

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FOX Factory, Inc.,
Petitioner,

v.

SRAM, LLC,
Patent Owner.

IPR2024-00491
U.S. Patent No. 10,328,993

**DECLARATION OF ALEXANDER SLOCUM, PH.D. IN SUPPORT OF
INTER PARTES REVIEW OF U.S. PATENT 10,328,993**

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I, Alexander H. Slocum, declare as follows:

I. INTRODUCTION

1. I have been retained as a technical expert in the field of engineering and mechanical devices by Finnegan, Henderson, Farabow, Garrett & Dunner, LLP (“Finnegan”) on behalf of FOX Factory, Inc. (“FOX”). This Declaration is in support of *inter partes* review of claims 1-4, 6, 8, 10, 12, 14-18, 20, 22, 24, 26-29, 31, 33-38, 40, 42, 44, 46-49, 51, 53, and 56-64 (“the Challenged Claims”) of U.S. Patent No. 10,328,993 (“the ’993 patent”).

2. I am being compensated for my work on this matter at my standard rate of \$800.00 per hour. My compensation in no way depends on the outcome of this proceeding, the content of my testimony, or any issues involved in or related to this proceeding. In preparing this Declaration, I reviewed and considered the ’993 patent, the prosecution history of the ’993 patent, and the prior art references that I discuss in this Declaration. In addition to these materials, I may consider additional documents and information in forming any supplemental opinions. To the extent I am provided additional documents or information, including any expert declarations filed by Patent Owner in this proceeding, I may offer further opinions.

3. Based on my experience, knowledge of the art at the relevant time, analysis of the prior art references, and the understanding a person of ordinary skill in the art

would have of the claim terms in light of the specification, it is my opinion that the Challenged Claims of the '993 patent are obvious based on the prior art references discussed below.

II. QUALIFICATION AND EXPERIENCE

4. I am the Walter M. May and A. Hazel Professor of Mechanical Engineering at the Massachusetts Institute of Technology ("MIT"). I received an undergraduate degree in Mechanical Engineering from MIT in 1982. I received a Master's degree in Mechanical Engineering from MIT in 1983. I received a Ph.D. in Mechanical Engineering from MIT in 1985. I have over 30 years of experience in teaching and directing research related to mechanical engineering and precision machine design. A copy of my curriculum vitae is attached hereto as Exhibit A.

5. From 1982 to 1986, I worked as a mechanical engineer for the National Institute for Standards and Technology (NIST, which was then called the "National Bureau of Standards" or NBS) under the United States Department of Commerce. From 1985 to 1989, I was an Assistant Professor of Civil Engineering at MIT. From 1989 to 1990, I was a visiting professor of mechanical engineering at the Cranfield Institute of Technology. Since 1991, I have been and continue to be a professor of mechanical engineering at MIT.

6. I have published extensively and have numerous patents that have resulted in many successful products. I hold 170+ patents issued in the United States and

abroad, including many that relate to fluid systems and mechanical design, including damping systems.

7. I have taught many thousands of students and supervised hundreds of student theses. Complete lists are provided in Exhibit A.

8. I am a member of the National Academy of Engineering (“NAE”) and am active in several engineering societies and have received many awards and professional honors. I consult extensively with industry on the development of new products, and I have also helped start several successful companies.

9. My principal research interest is precision engineering and precision machine design. I currently serve as the director of the Precision Engineering Research Group at MIT (pergatory.mit.edu). Precision engineering addresses the design and manufacture of all manner of things from consumer products, machines, devices, fixtures, and other structures that have and require critical tolerances, and that are very repeatable and stable over time. For over 30 years, I have been focused on the design and development of precision machines, medical devices, and other products, often specifically on the structural design and coupling and interconnection of components in those products. In particular, I am an acknowledged world expert on precision machine structures, bearings, and couplings between mechanical elements

and maintain a free video lecture resource for industry and academia (*see, e.g.*, <https://www.youtube.com/@FUNdaMENTALs42>).

10. In addition, I have significant experience with recreational biking (off and on-road), having owned many bikes over the years. I love bicycle riding and have completed 22 Ironman 140.6 races and am very familiar with bicycle design and maintenance. I also ride my bikes on trails that span many miles around my farm in New Hampshire. My most extensive ride was the White Rim 100-mile ride which I did with my friend in one day (13 hours), unsupported—we took all our own stuff. A video shows my taped-on flashlight, milkcrate for hauling water, and yes, embarrassingly walking up one very nasty hill: <https://www.youtube.com/watch?v=eCHDJcdD2wE>.

11. Based on my education and experience, I am qualified to opine on the subject matters at hand and in this Declaration.

III. LEGAL STANDARDS

A. Claim Construction

12. I have been informed by counsel and I understand that the first step in determining the patentability of a patent claim is for the claim terms to be properly construed. I understand that claim terms are construed in light of the claim language, the patent specification, and the prosecution history of the patent. I also understand that extrinsic sources, for example, dictionaries, treatises, textbooks, etc., may shed

light into the meaning of claim terms. I further understand that a claim term is given its plain and ordinary meaning as understood by those skilled in the art if that claim term does not need construction.

B. Anticipation

13. I am not an attorney and have not been asked to offer my opinion on the law. However, as an expert offering an opinion on whether the Challenged Claims of the '993 patent are unpatentable, I have been told that I am obliged to follow existing law.

14. I have been told the following legal principles apply to an analysis of patentability pursuant to 35 U.S.C. § 102, a provision in the patent law regarding anticipation. I have been told that, in an *inter partes* review proceeding, patent claims may be deemed unpatentable if it is shown by a preponderance of the evidence that the claims were anticipated by prior art patents or printed publications.

15. I have been told that for a claim to be anticipated under § 102, every limitation of the claimed invention must be disclosed by a single prior art reference, viewed from the perspective of a person of ordinary skill in the art.

C. Obviousness

16. I have been told that under 35 U.S.C. § 103, “[a] patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention

and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains.”

17. When considering the issues of obviousness, I have been told that I am to do the following:

- a. Determine the scope and content of the prior art;
- b. Ascertain the differences between the prior art and the claims at issue;
- c. Resolve the level of ordinary skill in the pertinent art; and
- d. Consider evidence of secondary indicia of non-obviousness (if available).¹

18. I have been told that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of alleged invention, which I have assumed is shortly before the effective filing date of the application leading to the '993 patent (December 30, 2014).

¹ I am not aware of any secondary indicia, such as commercial success, praise, etc., that would support non-obviousness of the Challenged Claims.

19. I have been told that any assertion of secondary indicia of non-obviousness must be accompanied by a nexus between the merits of the invention and the evidence offered.

20. I have been told that a reference may be combined with other references to disclose each element of the invention under § 103. I have been told that a reference may also be combined with the knowledge of a person of ordinary skill in the art and that this knowledge may be used to combine multiple references. I have also been told that a person of ordinary skill in the art is presumed to know the relevant prior art. I have been told that the obviousness analysis may account for the inferences and creative steps that a person of ordinary skill in the art would employ.

21. I have been told that whether one or more prior art references render a patent claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art. I have been told that there is no requirement that the prior art contain an express teaching or suggestion to combine known elements to achieve the claimed invention, but that a motivation or rationale for combining prior art elements in a way that realizes the claimed invention is required to show obviousness, and that it seeks to counter impermissible hindsight analysis.

22. I have been told that when a work is available in one field, design alternatives and other market forces can prompt variations of it, either in the same field or in

another. I have been told that if a person of ordinary skill in the art can implement a predictable variation and would see the benefit of doing so, that variation is likely to be obvious. I have been told that, when there is a design need or market pressure and there are a finite number of predictable solutions, a person of ordinary skill in the art has good reason to pursue those known options that realize the claimed invention. In addition, I have been informed and I understand that there must be a reasonable expectation of success—not absolute predictability of success—in combining prior art teachings to arrive at the claimed invention.

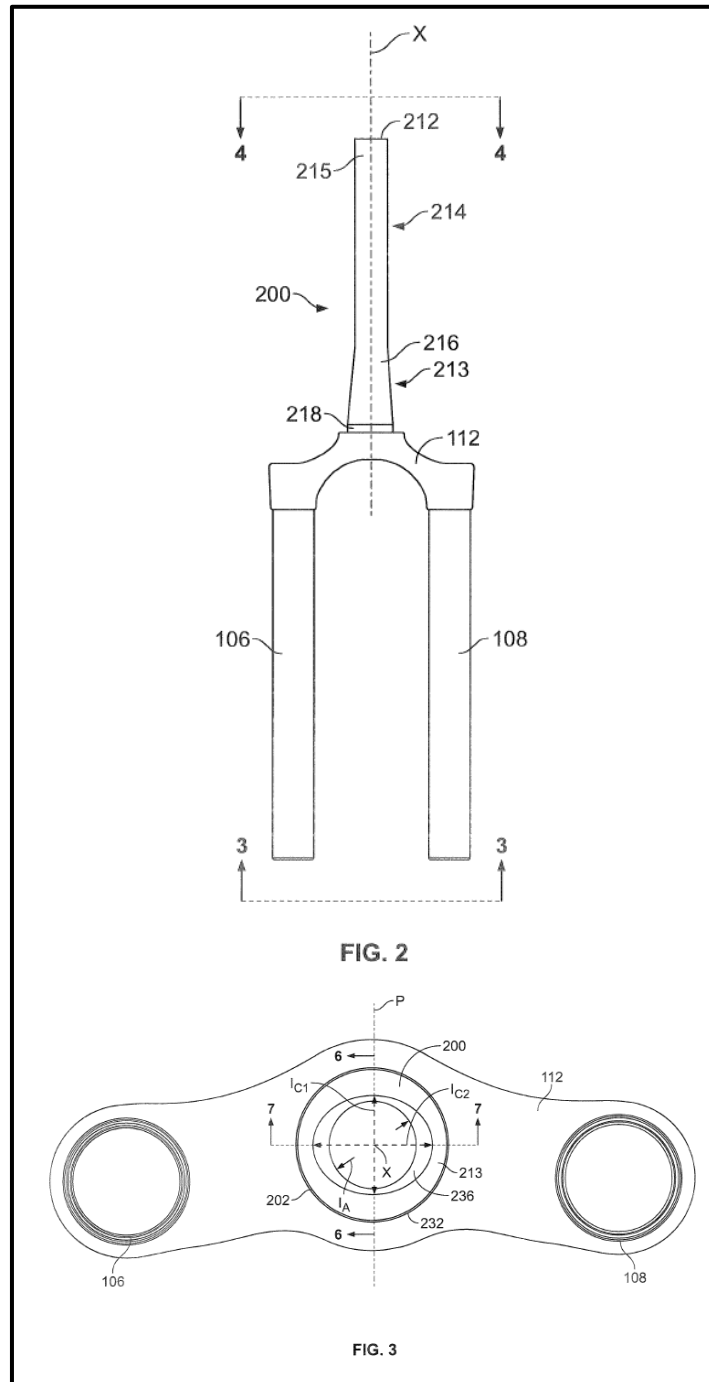
IV. DEFINITION OF A PERSON OF ORDINARY SKILL IN THE ART

23. At the time of the alleged '993 patent invention, a person of ordinary skill in the art (“POSITA”) would have had (1) a Bachelor’s degree in Mechanical Engineering or an equivalent degree, and 1-2 years of experience in design work related to optimal mechanical and structural design (e.g., minimizing weight while maximizing strength and stiffness for a particular type of loading) such as practiced, for example, in aerospace, bicycle, or machinery (such as robotics) industries; or (2) at least a Master’s degree in Mechanical Engineering or an equivalent degree with a focus on design of mechanical elements and structures, and a good understanding of mechanical and structural design principles.

