

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SHENZHEN TUOZHU TECHNOLOGY CO., LTD.,

Petitioner

v.

STRATASYS, INC.

Patent Owner.

PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 9,421,713

Case No. IPR2025-00321

DECLARATION OF DR. TIM A. OSSWALD

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EXHIBIT LIST

<u>Exhibit No.</u>	<u>Description</u>
2001	Docket Navigator – Judge Rodney Gilstrap Motion Success for Stay Pending IPR and Time to Milestones
2002	United States District Courts — Judicial Caseload Profiles for Eastern District of Texas (Sept. 30, 2024 and Dec. 31, 2024), available at https://www.uscourts.gov/data-news/reports/statistical-reports/federal-court-management-statistics
2003	Minute Entry for proceedings held before District Judge Gilstrap on Nov. 7, 2024, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG (E.D. Tex. Nov. 14, 2024)
2004	Discovery Order, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 35 (E.D. Tex. Dec. 2, 2024)
2005	Protective Order, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 36 (E.D. Tex. Dec. 3, 2024)
2006	e-Discovery Order, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 41 (E.D. Tex. Dec. 19, 2024)
2007	Invalidity and Ineligibility Contentions, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, (E.D. Tex. Jan. 30, 2025)
2008	Transcript of Hearing on the Nomination of Howard Lutnick, of New York, to be Secretary of Commerce (Jan. 29, 2025)
2009	U.S. Patent No. 6,645,412 (“ <i>Priedeman-412</i> ”)
2010	Declaration of Gary Larson
2011	Declaration of Paul Leavitt
2012	Complaint, <i>Stratasys, Inc. v. Shenzhen Tuozhu Technology Co. Ltd.</i> , No. 2:24-cv-00644-JRG, Dkt No. 1 (E.D. Tex. Aug. 8, 2024)
2013	Declaration of Dr. Tim A. Osswald related to IPR2025-00321
2014	Amended Declaration of Gary Larson
2015	Amended Declaration of Paul Leavitt
2016	Transcript of August 29, 2025 Deposition of Dr. Hickner related to IPR2025-00321

2017	Image from combined file representing EX1014 and EX1015
2018	Osswald, T.A., UNDERSTANDING POLYMER PROCESSING, Hanser Publishers (2011)

I. INTRODUCTION

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

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

3. I have been asked to provide technical assistance in the *inter partes* review of U.S. Patent No. 9,421,713, which I may abbreviate as “the ’713 Patent” or refer to as the “Challenged Patent.” I understand that this patent was formerly owned by Stratasy, Inc. (“Stratasy”). This declaration is a statement of my opinions on issues related to the patentability of claims of the Challenged Patent.

A. Qualifications and Experience

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

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

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

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

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

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

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

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

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

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

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

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

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

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

compendium of polymer materials, polymer processes and polymer characterization techniques. The processing chapter presents the major additive manufacturing techniques. While the Plastics Handbook is a book for practitioners and engineers, some of my other books are polymer engineering textbooks that are used in courses taken by undergraduate and graduate students throughout the world. One such book is Understanding Polymer Processing, which contains a chapter on additive manufacturing. Other books are more advanced, and are used by researchers at universities and in the industry to acquire in-depth knowledge in polymer engineering.

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

B. Compensation

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

C. Scope of Work and Materials Considered

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

18. I have been asked to review the Challenged Patent and its prosecution history, to provide an understanding of the technology relevant to the Challenged

Patent, to review certain prior-art references, and to analyze whether or not those references disclose or teach limitations of claims from the Challenged Patent.

19. The opinions stated in this declaration are from the perspective of a Person of Skill in the Art (POSITA) as of November 20, 2011, whose qualifications and abilities are described below. I understand that Petitioners and Patent Owner may have a dispute as to whether the claims of the Challenged Patent are entitled to a priority date of at least November 20, 2011 or March 8, 2013. Unless otherwise noted, my opinions expressed in this report remain unchanged regardless of the date used.

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

II. THE CHALLENGED CLAIMS OF THE '218 PATENT

21. I understand that Petitioner has challenged claims 1, 2, 5-7, 9, 16, and 17 of the '713 Patent (the "Challenged Claims"). The Challenged Claims are set forth below, with some claim elements further sub-divided for ease of reference:

Claim Element	Claim Language from '218 Patent
1(Preamble)	1. A method for printing a three-dimensional part with an additive manufacturing system, the method comprising:
1(a)	printing layers of the three-dimensional part and of a support structure for the three-dimensional part from multiple print

Claim Element	Claim Language from '218 Patent
	heads or deposition lines using a layer-based, additive manufacturing technique;
1(b)	switching the print heads or deposition line between stand-by modes and operating modes in-between the printing of the layers of the three-dimensional part and the support structure;
1(c)	performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner, wherein the layers of the at least one purge tower are printed from the print head or deposition line switched to the operating mode.
2	<p>2. The method of claim 1, wherein the multiple print heads or deposition lines comprise a first deposition line and a second deposition line, and wherein switching the deposition lines between the stand-by modes and the operating modes comprises:</p> <p style="padding-left: 40px;">switching the first deposition line from the stand-by mode to the operating mode; and</p> <p style="padding-left: 40px;">switching the second deposition line from the operating mode to the stand-by mode.</p>
5.	5. The method of claim 1, wherein the at least one purge tower has a cross-sectional area that reduces in height along an axis that is perpendicular to a build plane.
6	6. The method of claim 1, wherein the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure.
7	7. The method of claim 1, and further comprising: generating tool path instructions for printing the layers of the three-dimensional part and of the support structure; and generating tool path instructions for printing the layer of the at least one purge tower.
9	9. The method of claim 7, wherein the generating of the tool path instructions for printing the layer of the at least one

Claim Element	Claim Language from '218 Patent
	purge tower is performed prior to printing the layers of the three-dimensional part and of the support structure.
16(preamble)	16. A method for printing a three-dimensional part with an additive manufacturing system, the method comprising:
16(a)	(a) printing a first layer of a support structure from a support material for the three-dimensional part;
16(b)	(b) printing a first layer of a purge tower from a part material;
16(c)	(c) printing a first layer of the three-dimensional part on at least a portion of the first layer of the support structure from the part material after printing the first layer of the purge tower;
16(d)	(d) printing a second layer of the purge tower from the support material; and
16(e)	(e) printing a second layer of the support structure on at least a portion of the first layer of the three-dimensional part from the support material after printing the second layer of the purge tower.
17	17. The method of claim 16, and further comprising repeating steps (b)-(e) for at least a portion of the three-dimensional part and support structure.

III. LEVEL OF ORDINARY SKILL IN THE ART

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

23. I have been instructed by counsel that the person of ordinary skill in the art (“**POSITA**”) is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor’s skill is not determinative of the level of

ordinary skill. I further understand that a person of ordinary skill in the art is determined by looking at (1) the type of problems encountered in the art; (2) the prior-art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the educational level of active workers in the field.

24. In my opinion, a person of ordinary skill in the art with respect to the '713 Patent is someone with bachelor's degree in Mechanical Engineering, Computer Engineering, Chemical Engineering, Materials Science, or a comparable field and at least two years of experience related to 3D printing, with additional experience potentially being a substitute for a formal degree or training (and vice versa).

25. I understand that Petitioner and Dr. Hickner have proposed a somewhat different level of ordinary skill in the art. Specifically, they assert that a person of ordinary skill in the art "would have had (1) at least a bachelor's degree in Mechanical Engineering, Computer Engineering, Chemical Engineering, Materials Science, or a related field, and (2) at least two years of research or industry experience in 3D printing or materials used for 3D printing. Additional experience could substitute for a formal degree or formal training (and vice versa)." EX1003, ¶15; Pet. at 5. My opinions in this declaration would not change under this proposed level of ordinary skill in the art.

26. As of at least November 20, 2011, which I understand is the date at least by which the Challenged Claims were reduced to practice, and including as of the March 8, 2013 filing of the application that resulted in the '713 Patent, I had at least the level of skill required under either my or Dr. Hickner's definitions of a person of ordinary skill in the art. In rendering my opinions, I have viewed the '713 Patent from the perspective of a person of ordinary skill in the art.

IV. LEGAL STANDARDS

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

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

A. Legal Standard for Claim Construction

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

30. I have been instructed by counsel on the law regarding claim construction and patent claims. I understand that a patent may include two types of claims: independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim, or it can further depend from another dependent claim. I understand that a dependent claim includes all the limitations that it recites, as well as all the limitations recited in the claim(s) from which it depends.

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

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

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

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

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

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

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

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

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

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

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

B. Legal Standard for Prior Art

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

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

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

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

C. Legal Standard for Patentability

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

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

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

1. Anticipation and Inherency

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

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

2. Obviousness

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

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

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

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

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

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

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

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

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

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

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

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

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

V. THE '713 PATENT AND THE CHALLENGED CLAIMS

A. Summary of the '713 Patent (EX1001)

59. I have reviewed the '713 Patent, which relates to “additive manufacturing systems” to print 3D parts and support structures using “purge operation techniques.” EX1001 at 1:6-13. The '713 Patent explains that “part material is extruded through an extrusion tip or nozzle carried by a print head of the system, and is deposited as a sequence of roads.” *Id.* at 1:30-32. In making 3D parts, “supporting layers or structures are typically built underneath overhanging portions or in cavities of 3D parts under construction.” *Id.* at 1:40-44. A computer “generates additional geometry acting as a support structure” and “[s]upport material is then deposited from a second nozzle pursuant to the generated geometry during the printing process.” *Id.* at 1:46-50; *see also id.* at 1:50-53.

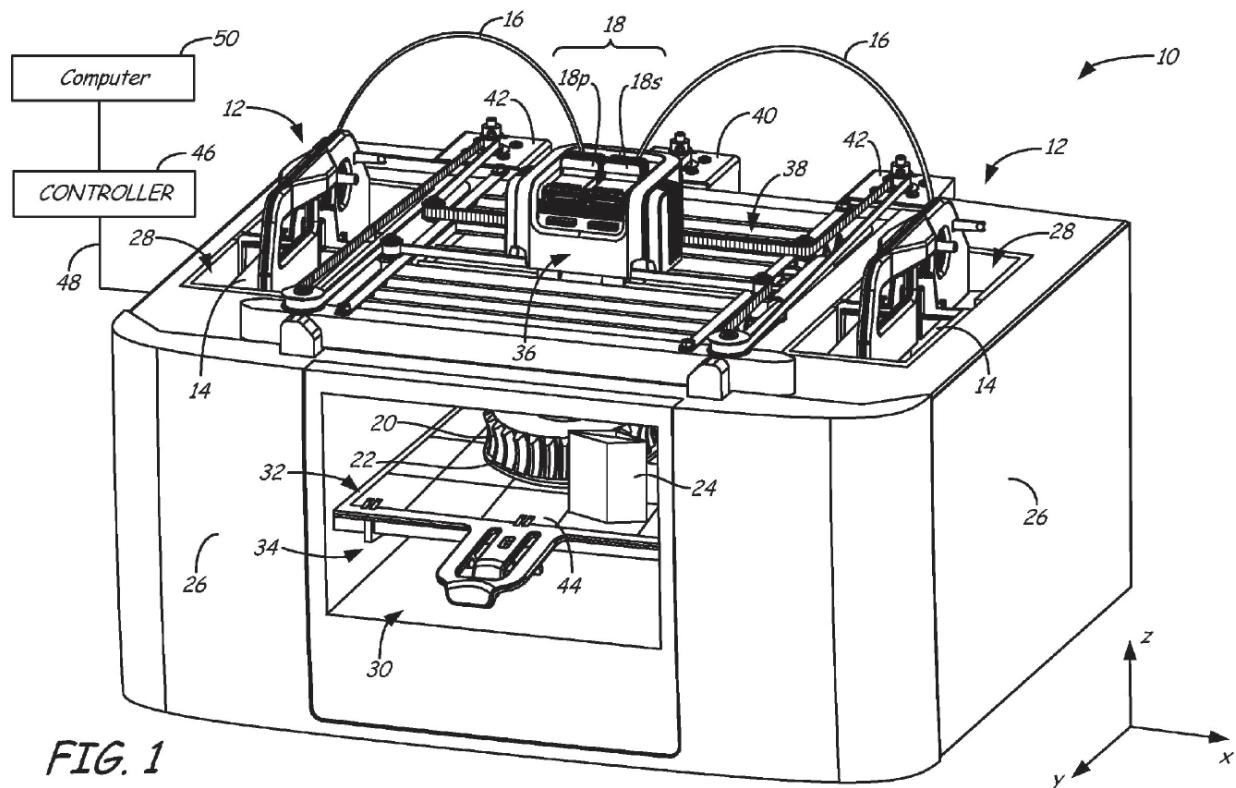
60. The specification of the '713 Patent discloses such additive manufacturing systems “with the use of a purge tower (or multiple purge towers).” EX1001 at 3:41-44. Specifically, the '713 Patent teaches that “the additive manufacturing system may utilize multiple print heads or deposition lines, where a first print head or deposition line may be used to print the 3D part, and a second material print head or deposition line may be used to print the support structure.” *Id.* at 3:52-56. It further teaches that “[w]hen printing with multiple print heads (or multiple deposition lines), each print head or deposition line is preferably switchable between an ‘operating mode’ and a ‘stand-by mode’.” *Id.* at 4:1-4.

61. The '713 Patent explains that when a print head or deposition line switches to an operating mode, it can undergo a purge operation, such as extruding material into a purge station or bucket. EX1001 at 4:39-45; *see also id.* at 4:46-62. However, there are numerous issues with the purge station or bucket, such as requiring “a sufficient amount” of material to be extruded “to have enough weight to fall away” and “into a purge bucket,” reducing the useable build volume due to the sizeable footprint of the purge station, and need for the purge station or bucket to be emptied periodically. *See id.* at 4:63-5:6.

62. Unlike the purge station or bucket, the '713 Patent discloses a process that prints one or more purge towers “during the purge operations.” *Id.* at 5:7-10. As a result, there is no need to use a separate purge station and thus use of the purge

tower can increase the useable build volume, reduce the materials consumed during purge operations, and allow automated operation of an additive manufacturing system. *See id.* at 5:10-17.

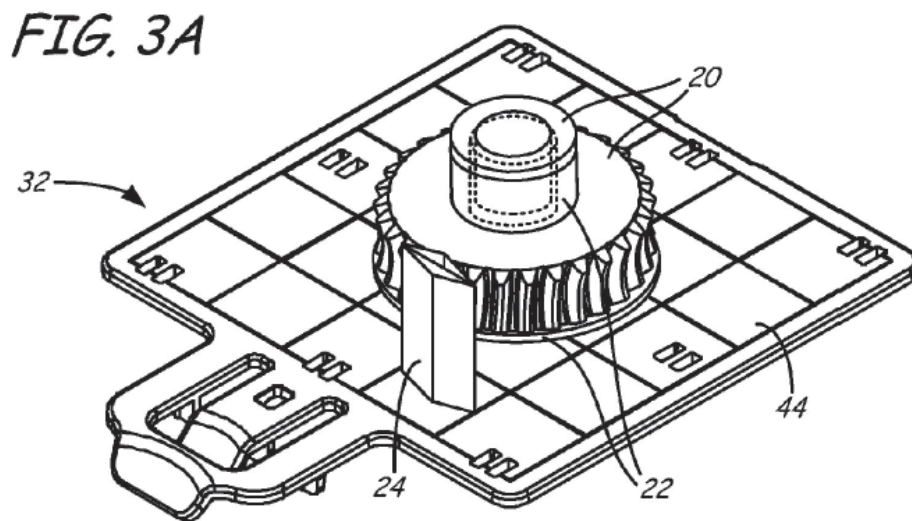
63. The '713 Patent illustrates and describes several figures that further detail the use of a purge tower. Figure 1 shows a system (10) in use with consumable assemblies (12) to print a 3D part (20) and support structure (22) and a purge tower (24).

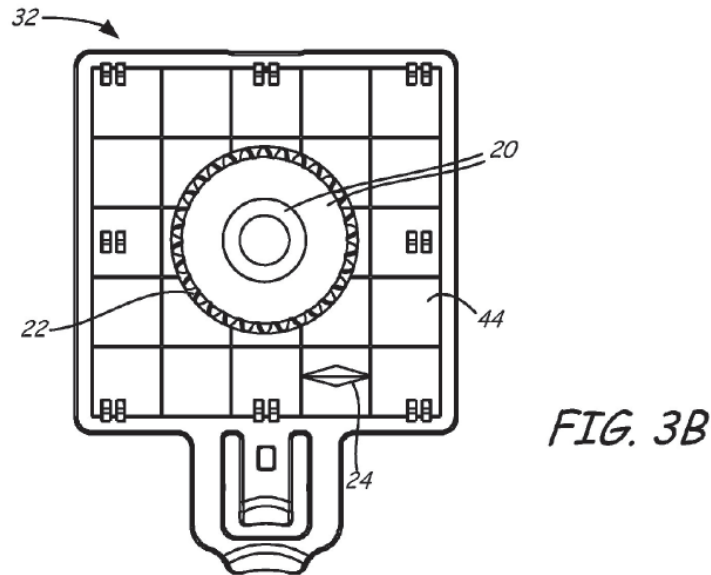


EX1001 at Fig. 1, 5:18-30, 5:60-67. As shown, there are two consumable assemblies (12), one for part material and the other for support material. *See id.* at 5:25-30. Head carriage (36) includes “one or more [] print heads,” such as part print head (18p) that

draws consumable part material filament and support print head (18s) that draws consumable support material filament. *Id.* at 5:31-35, 6:51-53. Within the chamber (30) of the system (10), 3D part (20), support structure (22), and purge tower (24) are printed in a layer-by-layer manner. *See id.* at 8:6-9. “After the print operation is complete, the resulting 3D part [] and support structure [] may be removed from chamber 30, and support structure 22 may be removed from 3D part 20. Purge tower 24 itself may be then recycled or otherwise discarded as desired.” *Id.* at 8:24-28.

64. “[E]ach layer of purge tower 24 is printed by either the part material or by the support material depending on when print heads 18 switch between their operating modes and their stand-by modes and perform the purge operations.”





Id. at Figs. 3A and 3B, 8:34-38; *see also id.* at Figs. 7-8, 12:5-14:41. The purge tower may be printed with one or more tool paths. *See id.* at 8:39-53.

65. Numerous claims embody these solutions, including independent claims 1 and 16. Among other things, claim 1 recites “switching the print heads or deposition line between stand-by modes and operating modes in-between the printing of the layers of the three-dimensional part and the support structure;” and “performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner, wherein the layers of the at least one purge tower are printed from the print head or deposition line switched to the operating mode.” EX1001 at 15:49-58.

66. Similarly, claim 16 recites a “method for printing a three-dimensional part with an additive manufacturing system, the method comprising: (a) printing a

first layer of a support structure from a support material for the three-dimensional part; (b) printing a first layer of a purge tower from a part material; (c) printing a first layer of the three-dimensional part on at least a portion of the first layer of the support structure from the part material after printing the first layer of the purge tower; (d) printing a second layer of the purge tower from the support material; and (e) printing a second layer of the support structure on at least a portion of the first layer of the three-dimensional part from the support material after printing the second layer of the purge tower.” *Id.* at 17:26-18:11 (emphases added).

67. As I explain below, Grounds 1, 2A, 2B, and 3 fail to disclose or teach these elements of independent claims 1 and 16. As a result, the same grounds fail to teach claims 2, 5-7, and 9, which depend from claim 1, and claim 17, which depends from claim 16, for at the same reasons.

68. As I also explain below, Grounds 1, 2A, 2B, and 3 fail to disclose or teach additional elements of dependent claims 5, 6, and 17. Claims 5 and 6 depend from claim 1 and require that “the at least one purge tower has a cross-sectional area that reduces in height along an axis that is perpendicular to a build plane” and “the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure,” respectively. EX1001 at 16:18-24. Claim 17 depends from claim 16 and requires

“repeating steps (b)-(e) for at least a portion of the three dimensional part and support structure.” *Id.* at 18:13-15.

B. Summary of the Prosecution History of the '713 Patent (EX1002)

69. I reviewed the prosecution history of the '713 Patent (EX1002). During prosecution, the applicant amended claim 1 to recite printing “at least one purge tower in a layer-by-layer manner, wherein the layers of the at least one purge tower are printed from the print head or deposition line switched to the operating mode.” EX1002 at 149. According to the applicant, using a purge bucket for a purge operation, as disclosed in the cited art, does not relate to the printing of a purge tower in a layer-by-layer manner as claimed. *See id.* at 154.

70. In response, the examiner agreed and issued a notice of allowance, noting that “none of the prior art alone or in combination teach purging of one or more print heads by printing a purge tower.” *Id.* at 165, 159. Rather, the examiner stated that the “closest prior art discloses the use of wiping blades and purge buckets.” *Id.* I note that the examiner had numerous references before them that are identical or very similar to the ones that Petitioner included in the Petition, including *Leavitt* (*see id.* at 165, 175 (citation no. A45 to *Leavitt*)) and *Priedeman* (*see id.* at 165, 174 (citation no. 23 to similar reference, EX2009 (Prideman-412); *compare Priedeman-412* (EX2009) at Fig. 1 *with Priedeman* (EX1007) at Fig. 1).

71. As I explain in detail below, the references asserted in the Petition suffer from many of the same deficiencies as the art cited during prosecution and the asserted grounds do not teach all elements of the challenged claims.

