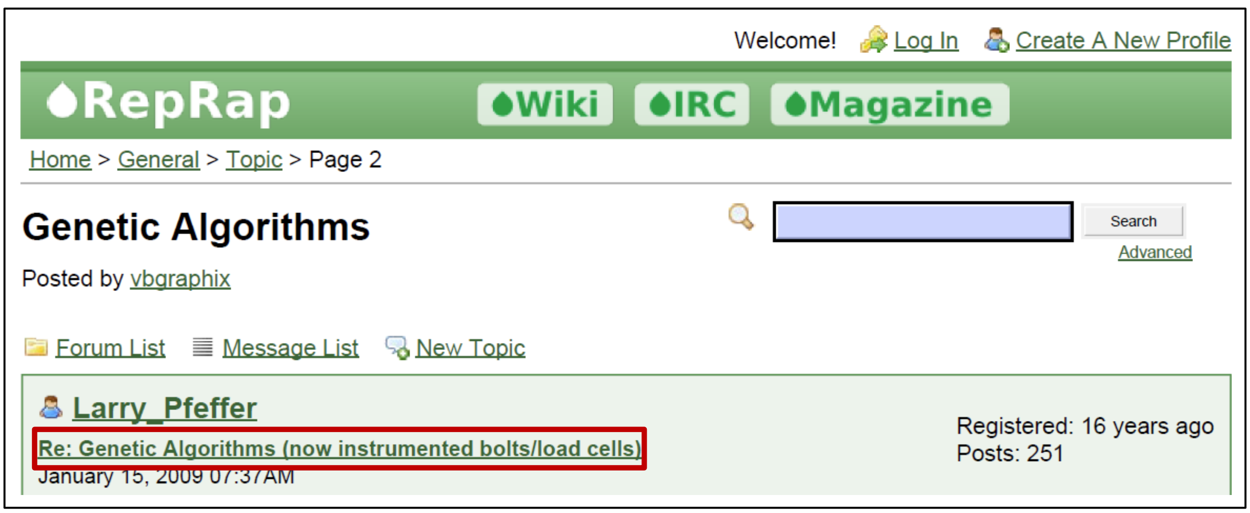
Calderon fabricates two layers of build material on a porous foam substrate, which stabilizes the model as it is built. EX1009, 2:36-54. Thus, contrary to PO's argument, Calderon teaches fabricating a layer to reduce surface irregularities on the substrate. For rigid substrates, however, Calderon benefits from Napadensky's leveling, which includes fabricating a newly formed layer and straightening that layer with a leveling device. EX1005, 18:25-47, 17:56-18:4; EX1003, ¶¶239-240.

XIII. REPRAP20208 IS A PRINTED PUBLICATION

The Board invited the parties to further develop the record concerning RepRap20208's status as a printed publication. ID, 15. As discussed previously, RepRap20208 is a printed publication. Petition, 2; EX1014, *passim*. First, it is not disputed that the RepRap website hosts a text-searchable forum known to, and visited by, professionals, hobbyists, and others, to "share knowledge and information regarding development of RepRap machines and 3D printing in general," as explained by RepRap founder Adrian Bowyer. EX1014 ¶4.

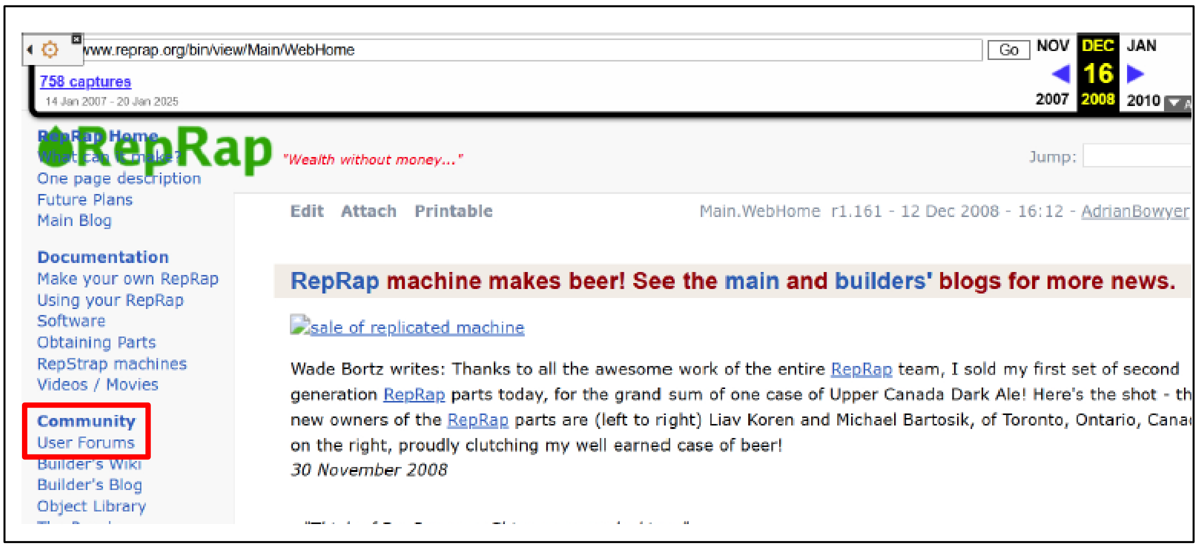
Mr. Bowyer testified that "the forums were (and still are) fully keyword searchable, allowing users to search for and readily identify relevant discussion threads." EX1014 ¶6. Bowyer added that the "search functionality allowed users to search for posts based on…the content of the posts." EX1014 ¶6.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

RepRap20208 also discusses strain gauges as force sensors for z-axis calibration and collision detection. EX1010, 13-21. The discussion included contributions from 9 different participants over the course of three days (January 14-16, 2009). *E.g.*, EX1010, 13-21. Some of these participants, including Wade, were not involved in earlier discussions about Genetic Algorithms, but still found and contributed to the discussion about strain gauges. EX1010. Moreover, the title of the thread was adjusted as the topics evolved, as shown below:



EX1010, 16 (annotated)

The POPR argues that EX1013 only references the RepRap wiki, without mentioning the RepRap forum. POPR, 32. But POPR admits that the face of EX1001 includes a link to the RepRap forum. EX1001, face; POPR, 32. Following that link would undoubtedly take a user to the RepRap forum, from which they could explore other threads of the forum, for example, through text-based searching. Bowyer testified that the "RepRap forums were (and still are) linked to the main page," and provided a screenshot of the RepRap landing page from December 16, 2008 that shows a link to "User Forums" front-and-center:



EX1014, ¶6, page 33 (showing exhibit B-1) (annotated)

PO provides no evidence that contradicts Bowyer's testimony that RepRap20208 is a printed publication.

XIV. CONCLUSION

Petitioner has established that the Challenged Claims are unpatentable and respectfully requests that the Board find the same.

Respectfully submitted,

Dated: May 11, 2026

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CERTIFICATION UNDER 37 CFR §42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petitioner's Reply to Patent Owner's Response totals 5,570 words, which is less than the 5,600 allowed under 37 CFR § 42.24(c)(4).

Dated: May 11, 2026

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR § 42.6(e)(4), the undersigned certifies that on May 11, 2026, a complete and entire copy of this Petitioner's Reply to Patent Owner's Response to Petition and Accompanying Exhibit was provided by email to the Patent Owner by serving the email correspondence address of record as follows:

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