24. I believe that I have the relevant experience and understanding of one of ordinary skill in this field.

V. OVERVIEW OF THE '993 PATENT

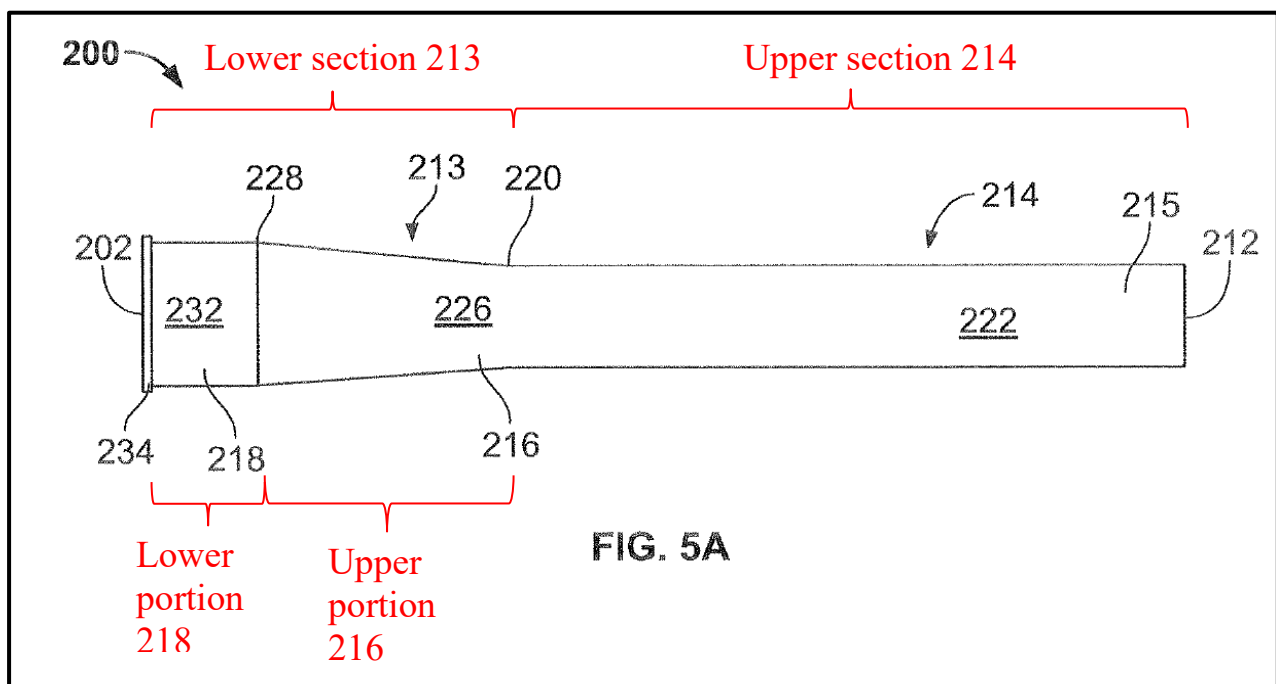
25. The '993 patent discloses and claims a bicycle steerer tube with varying wall thicknesses over a cross-section. Ex. 1001, 1:46-59, 3:26-32. As shown below, and like the conventional bicycle 100 described in the background section of the '993 patent (discussed below), steerer tube 200 includes an elongate hollow body arranged around a steering axis X and extending from a lower end 202 to an upper end 212. Ex. 1001, 1:19-32, FIGS. 1, 2, 5A. Steering axis X is located in a vertical plane of travel P of the bicycle. Ex. 1001, 1:8-22. The hollow body includes an upper section 214 and a lower section 213. Ex. 1001, 3:33-36. Upper section 214 extends from upper end 212 to a lower end 220. Ex. 1001, 3:33-38. A segment 215 of upper section 214 adjacent to upper end 212 is adapted to be joined to a bicycle handlebar 104. Ex. 1001, 3:38-39.



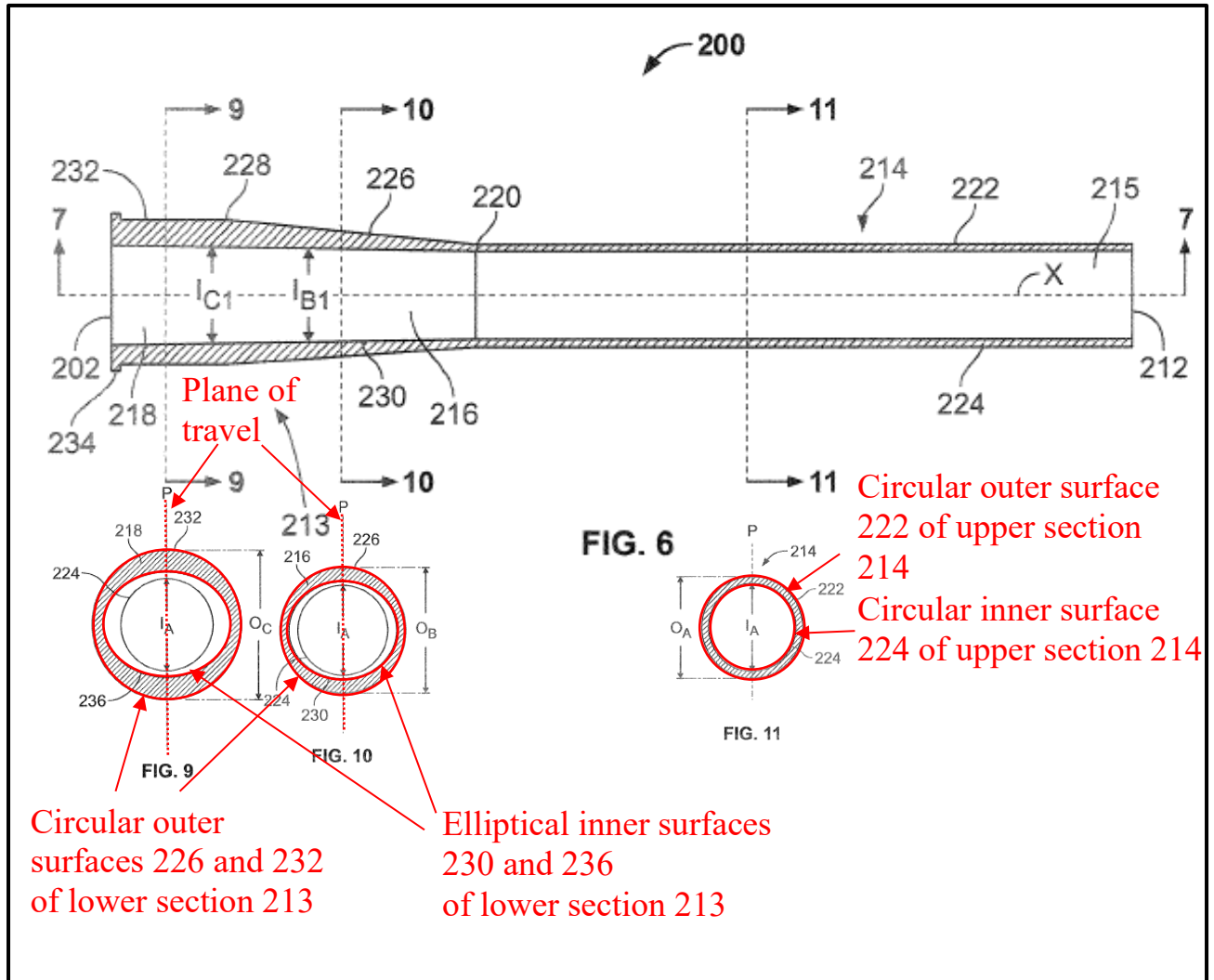
Ex. 1001, FIGS. 2-3.

26. As shown below, lower section 213 is further subdivided into: (1) an upper portion 216 extending from upper end 220 to lower end 228 (Ex. 1001, 3:58-60,

FIGS. 5A-7), and (2) a lower portion 218 extending from lower end 228 (of upper portion 216) to lower end 202 (Ex. 1001, 4:23-26, FIGS. 5A-7). A segment 234 of lower portion 218, adjacent to lower end 202 of the steerer tube, is adapted to be joined to a crown 112 of a front suspension fork of the bicycle. Ex. 1001, 4:26-29, FIGS. 2, 5A-7.



Ex. 1001, FIG. 5A (annotations added).



Ex. 1001, FIGS. 6, 9-11 (annotations added).

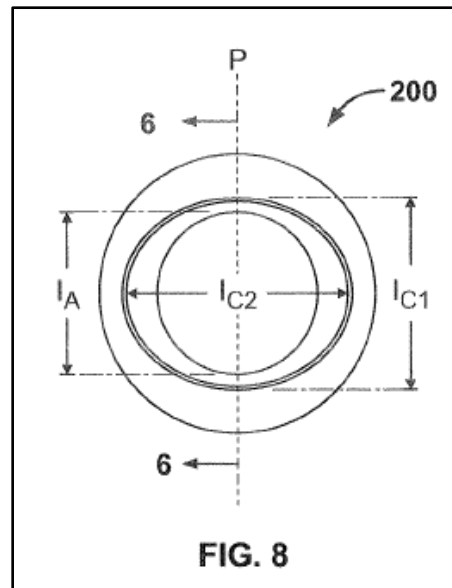
27. As shown above, upper section 214 has an outer surface 222 and an inner surface 224, both being circularly cylindrical throughout the length of upper section 214. Ex. 1001, 3:39-43, FIGS. 5A-7.

28. Upper portion 216 of lower section 213 has an outer surface 226 and an inner surface 230. Ex. 1001, 3:55-4:17, FIGS. 5A-7. Outer surface 226 is circular in cross-

section and tapers from upper end 220 to lower end 228. Ex. 1001, 3:55-4:17, FIGS. 5A-7. The shape of inner surface 230 changes as a function of distance from upper end 220, where the cross-section of inner surface 230 is circular at upper end 220 and becomes more elliptical towards lower end 228. Ex. 1001, 4:5-17. Lower portion 218 of lower section 213 has an outer surface 232 and an inner surface 236. Ex. 1001, 4:21-44, FIGS. 5A-7. Outer surface 232 is circularly cylindrical. Ex. 1001, 4:21-23. Inner surface 236 gradually changes cross-sectional shape from lower end 228 towards tube end 202. Ex. 1001, 4:21-44, FIGS. 5A-7.

29. That is, the cross-sectional shapes of inner surfaces 230 and 236 of lower section 213 change from circular to elliptical from upper end 220 towards tube end 202, while outer surfaces 226 and 232 remain circular. Ex. 1001, 4:7-26, FIGS. 5A-10. Given the elliptical cross-sectional shapes of the inner surfaces 230 and 236, a thickness of the wall of lower section 213 varies over a cross-section of the wall, the wall thickness being at a maximum in the plane of travel P of the bicycle. Ex. 1001, 4:7-26, FIGS. 5A-10. In other words, the minor axis (I_{C1}) of an inner elliptical cross-sectional shape of the lower section 213 lies along the plane of travel P of the bicycle, and the major axis (I_{C2}) is perpendicular to the plane of travel P. *See* Ex. 1001, FIG. 8. Thus, the elliptical inner contour results in increase in wall thickness in the plane of travel P, which in turn gives the tube greater strength to bear the higher

loads and forces in the plane of travel P, while lowering the weight of the tube by having a thinner wall in a plane orthogonal to the plane of travel P (where the loads and forces are lower). Ex. 1001, 2:4-9, 3:29-32, 7:57-62.



Ex. 1001, FIG. 8.

VI. CLAIM CONSTRUCTION

30. No claim construction of any term or limitation in the Challenged Claims is needed for this IPR; rather, the plain meaning of each claim term may be applied.

VII. SUMMARY OF THE PROSECUTION HISTORY OF THE '993 PATENT

31. The '993 patent issued from U.S. Patent Application No. 14/585,629, filed December 30, 2014, and does not claim priority to any earlier filed application.

Ex. 1002, 293-301.

32. The Office issued a first non-final Office Action on July 11, 2017, rejecting the elected claims as being anticipated by or obvious over Moechnig.² Ex. 1002, 210-218. In response, Applicant argued that:

Moechnig discloses that “[a] steerer tube extends upward from the fork crown and into the head tube and includes a portion with an oblong cross-section.” (Moechnig, col. 2, ln. 65-67). **Moechnig discloses a cross-section having a consistent wall thickness.** (See Moechnig, col. 7, ln 49-51; *see also* Moechnig, Figs. 4-6). **Moechnig does not disclose varying thickness of a wall. Therefore, Moechnig does not disclose a thickness of the wall at any point in the lower section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel.**

Ex. 1002, 185-186 (alteration in original) (emphases added).