VI. SUMMARY OF THE PRIOR ART

72. I have reviewed the references listed below, which I understand Petitioner has cited in support of Grounds 1-3 of their Petition:

Ground	Claims	References Cite
1	1, 2, 5-7, 9, 16, 17	<i>Leavitt</i> (EX1004) in view of <i>RepRap Article</i> (EX1005) and <i>RepRap Video</i> (EX1006)
2A	1, 2, 6, 7, 9, 16, 17	<i>Priedeman</i> (EX1007) view of <i>KISSlicer</i> (EX1010)
2B	5	<i>Priedeman</i> in view of <i>KISSlicer</i> , <i>RepRap Article</i> , and <i>RepRap Video</i>
3	1, 2, 6, 7, 9	<i>Boyer</i> (EX1008)

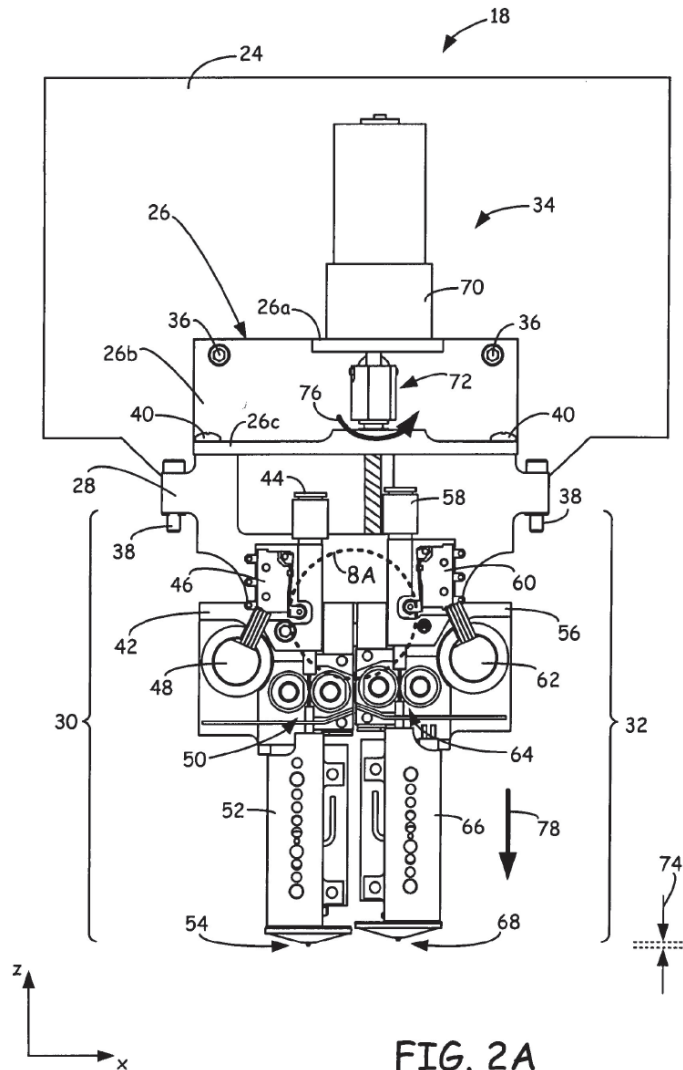
A. Overview of *Leavitt* (EX1004)

73. *Leavitt* (U.S. Patent Pub. No. 2009/0036405 A1) is directed to an extrusion head that deposits multiple materials by toggling between a build and support state for depositing build and support materials, respectively. EX1004 at ¶[0022], Title, Abstract.

74. *Leavitt* addresses the risk that “residual support material comes into contact with the layer of 3D object 20 being formed” by positioning one tip for a material (e.g., support tip 68) higher than another tip for a second material (e.g.,

build tip 54), by a raised offset distance (e.g., 74 in Figure 2A or 80 in Figure 2B).

Id., ¶¶[0032], [0035].



Id. at Fig. 2A. *Leavitt* teaches that the offset distance allows the lower tip to extrude material without interference from the higher tip. *Id.*, ¶¶[0032], [0035].

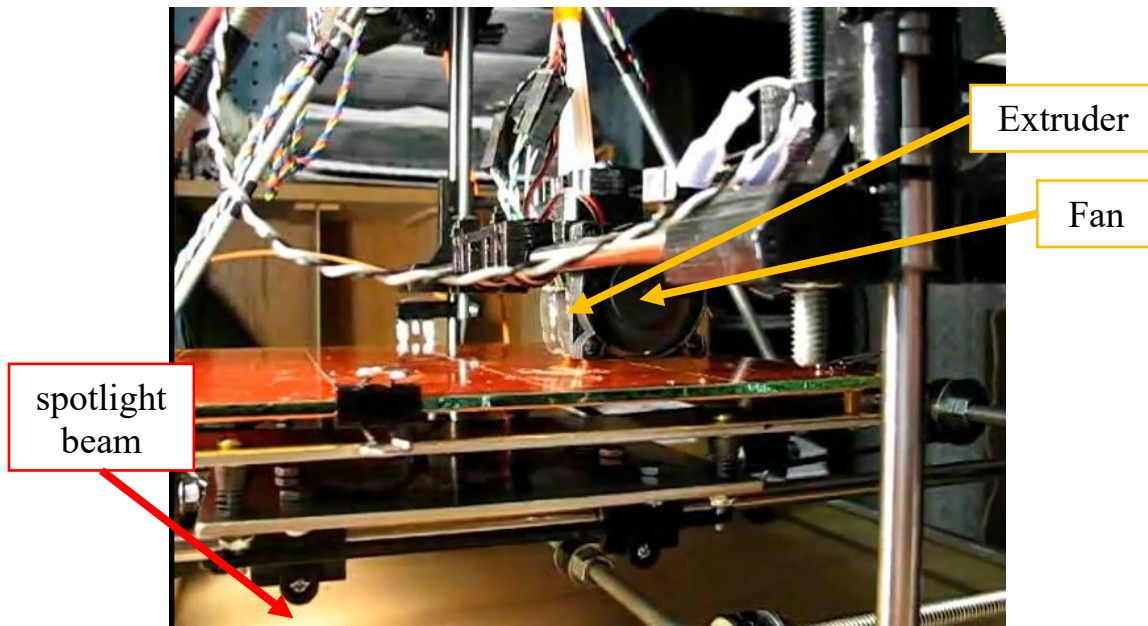
75. As I explained above, the examiner allowed the claims of the '713 Patent over numerous cited references, including *Leavitt*. *Supra* Section V.B; *see also* EX1002 at 175 (citation no. A45).

B. Overview of *RepRap Article* (EX1005)

76. The *RepRap Article* (EX1005) appears to be a printout from a blog post on a website titled “OkOb.net” and relates to temperature changes when lowering and restoring the temperature of an idle extruder. *See* EX1005 at 1 (“Lowering the temperature of the idle extruder while it is not needed and restore it when it is time to start printing with that extruder again helps to deal with leaking.”). It discusses printing a parking space that plugs both nozzles during a temperature change and primes the extruders before printing to “establish the consistent flow of plastic.” *Id.* The *RepRap Article* describes that its “technique works the best for printing a few layers of color, for example a colored text on the top and bottom of the object,” and states that “the time needed to adjust the temperatures [] slows down the print substantially when there are a lot of layers requiring extruder switching.” *Id.* The *RepRap Article* also purports to link to a video on YouTube and describes “a dual color whistle” with what appears to be links to a whistle body and text. *See id.* (“Whistle X2 body” and “Whistle X2 text”); *see* EX1014-EX1015.

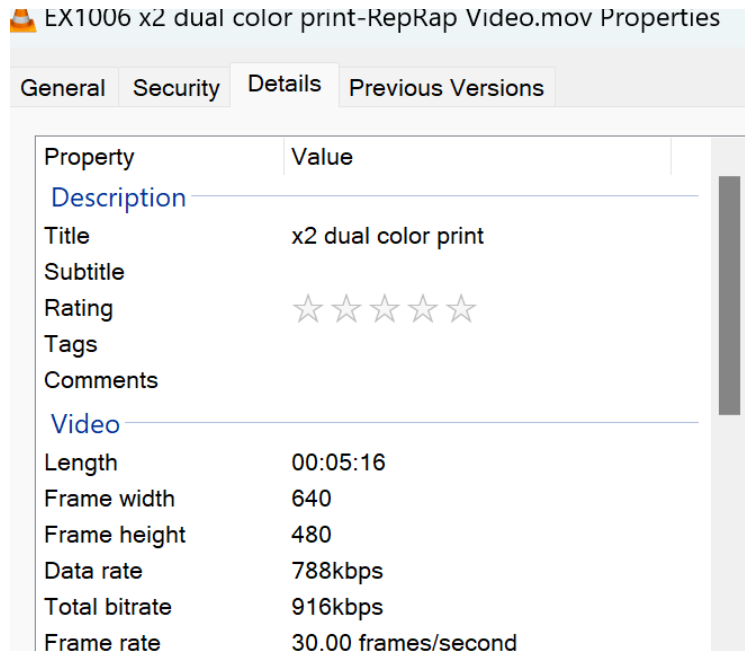
C. Overview of *RepRap Video* (EX1006)

77. The *RepRap Video* (EX1006) appears to be a video that is linked in the *RepRap Article*. *See* EX1005 at 1. The video records excerpts of someone using a printer in a dim environment with what appears to be a spotlight on the left side of the frame opposite the print operation.



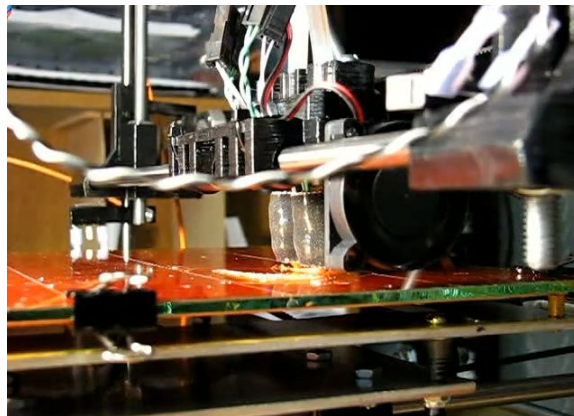
EX1006 at 0:04. As shown in the above image, the view of what is being printed is obstructed by an extruder, as well as what appears to be a large fan that is proximate to the camera and the camera angle. *Id.*

78. In addition, the properties of *RepRap Video* indicate that it has a very low resolution of 640 x 480.

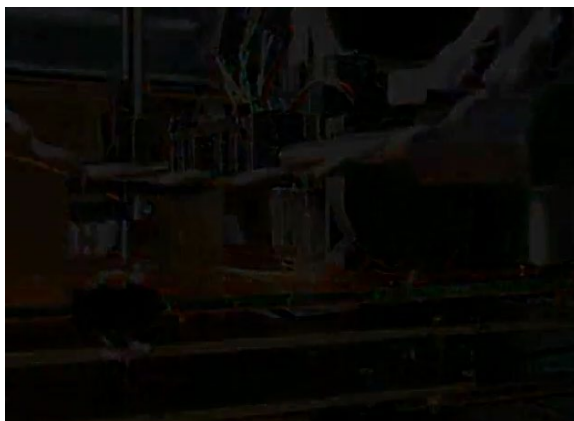


See EX1006 (file properties, Details).

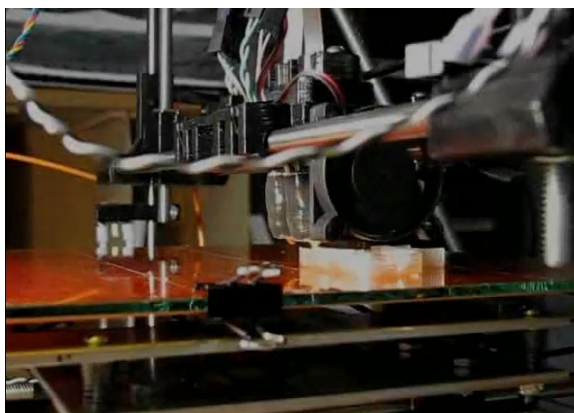
79. The *RepRap Video* is not a continuous recording. It fades out and back in around the 03:15 mark, at which point the printed object looks substantially different.



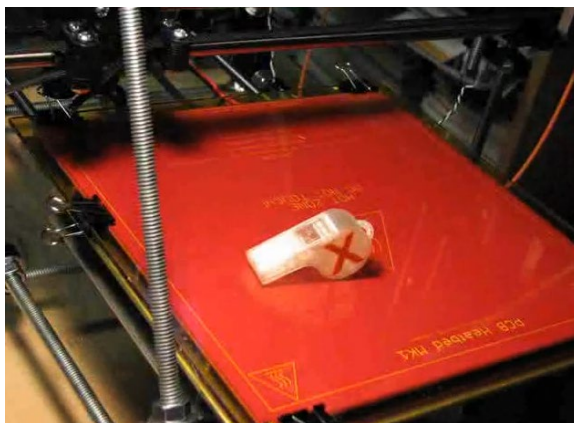
Id. at 03:14.



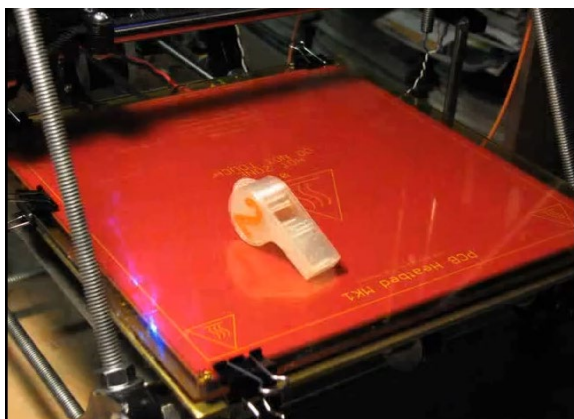
Id. at 03:15.



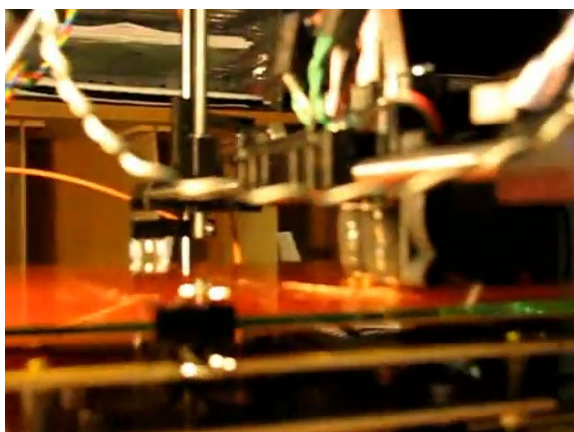
Id. at 03:16. Other discontinuous sequences occur around at 04:03, 04:20, 05:00, and 05:06 in the video. A different object appears to be shown from various perspectives but without any printing at the 05:08 and 05:16 marks.



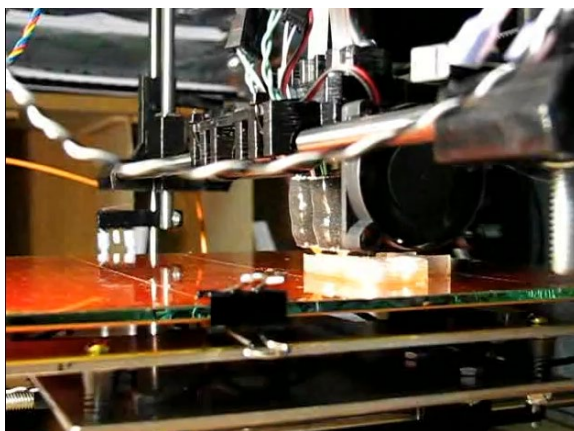
Id. at 05:08.



Id. at 05:16. Additionally, several portions of the *RepRap Video* appear to be blurry or out of focus, as shown below.



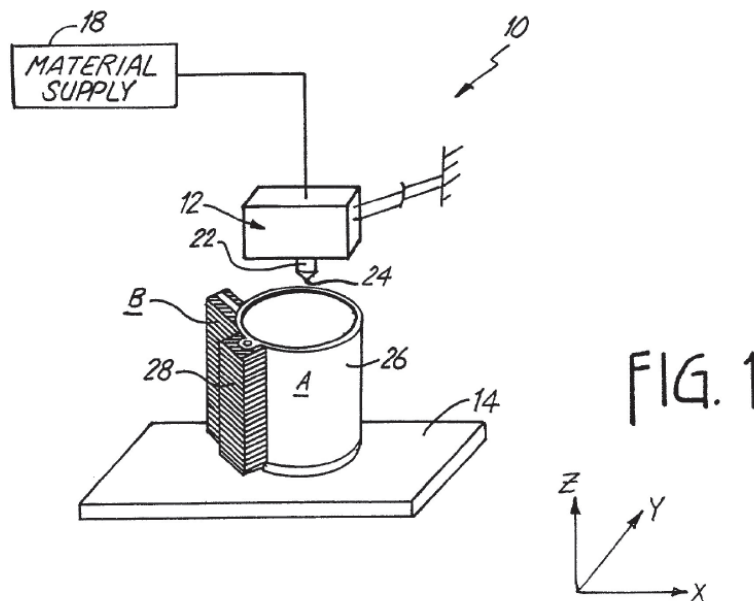
Id. at 02:26.



Id. at 03:17.

D. Overview of *Priedeman* (EX1007)

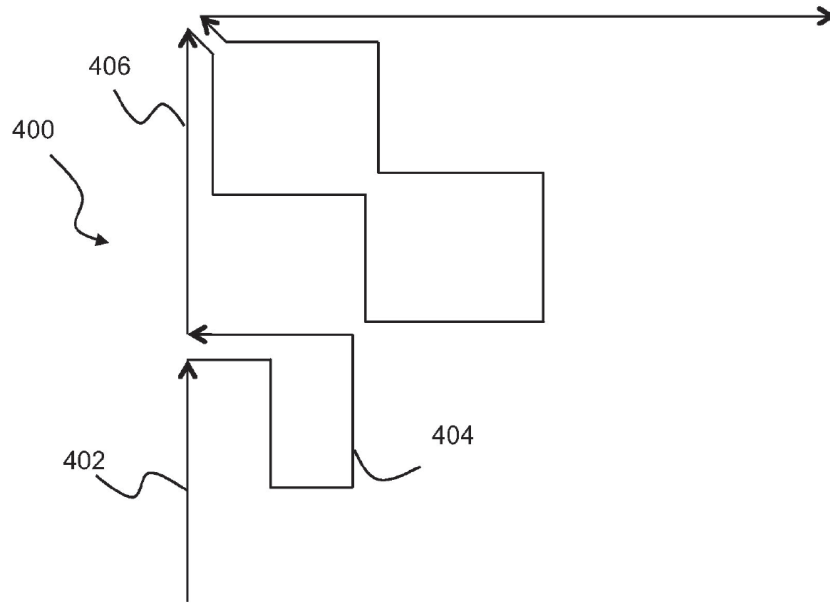
80. *Priedeman* (U.S. Patent Pub. No. 2003/0004600 A1) relates a method for three-dimensional modeling that forms a support structure and/or model. EX1007 at Abstract, Title. Figure 1 shows an extrusion apparatus 10 for building a model 26 supported by a support structure 28.



Id. at Fig. 1, ¶[0016]. A material supply 18 supplies material to the extrusion head 12, and a liquefier 22 heats and melts the material for extrusion through an orifice 24. *Id.*

E. Overview of *Boyer* (EX1008)

81. *Boyer* (U.S. Patent Pub. No. 2014/0034214 A1) relates to apparatus and methods for 3D printing to deposit multi-color materials. EX1008 at Abstract, Title. Figure 4 of *Boyer* shows a cross section of a multi-color object.



Id. at Fig. 4, ¶[0032]. The tool path 400 of the object has first (402), transition (404), and third segments (406). *Id.* The first segment traverses a portion of the object’s exterior surface with a first color (e.g., red) and the third segment traverses a different portion of the exterior with a second color (e.g., blue). *Id.* Between the first and third segments is a transition segment 404 that “turn[s] in toward an interior of the object and infill[s] with” a transition between the first and second colors. *Id.*

F. Overview of *KISSlicer* (EX1010)

82. *KISSlicer* (EX1010) is an eleven-page “Quick-Start Guide” for creating a “first print file.” EX1010 at 1. The guide describes an overview of settings (*id.* at 2-6), loading a file and viewing and positioning a part (*id.* at 6-8), setting printer parameters (*id.* at 8-9), and a parameter quick reference guide (*id.* at 9-11). Included in the settings that *KISSlicer* references is an optional “wipe pillar” used to “clean the extruder tip” to “reduce[] hairing.” EX1010 at 9. Separately from the “wipe

pillar,” *KISSlicer* includes a “Wipe [mm]” setting that relates to how much filament “the printer will push (prime)” “after a warm up” to “ensure the printer is ready.” EX1010 at 10.

VII. GROUND 1: CLAIMS 1, 2, 5-7, 9, 16, AND 17 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 1 (*LEAVITT* IN COMBINATION WITH *REPRAP ARTICLE* AND *REPRAP VIDEO*)

83. In Ground 1 of the Petition, Petitioner asserts that claims 1, 2, 5-7, 9, 16, and 17 are obvious over *Leavitt* in view of the *RepRap Article* and *RepRap Video*. Pet. at 1.