33. The Office issued a second non-final Office Action on January 17, 2018, rejecting independent claim 1 and various dependent claims as anticipated by or obvious over Murphy (Ex. 1011). Ex. 1002, 180-182. In response, Applicant argued:

² The Examiner applied the Moechnig patent, U.S. Patent No. 7,909,346, that issued from the Moechnig publication (Ex. 1008) used in this Declaration.

Murphy discloses that the thickness varies along the length of the shaft. Varying along a length is different than varying as a function of an angle from a plane of travel. Murphy does not disclose varying thickness of a wall as a function of the cross-sectional angle of the point relative to the plane of travel.

Ex. 1002, 65.

34. The Office issued a third non-final Office Action on August 10, 2018, rejecting independent claim 1 and various dependent claims as obvious over D'Aluisio (Ex. 1012) in view of Galasso (Ex. 1013), but indicating that several dependent claims would be allowable. Ex. 1002, 39-44. The Office stated that:

Galasso discloses a vehicle suspension comprising: a tube (8) with a thickness of the wall at any point in a section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel, the wall thickness being at a maximum in the plane of travel of the vehicle (See figure 2A). It would have been obvious for one of ordinary skill in the art before the effective filing date of the current invention to modify D'Aluisio by adjusting the thickness of the body at any section to match the appearance of the tube in Galasso, in order to enhance the stiffness of the tube to include a major and minor stiffness (see summary of the invention in Galasso at the bottom of Col. 1 and the beginning of Col. 2). Wherein the

combination of D’Aluisio and Galasso can be seen as a combination of prior art elements according to known methods to yield predictable results.

Ex. 1002, 42.

35. In response, Patent Owner amended independent claim 1 to recite that the “outer surfaces of the upper and lower sections of the body [are] circular in cross-section” (which was originally recited in allowable claim 2); rewrote allowable dependent claim 14 reciting “an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body” into an independent claim (now independent claim 61); and rewrote dependent claim 18 reciting “the segment of the lower section of the body is joined to the crown of the front wheel fork, the body formed of a material different from the crown of the front wheel fork” into an independent claim (now independent claim 64). Ex. 1002, 24-30.

36. In response to these amendments, the Office issued a Notice of Allowance on February 12, 2019. Ex. 1002, 7-14. Patent Owner paid the issue fee on May 7, 2019, and the ’993 patent issued on June 25, 2019. Ex. 1002, 1-2.

37. Throughout prosecution, Applicant filed three information disclosure statements (IDS) dated June 18, 2015; November 29, 2016; and April 12, 2018. Ex. 1002, 261-263, 249-251, 67-69. The Examiner indicated that all references submitted in these statements were considered. Ex. 1002, 219-221, 205-207, 47-49.

Neither of the primary references Denk or Valat that form the grounds of this IPR were cited or considered during prosecution. Although Moechnig was cited in an IDS and applied by the Examiner in the first Office Action, it is being relied upon in a very different context in this Declaration. The secondary reference Schroeder was cited in an IDS, but not applied by the Examiner in any of the Office Actions.

VIII. OVERVIEW OF THE PRIOR ART

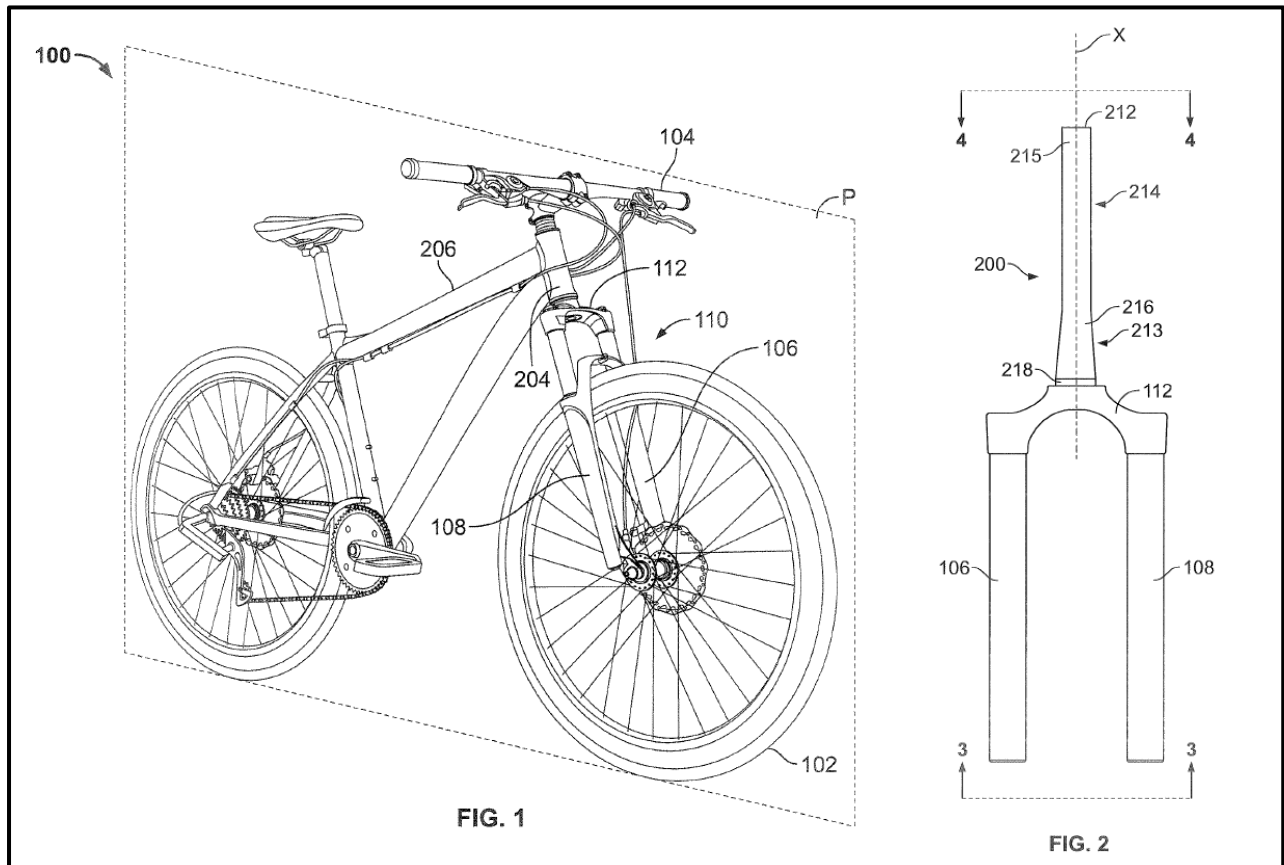
A. AAPA

38. The '993 patent discloses the following applicant admitted prior art ("AAPA"):

A conventional bicycle (a mountain bike is shown at 100 in FIG. 1) is steered by varying the plane of its front wheel 102 out of a plane of travel P, which is aligned with the running direction of the bicycle. This is done by linking the front wheel 102 to a rider-operated handlebar 104. The front wheel 102 is rotatably suspended between left and right tubes 106, 108 of a fork indicated generally at 110. The left and right fork tubes 106, 108 are joined, either in solid fashion or by shock absorbing apparatus, to a fork crown 112 positioned upward from the front wheel.

Referring to FIGS. 1 and 2, **a steerer tube 200 has its lower end 202 affixed to the fork crown 112 and is disposed along an upwardly and usually rearwardly**

extending steering axis X. Axis X is within the plane of travel P. The steerer tube 200 is inserted into a coaxial head tube 204 that is part of a bicycle frame 206. Bearings are mounted between the steerer tube 200 and the head tube 204 to permit the free rotation of the steerer tube 200 relative to the head tube 204. **The handlebar 104 is affixed in some fashion (as by a star nut, not shown) to an upper end 212 of the steerer tube,** and permits the rider to impart torque to the steerer tube 200, the fork 110 and the front wheel 102, which in response rotate around the steering axis X as a unit. Thus, the rider may steer the bicycle 100 right or left as desired.



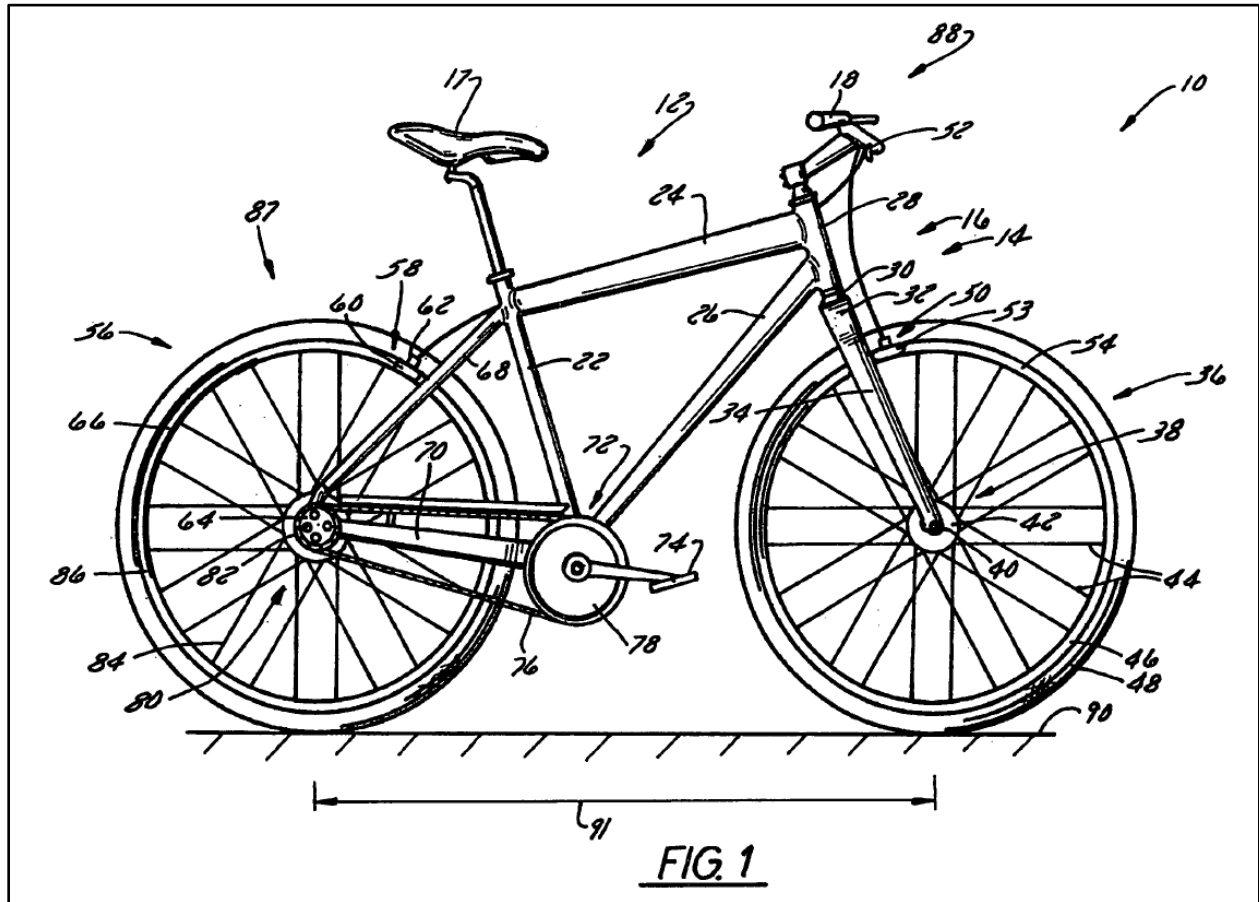
Ex. 1001, 1:8-32 (emphases added) (“AAPA”), FIGS. 1-2.

39. It is my understanding that statements in the background section of a challenged patent, like the statements above, may be used as admitted prior art in an IPR proceeding. Here, the AAPA is evidence of at least the general knowledge at the time of the purported invention that: (1) a bicycle has a steerer tube; (2) a bicycle has a plane of travel aligned with the running direction of the bicycle; (3) a bicycle steerer tube has an elongate body disposed about a steering axis that lies within the plane of travel of the bicycle; and (4) the lower end of a bicycle steerer tube is affixed

to a crown of a front suspension fork of the bicycle and the upper end of the steerer tube is affixed to a handlebar of the bicycle.

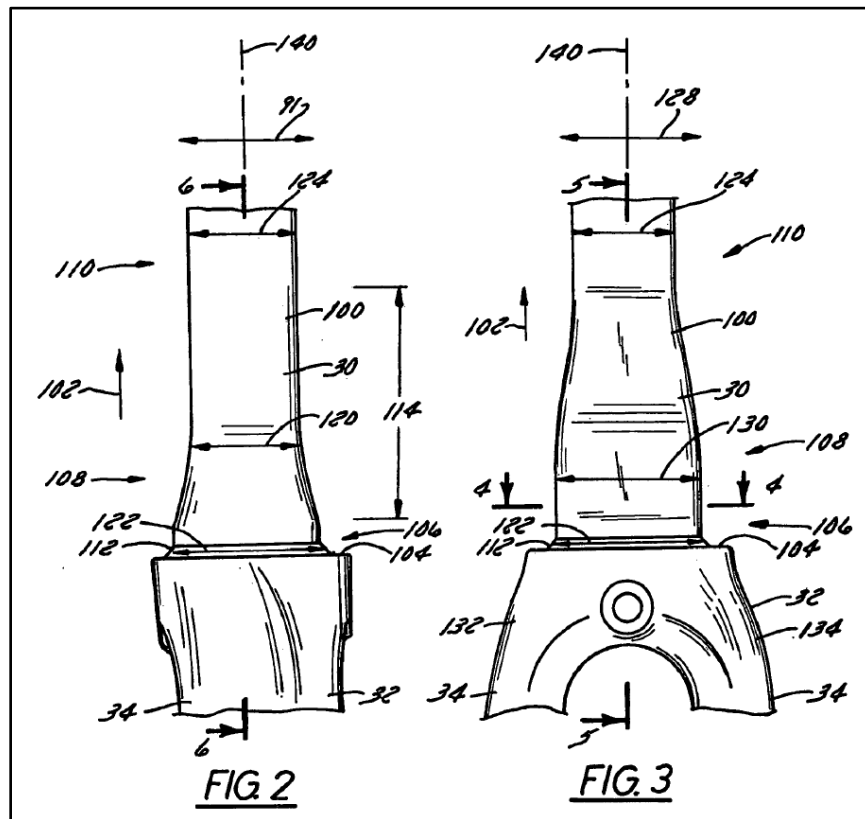
B. Moechnig (Ex. 1008)

40. Moechnig discloses a steerer tube for a bicycle, such as a street or road bike or a mountain bike. Moechnig, Abstract, [0001], [0033]. Bicycle 10 includes a frame 12, a handlebar 18, a steerer tube 30, a fork crown 32, and a suspension fork 34 connected to an axle 40 of a front wheel assembly 36. Moechnig, [0002]-[0003], [0025]-[0026], [0028], [0033]. Steerer tube 30 passes through a head tube 28 of frame 12, and connects to handlebar 18 at the upper end and a fork crown 32 at the lower end, such that rotation of handlebar 18 rotates fork crown 32 and thereby rotates or pivots front wheel 36 relative to a longitudinal direction of the bicycle, which in turn steers the bicycle. Moechnig, [0026]-[0027], [0032], [0034]. Moechnig describes that the longitudinal direction generally refers to the fore-aft direction of travel of the bicycle. Moechnig, [0005].



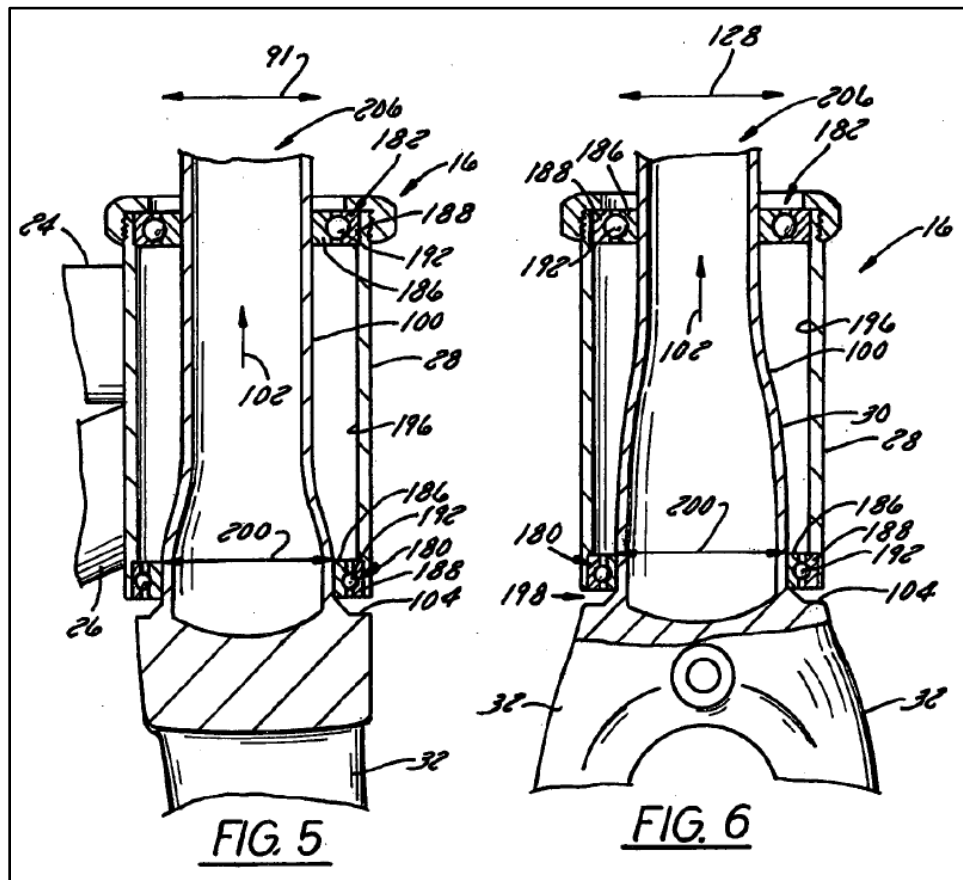
Moechnig, FIG. 1.

41. As shown below, Moechnig's steerer tube 30 has a body 100 extending along a longitudinal axis and including an upper radial portion 110, a lower radial portion 106 joined to fork crown 32, and a radially asymmetric portion 108 extending over a portion 114 of the length of the steerer tube. Moechnig, [0002], [0027], [0035], FIGS. 2-3.



Moechnig, FIGS. 2-3.

42. Moechnig discloses that steerer tube 30 is lightweight and yet capable of withstanding fore and aft impact loading that is comparable to heavier steerer tube assemblies. Moechnig, [0001], [0009], [0049]. For example, as shown below, steerer tube 30 includes a cavity 206 and a steerer tube wall having a thickness that is specifically selected to withstand the loaded interaction between steerer tube 30 and head tube 28. Moechnig, [0045], FIGS. 5-6.



Moechnig, FIGS. 5-6.

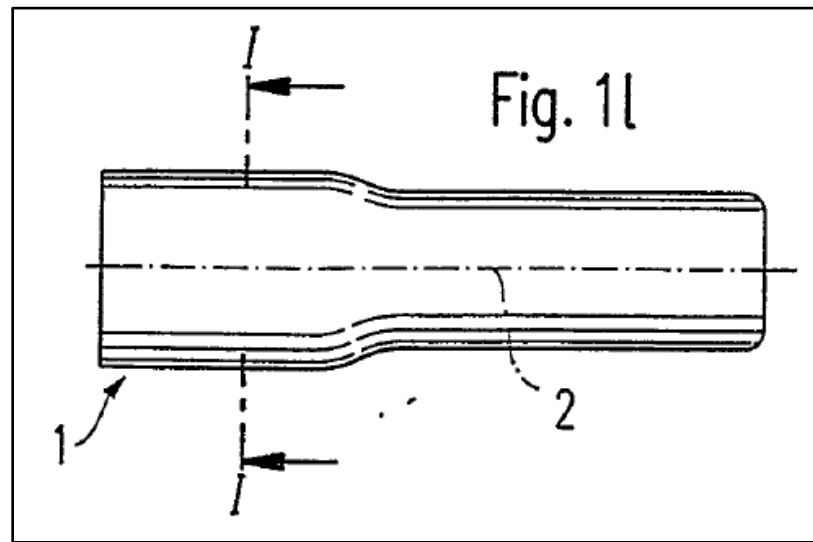
43. To be sure, while Moechnig does not specifically teach a varying wall thickness over a cross-section (as defined by the '993 patent), Moechnig teaches that different lateral and longitudinal diameters along the radially asymmetric portion 108, which results in oblong inner and outer cross-sections along asymmetric portion 108, is desirable. Moechnig, [0040], FIG. 4. A POSITA would have understood that the oblong radially asymmetric shape taught by Moechnig is structurally equivalent to varying the wall thickness over a cross-section as discussed in the '993 patent. Moechnig, [0040]. Furthermore, a POSITA would have understood that varying

cross-sections and wall thicknesses are common to minimize weight and obtain desired strength and stiffness, and formulas to develop such designs are even provided in design handbooks, such as “Roark’s Formulas for Stress and Strain.” Ex. 1017.

C. Denk (Ex. 1005)³

44. Denk discloses a lightweight design suitable for all tubular components of a bicycle frame, including a top tube, down tube, seat tube, head tube, fork tubes, rear wheel stay, seat posts, handlebars, handlebar stem, and the like. Denk, Abstract, cols. 1, 4. Denk’s lightweight design would also have been suitable for a bicycle steerer tube to minimize the overall weight of the bicycle, while withstanding the loads or forces on the steerer tube in the plane of travel of the bicycle. As shown below, the lightweight component has an elongate tubular body that extends symmetrically around a center line 2. Denk, col. 5. In one embodiment, Denk discloses that the outer cross-sectional contour is cylindrical throughout the length of the tube. Denk, col. 8, Fig. 2a. In another embodiment, Denk discloses that the tube has two cylindrical sections joined by a tapering area, as shown in Figure 11, below.

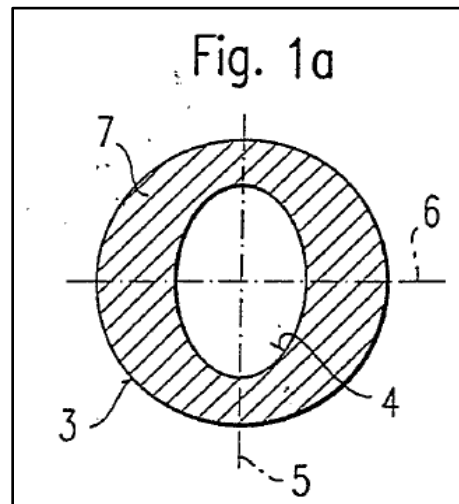
³ All reference cites are based on the translation (Ex. 1006).



Denk, Fig. 11.

45. Denk discloses that the tubular body has a wall thickness that changes over its cross-section along the length of the tubular body to adapt to the loads that occur during use, specifically “the profile of the wall thickness over the cross-section may be optimally adapted to the actual requirements with regard to strength and rigidity.”

Denk, Abstract, cols. 1-2. In one embodiment, as shown below, the tube has a circular outer cross-sectional contour 3 and an elliptical inner cross-sectional contour 4. Denk, cols. 3, 6, 11-12, Figs. 1a, 4c. The tube has maximum thickness, and thus optimal load-bearing capacity, along a plane 6 and minimum thickness along a plane 5 perpendicular to plane 6. Denk, cols. 3, 8, 9, Figs. 1a, 4c.