84. I understand that Petitioner asserts that *RepRap* (referring collectively to the *RepRap Article* and *RepRap Video*) discloses a purge operation performed for each deposition line switching to the operating mode. Pet. at 24 (citing to §V.A.3 of Petition); *see also* Pet. at 25–27. According to Petitioner, the *RepRap* extruders are “configured to print a 3D part by depositing” two materials “using a layer-by-layer technique where the printer alternates between depositing one material using ‘extruder 0’ and depositing the other material using ‘extruder 1.’” Pet. at 25 (citing EX1005 (*RepRap Article*) at 1). Petitioner further contends that, by moving the extruder head away from the 3D part and lowering the temperature within an idle extruder, the *RepRap Article* addresses a problem regarding the oozing of residual material from the nozzle of an idle liquefier pump. Pet. at 24–26 (citing EX1004 (*Leavitt*) at ¶[0032], EX1005 at 1; EX1003, ¶79). On this basis, Petitioner asserts

that *RepRap*'s purported "purge tower is printed in a layer-by-layer manner through purge operations occurring when one of the extruders is switched to the operating mode." Pet. at 27–28 (citing EX1006 (*RepRap Video*) at 05:04); *see also* Pet. at 28 (asserting that the combination "print[s] at least one layer of the purge tower in response to switching from a stand-by mode to an operating mode"). I disagree with Petitioner's assertions.

85. I have reviewed Petitioner's challenges in Ground 1, and it is my opinion a POSITA would not have been motivated to combine *Leavitt* with *RepRap* or had a reasonable expectation of success in doing so. Further, even if combined, Ground 1 fails to teach or suggest all elements of claims 1, 2, 5-7, 9, 16, and 17. I explain my opinions below in detail.

A. No Motivation to Combine *Leavitt* and *RepRap* or Reasonable Expectation of Success in Doing So

86. It is my opinion that a POSITA would not have been motivated to combine, or have had a reasonable expectation of success in combining, *Leavitt* and *RepRap* to achieve the inventions claimed by the '713 Patent. Petitioner advances four reasons why a POSITA would have been motivated to combine *Leavitt* and *RepRap* to achieve the claimed inventions. It is my opinion that each of these reasons rely on a misunderstanding of the art and/or would not lead the POSITA to the '713 Patent's claimed inventions.

87. First, Petitioner contends that “a POSITA would have been prompted to implement Leavitt’s system with the purge tower suggestion of RepRap because doing so would result in Leavitt’s deposition lines 30 and 32 advantageously ‘priming’ their nozzles before printing the layers of 3D object 20 and support structure 22.” Pet. at 12–13 (citing EX1005, 1; EX1003, ¶53). In support of this conclusion, Petitioner cites Dr. Hickner’s opinion that “[i]t is apparent from Leavitt’s teachings that the material at the nozzle tip of the idle liquefier pump would have an inconsistent texture, especially if a portion of the material slightly oozes from the tip of the nozzle.” EX1003, ¶53. Dr. Hickner further states that “that the ‘priming’ of such material into the suggested purge tower would have advantageously avoided uneven deposition or defects imposed upon the 3D part.” *Id.*

88. I disagree with Petitioner and Dr. Hickner that a POSITA would understand “from Leavitt’s teachings that the material at the nozzle tip of the idle liquefier pump would have an inconsistent texture” or that *Leavitt*’s system would result in “uneven deposition or defects imposed upon the 3D part.” *Id.* First, I note that *Leavitt* does not mention anything about “an inconsistent texture” or “uneven deposition.” See EX1004. Second, Paragraph 32 of *Leavitt* (cited by Dr. Hickner for support), specifically describes how *Leavitt*’s method of raising the extruder head solves the problem of “defects imposed upon the 3D part”: “Raised offset distance

74 allows build liquefier pump 30 to extrude roads of build material to form a layer of 3D object 20 without interference from support tip 68” and “reduces the risk of support material becoming embedded in 3D object 20.” EX1004, ¶32. As the ’713 Patent recognizes, using purge operations to “prime” the extruders in general was already known and would not require or motivate combination with *RepRap*’s parking space technique. See EX1001 at 4:41-62. Thus, a POSITA reading *Leavitt* would not be motivated to combine it with *RepRap* to solve the issue already resolved by *Leavitt*.

89. Second, Petitioner asserts that “printing a purge tower on the build substrate next to the 3D part (as suggested by RepRap) would have beneficially allowed Leavitt’s extruder head to prime such material and prepare the deposition line for operating mode in a prompt and efficient manner” and “thereby providing a time savings as compared to other purging procedures.” Pet. at 13 (citing EX1003, ¶54). In support, Petitioner cites to Dr. Hickner’s Paragraph 54, including his opinion that “printing a purge tower can reduce an amount of time required to complete a multi-material build as compared with other purge methods.” EX1003, ¶54.

90. I disagree with Petitioner and Dr. Hickner that a POSITA would have been motivated to combine *Leavitt* and *RepRap* for such purported “time savings.” In fact, *RepRap* expressly teaches the opposite. Specifically, the *RepRap Article* describes that its “technique works the best for printing a few layers of color, for

example a colored text on the top and bottom of the object,” and states that “the time needed to adjust the temperatures [] **slows down the print substantially when there are a lot of layers requiring extruder switching.**” EX1005 at 1 (emphasis added).

As such, a POSITA would not be motivated to combine *RepRap*’s parking space with *Leavitt*, nor had a reasonable expectation of success in doing so, as *Leavitt* explains that “[f]or even a single 3D object and corresponding support structure (e.g., 3D object **20** and support structure **22**), extrusion head **18** toggles between the build state and the support state numerous times,” and that “[t]his number is multiplied when fabricating large quantities of 3D objects and support structures in a rapid manufacturing process.” EX1004, ¶24; *see also id.*, ¶36 (describing that its solution is intended to “reduce[] time required during a build operation.”). Quite contrary to Dr. Hickner’s opinion that the combination would “reduce an amount of time required to complete a multi-material build” (EX1003, ¶54), a POSITA would understand from the express teachings of the references that the combination would “slow[] down the print substantially.” EX1005 at 1. As a result, a POSITA would in fact be taught *away* from the combination.

91. Third, Petitioner contends that “a POSITA would have understood that implementing *Leavitt*’s system with *RepRap* Article’s suggestion to lower the temperature of an idle extruder would provide an improved approach for preventing the idle extruder from leaking oozed material while positioned over the 3D part.”

Pet. at 13-14 (citing EX1005, ¶55). In support, Petitioner cites to Dr. Hickner's Paragraph 55, including his opinion that "POSITA would have recognized that cooling Leavitt's deposition line 32 switched into the stand-by mode while deposition line 30 occupies the operating mode and extrusion head 18 is positioned above the 3D part would have advantageously decreased the likelihood of deposition line 32 dripping any oozed material along the 3D part, an issue that Leavitt expressly acknowledges in multi-material builds." EX1003, ¶55.

92. I disagree with Petitioner and Dr. Hickner that a POSITA would have been motivated to combine *Leavitt* and *RepRap* to address issues of "leaking" or "dripping" of "oozed material." A POSITA would have understood that polymers melts would not "leak" or "drip" from the extruder head onto the part because of their high viscosity and surface tension. A POSITA would recognize that inertial effects contributing to flow are negligible in polymer melt behavior. In my textbook *Understanding Polymer Processing*¹, which is used in a required undergraduate plastics processing course, I emphasize that inertial effects can be disregarded in nearly all polymer processing operations. The '713 Patent itself acknowledges that material will not drip, stating that "a sufficient amount of the part or support material [must] be extruded from the print head to have enough weight to fall away from the

¹ EX2018 (Osswald, T.A., *Understanding Polymer Processing*, Hanser Publishers (2011)) at 192, 193, 199, 226, and 260.

given print head.” EX1001 at 4:63-66. While *Leavitt* states that “residual amounts of support material may potentially ooze from support liquefier pump 32”—*Leavitt*’s only discussion of “ooze”—a POSITA would understand that this refers to support material oozing and collecting on the extruder tip, which would not “leak” or “drip” onto the 3D part due to the aforementioned properties of the polymer material. As I already discussed with respect to Petitioner’s first motivation to combine, *Leavitt* teaches that the issues related to the ooze on the extruder head is addressed by raising the extruder head when that extruder is not printing. EX1004, ¶32. As such, a POSITA would not have been motivated to combine *Leavitt* and *RepRap* to address an issue that *Leavitt* has already solved.

93. Finally, Petitioner asserts that “POSITA would have applied RepRap Video’s teaching to print a purge tower on the substrate to Leavitt’s system . . . because doing so would provide an efficient way to concentrate waste material for rapid disposal in the compact purge tower.” Pet. at 14 (citing EX1003, ¶56). In support, Petitioner cites Dr. Hickner’s Paragraph 56. *Id.*

94. I disagree with Petitioner and Dr. Hickner that “provid[ing] an efficient way to concentrate waste material for rapid disposal,” would have motivated a POSITA to combine *Leavitt* and *RepRap*. First, I note that *Leavitt* describes no such issues with disposing waste material. *See generally* EX1004. Second, Petitioner and Dr. Hickner ignore that the conventional methods of conducting purge operations,

such as using a purge bucket, already “provid[ed] an efficient way to concentrate waste material for rapid disposal.” Pet. at 14; *see* EX1001 at 4:42-45, 4:62–5:3 (describing use of purge buckets in the art). As such, a POSITA would not have been motivated to combine *Leavitt* with *RepRap*, as the combination would not result in a more “efficient way to create waste material for rapid disposal” than already conventional in the art.

95. For the foregoing reasons, it is my opinion that a POSITA would not have been motivated to combine *Leavitt* with *RepRap* to achieve the inventions claimed in the ’713 Patent. It is also my opinion that, for the reasons stated above and for the issues discussed below with respect to *RepRap*’s implementation (*see infra* § VII.B-D), a POSITA would not have had a reasonable expectation of success in achieving the claimed inventions through the combination of *Leavitt* and *RepRap*. Finally, as discussed below, even if a POSITA combined *Leavitt* and *RepRap*, the combination still does not teach all elements of claims 1, 2, 5-7, 9, 16, and 17.

B. Claim 1

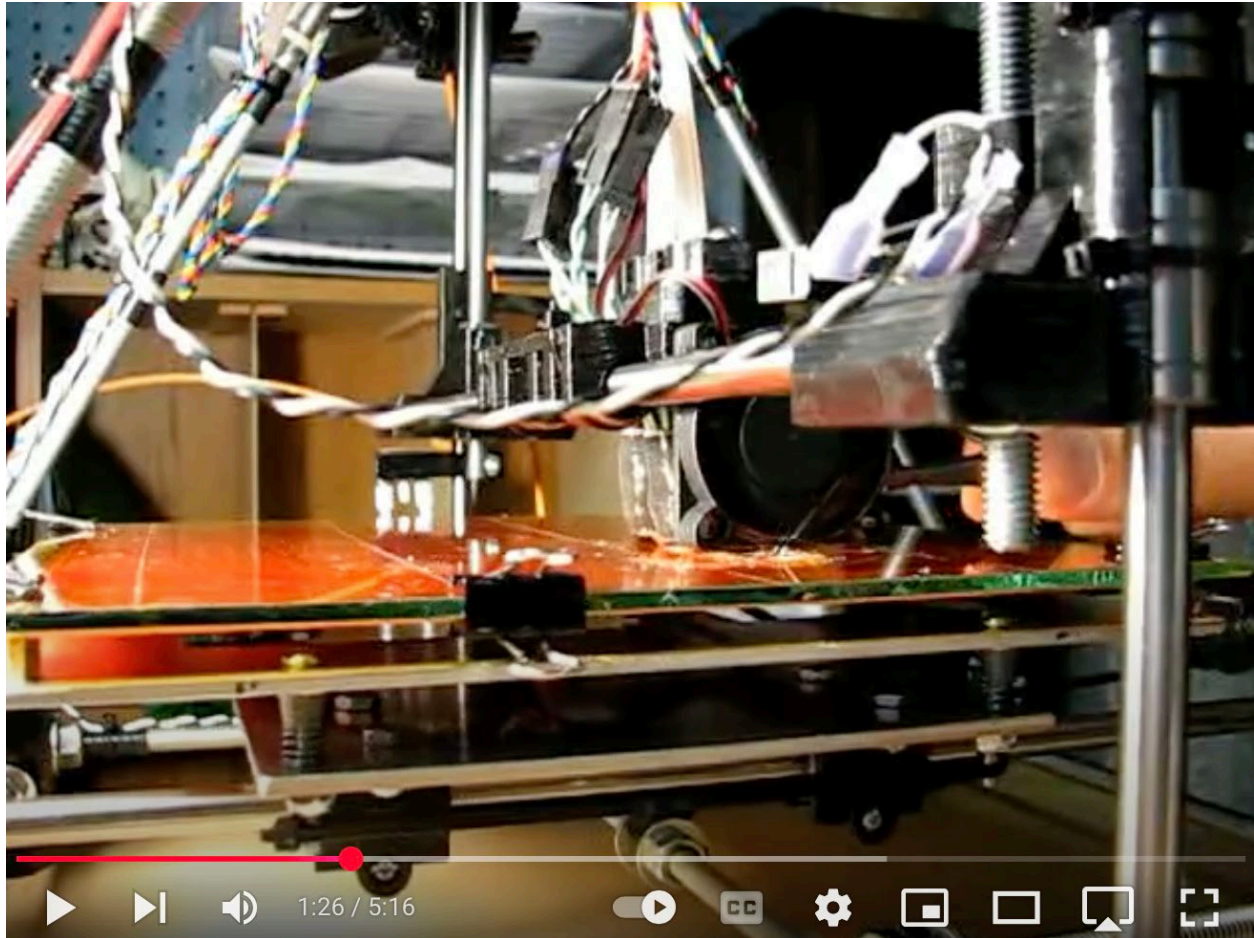
96. Claim 1 of the ’713 Patent requires, among other elements, “performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner, wherein the layers of the at least one purge tower are printed from

the print head or deposition line switched to the operating mode.” EX1001 at 15:53-58.

97. It is my opinion that *RepRap* discloses a parking space used to address temperature changes, rather than a layer-by-layer purge tower as asserted by Petitioner. I first note that there is no disclosure or teaching in the *RepRap Article* that the parking space is printed in a layer-by-layer manner, in which the layers are printed from the print head or deposition line switched to the operating mode. The *RepRap Article* discloses that, at any given point in a print process, the same parking space serves two purposes. EX1005 at 1. The *RepRap Article* describes that one purpose is to plug the nozzles while the temperature changes to address “plastic leaking from the idle extruder” and the other purpose is to “prime” both extruders to “establish the consistent flow of plastic” “before printing the actual object after the temperature change.” *Id.* As a result, a POSITA would understand that *RepRap*’s parking space includes, at any given point, leakage from one plugged nozzle/extruder and material extruded from both nozzles/extruders.

98. Importantly, this approach does not solve the “leakage” problem—it merely shifts it to another location. Indeed, as the video at 1:26 plainly shows, the operator must intervene to remove debris, almost certainly caused by the leaking idle extruder, in order to prevent interference with the active extruder’s printing. Far from eliminating leakage, the parking space demonstrates that the problem persists and

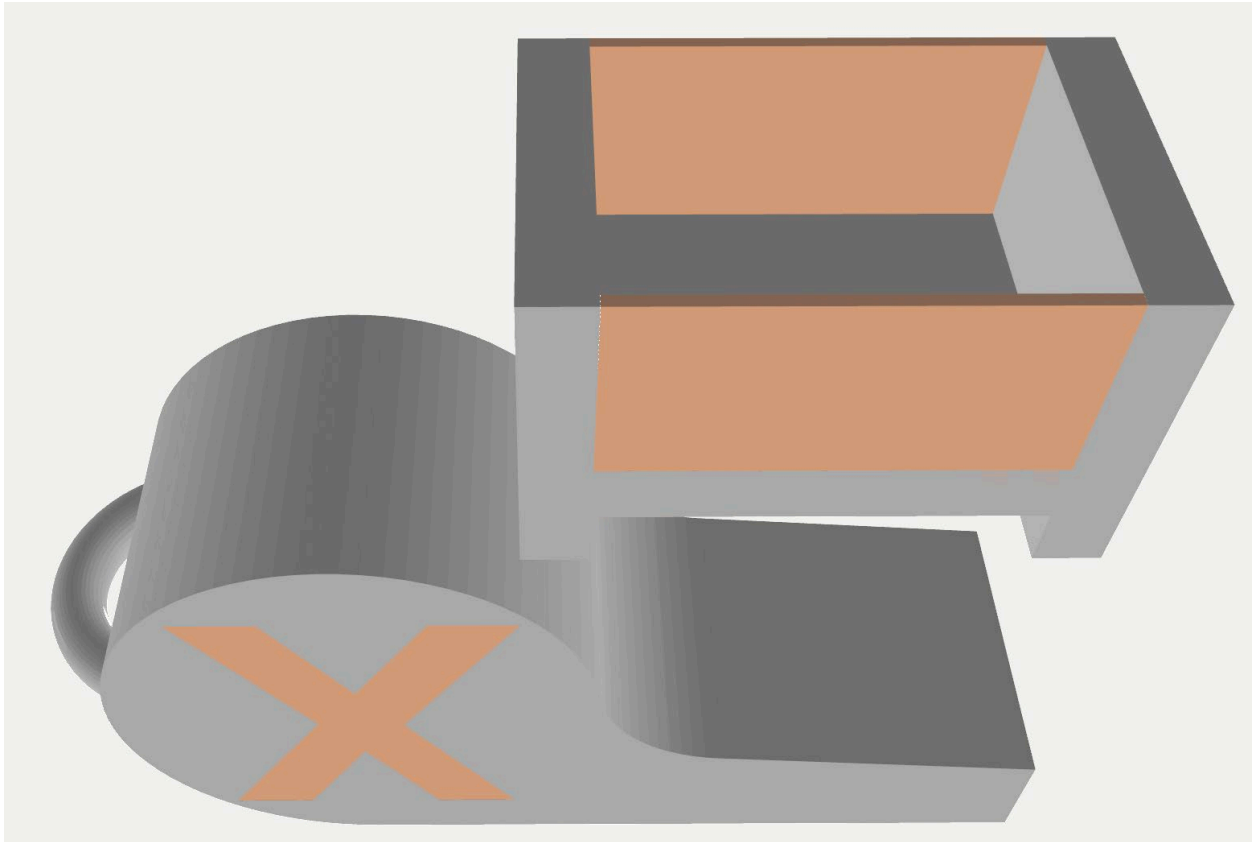
requires manual correction, underscoring that the purported “solution” fails to achieve its stated purpose.



EX1006 at 01:26.

99. Furthermore, the purported dual-material, dual-purpose parking space is not fabricated in the claimed layer-by-layer fashion, in which each layer is deposited by the print head or deposition line switched into the operating mode. To the contrary, when the two STL files from the *RepRap Article* are merged—one containing the whistle body and part of the parking space (*whistle_x2_body.stl*, EX1014), and the other containing the orange letters and rectangular plates of the

parking space (*whistle_x2_text.stl*, EX1015)—it becomes indisputable that the parking space is not produced layer-by-layer by the print head or deposition line switched into the operating mode. The merged model shows that the orange plates are embedded directly within the structure of the parking space, such that single layers necessarily include material from both extruders. This directly contradicts the asserted teaching of the '713 Patent, demonstrating that the claimed approach is not practiced in the RepRap design.



EX2017.

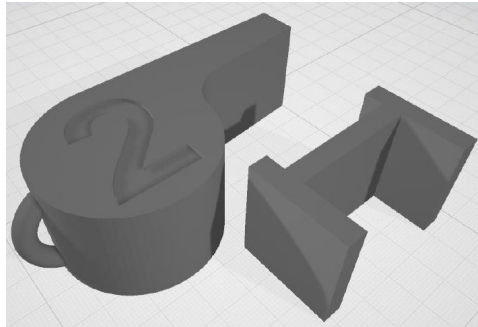
100. It is also my opinion that the *RepRap Video* provides little clarity regarding what occurs during a print process and that it fails to remedy the

deficiencies with the *RepRap Article*. As explained previously, the video has a poor quality in a dim environment with a spotlight, which creates severe reflections off of a glass surface (*see* EX1006 at 0:04), a view obstructed by an extruder and large fan (*id.* at 0:04), a low-resolution recording (*see* EX1006), a discontinuous recording showing different objects from different views (*see id.* at 03:15, 04:03, 04:20, 05:00, and 05:06, 05:08, and 05:16), and several portions that are blurry or out of focus (*see id.* at 02:26, 03:17). *Supra* § VI.C. The poor quality of the video fails to provide much clarity as to how exactly the parking space is printed. *See* EX2016 (Hickner Dep. Tr.) at 126:9-20 (admitting that aspects of the parking space are “difficult to tell from the color figure or the excerpted figure from the video”). For instance, the view of the object after printing is completed, which Petitioner provides as a screenshot of on page 28 of the Petition, shows many characteristics inconsistent with Petitioner’s assertions.

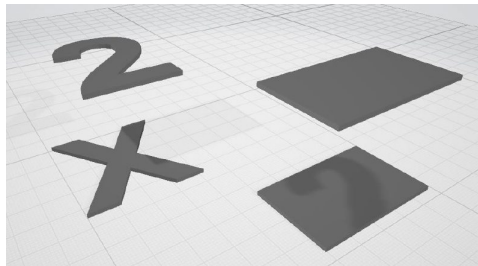


EX1006 at 05:04. As shown, the parking space that Petitioner alleges is a purge tower barely resembles the purported model of the parking space shown in Exhibits 1014 and 1015. *See* Pet. at 36 (asserting that EX1014 and EX1015 purportedly

corroborate that build data is generated for each layer of a model); EX1005 at 1 (describing base and text).