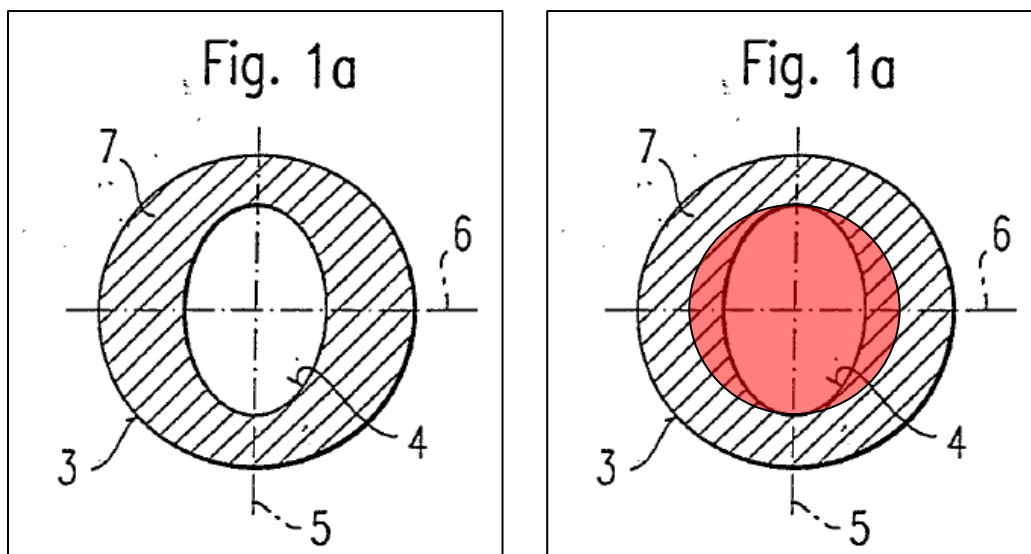


Denk, Fig. 1a.

46. Denk discloses that bicycle frames, such as those of mountain bikes, need to have low weight but high strength and rigidity, particularly in the vertical plane of the frame (which is same as the vertical plane of travel) where high loads occur during use. Denk, cols. 1-2. A significant advantage of Denk's lightweight component is that the wall thickness over the cross-section may be adapted to the requirements of strength and rigidity such that "for the same overall strength and rigidity, the weight may be reduced, or for the same weight, the strength and rigidity may be significantly increased in the load direction specified by the design." Denk, cols. 1-2. Accordingly, when implementing Denk's lightweight tubular component as a steerer tube, it would have been obvious and practical to align plane 6 with the plane of travel of the bicycle (i.e., the vertical plane of the bicycle frame, *see* discussion below in claim term 1[d], Section IX.A.2.e), such that the areas of

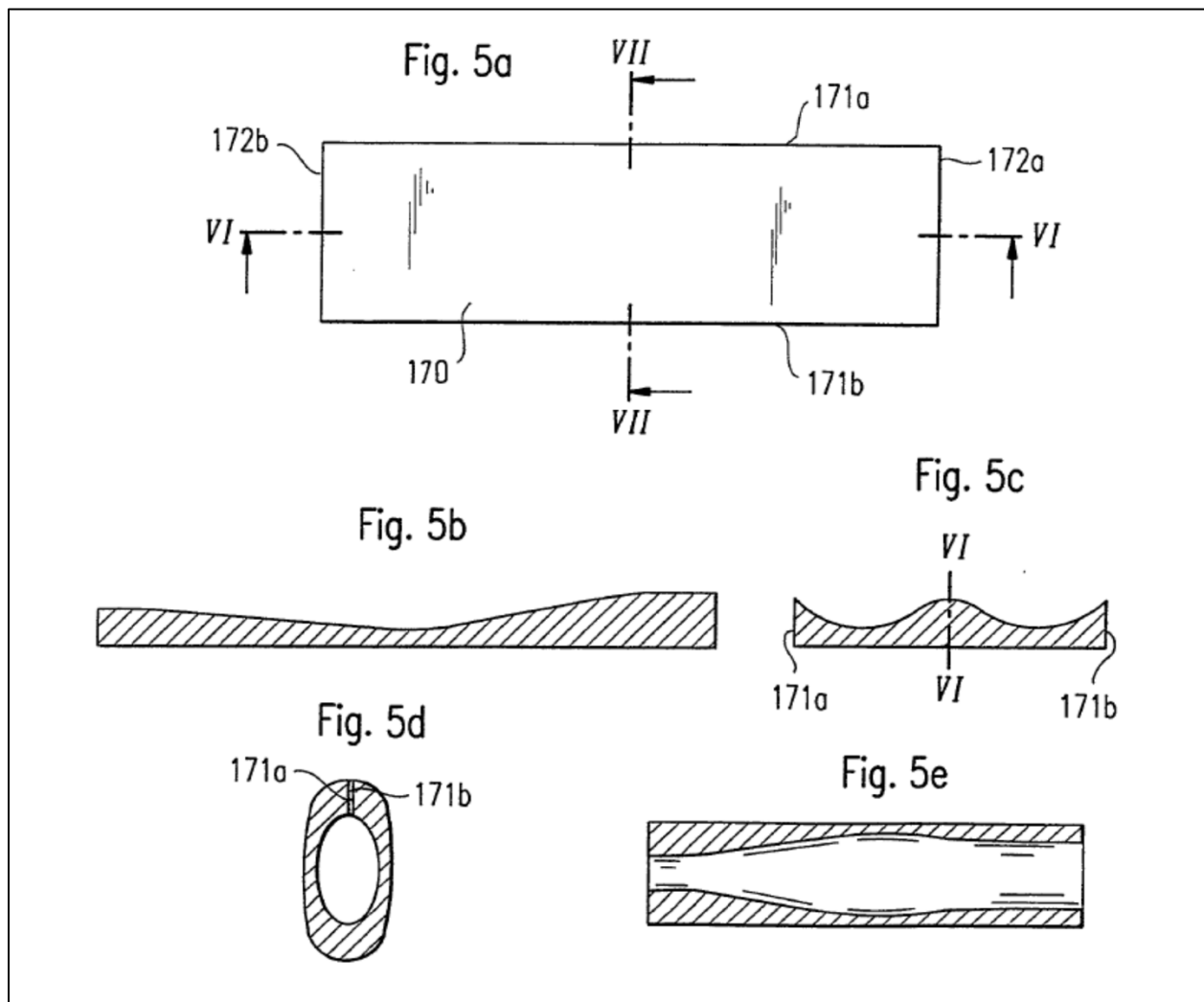
maximum thickness of the steerer tube are in the plane of travel, because the loads or forces on the steerer tube are highest in the plane of travel. Denk, cols. 1-2.

47. With respect to the embodiment of Figure 1a, Denk further discloses that the elliptical inner cross-sectional contour 4 can continually transition into a circular cross-sectional contour in a certain area of the tube. Denk, col. 8. Accordingly, a POSITA would have understood that, in the embodiment shown in Figure 1a, the wall thickness of the tube varies along the length of the tube as the elliptical inner cross-sectional contour 4 gradually transitions into a circular inner cross-sectional contour (as illustrated by the red circle in the modified Figure 1a, below) per the requirements of strength and rigidity of the tube.



Denk, Fig. 1a (original) and Fig. 1a (modified).

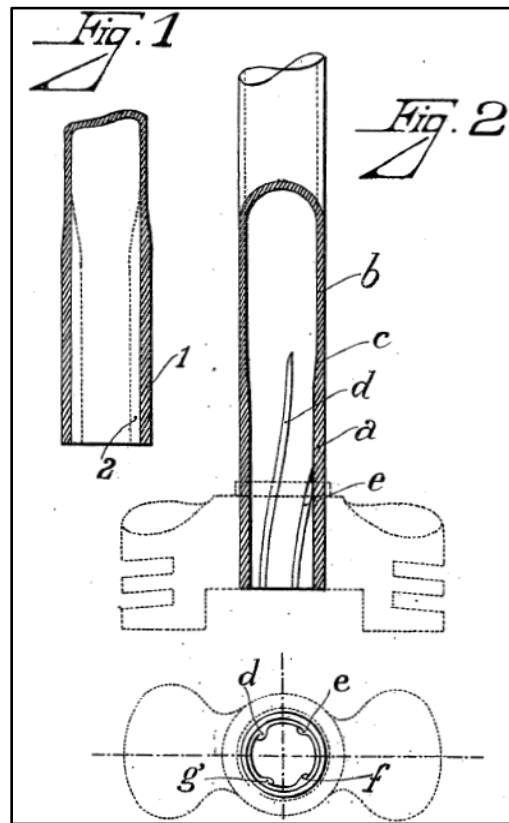
48. This is further seen in Figures 5a, 5b, 5c, and 5e, which imply to a POSITA that the inner cross-section may transition from an ellipse to a circle along the length of the tube, or it may be an ellipse of varying major and minor diameters along the length of the tube, according to the optimal structure required for the loads to be encountered by the bicycle. Indeed, an ellipse is the most general form of a circle, and a circle is just an ellipse with equal minor and major axes.



Denk, Figs. 5a-5e.

D. Valat (Ex. 1007)

49. Valat discloses a steerer tube for a bicycle. Valat, 1:44-54. As shown below, the steerer tube can have two alternative configurations, 1 and 2, and is mounted on a fork bridge. Valat, 1:58-63, Figs. 1-2. The steerer tube has a lower part *a* and an upper part *b*. Valat, 1:70-78, Fig. 2. Lower part *a*, where the loads are greatest, has a greater thickness than upper part *b*. Valat, 1:43-50, 1:70-78. In configuration 1, shown in Figure 1, the outer diameter of the steering tube wall in the lower part *a* is greater than the outer diameter in upper part *b*. In configuration 2, depicted in Figures 1 and 2, the inner diameter of the steering tube wall in the lower part *a* is smaller than the inner diameter in upper part *b*. Valat's steerer tube also includes interior reinforcements, such as parallel or helical ribs, that taper towards the change in the internal or external diameter of the tube, thereby providing wall thickness that varies over the cross-section in lower part *a* and along the tube length. Valat, 1:79-90, Figs. 2-5.

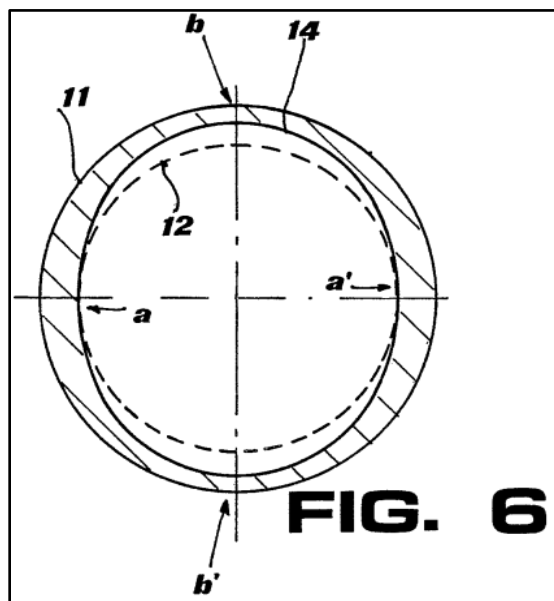


Valat, Figs. 1-2.

E. Campagnolo (Ex. 1009)

50. Campagnolo discloses a light and strong tube structure for bicycle frames. Campagnolo, Abstract, 2:32-3:4, 3:17-18, 7:29-32. Campagnolo discloses that the tube has a wall of variable thickness with the material concentrated in areas designed to undergo higher stresses and removed from the areas that are subject to lesser stresses. Campagnolo, 6:16-21. In one example, as shown below, the tube has a cross-section outwardly defined by a circle 11 and inwardly defined by an ellipse 14 such that the tube has a maximum thickness at areas *a* and *a'* and minimum thickness

at areas *b* and *b'*. Campagnolo, 7:2-6. Thus, the tube can withstand higher stress in areas *a* and *a'*. Campagnolo, 7:8-9. Campagnolo discloses that the tube should be mounted “with an accurate positioning, which should correspond to the real needs and should take into account the actual stresses involved and their possible variations.” Campagnolo, 7:29-8:3.