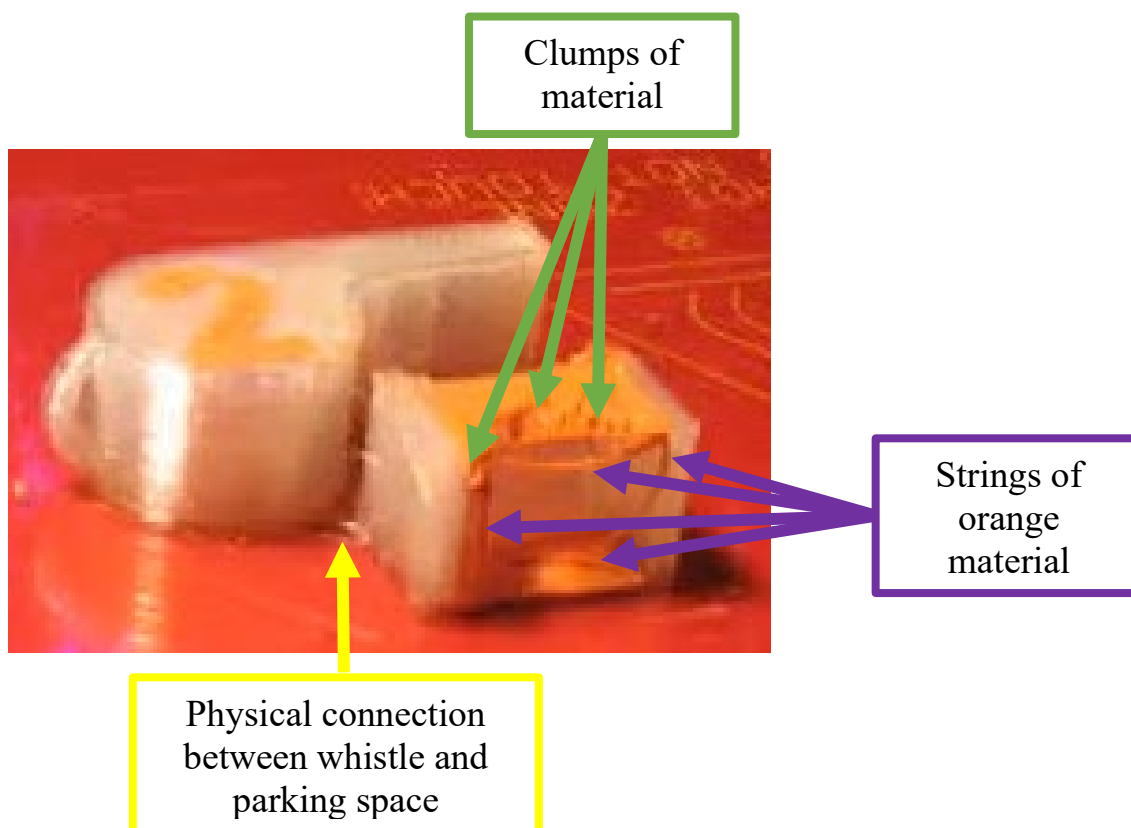


EX1014 (base).



EX1015 (text). As shown in Exhibit 1014, the parking space is supposed to be separate from the whistle and has two vertical surfaces connected together with a third vertical surface. Exhibit 1015 also shows that the two ends of the parking space are supposed to be two equal-sized plates.

101. I further note that, contrary to what is seen in Exhibits 1014 and 1015, the *RepRap Video* illustrates that there are many strings of orange-colored material all across the object (annotated in purple), with clumps of orange-colored material on top (annotated in green).



EX1006 at 05:04 (annotated). The parking space is *physically connected* to the whistle to form a single object, as shown by the annotations in yellow in the screenshots above and below.



Physical connection
between whistle and
parking space

EX1005 at 4:22. It is my opinion that a POSITA would not have considered a structure physically connected to the print object, such *RepRap*'s parking space, to teach the claimed purge tower. Indeed, Dr. Hickner confirmed that a POSITA would understand the "purge tower" is a "separate physical object" from the three-dimensional part. EX2016 (Hickner Dep. Tr.) at 64:1-9 ("[T]he part is something that a POSITA, if a POSITA is performing this operation, that's the desired component that one would take and use. And the purge tower is a separate physical object[.]"); *see also id.* at 28:8-10 ("The patent clearly shows separate components, the 24 components separated from --sorry, the 24 purge tower separated from the part."). A purge tower physically connected to the printed part would have to be broken away, inevitably leaving seams and residual material. In the case of the *RepRap* parking space, some of this residual material is of a different color, leaving

visible orange marks on the finished part—the very defect the *RepRap Article* and *RepRap Video* purport to address in the first place. I further note that the *RepRap Video* has no audio or other explanation as to how the parking space is made to explain why the result of the print is different than the *RepRap Article* and Exhibits 1014 and 1015. There is also no explanation about various features that differ from the purported models in Exhibits 1014 and 1015, including the strings of orange-colored material, the clumps of orange-colored material on the top of the parking space, or the single object printed with a physical connection between the whistle and parking space. *See* EX1014, EX1015, EX1006 at 04:22, 05:04. Thus, the whistle (alleged 3D part) and parking space (alleged purge tower) are printed as a single interconnected structure, and a POSITA would not be taught by the combination to “print[] layers of the three-dimensional part” and also “perform[] a purge operation” that comprises “print[] at least one purge tower.”

102. In addition, even if I assume for the sake of argument that the *RepRap* parking space is a purge tower, the *RepRap Video* does not teach that a layer of the parking space is printed when an extruder or a deposition line is switched into operation, as required by claim 1. Between the video’s low-resolution capture, obstructions, reflections, blurry images, and discontinuous sequences (all discussed above), there is no clear indication whether the whistle or parking space is printed first when an extruder or a deposition line is switched into operation or whether a

layer of the parking space is printed from the print head or deposition line switched to the operating mode. In fact, the resulting 3D part shown at the end of the *RepRap Video*, as well as the STL that results after merging of the STL files from EX1014 and EX1015, indicate that the print operation is different than what claim 1 of the '713 Patent requires.

103. Thus, there is no teaching in the combination of “performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner, wherein the layers of the at least one purge tower are printed from the print head or deposition line switched to the operating mode.” Accordingly, the combination in Ground 1 of *Leavitt* and *RepRap* fails to disclose or teach all the elements of claim 1 and its dependent claims.

C. Claim 16

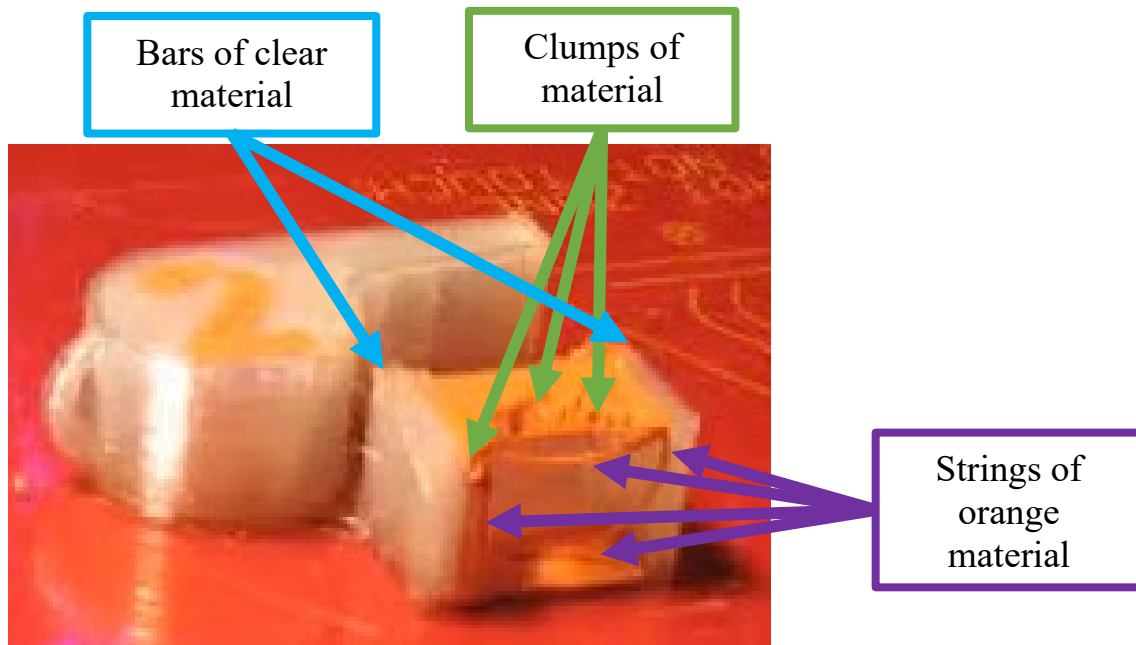
104. In Ground 1 of the Petition, Petitioner asserts that claim 16 is obvious over the *Leavitt-RepRap Article-RepRap Video* combination. Independent claim 16 of the '713 Patent requires, among other elements, “printing a first layer of a support structure from a support material for the three-dimensional part,” “printing a first layer of a purge tower from a part material,” and “printing a first layer of the three-dimensional part on at least a portion of the first layer of the support structure from the part material after printing the first layer of the purge tower.” EX1001, 18:1-6.

Petitioner argues the combination teaches that the extruder “prints a layer of the purge tower each time that build liquefier pump 30 transitions from an idle state to an active state as taught by RepRap.” Pet. at 37. On this basis, Petitioner contends that the *RepRap* extruder in the combination “prints a first layer of the purge tower from the part material when the build liquefier pump 30 transitions from the idle state to the active state.” *Id.* I disagree with Petitioner’s assertions.

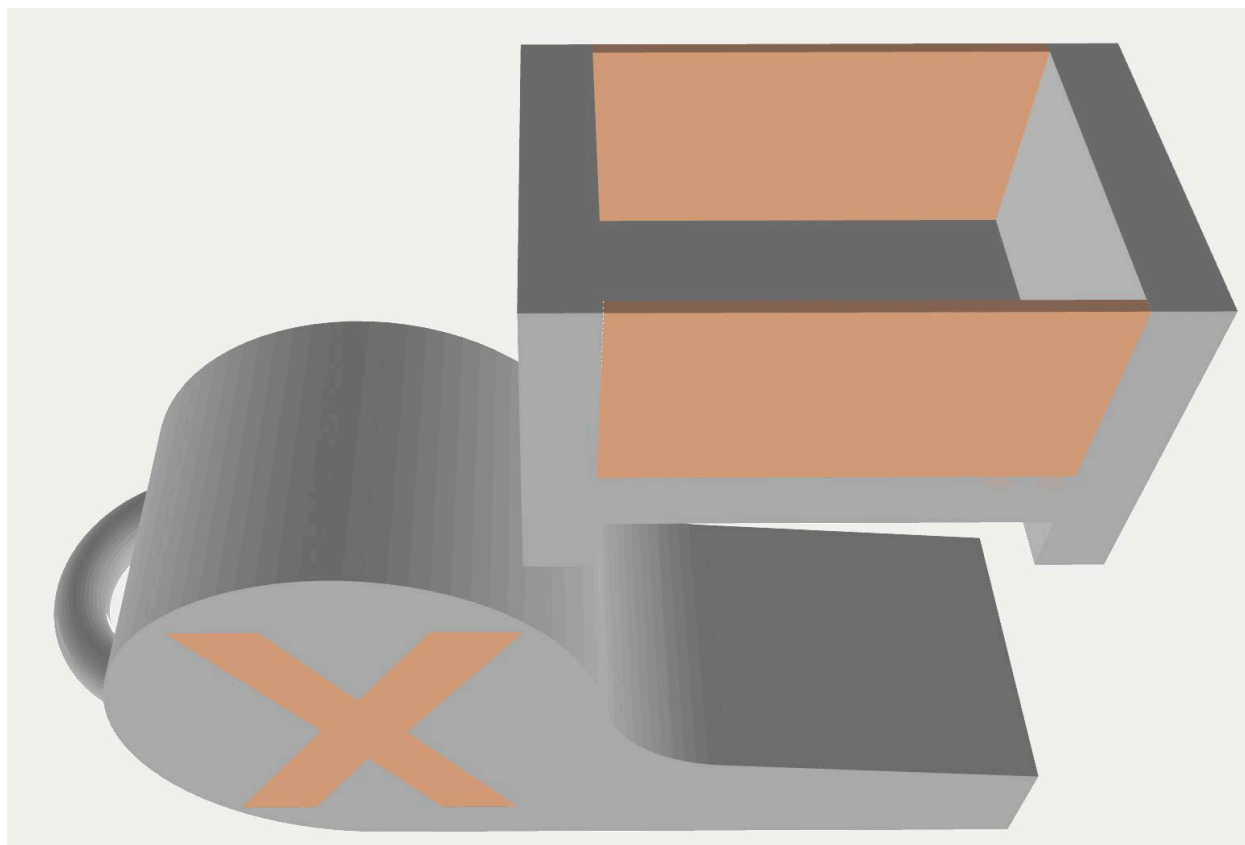
105. It is my opinion that Petitioner’s conclusion that the transition from idle to active is the first transition when a first layer of the tower is printed is unsupported and conclusory. As I discussed above for claim 1, the combination of *Leavitt* and *RepRap* does not teach printing a purge tower in a layer-by-layer manner in which the layer of the tower is printed when a print head or deposition line is switched into an operating mode. *Supra* § VII.B. For at least the same reasons I discussed previously, the combination also does not teach printing a first layer of a purge tower from part material after a first layer of a support structure is printed from a support material. A POSITA would not understand the *RepRap Article* or *RepRap Video*, whether alone or in the combination, to teach such a layered approach to printing the parking space.

106. In fact, as I discussed previously, the *RepRap Article* describes a parking space that has a dual purpose to handle leakage from one nozzle while handling priming for multiple nozzles. *See* EX1005 at 1; *supra* § VII.B. Thus, at any

given point, a POSITA would understand that the parking space contains *a mixture of materials* from both nozzles. *Id.* For example, as shown in the annotated image below, the top layer of the parking space shown in the *RepRap Video* includes strings and clumps of orange-colored material and two bars of clear material that embed the orange plate.



EX1006 at 05:04 (annotated); *supra* § VII.B. The merged STL files show more clearly that the orange plates are embedded within the parking space structure itself, such that individual layers necessarily incorporate material from both extruders.



EX2017. Additionally, nearly every given point of the parking space or purported layer includes strings of orange-colored material with the other material. *See* EX1006 at 05:04. As a result, there is no indication whether the whistle or parking space is printed first with part material when a print head or a deposition line is switched to an operating mode. *See id.*; *see also* EX1005 at 1 (dual-purpose of parking space). For these reasons, a POSITA would not understand *RepRap*, whether alone or in the combination, to teach printing a first layer of a support structure from a support material, printing a first layer of a purge tower from a part material, and printing a first layer of a 3-D part from the part material on at least a portion of the first layer of the support structure after printing the first layer of the purge tower.

107. It is also my opinion that *Leavitt* does not address these deficiencies with *RepRap* in the combination. Indeed, *Leavitt* does not teach printing a purge tower at all, which Petitioner's expert confirmed. EX2016 (Hickner Dep. Tr.) at 121:22–122:1 (“Leavitt does not have any depictions or explanations of a purge tower”). In addition, I note that Figure 1 of *Leavitt* shows that the bottom of an object has both support material 22 and part material 20.

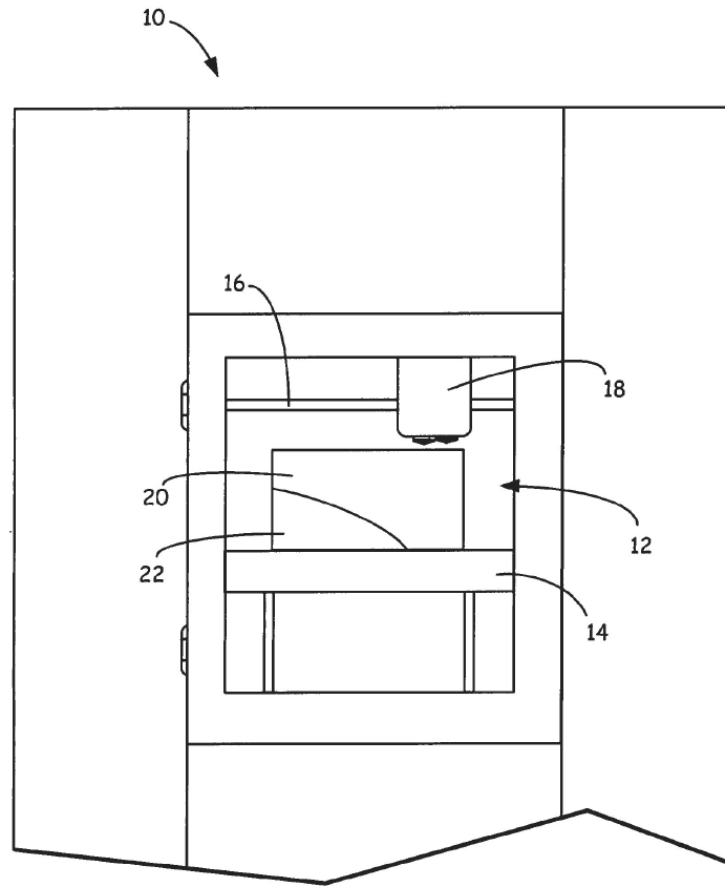


Fig. 1

EX1004 at Fig. 1, ¶[0023] (“During a build operation, extrusion head 18 is initially positioned in the build state, which allows extrusion head 18 to deposit the build material in a sequence of roads to form a layer of 3D object 20. *After the layer of 3D object 20 is complete, extrusion head 18 then toggles to the support state, which allows extrusion head 18 to deposit the support material in a sequence of roads to*

form a layer of support structure 22.”). Thus, the combination does not teach printing a first layer of a support structure, printing a first layer of a purge tower from part material, and then printing a first layer of a 3-D part from part material.

108. For the reasons discussed above (*see supra* § VII.A), it is also my opinion that the POSITA would not have been motivated to combine the *RepRap Article* and *RepRap Video* with *Leavitt* to practice this claim, which requires printing successive layers of part and support material, nor have had a reasonable expectation of success in doing so. The *RepRap Article* expressly teaches away from such a solution. Specifically, the *RepRap Article* states that, while its “technique works the best for printing a few layers of color, for example a colored text on the top and bottom of the object,” “the time needed to adjust the temperatures [] slows down the print substantially when there are a lot of layers requiring extruder switching.” EX1005 at 1. *Leavitt* itself acknowledges that “[f]or even a single 3D object and corresponding support structure (e.g., 3D object **20** and support structure **22**), extrusion head **18** toggles between the build state and the support state numerous times,” and that “[t]his number is multiplied when fabricating large quantities of 3D objects and support structures in a rapid manufacturing process.” EX1004, ¶24. *Leavitt* further teaches that its solution is designed to “reduce[] time required during a build operation.” EX1004, ¶36. Thus, a POSITA would have been expressly taught away from combining *RepRap*’s parking space, which “slows down the print

substantially when there are a lot of layers requiring extruder switching,” EX1005 at 1, with *Leavitt*’s system where the “extrusion head **18** toggles between the build state and the support state numerous times,” EX1004, ¶24, to print using part and support material in the alternating method of claim 16.

109. Accordingly, the combination in Ground 1 fails to teach or suggest all the elements of claim 16 and its dependent claims.

D. Dependent Claims

110. In addition to the limitations of claims 1 and 16 not taught or suggested by Ground 1, additional limitations from dependent claims 5 and 17 are also not taught by this ground.