Campagnolo, FIG. 6.

51. Indeed, as stated by Campagnolo, the “tube” is a tube in a bicycle, and as such, a POSITA would have understood that Campagnolo’s tube may be used as a steerer tube, and that the optimization described below may be applied to a steerer tube as well as any other frame tube:

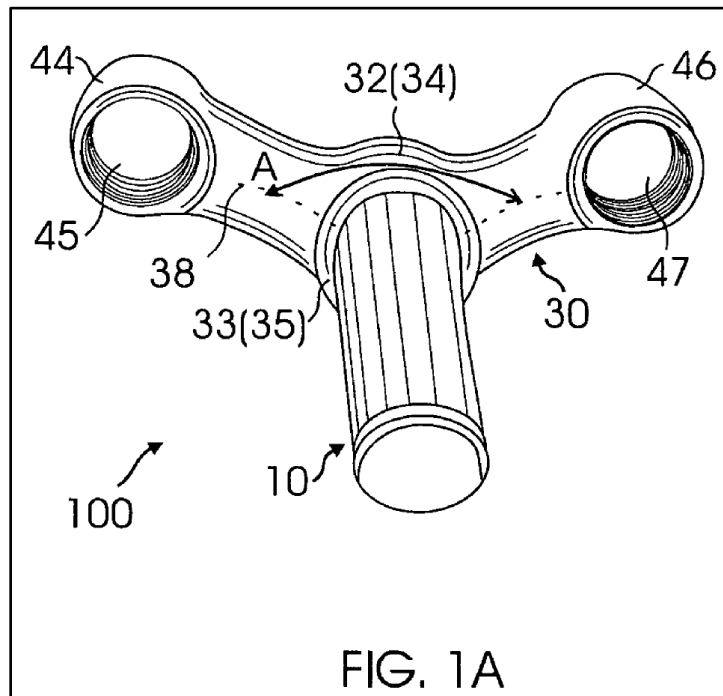
Figures 5 to 7 of the drawings show the straight cross-sections of some simplified structures of the tube

according to the invention. These structures comprise only the essential characteristic of the invention, that is, having the wall of variable thickness, with the material concentrated in the areas designed to undergo higher stresses and removed from the areas less subject to stresses, such structures being thus formed of a simple metallic tube, without any lining.

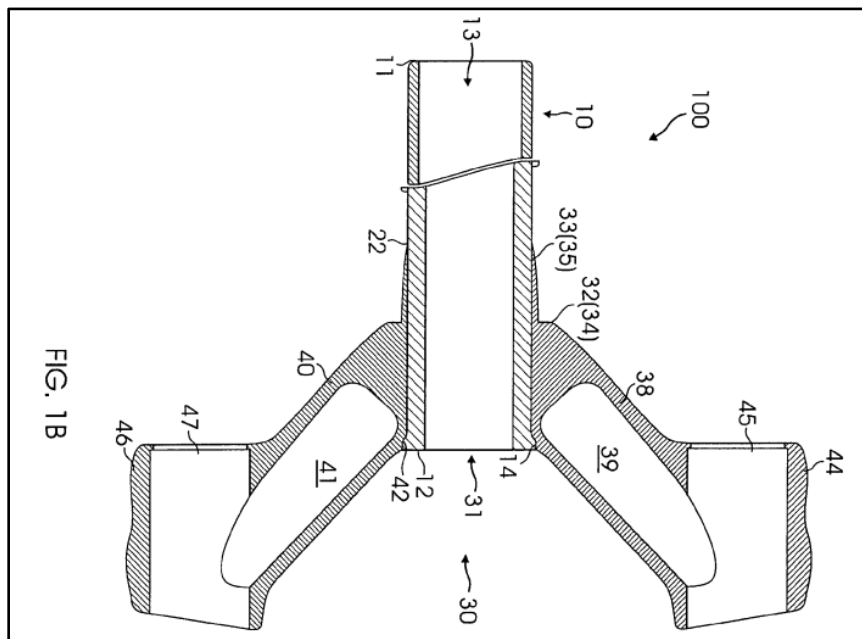
Campagnolo, 6:14-21.

F. Schroeder (Ex. 1010)

52. Schroeder discloses a molded assembly having a steerer tube 10 connected to a crown 30 of a bicycle fork, as shown below. Schroeder, 4:8-12, 6:1-4, FIGS. 1A-2. The steerer tube is initially formed of uncured resin blended with carbon fiber composites, and the crown is made of aluminum, copper, magnesium, or titanium to improve durability and shock absorption capabilities. Schroeder, 4:19-26, 4:48-53, 5:21-25, 5:63-67, 7:20-44, 8:8-17, 9:39-49. The bicycle fork has improved durability and shock adsorption after the steerer tube is heat cured and bonded to the crown. Schroeder, 4:34-39, 4:48-53, 4:62-67, 7:20-30.

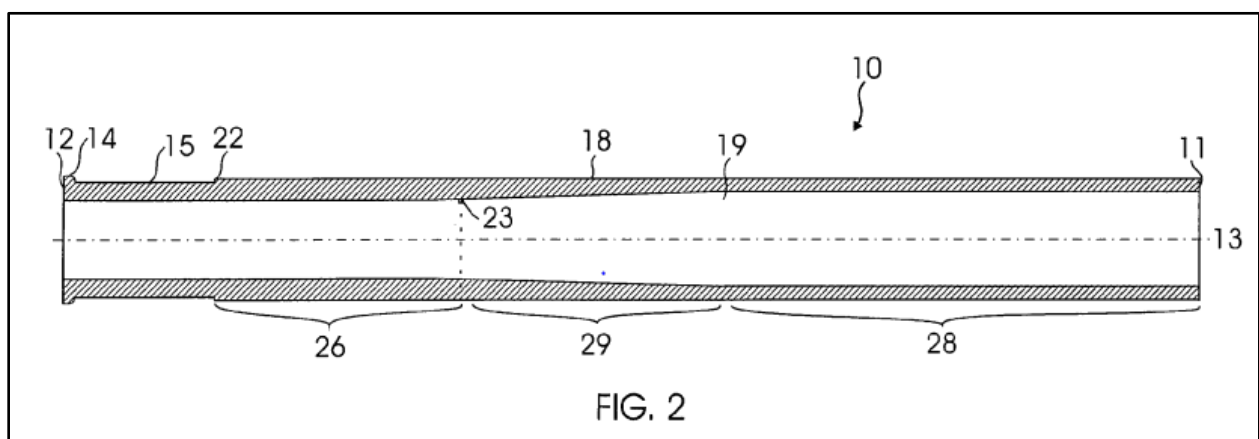


Schroeder, FIG. 1A.



Schroeder, FIG. 1B.

53. As shown below, Schroeder's steerer tube 10 includes a first proximal end 11, a second distal end 12, and a central bore 13. Schroeder, 6:5-9, FIGS. 1B-2. Steerer tube 10 has a thick tube wall section 26 from second distal end 12 to a location 23 of the tube, a thin tube wall section 28 extending from first proximal end 11 to another location 19, and a section 29 between the positions 19 and 23 where the tube wall thickness gradually decreases from position 23 to 19. Schroeder, 6:15-21, FIG. 2. A POSITA would have understood that thin tube wall section 28 would form an "upper section," and thick tube wall section 26 and section 29 would collectively form a "lower section," when the steerer tube is mounted on a bicycle frame in a conventional manner, as taught by Moechnig and the AAPA. Schroeder further discloses that a steerer tube designed in accordance with this configuration has the advantage of reduced weight and improved mechanical strength. Schroeder, 6:16-26.



Schroeder, FIG. 2.

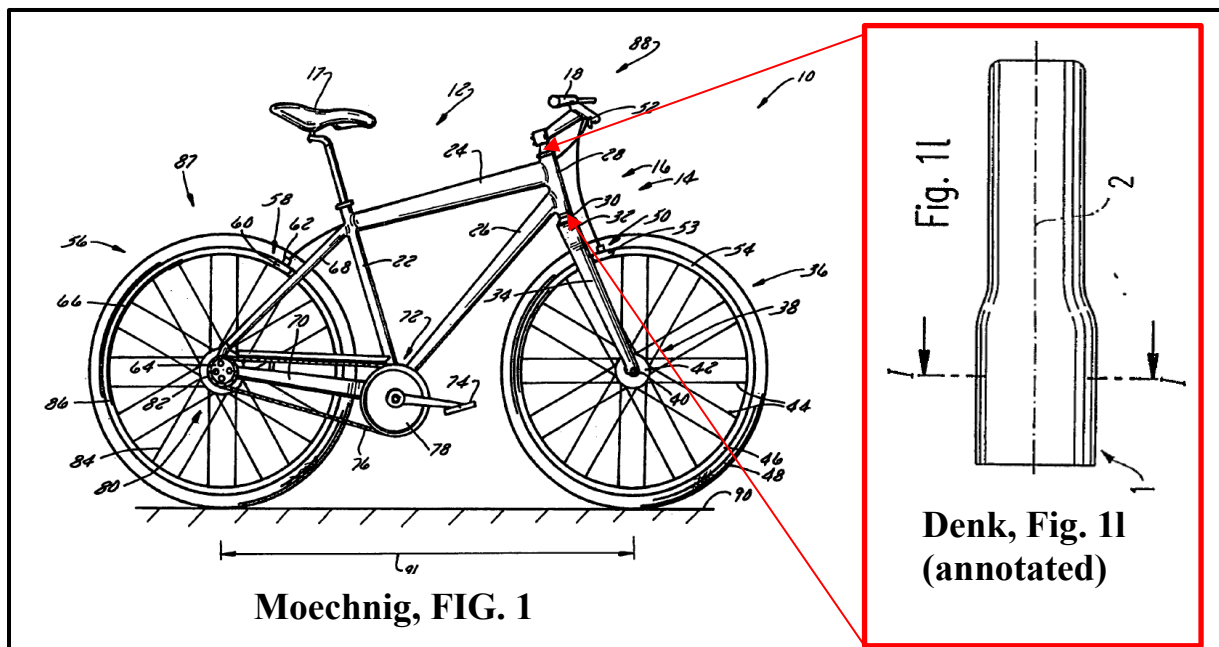
54. As discussed above, Moechnig, Denk, Valat, Campagnolo, and Schroeder are in the same field of bicycle frames and steerer tube configurations. These references are therefore analogous art to the '993 patent.

IX. DENK-BASED GROUNDS

A. [Ground 1] Claims 1-4, 6, 8, 10, 12, 14-18, 20, 22, 24, 26-29, 33-38, 40, 42, 44, 46-49, 53, and 56-63 Are Rendered Obvious by Denk in View of Moechnig

1. A POSITA would have been motivated to combine Denk and Moechnig, and would have reasonably expected success in doing so

55. A POSITA would have found it obvious to use Denk's lightweight tubular component as a bicycle steerer tube and would have mounted it in a conventional manner, i.e., connect it to the handlebar on the upper end and with the fork crown on the lower end, as disclosed in Moechnig and shown in the figure below.



56. Denk discloses that the lightweight component is **suitable for all tubular components of a bicycle frame**, including a top tube, down tube, seat tube, head tube, fork tubes, rear wheel stay, seat posts, handlebars, handlebar stem, and the like. Denk, Abstract, cols. 1, 4. A POSITA would have known that a bicycle steerer tube is a tubular component similar to the exemplary tubular components listed in Denk (*see also* Valat, Figs. 1-2; Moechnig, FIGS. 2-6; Schroeder, FIGS. 1A-2), and that Denk's tubular component, which is designed to be lightweight and has improved force absorption capability, would have been a suitable and obvious option for a bicycle steerer tube.