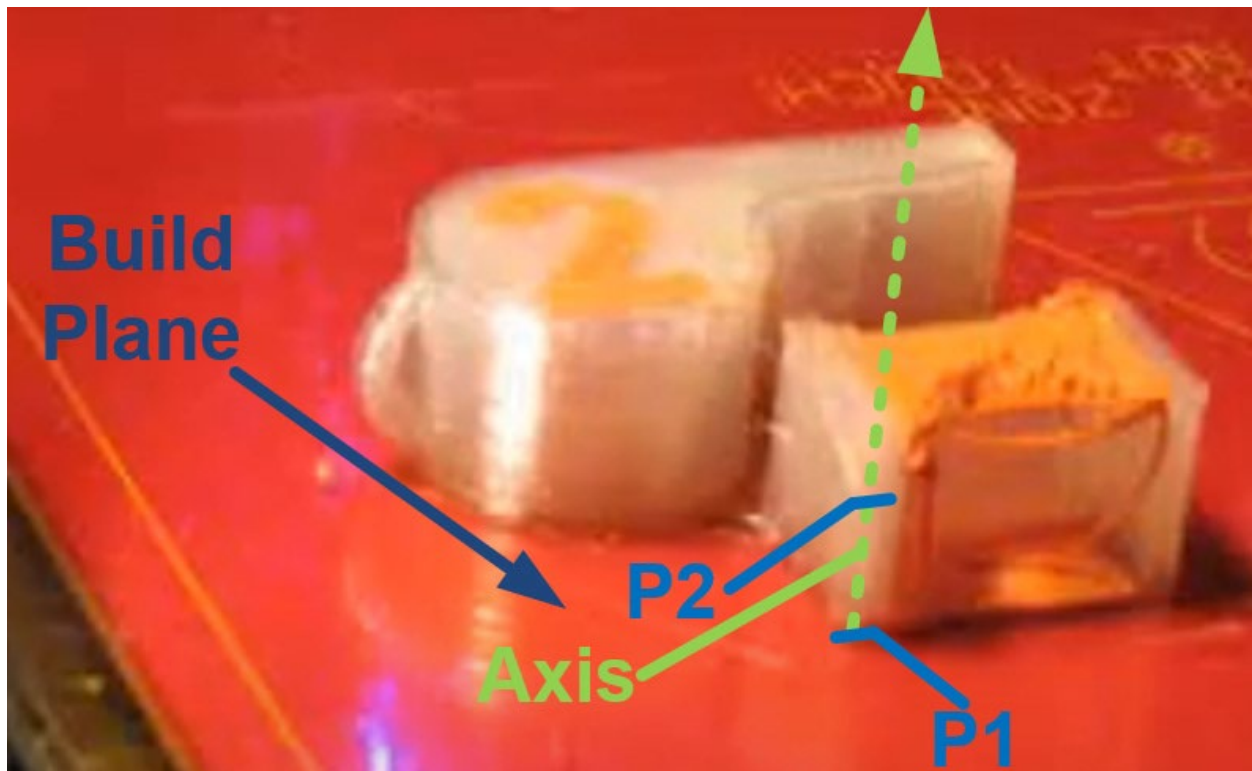
1. Claim 5: “wherein the at least one purge tower has a cross-sectional area that reduces in height along an axis that is perpendicular to a build plane”

111. Claim 5, which depends from claim 1, further requires that “the at least one purge tower has a cross-sectional area that reduces in height along an axis that is perpendicular to a build plane.” EX1001 at 16:18-20. The ’713 Patent explains why the claimed reduction in height is necessary for some builds:

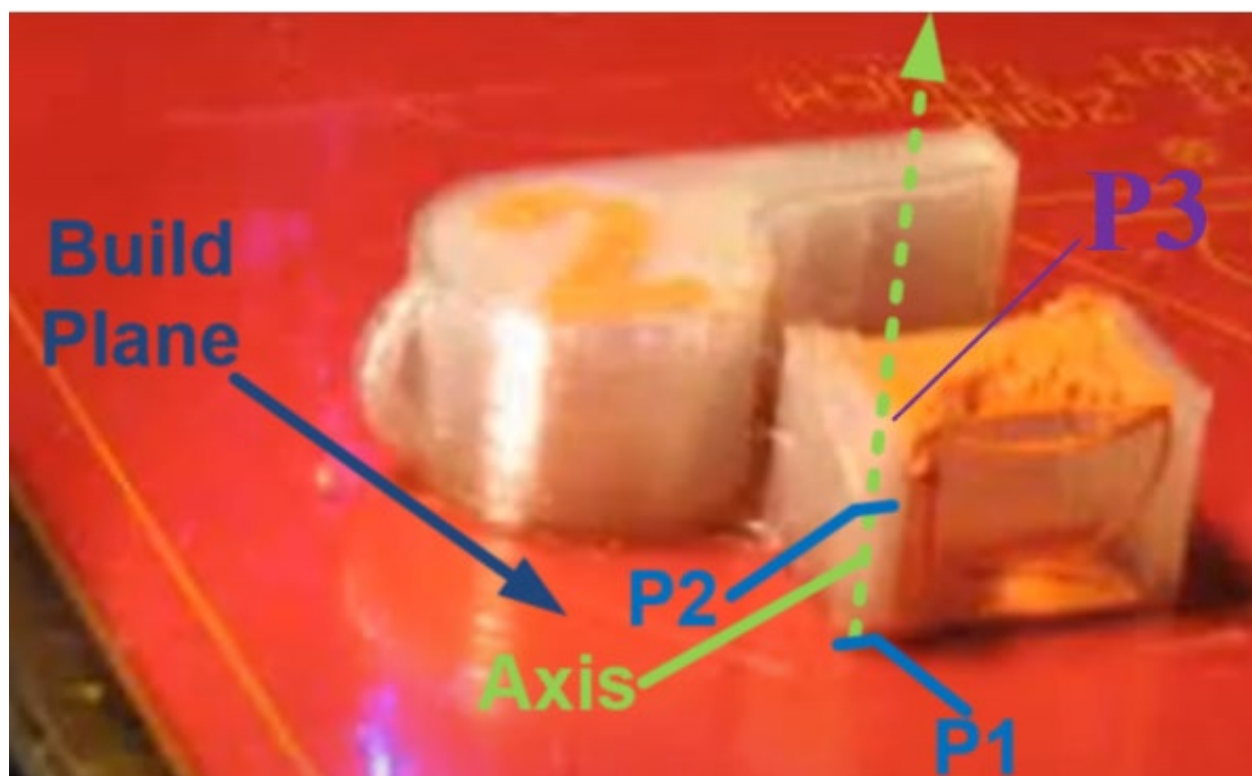
[I]n situations in which purge tower **24** will be printed high enough that its height is substantially greater than its cross-sectional area, it can be beneficial to print the lower layers **24a** of purge tower **24** with larger cross-sectional areas, with walls that slope or taper to small cross-sectional areas at the higher layers. This preferably prevents [] the portion of purge tower **24** from wobbling during the printing operation, which can otherwise impair the printing of subsequent layers.

EX1001 at 9:61–10:3.

112. For claim 5, I understand that Petitioner contends that *RepRap*'s parking space “has cross-sectional areas that differ between a first cross-sectional position (P1) at a base of the purge tower and a second cross-sectional position (P2) above P1 relative to the build plane” with reference to following annotated image:



Pet. at 31 (excerpting EX1006, 5:04 (annotated)). I disagree with Petitioner's assessment of *RepRap* as it relates to this claim. First, I note that Petitioner ignores that the cross-sectional area of *RepRap*'s parking space *increases* again at point P3 (annotated below) to what appears to be the same cross-sectional area as P1.



Pet. at 31 (excerpted EX1006, 5:04 (annotated)) (further annotated to add P3 marking). During deposition, Petitioner's expert admitted that "the orange layer at the bottom of the parking space has the same cross-sectional area as the orange layer at the top of the parking space" and that "both of those layers have a larger cross-sectional area than the layer corresponding to P2." EX2016 (Hickner Dep. Tr.) at 126:2-20. I further note that the *RepRap Video* itself demonstrates the problems with its parking space *not* reducing in cross-sectional area as the height increases (e.g., orange material has fallen down during the printing operation). As such, a POSITA would not understand *RepRap* to teach or suggest that the parking space "has a cross-sectional area that reduces in height along an axis that is perpendicular to a build plane" as required by claim 5.

2. Claim 17: “The method of claim 16, and further comprising repeating steps (b)-(e) for at least a portion of the three dimensional part and support structure.”

113. Claim 17, which depends from claim 16, further requires “repeating steps (b)-(e) for at least a portion of the three-dimensional part and support structure.” EX1001 at 18:13-15. Steps (b)-(e) of claim 16 require: “(b) printing a first layer of a purge tower from a part material; (c) printing a first layer of the three-dimensional part on at least a portion of the first layer of the support structure from the part material after printing the first layer of the purge tower; (d) printing a second layer of the purge tower from the support material; and (e) printing a second layer of the support structure on at least a portion of the first layer of the three-dimensional part from the support material after printing the second layer of the purge tower.” *Id.* 18:2-12.

114. For claim 17, Petitioner relies on the same flawed reasoning that I addressed above for claim 16. For the reasons I discussed previously, the combination of Ground 1 does not teach printing a first layer of a support structure, printing a first layer of a purge tower from part material, and then printing a first layer of a 3-D part from part material. *See supra* § VII.B. Furthermore, as I noted above, *RepRap* teaches away from this repeated alternation between printing part and support material using its teachings because its method “slows down the print substantially when there are a lot of layers requiring extruder switching,” EX1005

at 1. As such, the POSITA would not have been motivated to combine the *RepRap* teachings with *Leavitt* to additionally “repeat[e] steps (b)-(e) [of claim 16] for at least a portion of the three dimensional part and support structure.”

VIII. GROUND 2A: CLAIMS 1, 2, 6, 7, 9, 16, AND 17 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 2A (*PRIEDEMAN* IN COMBINATION WITH *KISSLICER*)

115. In Ground 2A of the Petition, Petitioner asserts that claims 1, 2, 6, 7, 9, 16, and 17 are obvious over *Priedeman* in view of the *KISSlicer*. Pet. at 1. I have reviewed Petitioner’s challenges in Ground 2A, and it is my opinion that Ground 2A fails to teach or suggest all elements of claims 1, 2, 6, 7, 9, 16, and 17. I explain my opinions below in detail.

A. Claims 1 and 16

116. The Petition argues that claims 1 and 16 are obvious over *Priedeman* in view of *KISSlicer* (Ground 2A). Pet. at 1. However, Petitioner’s challenge in Ground 2A fails to teach or suggest all elements of claims 1 and 16.

117. I understand that claim 1 of the ’713 Patent requires, among other elements, “performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner, wherein the layers of the at least one purge tower are printed from the print head or deposition line switched to the operating mode.” EX1001 at 15:53-58. Similarly, claim 16 of the ’713 Patent requires, among other elements, “printing a first layer of a support structure from a support material

for the three-dimensional part,” “printing a first layer of a purge tower from a part material,” and “printing a first layer of the three-dimensional part on at least a portion of the first layer of the support structure from the part material after printing the first layer of the purge tower.” *Id.* at 18:1-6. It is my opinion that *Priedeman* alone or in combination with the *KISSlicer* reference does not teach these elements of claims 1 and 16.

118. As an initial matter, I understand that Petitioner does not contend that *Priedeman* itself discloses or teaches a purge tower. *See* Pet. at 42-43. I note that Petitioner’s expert admitted as much during deposition. *See* EX2016 (Hickner Dep. Tr.) at 128:9-11 (admitting “there [are] no examples of purge towers in [*Priedeman*]”). Instead, I understand that Petitioner asserts that the *Priedeman-KISSlicer* combination teaches a purge operation after warm up. *See* Pet. at 50-51 (citing EX1010 at 9-10); *see also* Pet. at 43-46. However, it is my opinion that *KISSlicer* does not teach a purge operation that prints a purge tower in the manner recited in claims 1 and 16. Rather, the reference discloses a “wipe pillar,” which a POSITA would understand from *KISSlicer*’s teachings is used to “clean the extruder tip” to “reduce[] hairing,” which is entirely unrelated to a purge operation, let alone one comprising the steps recited by claims 1 and 16. EX1010 at 9. I note this understanding is corroborated by the ’713 Patent, which teaches that “tip-wipe operation[s]” are distinct and optional processes that could be performed after

purging. *See* EX1001 at 15:53-58, 18:1-6; *see also id.*, 4:41-45 (describing a purge operation optionally followed by a tip-wipe operation), 9:47-59 (“optionally” performing a separate tip-wipe operation, “as illustrated by tool path segment 58f” between vertices 64 and 66 in Figure 5), Fig. 5. As described by the ’713 Patent, a POSITA would understand that a “purge operation” is performed for a variety reasons related to ensuring the print head is ready to print, none of which have to do with eliminating hairing after printing:

[A] purge operation provides several desired functions. First, it frees any part or support material filament that may be adhered to the walls of the liquefier assembly, and verifies that the print head can extrude the part or support material. It also removes any entrained gases and degraded materials in the print head, and brings the print head to a known operating state for printing the subsequent layer, such as bringing a meniscus in the liquefier assembly to a substantially known position and raising the internal temperature of the liquefier assembly to a substantially steady-state condition. It also removes variable ooze that may hang from a nozzle of the liquefier assembly while the print head is idle or in its stand-by mode, and can account for variability of any voids in a tip pipe region of the nozzle. Additionally, for very low-volume-per-layer 3D parts, it may provide a minimum flow volume per layer to reduce the residence time-at-temperature for the part material.

EX1001 at 4:46-62.

119. Even if one were to assume that the “wipe pillar” in the *KISSlicer* reference is a “purge tower” in general, it is my opinion that *KISSlicer* still fails to teach the specific requirements of claims 1 and 16 that the purge tower is printed in a layer-by-layer manner from the print head or deposition line switched to the operating mode (such as a first layer of the purge tower printed from part material

before printing a first layer of the 3D part from the same material). First, a POSITA would understand that in Petitioner's proposed combination the wipe pillar is printed after—not before—that print head prints the part or support structure. A POSITA would understand that a “wipe pillar” is a structure used to clean the extruder tip to eliminate hairing on the 3D part and that the wipe pillar is printed *after* the extruder has finished printing the part/support structure, not before as Petitioner suggests. Pet. at 51-52 (arguing “[*KISSlicer*'s] extruder prints one or more layers of the [wipe pillar] before printing the three-dimensional part or support structure”). A POSITA would understand that hairing or stringing (as it is referred to in the '713 Patent) results when an extruder ceases to print on a given layer and is then moved to a different location. *See, e.g.*, EX1013 at 19. Hairing occurs due to the cohesive forces in the polymer melt, arising from its high molecular weight, just extruded and the residue remaining at the extruder tip. These cohesive forces cause thin strands of material (i.e., hairs) to form as the extruder is moved away from the location of the print. This effect operates similarly to stretching silly putty—i.e., as the material in the extruder head is stretched away from the material just extruded, small strands of the material may be formed until the two materials completely separate. These hairs can become stuck to the extruder tip. *See* EX2016 (Hickner Dep. Tr.) at 132:16–133:5 (“it's possible that a hair is stuck to the extruder tip or the extrusion nozzle.”). A POSITA would understand that one way to deal with the problem of hairs on the

extruder tip is by taking the extruder that has just *finished printing* the part/support structure and printing a “wipe pillar” to capture these hairs off the end of the extruder. While *KISSlicer* states that the “wipe pillar” is printed “before every layer to clean the extruder tip,” a POSITA would understand that this refers to the case of a single extruder and that, in that circumstance, printing the wipe pillar “before every layer” is the same as printing the wipe pillar at the conclusion of every layer. In the context of “dual head prints,” a POSITA would understand that the extruder that just completed its print operation would print its wipe pillar before the other extruder begins printing on the same layer. Doing so removes the hairs on the tip of the inactive extruder so they will not contact the build while the other active head performs its print operation. For instance, in a dual-extruder printer like that described in *Priedeman*, a POSITA would understand that the wipe pillar is printed by the extruder that has just completed printing the part/support structure so that the hairs on the end of this inactive extruder will not contact the build while the other extruder head is performing its print operation. As such, a POSITA would understand that for dual extruder operations, *KISSlicer* teaches printing a wipe pillar *after* printing the part / support structure on a given layer, not before. Second, *KISSlicer* teaches that an entire structure (a cylinder) is printed, which suggests that many cylinders are printed as layers are printed, not a structure printed in a layer-by-layer manner as claimed. EX1010 at 9.

120. I further note that Petitioner relies on *KISSlicer*'s "Wipe" setting to support the conclusion that layers of the wipe pillar are printed "after a warm up." Pet. at 44-45. I disagree with Petitioner's reading of *KISSlicer*. A POSITA would not understand *KISSlicer*'s "wipe" setting as being related to its wipe pillar. See EX1010 at 10 ("Wipe [mm]: after a warm up the printer will push (prime) this amount of filament to ensure the printer is ready."). In particular, *KISSlicer*'s wipe setting is only performed "after warm up" and is "to ensure the printer is ready," (EX1010 at 10), whereas *KISSlicer*'s wipe pillar is printed for "every layer" and is used "to clean the extruder tip" (*id.* at 9). See also *id.* at 3 (Material settings menu showing separate settings for "Prime" and "Wipe"), 9-10 (describing separate "destring" suck/prime setting to address "oozing"). In other words, a POSITA would understand that the priming of the "Wipe" setting happens only once at the beginning of the print "after warm up" of the printer. There is no teaching in *KISSlicer* that the priming after warm-up of the printer is related to switching a particular print head or deposition line to an operating mode, nor is there any teaching that a wipe pillar is printed in relation to warming up the printer. See Pet. at 50. In fact, as discussed above, a tip wipe operation, such as by using *KISSlicer*'s wipe pillar, is different from a priming operation performed on the printer "after a warm up . . . to ensure the printer is ready," (EX1010 at 10), which are both different from the layer-by-layer purge tower printing required by claims 1 and 16. Thus, the combination fails

to teach performing a purge operation comprising printing a purge tower in a layer-by-layer manner, in which the layers of the purge tower are printed from the print head or deposition line switched to the operating mode (claim 1), such as printing a first layer of a support structure from a support material, printing a first layer of a purge tower from part material, and then printing a first layer of the three-dimensional part on at least a portion of the first layer of the support structure from the part material (claim 16).

121. Accordingly, the combination in Ground 2A fails to provide all the elements of independent claims 1 and 16, and their dependent claims.

B. Dependent Claims

122. In addition to the limitations of claims 1 and 16 not taught or suggested by Ground 2A, Grounds 2A also fails to teach or suggest the additional limitation of dependent claim 6.

1. Claim 6: “wherein the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure”

123. Claim 6, which depends from claim 1, further requires “wherein the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure.” EX1001 at 16:21-24.

124. As I discussed above for claims 1 and 16, there is no teaching in *KISSlicer* of a “purge tower,” let alone one that is “stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure” as required by claim 6. To the contrary, even if Petitioner’s arguments regarding *KISSlicer*’s “wipe pillar” are adopted, *KISSlicer* specifically states that the “wipe pillar”—referred to by Petitioner as a purge tower—is “printed before *every layer*,” regardless of material change. EX1010, 9. A POSITA would understand *KISSlicer* to teach printing the wipe pillar on “every layer,” agnostic as to any changing of material. As such, it is my opinion that, not only is there no teaching or suggestion in the *Priedeman-KISSlicer* combination to stop the printing of a purge tower “at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure,” but instead there is an express teaching *not* to stop the printing of the purported purge tower at the last material change.

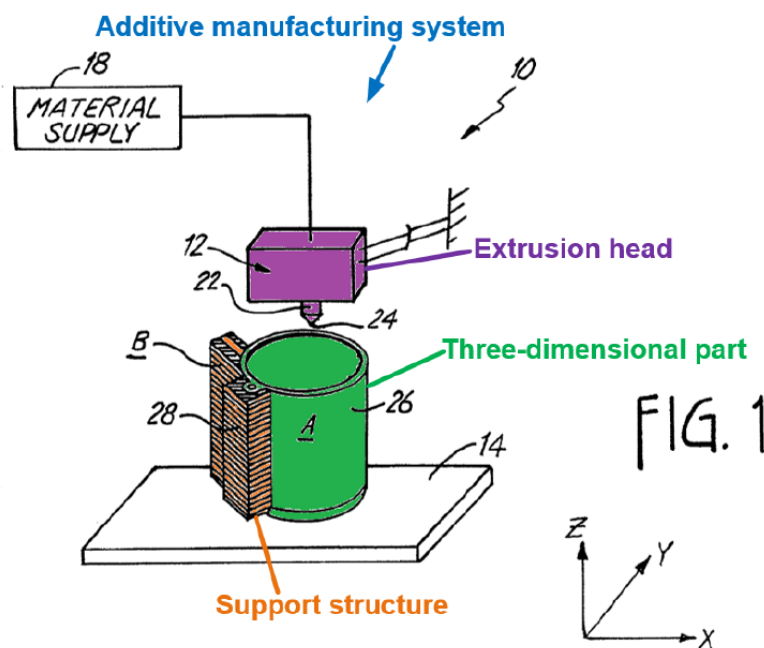
IX. GROUND 2B: CLAIM 5 WOULD NOT HAVE BEEN OBVIOUS OVER GROUND 2B (*PRIEDEMAN* IN COMBINATION WITH *KISSLICER*, *REPRAP ARTICLE*, AND *REPRAP VIDEO*)

125. In Ground 2B of the Petition, Petitioner asserts that claim 5 is obvious over *Priedeman* in view of *KISSlicer*, *RepRap Article*, and *RepRap Video*. Pet. at 1. I have reviewed Petitioner’s challenge in Ground 2B, and it is my opinion that

Ground 2B fails to teach or suggest all elements of claim 5. I explain my opinions below in detail.

126. As an initial matter, because claim 5 depends from claim 1 and Petitioner relies on its assertions under Ground 2A for the elements of claim 1, it is my opinion that claim 5 is not obvious in view of Ground 2B at least because it does not teach or suggest all the elements of claim 1. *See supra* § VIII.A.

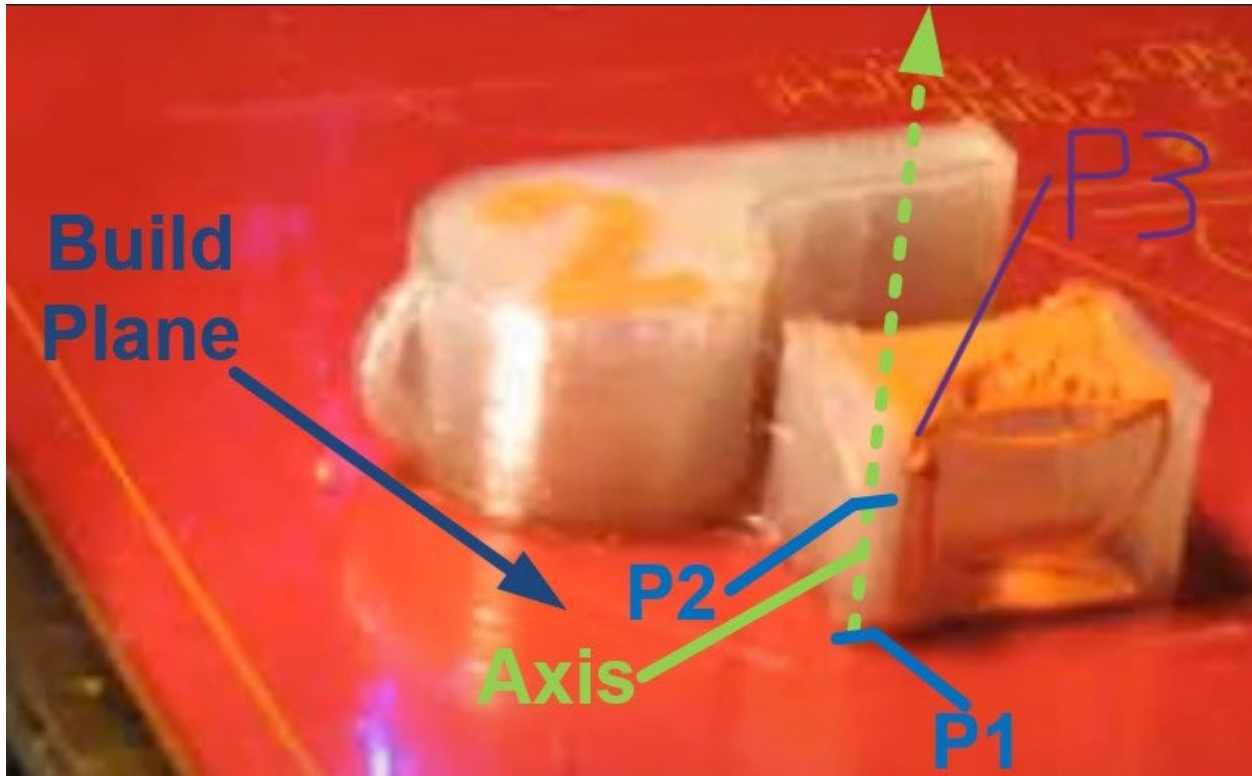
127. In addition, as I discussed above for Ground 1 (*see supra* § VII.A), it is my opinion that a POSITA would not have been motivated to implement *RepRap*, which “slows down the print substantially when there are a lot of layers requiring extruder switching,” (EX1005 at 1), with a system like *Priedeman* that teaches extruder switching at every layer, as depicted by Petitioner’s annotated *Priedeman* Figure 1 below:



Pet. at 48 (citing EX1007 at Fig. 1 (annotated); *see also* EX1007, ¶¶17-18; EX1003, ¶174 (“... [Priedeman’s] extruder head 12 must alternate between printing layers of the model 26 and printing layers of the support structure 28 to achieve the multi-material build.”)).

128. Even if a POSITA made the combination advance by Petitioner, *RepRap* does not teach claim 5’s additional requirement that “the at least one purge tower has a cross-sectional area that reduces in height along an axis that is perpendicular to a build plane,” as I previously discussed. EX1001 at 16:18-20; *see supra* § VII.C.1. As such, it is my opinion that *RepRap* in combination with the references of Ground 2A also does not teach or suggest claim 5’s additional limitation.

129. Furthermore, I note that Petitioner’s assertion that, based on *RepRap*’s parking space, “a POSITA would have been motivated in implement the resulting purge tower of the Priedeman-KISSlicer combination (Ground 2A) in this manner to advantageously construct a more stable, less top-heavy tower” is both conclusory and incongruent with the facts. Pet. at 62. As I discussed previously, *RepRap*’s parking space itself is neither “stable” nor a “less top-heavy tower,” as shown by the image below that appears to depict the *RepRap* parking space partially collapsed:



See supra § VII.C.1. For the foregoing reasons, it is my opinion that Ground 2B does not teach or suggest claim 5.

X. GROUND 3: CLAIMS 1, 2, 6, 7, AND 9 IS NOT ANTICIPATED BY GROUND 3 (BOYER)

130. The Petition argues that claims 1, 2, 6, 7, and 9 are anticipated by *Boyer* (Ground 3). Pet. at 1. It is my understanding that for a reference to anticipate, as opposed to render obvious, a claim, the reference must disclose all elements of the claim either expressly or inherently within the four corners of the document and disclose those elements arranged as in the claim. As such, I understand that to establish that a reference anticipates a claim it is not enough that the prior art reference discloses part of the claimed invention, which an ordinary artisan might

supplement to make the whole, or that it includes multiple, distinct teachings that the artisan might somehow combine to achieve the claimed invention. With this understanding, it is my opinion that a POSITA would not understand *Boyer* to disclose, expressly or inherently, all of the elements of claims 1, 2, 6, 7, and 9. As a result, it is my opinion that those claims are not anticipated by *Boyer*.

A. Claim 1

131. Claim 1 requires, among other elements, “printing layers of the three-dimensional part and of a support structure for the three-dimensional part from multiple print heads or deposition lines” and “performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner.” EX1001 at 15:43-58. In support of its assertion that *Boyer* discloses these limitations, Petitioner provides the following annotated version of *Boyer*’s Figure 4, which depicts the purported “[l]ayers of three-dimensional part,” “[l]ayer of support structure,” and “[p]urge tower layers”:

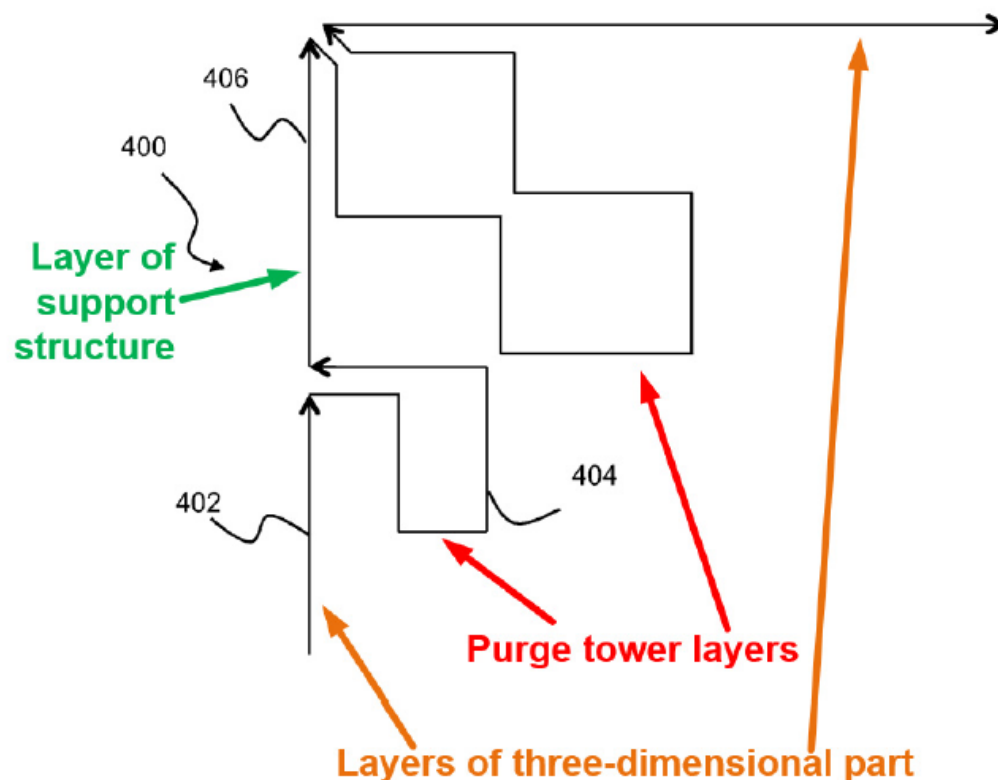


Fig. 4

Pet. at 72 (EX1008 at Fig. 4 (annotated by Petitioner)). Petitioner explains its understanding that “first segment 402” uses “part material” and “third segment 406” uses “support material.” Pet. at 69. Finally, Petitioner provides the following explanation regarding the printing process disclosed by *Boyer*’s Figure 4:

Boyer’s extruder 200 prints the first segment 402 with first build material 214 using the first **deposition line** when extruder head 202 is aligned with the first feed 210. EX1008, [0025]-[0029], [0034], FIG. 2, FIG. 4. After printing the first segment 402, Boyer’s first **deposition line** switches to the **stand-by mode** and Boyer’s second **deposition line** switches to the **operating mode** when extrusion head 202 transitions from alignment with first feed 210 to alignment with second feed 212. EX1008, [0025]-[0029], [0034], FIG. 2, FIG. 4.

Upon the second *deposition line* switching to the *operating mode*, extruder 200 performs a *purge operation* by printing transition segment 404 using the second *deposition line*. EX1008, [0032]; EX1003, ¶234. After the *purge operation*, extruder 200 prints the third segment 406 with second build material 216 using the second *deposition line* when extruder head 202 is aligned with the second feed 212. EX1008, [0025]-[0029], [0034], FIG. 2, FIG. 4. . . . Consequently, Boyer's extruder 200 will, in some cases, perform a *purge operation* each time there is a material change where one of the *deposition lines* transitions from the *stand-by mode* to the *operating mode*. EX1008, [0032]-[0034], [0037]-[0043], FIGS. 4-5; EX1003, ¶235.

Pet. at 70-71. For the reasons discussed below, I disagree with Petitioner's assessment that *Boyer* discloses the elements of "printing layers of the three-dimensional part and of a support structure for the three-dimensional part from multiple print heads or deposition lines" and "performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner," either expressly or inherently. EX1001 at 15:43-58.

1. Limitation [1a]: "printing layers of the three-dimensional part and of a support structure for the three-dimensional part from multiple print heads or deposition lines"

132. As an initial matter, it is my opinion that *Boyer* does not disclose printing layers of the three-dimensional part and support structure in the manner identified by Petitioner. The sole reference in *Boyer* to "support" structures discloses that "sacrificial support structures may be fabricated from materials that are lower in cost, or that dissolve or break away easily from the main structure of an object."

EX1008, ¶[0044] (cited by Pet. at 65, 70, 73). There is no disclosure in *Boyer* that support material is used to print the transition segment (404) or other exterior segment (e.g., first segment 402 or third segment 406) in Figure 4, as Petitioner asserts. *See* Pet. at 72. As *Boyer* explains, Figure 4 simply shows the use of “multiple build materials to obtain *different colors* on an exterior of an object.” *Id.*, ¶[0032].

133. I understand that in in the Board’s Institution Decision, the Board stated that “the disclosure of *Boyer* that Petitioner cites is not limited to different colors of material; instead, on the present record, we are persuaded that it also encompasses different materials, including those used to print support structures.” Paper 10 at 24. Specifically, the Board identified that *Boyer* teaches “the same techniques may be employed to switch between multiple build materials for a variety of other reasons.” Paper 10 at 24 (quoting Ex. 1008 ¶29). The Board further identified that “[a]mong these reasons are ‘different mechanical properties,’ such as ‘strength,’ and ‘different chemical properties,’ such as ‘solubility,’” concluding that “[a]t least on the present record, these materials appear to satisfy the need that *Boyer* describes for ‘sacrificial support structures [that] may be fabricated from materials that . . . dissolve or break away easily from the main structure of an object.” Paper 10 at 24-25 (quoting *Id.*, ¶¶29, 44).

134. While the Board is correct that *Boyer* generally references other building materials and “sacrificial support structures,” it fails to disclose the use of

such support structures in the manner proposed by Petitioner. Specifically, to support its position that claim 1 is anticipated by *Boyer*, Petitioner relies on Figure 4 of *Boyer* and asserts that the POSITA would understand that segment 406 constitutes a “[l]ayer of support structure”:

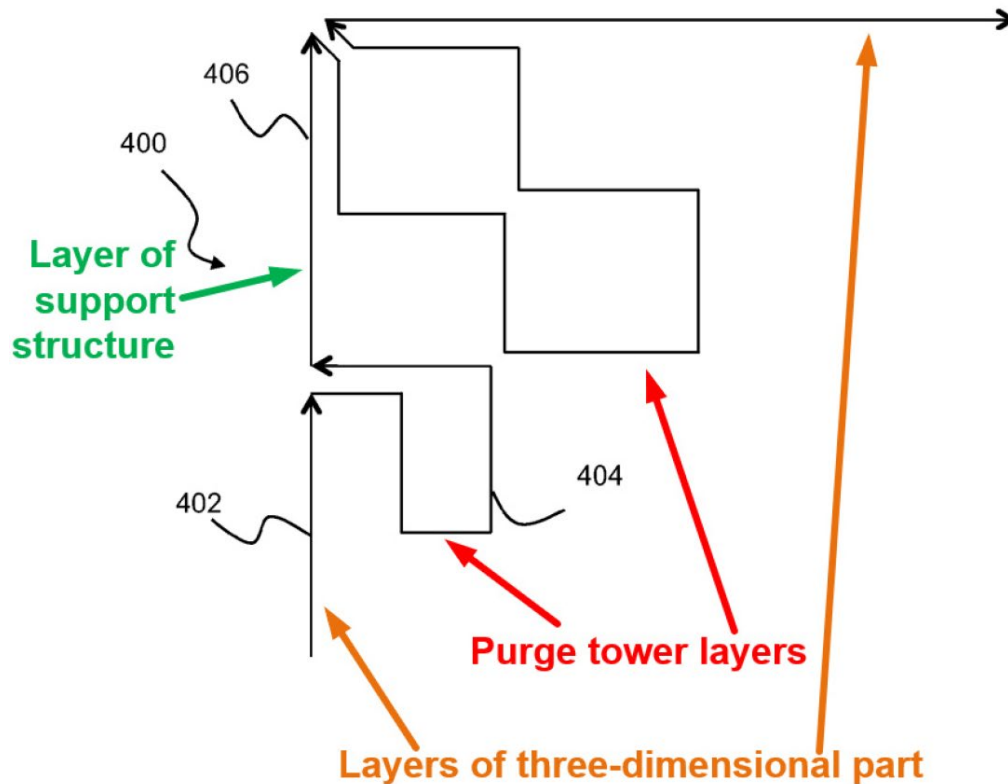


Fig. 4

EX1008, FIG. 4 (annotated).

Pet. at 72. However, a POSITA would not understand that segment 406 constitutes a “[l]ayer of support structure.” Instead, a POSITA would understand from *Boyer* itself that the exterior segments in Figure 4 (including 406) form the outside or “main structure of the object,” and that such exterior segments cannot be made from

sacrificial support structures that “dissolve or break away easily.” *See* EX1008, ¶[0032], [0044]; *see also* EX1001 at 1:50-53 (“The support material adheres to the part material during fabrication, and is removable from the completed 3D part when the printing process is complete.”). A POSITA would not consider dissolving the “main structure” of a part, since doing so (1) compromises its structural integrity and (2) exposes the internal infill. As Dr. Hickner said: “a part is made of part material and a support structure is made of support material.” EX2016 (Hickner Dep. Tr.) at 110:11–111:1. Boyer explains that segment 406 is a differently-colored portion of the three-dimensional part, not a support structure. EX1008, ¶[0032]. Because segment 406 is a portion of the part, a POSITA would certainly not understand that this very same segment could be printed from a support material instead of part material. If the part as printed with segment 406 as a differently-colored portion of the part has sufficient support without the need for any support material, then there would be no reason to replace the differently-colored portion of part material with a support material.

135. Notably, if Petitioner’s position discussed below (*see infra* §X.A.2.b) is adopted—namely, that subsequent “similar” layers are printed on top of the cross-section shown in Figure 4 such that the “purge tower” is printed in a “layer-by-layer” manner—then the purported support structure 406 would serve no function as it would never contact (and thus provide no support for) the layers of the three-

dimensional part. In fact, a POSITA reading *Boyer* would recognize that in a layer-by-layer ‘purge tower’ (segment 404), the switch between ‘part material’ and ‘support material’ (segment 402 to segment 406) must always occur at the same location, resulting in a support structure that supports nothing. *See* EX2016 (Hickner Dep. Tr.) at 17:11-20 (Dr. Hickner explaining that “the meaning of ‘support structure’ in its plain language is it's just supporting another section of the [three-dimensional] part.”). Conversely, if the positions of the segments shown in Figure 4 change (including the “support structure”), then the switch location—and therefore the ‘purge tower’ position—would also change, preventing layer-by-layer construction of a purge tower. As such, a POSITA would not understand *Boyer* to disclose, explicitly or inherently, that segment 406 is a “support structure for the three-dimensional part” as Petitioner contends.

136. For the foregoing reasons, it is my opinion that *Boyer* does not disclose, expressly or inherently, “printing layers of the three-dimensional part and of a support structure for the three-dimensional part from multiple print heads or deposition lines” in the manner Petitioner proposed.

2. Limitation [1c]: “performing a purge operation for each print head or deposition line switched to the operating mode, the purge operation comprising printing at least one purge tower in a layer-by-layer manner ... from multiple print heads or deposition lines”

137. Petitioner asserts that *Boyer*’s extruder performs “a purge operation by printing transition segment 404 using the second deposition line” because apparently the extruder will “in some cases, perform a purge operation each time there is a material change where one of the deposition lines transitions from the stand-by mode to the operating mode.” Pet. at 70-72. Petitioner’s annotated version of *Boyer*’s figure depicting such “purge tower layers” is reproduced below:

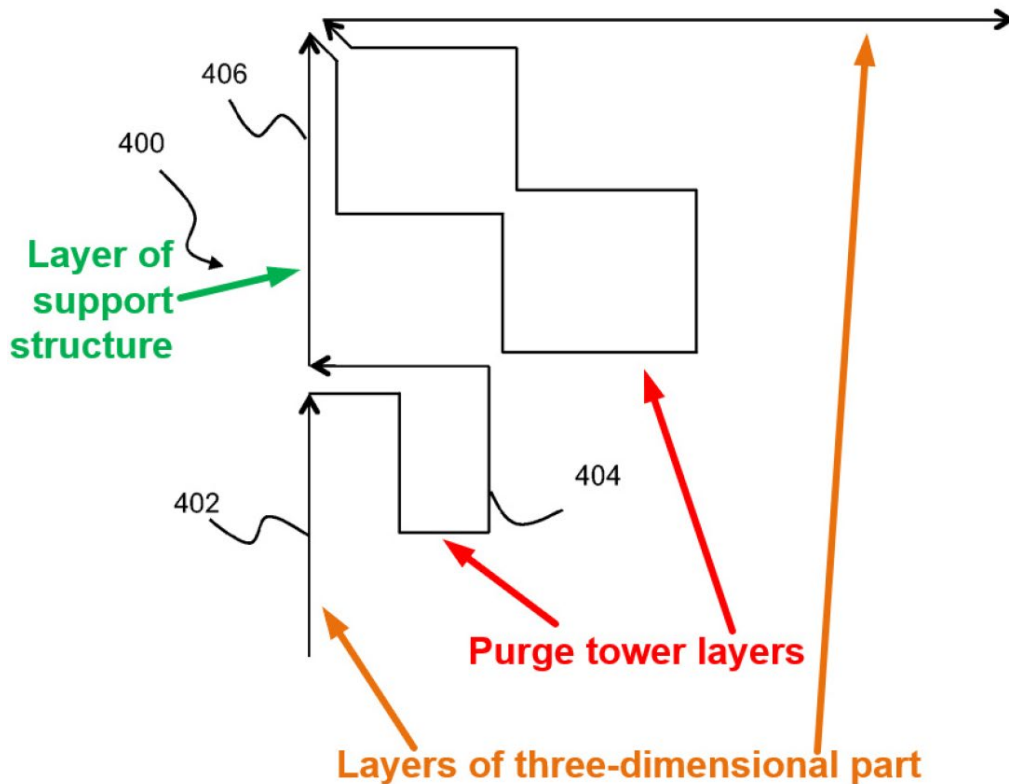


Fig. 4

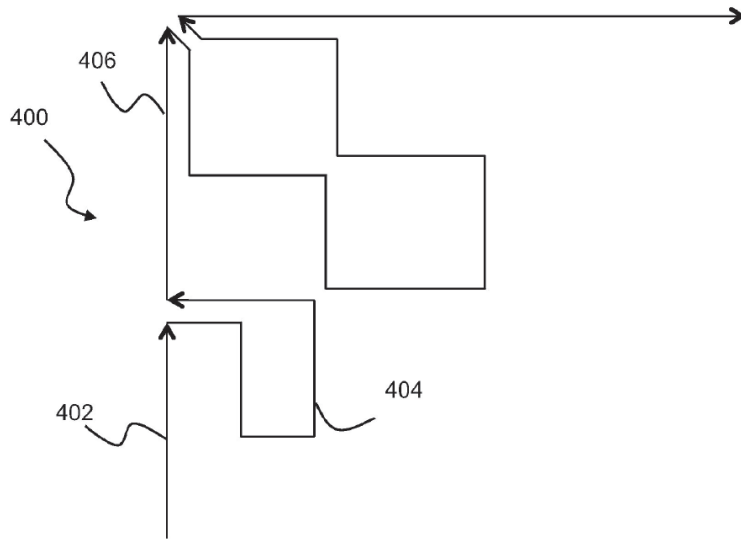
EX1008, FIG. 4 (annotated).

Pet. at 72. Petitioner further contends that “two-dimensional layers such as the one depicted in FIG. 4 [of *Boyer*] are stacked on top of one another so that the transition segments of FIG. 4 correspond to purge towers printed in a layer-by-layer.” Pet. at 73. As I explain below, *Boyer* does not support Petitioner’s assertions.

a) *Boyer* does not disclose a purge tower

138. First, a POSITA would not understand *Boyer* to describe both a three-dimensional part and “purge tower.” *Boyer* describes only a single object. Figure 4

of *Boyer* shows “a portion of a tool path [400] using multiple build materials to obtain different colors on an exterior of an object.”