57. A POSITA would also have used Denk's lightweight component as a bicycle steerer tube to have the advantages of improved mechanical strength and reduced weight expressly disclosed in Denk and known in the prior art, such as Moechnig. Denk, cols. 1-2; Moechnig, [0001], [0009], [0049]; *see also* Valat, 1:10-14; Schroeder, 6:22-26. A POSITA would have known that for most bicycles, from road bikes to mountain bikes, lower weight of the bicycle frame is desirable to improve performance. Denk further discloses that bicycle frames, such as those of mountain bikes, also need to have high strength and rigidity, particularly in the vertical plane of the frame where high loads occur during use to prevent undesirable bending or fracturing of the steerer tube during rides. *See* Denk, cols. 1-2. A significant

advantage of Denk's lightweight component is that the wall thickness over a cross-section is adapted to meet the requirements of strength and rigidity such that "for the same overall strength and rigidity, the weight may be reduced, or for the same weight, the strength and rigidity may be significantly increased in the load direction specified by the design." Denk, col. 2.

58. A POSITA would have known how to use Denk's lightweight tubular component as a steerer tube for a bicycle. Mounting a steerer tube on a bicycle frame by connecting it to the handlebar and fork crown, such that a rider can steer the bicycle by manipulating the handlebar, would have been well known for a POSITA at the time of the purported invention. Indeed, the '993 patent admits in the Background section that, in a conventional bicycle, the steerer tube is affixed to the fork crown at its lower end and the handlebar at its upper end to permit the rider to steer the bicycle as desired. Ex. 1001, 1:19-33.

59. In one example, Denk discloses that the outer cross-sectional contour of the tube is cylindrical throughout the length of the tube, as shown in Figure 2a. *See* Denk, col. 8, Fig. 2a. In another example, Denk discloses that the elongated tube has two cylindrical sections of different outer diameters that are joined by a tapering intermediate section. *See* Denk, Fig. 11. A POSITA would have understood that both configurations would have been suitable for a steerer tube, as known in the prior art.

See Valat, Fig. 1; Schroeder, FIGS. 1A-2; Moechnig, FIGS. 2-3. A POSITA would have found it obvious to consider Denk's elongated tube as shown in Figure 11 as a bicycle steerer tube because it allows for added reinforcement, such as a thicker wall, in the lower section, which is generally subjected to more loads or stresses during a ride due to its connection to the fork crown, such as by welding or clamping. *See* Valat, 1:44-51; *see also* Denk, col. 3.

60. A POSITA would have expected success in using Denk's lightweight tubular component as a steerer tube because mounting Denk's lightweight component on a bicycle frame in a conventional manner, as disclosed in Moechnig and the AAPA, would have required nothing more than the application of ordinary skill and basic knowledge of bicycle hardware. For instance, a POSITA would have known to (1) position the areas of maximum cross-sectional thickness of the steerer tube in the vertical plane of the bicycle frame, i.e., the plane of travel of the bicycle (*see* discussion below in claim term 1[d], Section IX.A.2.e), as disclosed in Denk; and (2) affix the upper end of the steerer tube to a handlebar or handlebar stem and affix the lower end of the steer tube to a fork crown by a nut (as taught by the AAPA), by welding, soldering, bonding, or clamping (as taught by Denk at col. 3), by molding (as taught by Schroeder in its Title, Abstract), or with mating securing structures, such as geometric or threaded connections (as taught by Moechnig at

[0002])). Using Denk's lightweight tubular component as a steerer tube in a bicycle frame as disclosed in Moechnig would have been a combination of known prior art elements according to their established functions, and the combination would have yielded the expected, predictable result of a bicycle with a lightweight steerer tube that has improved strength and rigidity properties in the plane of travel of the bicycle.

61. As defined above, a POSITA would have taken engineering classes that would have included the design of mechanical structures, and such a class would also typically include teaching students about the use of handbooks and references that contain useful formulas. Thus, a POSITA would have known how to combine Denk's lightweight tube as a steerer tube in Moechnig's bicycle frame using simple engineering principles and knowledge of bicycle structures.

2. Claim 1

62. Denk in view of Moechnig renders claim 1 obvious.

a. 1[pre]: "A steerer tube for a bicycle, the steerer tube comprising:"

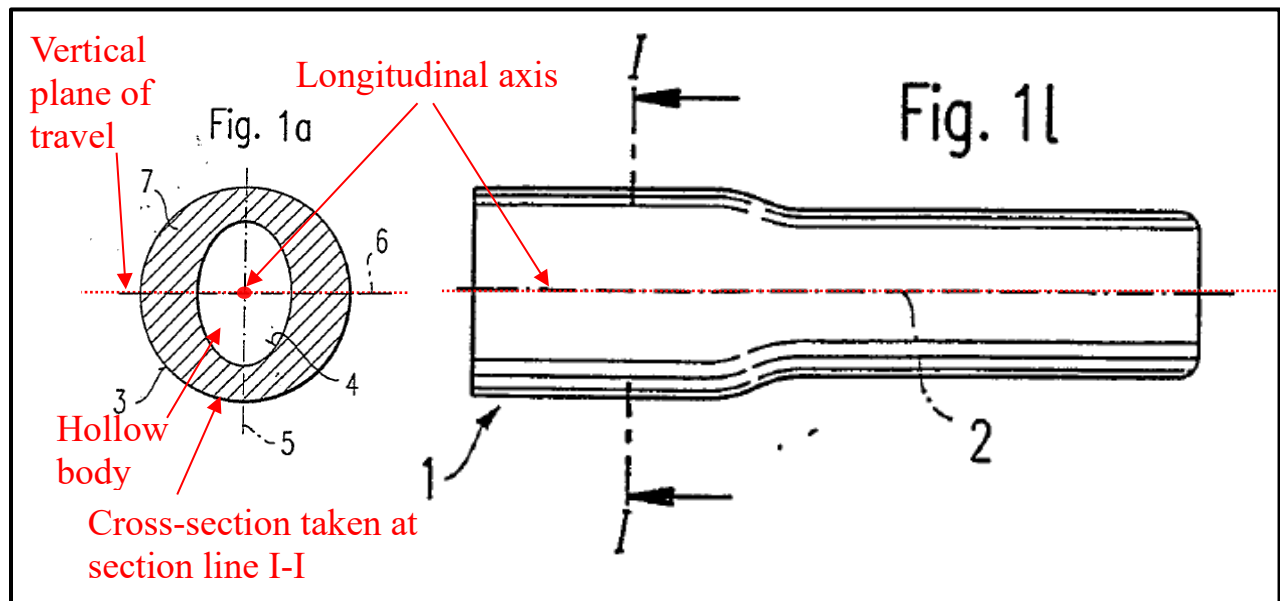
63. Denk discloses that its lightweight tubular component is suitable for all tubular components of a bicycle frame. Denk, Abstract, cols. 1, 4. Accordingly, a POSITA would have found it obvious to use Denk's lightweight tubular component as a bicycle steerer tube because it would have the known advantages of reduced weight and improved mechanical strength, and particularly improved strength and

rigidity in the plane of travel of the bicycle where high loads occur during use. Denk, cols. 1-2; *see also* Valat, 1:10-14; Schroeder, 6:22-26.

64. Moechnig also discloses a lightweight steerer tube for a bicycle. Moechnig, Title, Abstract, [0001], [0009], [0049].

b. 1[a]: “an elongate hollow body arranged around a steering axis located in a vertical plane of travel of the bicycle”

65. As shown below, Denk discloses that the lightweight component has “an essentially tubular body with a defined outer cross-sectional contour and a defined inner cross-sectional contour.” Denk, Abstract. The lightweight component is an elongated tube 1 extending symmetrically with respect to a straight center line 2. Denk, col. 5, Fig. 11. A cross-section of the tube has a circular outer cross-sectional contour 3 and an elliptical inner cross-sectional contour 4 arranged symmetrically with respect to a center line or center plane 5. Denk, col. 6, Fig. 1a.



Denk, Figs. 1a, 1l (annotations added).

66. A POSITA would have understood that Denk's tubular component has "an elongate hollow body" because it is "an elongated tube" and the tube structure has a hollow core. Denk, col. 5, Figs. 1a and 1l. A POSITA would have understood that Denk's "elongate hollow body" is arranged around a longitudinal axis because it "extends symmetrically with respect to a straight center line 2." Denk, col. 5, Fig. 1l. When Denk's tubular component is mounted on a bicycle as a steerer tube as taught by Moechnig, the longitudinal axis ("center line 2") of the tube would be "a steering axis" because the longitudinal axis of a steerer tube is the axis about which the front wheel rotates to change travel direction and thereby steer the bicycle.

67. A POSITA would also have understood that the steering axis is "in a vertical plane of travel of the bicycle" because the vertical plane of travel of the bicycle is

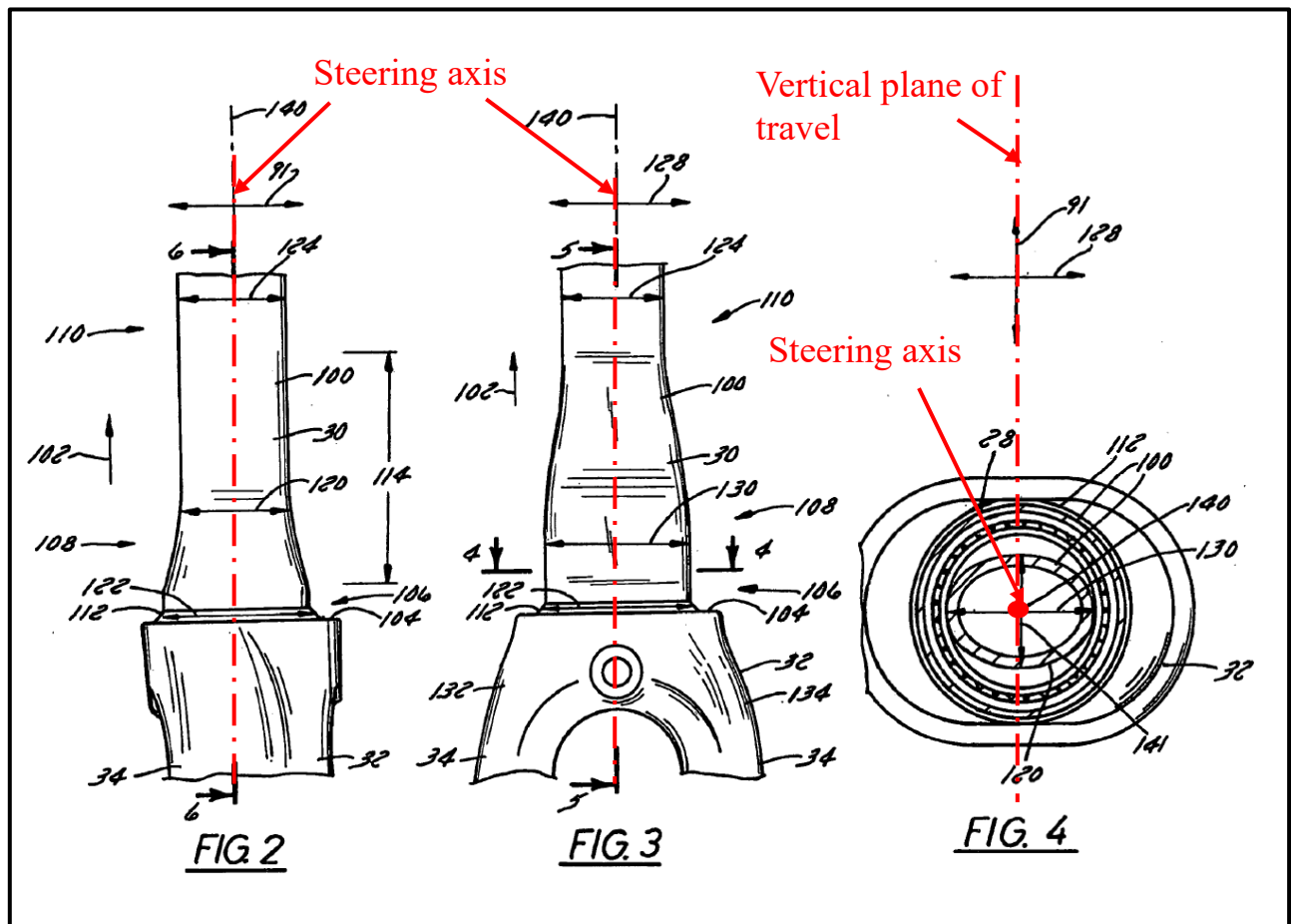
aligned with the fore-aft travel direction of the bicycle, and pivoting the front wheel about the steering axis in the vertical plane of travel would steer the front wheel out of the vertical plane of travel. *See also* AAPA.