EX1008, Fig. 4, ¶¶[0008], [0032]. The first segment 402 and third segment 406 of tool path 400 traverse portions of the exterior surface of the object and then tool path 400 “turn[s] in toward an interior of the object and infill[s] with a transition segment 404.” *Id.*, ¶[0032]. *Boyer* describes that the first segment is a first color, the transition segment is a mixture of a first and second color, and the third segment is the second color. *Id.* A POSITA would understand that an “infill” like “transition segment 404” is used to “help[] support the sides of the model” and “provide[] enough of a structure for the model to print well and hold up,” (EX1013 at 62, 64), and that “infill” does not constitute a “purge operation.”² As such, while *Boyer* generally

² I understand that Dr. Hickner was asked about “infill” in his deposition, and he stated that he was “not prepared to analyze infill and its correspondence or not to purge operations.” See EX2016 (Hickner Dep. Tr.) at 44:1-11, 56:6-9.

acknowledges that transitional lengths can be positioned on the outside of the object (*see id.*, ¶[0003]), there is no disclosure in *Boyer* that transition segment 404 of the tool path 400 forms a *different object* than the 3D object itself, much less a *purge tower*.

139. The Board states in the Institution Decision that it is “not persuaded, on the present record, that a purge tower must be a structure that is separate from the object being printed, as opposed to encompassing either a separate structure or a structure printed within the interior of the part.” Paper 10 at 22. However, as mentioned earlier it is my opinion that a POSITA reading claim 1 would understand that the purge tower must be separate from the three-dimensional part and support structure. Specifically, claim 1 requires “a three-dimensional part,” “a support structure for the three-dimensional part,” and “at least one purge tower,” which are all separate and distinct claim elements. EX1001, cl. 1. I further note that the specification describes that the “purge tower” is a distinct structure from the “three-dimensional part” and “support structure.” In particular, as the Board recognized, “[t]he figures of the ’713 patent all depict the purge tower as a separate structure.” Paper 10 at 22. The specification also explicitly states that the purge tower is “printed at any suitable free location on build substrate 44 (i.e., at any location in the x-y build plane *not occupied by 3D part 20 or support structure 22*).” EX1001 at 8:31-34 (emphasis added). The ’713 Patent further explains that after fabrication of the

three-dimensional part the “[p]urge tower 24 itself may be then recycled or otherwise discarded as desired,” which would not be possible if the purge tower was itself made part of the three-dimensional part. EX1001 at 8:27-28. I understand that Dr. Hickner agreed during deposition that a POSITA would understand the “purge tower” is a “separate physical object” from the three-dimensional part. EX2016 (Hickner Dep. Tr.) at 64:1-9 (“[T]he part is something that a POSITA, if a POSITA is performing this operation, that's the desired component that one would take and use. And the purge tower is a separate physical object[.]”); *see also id.* at 28:8-10 (“The patent clearly shows separate components, the 24 components separated from --sorry, the 24 purge tower separated from the part.”).

140. A POSITA would understand that if the purge tower was not a separate and distinct structure from the three-dimensional part and support structure, it would fail to accomplish its fundamental purpose of allowing a purge operation to occur while mitigating issues inherent in conventional purge operations. A POSITA reading the '713 Patent would not consider entrapping the purge tower within a part. The purpose of purging is to expel potentially degraded material from the nozzle so that fresh material can be used in manufacturing. Incorporating the purge tower into the part's structure would undermine this function, and in tall parts could create a purge tower of such height that it risks collapse. That is especially true in the case of *Boyer* where the purported “purge tower” correspond to transition segments that

contain both the first material and second material. *See, e.g.*, EX1008, ¶32 (describing “transition segment **404** between the first color and a second color,” and explaining that “[a]fter the transition is complete [] the second color can be extruded without mixing from the first color[.]”); EX2016 (Hickner Dep. Tr.) at 105:1-5 (“there can be mixing in segment 404”). A POSITA would understand that such a transition segment, if contiguous with the three-dimensional part as shown in *Boyer*’s Figure 4 (Petitioner’s annotated version below), would adhere to the three-dimensional part and not be easily removed and disposed of. As noted above, the ‘purge tower’ shown in Figure 4, as annotated by Petitioner, would either be entrapped within the part or require removal. Breaking off such a structure would leave marks that compromise both cosmetic and structural integrity.

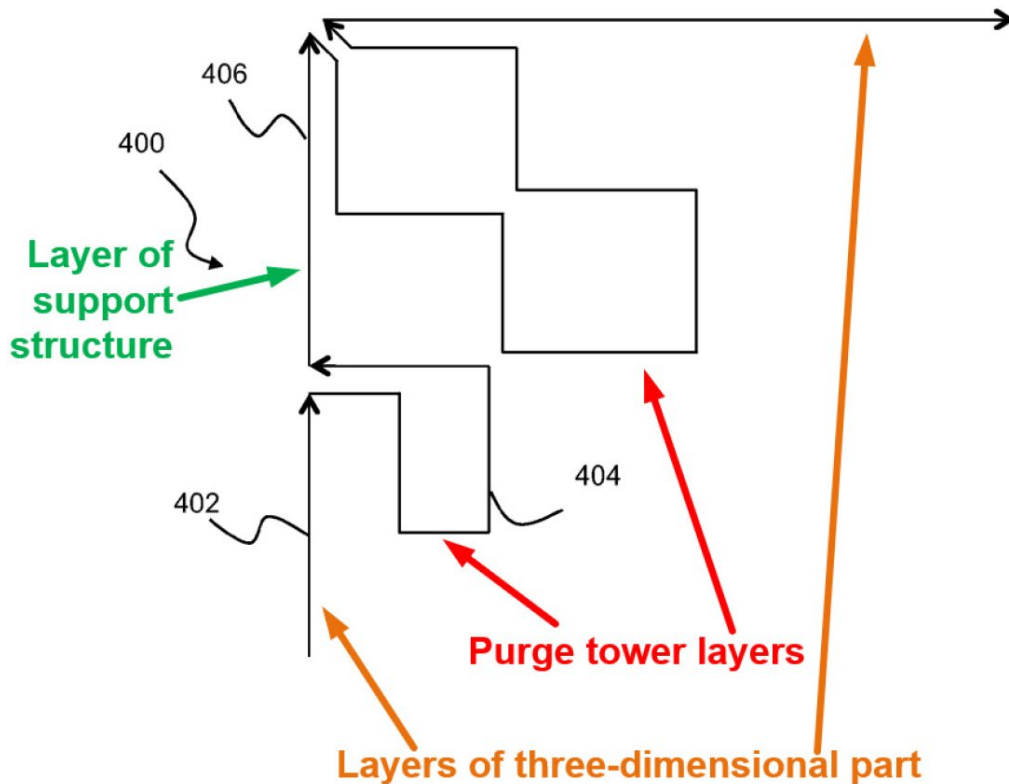


Fig. 4

EX1008, FIG. 4 (annotated).

Pet. at 72.

141. In addition, it is my opinion that even under the Board’s preliminary determination that the purge tower could “encompass[] either a separate structure or a structure printed within the interior of the part,” *Boyer* still does not disclose such a purge tower expressly or inherently. The “purge tower layers” identified by Petitioner as shown in its annotated Figure 4 are not “a structure printed within the interior of the part” but rather are contiguous with the part and purported support structure, as shown below.

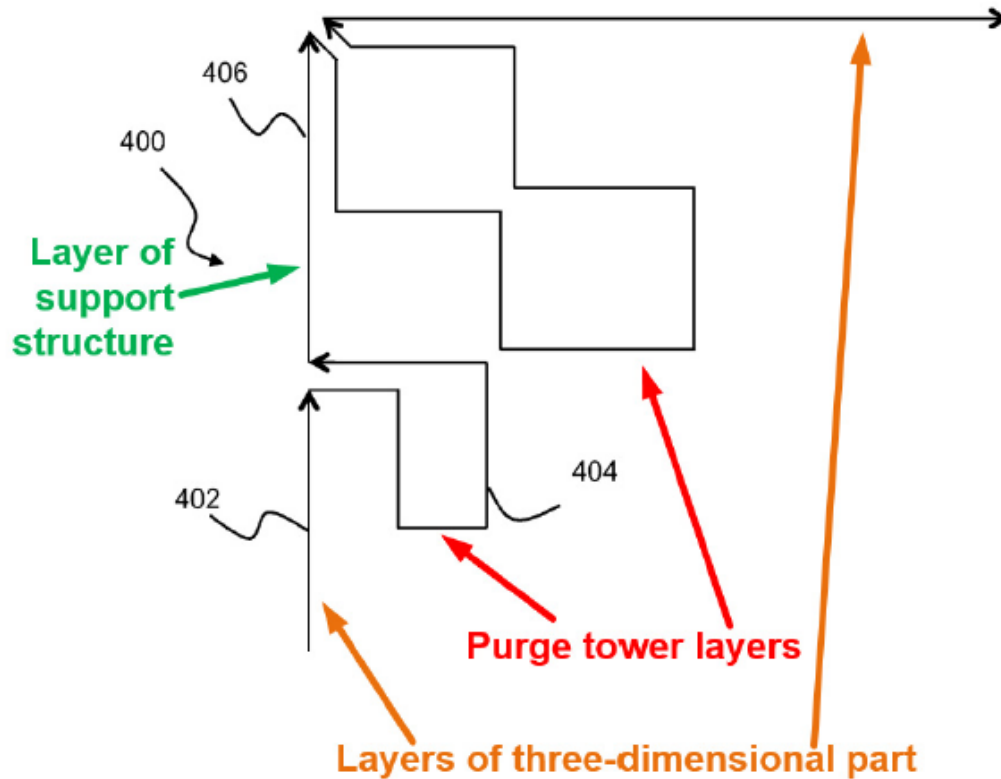


Fig. 4

EX1008, FIG. 4 (annotated).

Pet. at 72; *see* EX2016 (Hickner Dep. Tr.) at 107:7-9 (“The start and ends of 402, 404, and 406 are depicted in Figure 4 as in close proximity or touching in Figure 4.”); *see also id.* 107:15-19. Furthermore, a POSITA would have recognized that printing a purge tower “within the interior of the part” would not have been advisable due to the reasons elaborated above. As such, *Boyer* does not disclose, explicitly or inherently, a “purge tower” as required by claim 1.

b) **Boyer does not disclose layer-by-layer printing of a purge tower**

142. As I discussed above, claim 1 requires in part “printing at least one purge tower in a layer-by-layer manner.”

143. It is my opinion that *Boyer* does not disclose printing transition segment 404 for multiple layers of a purge tower, as Petitioner asserts. *See* Pet. at 73. *Boyer* simply describes that one can “position different segments,” including transition segments, “at suitable locations along a tool path in order to achieve specific colors (or more generally build materials) at specific locations.” EX1008 at ¶[0033]. There is no disclosure in *Boyer*, explicit or inherent, that the transition segments are stacked on top of each other “in a layer-by-layer manner” to create a purge tower. A POSITA would not understand *Boyer* to disclose such a configuration.

144. I understand that in the Institution Decision the Board noted that “Petitioner cites to evidence of record that a person of ordinary skill in the art would have interpreted *Boyer*’s disclosure to include stacked layers above and below those shown in Figure 4, including in the transition segments.” Paper 10 at 23 (citing Pet. 73 (citing Ex. 1003 ¶237)). In particular, the Board identified “the testimony of Dr. Hickner that, ‘[b]y describing tool path 400 as a “cross section” of a multi-material build, *Boyer* teaches that layers printed using a similar two-dimensional tool path can exist above and/or below FIG. 4’s cross section.’” Paper 10 at 23 (quoting Ex. 1003 ¶237 (citing Ex. 1008 ¶¶18, 24, 32–34, Fig. 4)).

145. However, even if “similar two-dimensional tool path[s] can exist above and/or below FIG. 4’s cross section,” EX1003, ¶237, a POSITA would not understand that *Boyer* discloses that the transition segments (e.g., 404) are actually printed one on top of another in a layer-by-layer manner. Indeed, during his deposition, Dr. Hickner admitted that “a POSITA would understand that Figure 4 shows one layer of a cross-section;” but “there’s different cross-sections of a three-dimensional object depending on the height.” EX2016 at 101:5-19; *see also id.* at 118:17-20 (“there are different cross-sections of three-dimensional parts. And so the arrangement of segments 402, 404, and 406 could be different in different examples.”). In fact, *Boyer* itself recognizes that the “transition segment” can be placed in a variety of locations other than that shown in Figure 4, including “an excursion outside an exterior of the object, or along infill structures, or between the infill in interstitial void space.” EX1008, ¶40; *see also id.* ¶¶34, 39. Even Dr. Hickner appears to recognize this as he merely says that “**similar** two-dimensional tool path[s] **can** exist above and/or below FIG. 4’s cross-section.” EX1003, ¶237. However, even if a POSITA understood that **similar** tool paths could be printed in successive layers, they would not understand *Boyer* itself to disclose “printing at least one purge tower in a layer-by-layer manner.” As Dr. Hickner admitted during his deposition, nothing in *Boyer* teaches that the exact same layer shown in Figure 4 is repeated for any other layers. EX2016 (Hickner Dep. Tr.) at 101:1-19. I note that

nothing in *Boyer* teaches that the exact same layer shown in Figure 4 is repeated for any other layers. Notably, Boyer's application involves color changes, which may occur at any location on the outer surface of a part, depending on the intended pattern. For example, in a blue surface with red polka dots, each transition from blue to red or red to blue would occur at different positions, meaning the transition segments would not align. Even with vertical outer walls, this variability creates problems, preventing layer-by-layer construction of a purge tower.

B. Dependent Claims

146. In addition to the limitations of claim 1 not disclosed in *Boyer*, the limitation added by dependent claim 6 is also not disclosed, explicitly or inherently, by *Boyer*.

1. Claim 6: “wherein the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure”

147. Claim 6, which depends from claim 1, further requires “wherein the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure.” EX1001 at 16:21-24.

148. For claim 6, Petitioner contends that “[b]ecause Boyer discloses that the printer deposits a transition segment in response to each material change, this means that the printer stops printing transition segments (and therefore stops printing

the purge tower) at the highest layer at which there is a material change for printed layers of the three-dimensional part and support structure.” Pet. at 75. However, a POSITA would not understand “the printer stops printing transition segments . . . at the highest layer at which there is a material change” (Pet. at 75) to be an explicit or inherent disclosure that “the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure.” I understand that, when asked during his deposition, Dr. Hickner stated that he “didn't analyze Boyer in the context of the final material change.” EX2016 at 120:7-12.

149. Claim 6 requires that “*the at least one purge tower* is stopped at a highest layer at which there is a material change,” not simply that a transition segment is printed at the final material change. As I discussed above with respect to claim 1, the “at least one purge tower” referred to in claim 6 must be printed “in a layer-by-layer manner” according to claim 1. EX1001 at 15:55-56. As such, claim 6 requires that this purge tower built in a layer-by-layer manner is stopped at a highest layer at which there is a material change. *Boyer* does not teach this expressly or inherently. In fact, as I discussed above with respect to claim 1, *Boyer* teaches that the “transition segment” can be placed in a variety of locations other than that shown in Figure 4, including “an excursion outside an exterior of the object, or along infill structures, or between the infill in interstitial void space.” EX1008, ¶40; *see also id.*

¶¶34, 39. In addition, *Boyer* teaches using multiple transition segments (aka “purge tower layers” according to Petitioner) even within the same layer:

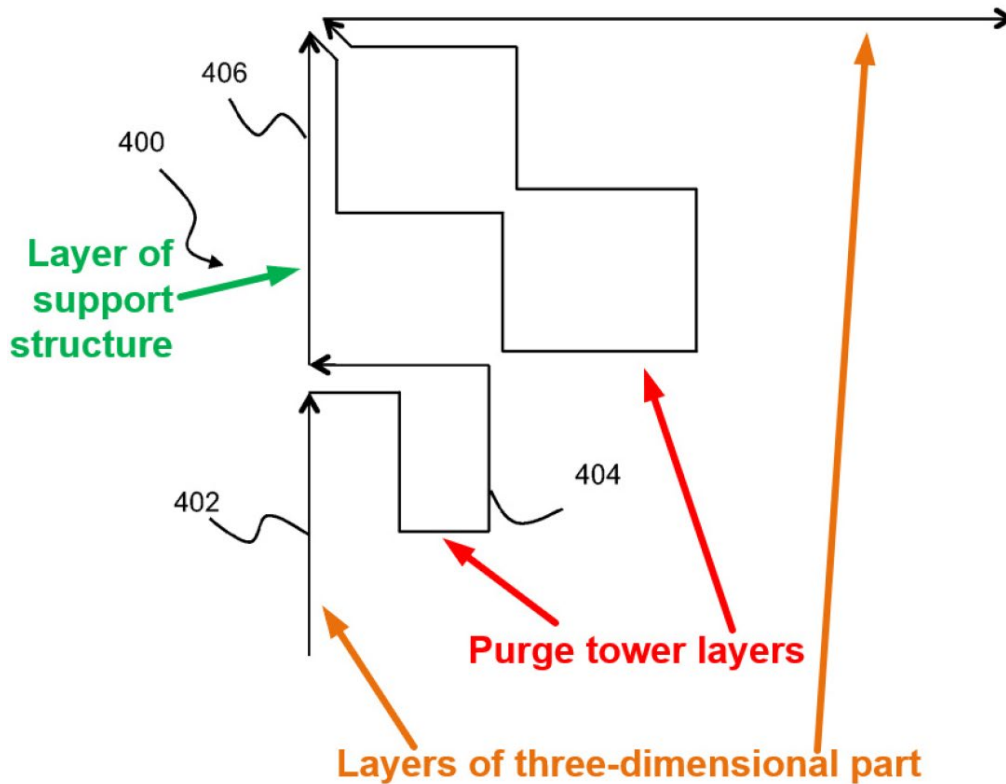


Fig. 4

EX1008, FIG. 4 (annotated).

Pet. at 72. As such, *Boyer* does not disclose, explicitly or inherently, that the transition segment at a highest layer where there is a material change will be printed on top of an existing set of transition segments that have been printed in a layer-by-layer manner. While it may be possible for such a transition segment to be printed on top of other transition segments (like anywhere else), I understand that the mere possibility that something could occur is not sufficient to show explicit or inherent

disclosure. As such, it is my opinion that *Boyer* does not disclose to a POSITA “wherein the at least one purge tower is stopped at a highest layer at which there is a material change for the printed layers of the three-dimensional part and support structure.”

XI. CONCLUSION

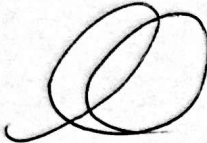
150. For the reasons set forth above, it is my opinion that claims 1, 2, 5-7, 9, 16, and 17 of U.S. Patent No. 9,421,713 would not have been obvious to a person of ordinary skill in the art at the relevant time.

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

152. I declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

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

Executed this 9/8/25

A handwritten signature in black ink, consisting of a large, stylized 'O' followed by a smaller, less distinct mark.

Dr. Tim A. Osswald

APPENDIX A

Professor Tim A. Osswald

Professor Emeritus - University of Wisconsin-Madison

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

Honorary Professor at the National University, Bogotá, Colombia

co-Director of the Polymer Engineering Center

EDUCATION:

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

POSITION HELD:

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

HONORS AND AWARDS:

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

PERSONAL INFORMATION:

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

Professor Tim A. Osswald

BOOKS

1. Osswald, T.A., and Román, A.J., *Understanding Polymer Processing*, 3rd Edition, Hanser Verlag, München, 2024
2. Baur, E., Drummer, D., Osswald, T.A., and Rudolph, N., *Saechtling Kunststoff-Taschenbuch*, 32st Edition, 2022. (German Plastics Handbook that appeared for the first time in 1936)
3. Gandhi, U., Goris, S., Osswald, T.A., and Song, Y.-Y., *Discontinuous Fiber-Reinforced Composites- Fundamentals and Applications*, Hanser Verlag, München, 2020
4. Baur, E., Osswald, T.A., and Rudolph, N., *Plastics Handbook - The Resource for Plastics Engineers*, Hanser Publishers, Munich, 2019
5. Osswald, T.A., *Understanding Polymer Processing*, 2nd Edition, Hanser Verlag, München, 2017
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7. Osswald, T.A. and G. Menges, *Materials Science of Polymers for Engineers*, 3rd Edition, Hanser Verlag, München, 2012.
8. Osswald, T.A., *Understanding Polymer Processing*, Hanser Verlag, München, 2010
9. Naranjo, A, Noriega, M., Osswald, T.A., Roldán, A. and Sierra, J., *Plastics Testing and Characterization - Industrial Applications*, Hanser Verlag, München, 2006. Spanish Translation, 2013.
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11. Osswald, T.A., Turng, L.-S., and P.J. Gramann, *Injection Molding*, 2nd Edition, Hanser Verlag, München, 2007.
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14. Osswald, T.A., Turng, L.-S., and P.J. Gramann, *Injection Molding Handbook*, Hanser Verlag, München, 2001, Russian and Chinese translation, 2006.

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15. Osswald, T.A. and G. Menges, *Materials Science of Polymers for Engineers*, 2nd Edition, Hanser Verlag, München, 2003. Spanish Translation 2009.
16. Davis, B.A., Gramann, P.J., Osswald, T.A., and Rios, C.A., *Compression Molding*, Hanser Verlag, München, 2003.
17. Osswald, T.A., *Polymer Processing Fundamentals*, Hanser Verlag, München, 1998. Spanish translation 2008.
18. Osswald, T.A. and G. Menges, *Materials Science of Polymers for Engineers*, Hanser Verlag, München, 1996. The book's Japanese edition appeared in 1997, and Korean edition in 1999.
19. Comer, J.J., T.A. Osswald and R.L. Pendleton, *An Introduction to Experimental Analysis of Stress and Strain*, SDSM & T Press, 1983.

Edited the following series (Plastics Pocket Power series)

1. Naranjo/Noriega/Sierra/Sanz *Extrusion Processing Data*, Plastics Pocket Power Series, T.A. Osswald, Editor, Hanser Publishers, Munich, 2001
2. Naranjo/Noriega/Sierra/Sanz, *Injection Molding Processing Data*, Plastics Pocket Power Series, Osswald, T.A. Editor, Hanser Publishers, Munich, 2001
3. Thielen, *Extrusion Blow Molding*, Plastics Pocket Power Series, Osswald, T.A. Editor, Hanser Publishers, Munich, 2001
4. Benatar/Grewell/Bonten Tuechert, *Welding*, Plastics Pocket Power Series, Osswald, T.A. Editor Hanser Publishers, Munich, 2001
5. Bonten, *Aging and Chemical Degradation*, Plastics Pocket Power Series, Osswald, T.A. Editor, Hanser Publishers, Munich, 2001
6. DeGreiff/Naranjo/Castaño, *Applied Rubber Technology*, Plastics Pocket Power Series, Osswald, T.A. Editor, Hanser Publishers, Munich, 2001

New Course Development and Major Course Revisions

Developed ME 310, Manufacturing: Polymers (2021).

This is a course based in part on ME313 and ME314 which are being phased out. The course has 28 lectures and 12 laboratory units ranging from hands-on experiments on polymer processing equipment to process modeling. Professor Osswald wrote the textbook *Understanding Polymer Processing*, Hanser (2010, 2017) that will be used in this course. A new edition of this book is being prepared.

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Revised ME 313, Manufacturing Processes-Plastics (1993).

This is a 7 week course taught two times a semester. It describes fundamentals of plastics manufacturing processes in a series of 14 lectures and 6 laboratories. For this course Osswald wrote the textbook *Polymer Processing Fundamentals*, Hanser Publishers, (1997). The textbook has been adopted at various universities around the world.

Re-developed ME 314, Material Processing - Fundamentals (2007)

This is a 7 week course taught two times a semester. It describes fundamentals of transport phenomena in material processing in a series of 14 lectures and 6 laboratories. This course is a required course in the mechanical engineering curriculum.

Revised ME 417, Introduction to Polymer Processing (1989).

The course describes the physical, thermal, and rheological properties of polymeric materials relevant to processing behavior. The basic transport phenomena equations are reviewed: mass, momentum, and energy. Analysis of various processing operations for the manufacture of polymeric articles, with particular emphasis on extrusion, injection molding, blow molding, thermoforming, and compression molding. Polymer recycling issues are also discussed. For this course Osswald wrote the Textbook *Polymer Processing - Modeling and Simulation*, Hanser Publishers, (2006). Parts I and II of this book will be used in this course.

Developed ME 718, Modeling and Simulation Polymer Processing (1991).

This course is designed to acquaint the student with computer simulation technology used for the engineering of polymer processes, such as compression molding, injection molding, extrusion, blow molding, and many others. The course reviews the basic equations of state, presents flow and heat transfer models used in polymer processing, and illustrates their numerical implementation using finite differences, finite elements, and boundary integral methods. The various numerical techniques are subsequently used to solve problems dealing with fluid flow, heat transfer, and structural development in polymer processing operations. For this course Osswald wrote the Textbook *Polymer Processing - Modeling and Simulation*, Hanser Publishers, (2006). Part III of this book will be used in this course.

Developed ME418, Engineering Design with Polymers (1995).

This course is intended to acquaint the student with a polymers' unique behavior and its relation to design. Molecular structure and basic properties are discussed. The relation between processing and properties of the final part are covered, as are mixing,

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anisotropy, and residual stresses during solidification. Important properties and the behavior of the polymer component are discussed: mechanical behavior, failure, optical properties, permeability, and electrical properties. For this course Osswald wrote the textbook *Materials Science of Polymers for Engineers*, Hanser Publishers, (1996), 2nd Ed. (2003). The textbook has been adopted at various universities around the world. The book was translated into Japanese and Korean.

Developed ME601 (ME420), Introduction to Composites Processing (2013)

This course is intended to acquaint the student with composites manufacturing processing. The course introduces basic physical, thermal, rheological and mechanical properties of composite materials and applies these to transport phenomena concepts to solve problems of flow through porous media, fiber orientation, curing reactions, shrinkage and warpage and mechanics of composites. Introduce laboratory material characterization experiments, CAE applied to composites product design, and apply these to a final group project for the design and manufacture of a composites product. The course is a 50-50 class-laboratory course with a strong design component.

UNIVERSITY DEGREES CREATED

Master of Engineering (Polymer Engineering and Science), College of Engineering, University of Wisconsin-Madison, Inaugural Class: Fall 1998, Degree Type: Interdisciplinary. Created with Professor A.J. Giacomin.

NON-ENGINEERING RELATED PAPERS AND BOOKS (HISTORY)

1. Osswald T.A., and S. Bolovari, *Wallace H. Carothers*, (1), 12, 1999.
2. Osswald T.A., *Hermann F. Mark*, *Plastics Insight*, (2), 11, 2000.
3. Osswald T.A., *Leo H. Baekeland*, *Plastics Insight*, (3), 7, 2001.
4. Osswald T.A., *Cellulose Plastics and the \$10,000 Prize*, *Plastics Insight*, (4), 10, 2000.
5. Osswald T.A., *Polyethylene: A Product of Brain and Brawn*, *Plastics Insight*, (5), 4, 2001.
6. Osswald T.A., *Galalith: The Milk Stone*, *Plastics Insight*, (6), 9, 2001.
7. Osswald T.A., *K is for Kunststoffe*, *Plastics Insight*, (7), 1, 2002.
8. Osswald, T.A., Chapter 1 - *Family Memories*, Robert Davidsohn, Eds. M. Ingerdaay, and W. Fastenrath-Vinattieri, Leo S. Olschki Publishing House, Florence, 2003.
9. Osswald, T.A., "In Search for the Right Books - A Historical Perspective of Polymer

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Engineering Education in The United States," *A chapter in Eine «Glenzende» Geschichte* Hanser Publishers, München, 2004.

10. Osswald, T.A., "Del Caucho Natural al Caucho Sintético: un Camino del Amazona a Auschwitz - Asuntos Éticos en Ciencia e Ingeniería," *Revista SLTCaucho*, Vol. 13, 20-30 (2016)
11. The 45 members of the Misión de Sabios, including Osswald, T.A., COLOMBIA HACIA UNA SOCIEDAD DEL CONOCIMIENTO, Misión de Sabios Report to the Colombian Presidency (2020)
12. Forero Pineda, C., Wasserman, M., and Osswald, T.A., Eds., *Colombia on the Path to a Knowledge-Based Society - Reflections and Proposals*, Volume 1, Published by the Vice-Presidency of the Republic of Colombia, 2020

REFEREED JOURNAL PUBLICATIONS

1. Barone, M.R. and T.A. Osswald, "Boundary Integral Equations for Analyzing the Flow of Chopped Fiber Reinforced Polymer Compound in Compression Molding," *J. Non-Newt. Fluid. Mech.*, 26, 185-206, 1987.
2. Barone, M.R. and T.A. Osswald, "A Boundary Element Analysis of Flow in Sheet Molding Compound," *Polymer Composites*, 9, 158-164, 1988.
3. Osswald, T.A. and C.L. Tucker, "A Boundary Element Simulation of Compression Mold Filling," *Polym. Eng. Sci.*, 28, 413-420, 1988.
4. Saßmannshausen, U., W. Essig and T.A. Osswald, "The Density Distribution in Pressed Charges: An Analytical Approach," *Propell., Explos., Pyrothec*, 14, 24-27, 1989.
5. Michaeli, W., V. Hammes, K. Kirberg, R. Kötte, T.A. Osswald, and O. Specker, "Das RTM-Verfahren - Technologie und Anwendungsgebiete (RTM Process, Technology and Applications)," *Kunststoffe*, 79, 7, 586-89, 1989.
6. Michaeli, W., V. Hammes, K. Kirberg, R. Kötte, T.A. Osswald, and O. Specker, "Prozeßsimulation beim RTM-Verfahren (Simulation of the RTM Process)," *Kunststoffe*, 79, 8, 739-42, 1989.
7. Michaeli, W., M. Mahlke and T.A. Osswald, "Analyse Messungen und Simulation des Fließens von SMC mit einem Preßrheometer (Analysis, Measurements and Simulation of the Flow of SMC Using a Compression Rheometer)," *Kunststoffe*, 80, 1, 70-74, 1990.

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8. Michaeli, W., M. Mahlke, T.A. Osswald, and M. Nöhlke, "Simulation des Fließens bei SMC (Flow Simulation for SMC)," *Kunststoffe*, 80, 6, 717-721, 1990.
9. Osswald, T.A. and C.L. Tucker, "Compression Mold Filling Simulation for Non-Planar Parts Using the Finite Element/Control Volume Approach," *Internat. Polym. Process.*, 5, 2, 79-87, 1990.
10. Osswald, T.A., "A Finite Element Analysis of the Thermomechanical Behavior of Fiber Reinforced Composites," *J. Thermoplastic Composite Materials*, 4, 173-189, 1991.
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12. Cohnen, W. and T.A. Osswald, "Experimental Study of High Reynolds' Number Flows Between Narrow Gaps," *Int. J. Polym. Proc.*, VII, 4, 314-319, 1992.
13. Igl, S.A. and T.A. Osswald, "Thermoforming Simulation of Natural Fiber Filled Polyolefins," *J. of Plastic Film and Sheeting*, 8, 4, 302-332, 1992.
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21. Osswald, T.A., E.M. Sun, and S.C. Tseng, "Experimental Verification on Simulating Shrinkage and Warpage of Thin Compression Moulded SMC Parts," *Polym. & Polym. Compos.*, (2), 3, 187, 1994.
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28. Gramann, P.J., A.C. Rios and T.A. Osswald, "Comparative Study of Mixing in co-rotating Twin Screw Extruders Using Computer Simulation," *Adv. Poly. Tech.* 17, 107, 1998.
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- 181 S. Goris, C. Fontana, and T. A. Osswald, "Fiber Orientation Measurements Using a Novel Image Processing Algorithm for Micro-Computed Tomography Scans," ANTEC, Annual Technical Conference Proceedings, Orlando, FL, 2015.
- 182 M. A. Hidalgo, J. Mina, and T. A. Osswald, "Time Temperature Superposition Principle for Predicting Long-Term Response of Figue-Fiber Reinforced Polyethylene- Aluminum Composites," ANTEC, Annual Technical Conference Proceedings, Orlando, FL, 2015.
- 183 N. P. Doll, A. J. Verdesca, E. Bast T. A. Osswald, and R. Kleiss, "Methodology for Quasi-Viscoelastic Simulation of Polymer Gears Made from Peek Using ANSYS ®," ANTEC, Annual Technical Conference Proceedings, Orlando, FL, 2015.
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- 185 C. J. Pérez, D. Ramírez, and T. A. Osswald, ""Mechanistic Model Simulation of a Compression Molding Process- Fiber Orientation and Fiber-Matrix Separation"," ANTEC, Annual Technical Conference Proceedings, Orlando, FL, 2015.
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- 188 Osswald, T.A., Goris, S., and Pérez, C.J., "The Use of a Direct Particle Simulation to Predict Fiber Motion in Processing of Long Fiber-Reinforced Thermoplastics," Polymer Processing Society Meeting, Graz, Austria, September 2015.
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195 Brill, A., and Osswald, T.A., “Viscoelastic Shear Analysis of Polymeric Foam Midsoles,” ANTEC, Annual Technical Conference Proceedings, Indianapolis, IN 2016.

196 Goris, S., and Osswald, T.A., “Analysis of the Process-Induced Microstructure in Injection Molding of Long Glass Fiber-Reinforced Thermoplastics,” ANTEC, Annual Technical Conference Proceedings, Indianapolis, IN 2016.

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198 Kuhn, C., Kucinski, W., Taege, O., and Osswald, T.A., “Lightweight Design with Long Fiber Reinforced Polymers – Technological challenges due to Effect of Fiber Matrix Separation,” Automotive Composites Conference and Expo (ACCE) (**Third Best Paper Award**), Detroit, MI 2016

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- 199.Simon, S., Goris, S., Bechara, A., and Osswald, T.A. "Study on Fiber Attrition of Long Glass Fiber-Reinforced Thermoplastics under Controlled Conditions in a Couette Flow," Automotive Composites Conference and Expo (ACCE), (**Best Poster Award**) Detroit, MI 2016
- 200.Duddleston, L.J.D., Woznick, K., Koch, C., Mazzei Capote, G., Rudolph, N., and Osswald, T.A., "Extrudate Mass Flow Rate Analysis in Fused Filament Fabrication (FFF): A Cursory Investigation of the Effects of Print Parameters," ANTEC, Annual Technical Conference Proceedings, Anaheim, CA 2017
- 201.Schäfer, C., Bryant, J. S., Meyer, S. P. and Osswald, T., "Micropelletization of Virgin and Recycled Thermoplastic Materials," ANTEC, Annual Technical Conference Proceedings, Anaheim, CA 2017
- 202.Goris, S., Simon, S., Montoya, C., Bechara, A., Brands, D., Angel, Y., Candal, M.V., Osswald, T.A., "Experimental Study on Fiber Attrition of Long Glass Fiber-Reinforced Thermoplastics under Controlled Conditions in a Couette Flow", ANTEC, Annual Technical Conference Proceedings, Anaheim, CA 2017
- 203.Walter, I., Goris, S., Teuwsen, J., Tapia, A., Perez C., Osswald, T.A., "A Direct Particle Level Simulation Coupled with The Folgar-Tucker RSC Model to Predict Fiber Orientation in Injection Molding of Long Glass Fiber Reinforced Thermoplastics", ANTEC, Annual Technical Conference Proceedings, Anaheim, CA 2017
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- 205.Obst, P., Launhardt, M., Drummer, D., Osswald, P.V., and Osswald, T.A., "Failure Criterion for SLS Additive Manufactured Parts", ANTEC, Annual Technical Conference Proceedings, Anaheim, CA 2017
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- 207.Walter, I., Kuhn, C., and Osswald, T.A., "Investigation of Fiber-Matrix Separation in Rib Filling During Compression Using a Direct Fiber Simulation", Automotive Composites Conference and Expo (ACCE), (3rd Place in Best Poster Award Competition) Detroit, MI 2017

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208.Osswald, T.A., "Fused Filament Fabrication Melting Model," RAPID 2018, Ft Worth, TX, April 25, 2018

209.Mazzei, G., and Osswald, T.A., "A Tensor Based Failure Criterion for Fused Filament Fabrication Manufactured Parts," RAPID 2018, Ft Worth, TX, April 25, 2018

210.Mulholland, T., Rudolph, N., and Osswald, T.A., "Fused Filament Fabrication for Manufacturing of Air-Colled Heat Exchangers," RAPID 2018, Ft Worth, TX, April 25, 2018

211.Johnson, C., Herrera, R., Osswald, T.A. (2018). "Strength Analysis of Fused Filament Fabricated Continuous Carbon Fiber Composite Test Samples," SPE ANTEC, Orlando, 2018.

212.Colón, J., Heckner, T., Chrupala, A., Goris, S., Pollock, J., Osswald, T.A. (2018). "Observed Particle Migration During Processing of Polypropylene with Glass Beads," SPE ANTEC, Orlando, 2018.

213.Simon, S., Bechara, A., and Osswald, T.A., "Fiber Orientation Evolution in Injection Molded Parts," SPE Automotive Composites Conference and Expo, Detroit, MI, September 6, 2018 (Best Paper Award)

214.Redmann, A., and Osswald, T.A., "3D Printed B-Stage Epoxy for Composite Joining and Feature Integration," SPE Automotive Composites Conference and Expo, Detroit, MI, September 6, 2018 (Second Best Paper Award)

215.Osswald, T.A., "Procesamiento y Reología de Polímeros," IV Simposio de Materiales Poliméricos (4th Symposium for Polymeric Materials) Cali, Colombia, September 13, 2018 (Plenary Lecture)

216.Mazzei Capote, G. A., Osswald T. A., "A novel failure criterion applied for Fused Filament Fabrication parts", AMUG, Chicago, IL, April 3rd, 2019

217.Osswald, T.A., "Hermann Mark – The Father of Polymer Science," Plastics Heritage Congress - 2019, 2Lisbon, Portugal, 9-31 May, 2019.

218.Oehlmann, P., Redmann, A., and Osswald, T.A., "3D Printed Dual Cure Epoxy for Hybrid Composite Structures," SPE Automotive Composites Conference and Expo, Detroit, MI, September 6, 2019 (Second Best Paper Award)

219.Simon, S.A., Bechara, A.S., and Osswald, T.A., "Direct Fiber Model Validation: Orientation Evolution in Simple Shear Flow," SPE Automotive Composites Conference and Exhibition, Novi, MI, September 4, 2019 (Best Paper Award)

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220.Osswald, T.A., Román, A., and Travis, J.Z., “Análisis estacional y caracterización de plantaciones de caucho natural: Propiedades térmicas, mecánicas, químicas y reológicas de látices obtenidos,” (“Seasonal Analysis and Characterization of Natural Rubber Plantations: Thermal, Mechanical, Chemical and Rheological Properties”) XV Jornadas Latinoamericanas de Tecnología del Caucho, Querétaro, Mexico, 11-15 November, 2019 (Invited presentation)

PATENTS

1. US 5,971,603 Static Mixer Head
2. US 6,136,246 Screw extruder with improved dispersive mixing elements
3. US 7,314,363 Device to visualize in-line and quantify the polymer melting in plasticating screw machines without significantly affecting its thermal regime
4. US 9,321,207 Polymer Pelletization Via Melt Fracture
5. US 9,205,590 Micropelletizer Using Rayleigh Disturbances
6. US 9,895,844 System for Use with Three Dimensional Printer and Method for Using the Same (applied 2015, granted 2018)
7. WO2015126733 System for Use with Three Dimensional Printer and Method for Using the Same
8. US11,207,799 B2 Pelletization Gas Guide
9. United States Patent Application 20230339155, METHOD FOR SIMULATING A FIBER ORIENTATION IN AN INJECTION-MOLDED PART MADE OF A FIBER-REINFORCED PLASTIC, AND DESIGN METHOD FOR DESIGNING AN INJECTION-MOLDED PART MADE OF A FIBER-REINFORCED PLASTIC
10. WO2023144631 Ammonia-Free Latex Compositions
11. US 11,911,949 Rotating Nozzle Structure and Method

EXTENSION/OUTREACH/SEMINARS

Extrusion Seminar at UW-Milwaukee Extension
Manufacturing with Plastics - College for Kids Workshop at UW

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Basic Manufacturing Engineering - Engineering Professional Development at UW

Polymers 101 - Engineering Professional Development at UW

Modeling in Polymer Processing - LKT, University of Erlangen, Germany

Simulation in Polymer Processing - LKT, University of Erlangen, Germany

Molding Processes Simulations - Neue Materialien Fürth GmbH, Germany

Polymer Processing - ICIPC, Colombia

Polymer Physics for Engineers - ICIPC, Colombia

Presents several seminars and courses at various industries and institutes in German, Spanish and English.

PROFESSIONAL SERVICE

1. International and National Committees and Boards

International advisory committee member of the International Society for Boundary Elements. 1994-2001.

Co-chair of the 17th International Boundary Element Conference sponsored by the International Society for Boundary Elements. (1995)

Editorial Board of *Engineering Analysis with Boundary Elements*. 1996-2001

Board of the Society of Plastics Engineers – Extrusion Division. 1997-2000

Editor for the Americas of *Journal of Polymer Engineering*. 1998-present.

Chief English Language Editor (Prof. G.W. Ehrenstein, Chief German Language Editor) for the *Journal of Polymer Technology (Archival Journal of the WAK)*, 2005-present

Editorial Board of *Journal of Composites Science*. 2017-Present

Editorial Board of *Polymers*. 2019-present

Editorial Manager for *Science and Engineering of Composite Materials*

Advisory Board of Hanser Publishers, 1998-present.

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Technical Advisory Board Member, Teel Plastics, Baraboo, WI, 2009-present

Scientific Advisory Board, SABIC, 2016-present

Editor of Polymer Composites (SPE archival journal) 2021-present

Scientific Advisory Board Member, RWTH-Aachen (Technical University-Aachen), Cluster of Excellence Integrative Production Technology for High-Wage Countries, Aachen, Germany, 2011-present

Editorial Board of *Journal of Science and Engineering of Composite Materials*, 2016-present

2. Professional Society Memberships

Polymer Processing Society (Treasurer)

Society of Rheology

Society of Plastic Engineers (Fellow)

ACS - Rubber Division

WAK, Scientific Alliance of Polymer Technology Professors

3. Technical Reviewer Activities

National Science Foundation

1990-present Have served one review panels yearly in the DMII Division, Engineering Directorate

Reviewer for the J. of Non-Newtonian Fluid Mech

Reviewer for the Int. J. of Polymer Processing

Reviewer for the Ohio Supercomputing Grant Awards

Reviewer for ASME WAM papers

Reviewer for ASME J. of Engineering for Industry

Reviewer for Int. J. of Polymer Proc., and Polym. Eng. and Sci.

Reviewer for J. Polym. Composites.

4. Faculty Advisor

Theta Tau Professional Fraternity

Society of Hispanic Professional Engineers (SHPE)

Society of Plastics Engineers