68. Further, when implementing Denk's tube as a steerer tube, a POSITA would have found it obvious to arrange the "elongate hollow body" of Denk's tube "around a steering axis located in a vertical plane of travel of the bicycle," as disclosed in Moechnig. Indeed, Moechnig discloses a steerer tube having an elongate body arranged around a steering axis (longitudinal axis 140) located in a vertical plane of travel of the bicycle. Moechnig, FIGS. 2 and 3 (showing steerer tube 30 having an elongate body 110 arranged around longitudinal axis 140), [0035] ("Radially asymmetric portion 114 tapers inward relative **to a longitudinal axis 140**, indicated by the intersection of longitudinal and lateral diameters 120, 130 as shown in FIG. 4, of body 100 as it extends from lower radial portion 106 toward upper radial portion 110." (emphasis added)).

69. Moechnig also discloses that body 100 may be hollow. Moechnig, FIG. 4 (showing body 100 being hollow), [0045] ("Steerer tube 30 includes **an optional cavity 206 formed in body 100. Optional cavity 206 can extend a majority of the length of steerer tube 30 and provides a lighter steerer assembly 16.** Such a construction forms a steerer tube wall 208 that has a thickness that is selected to

withstand the loaded interaction between steerer tube 30 and head tube 28.”
(emphasis added)).

70. As shown below, Moechnig discloses a longitudinal direction or axis 91 of the bicycle frame that is aligned with “a vertical plane of travel of the bicycle.” Moechnig, [0005], [0032]. A POSITA would have understood that the vertical plane, as shown in Moechnig’s Figure 1, is aligned with the fore-aft direction of travel and that longitudinal axis 91 of the bicycle frame would be in “a vertical plane of travel of the bicycle,” similar to the plane of travel disclosed in the ’993 patent. *See also* AAPA (’993 patent), FIG. 1.



Moechnig, FIGS. 2-4 (annotations added).

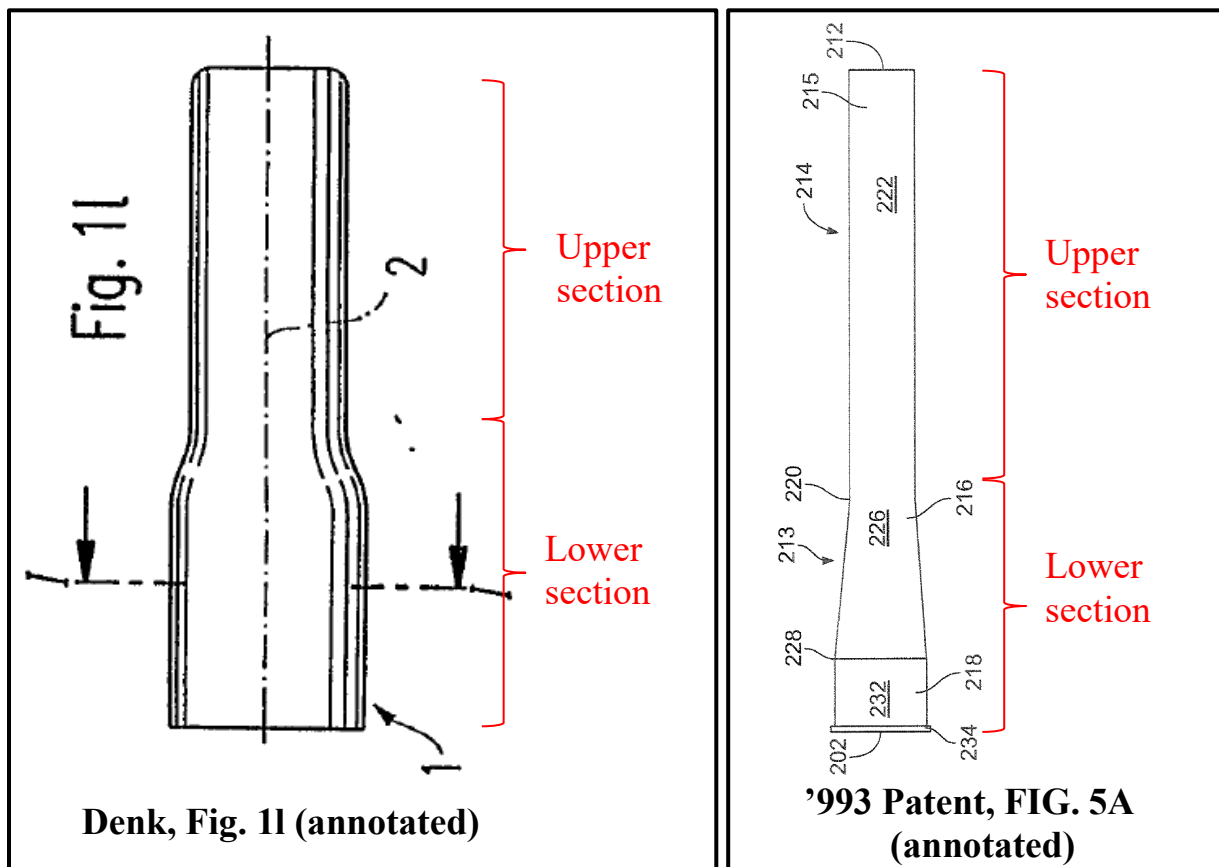
71. A POSITA would have further understood that Moechnig's longitudinal axis 140 is "a steering axis" because the steerer tube rotates about it to effectuate turning, and that Moechnig's longitudinal axis 140 is located in a vertical plane of travel of the bicycle. Moechnig, FIG. 1.

72. When Denk's tube is mounted on a bicycle frame as a steerer tube based on the teachings of Moechnig, the steerer tube would be arranged around a steering axis

in a vertical plane of travel of the bicycle, which was conventional and known at the time of the purported claimed invention. *See* AAPA.

- c. **1[b]: “the body having upper and lower sections, a segment of the upper section adapted to be joined to a bicycle handlebar, a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle, the lower section joined to the upper section”**

73. The body of Denk tubular component 1, when implemented as a steerer tube in view of Moechnig, has two sections joined to each other over a tapering area, like the body of the steerer tube of the '993 patent, as shown below.



74. A POSITA would have understood that when Denk's tube is mounted on a bicycle as a steerer tube, the elongate tubular body would extend in a substantially vertical direction such that one of the two sections would be an upper section and the other would be a lower section. *See* Moechnig, FIG. 3; AAPA.

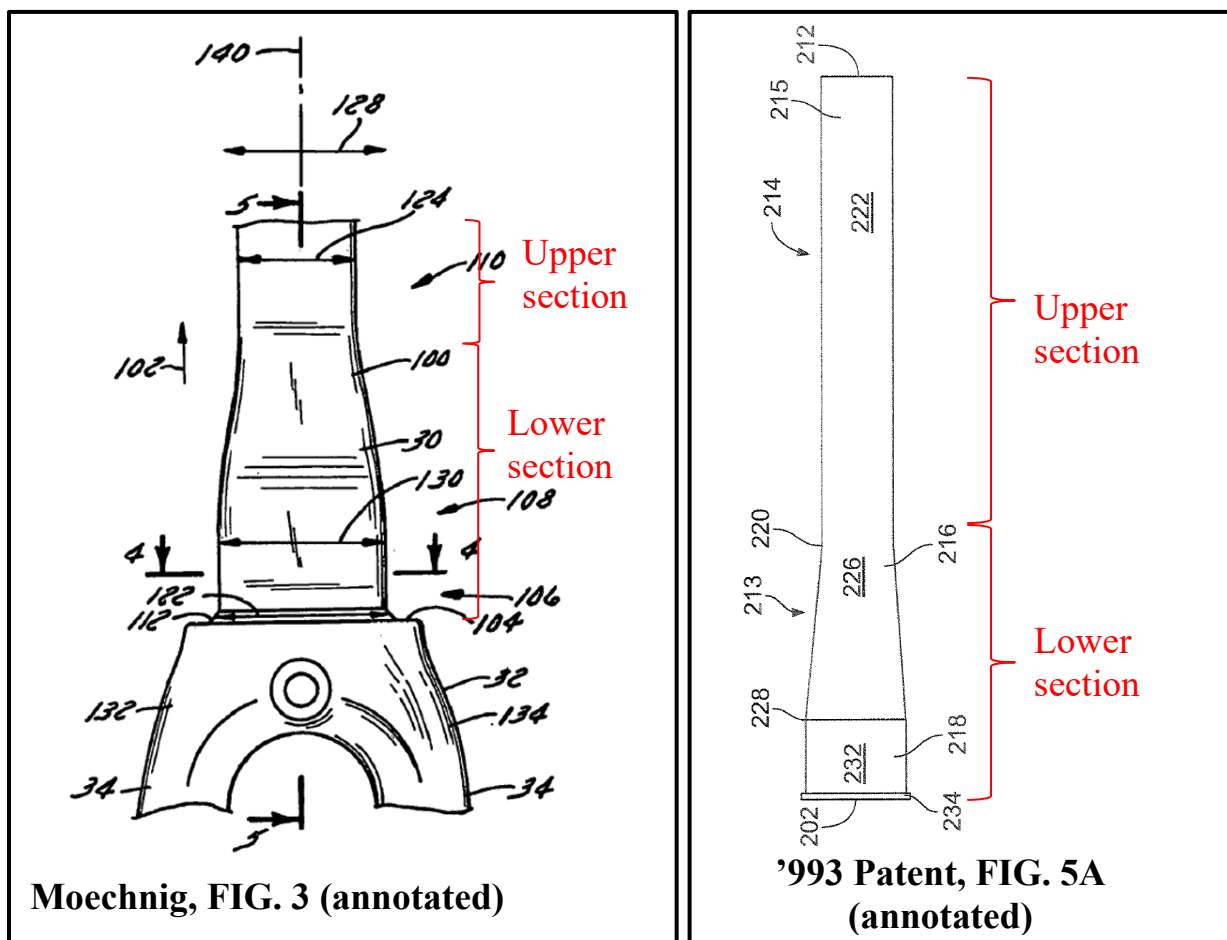
75. A POSITA would have found it obvious that the section of Denk's tube having the larger outer contour would have been the lower section because the larger outer contour allows for additional reinforcement, such as a thicker wall, in the lower section, which is subjected to more loads or stresses. *See* Valat, 1:44-51; Denk, col.

3. A POSITA would have understood that having an upper section with thinner wall and a lower section with thicker wall would advantageously improve the mechanical strength of the steerer tube in the lower section, while reducing overall weight of the tube. Schroeder, 6:16-26, FIGS. 1B-2. *See also* my force diagram and the calculations that a POSITA would do at ¶132 of this Declaration.

76. Although Denk does not explicitly disclose that a segment of the upper section of the tube is adapted to be joined to a bicycle handlebar and a segment of the lower section is adapted to be joined to a crown of a front wheel fork, a POSITA would have understood that when Denk's tube is implemented as a steerer tube in view of Moechnig, the top end of the upper section of Denk's tube would have been joined to a handlebar, and a lower end of the lower section of the tube would have been

joined to the crown of a fork, such that manipulation of the handlebar would allow for steering of the front wheel of the bicycle. *See* AAPA.

77. Indeed, Moechnig discloses a steerer tube 30 having a body 100, which includes a first or lower radial portion 106 and a radial asymmetric portion 108, which collectively form a “lower section.” Moechnig, [0035]. The “lower section” is joined to a second or upper radial portion 110 (“upper section”), as shown below. Moechnig, [0035], FIGS. 2, 3.



78. Moechnig discloses that “a segment of the upper section” of steerer tube body 100 is adapted to be joined to a bicycle handlebar because the stem of Moechnig’s handlebar 18 engages with steerer tube 30. Moechnig, [0001], [0026], FIG. 1.

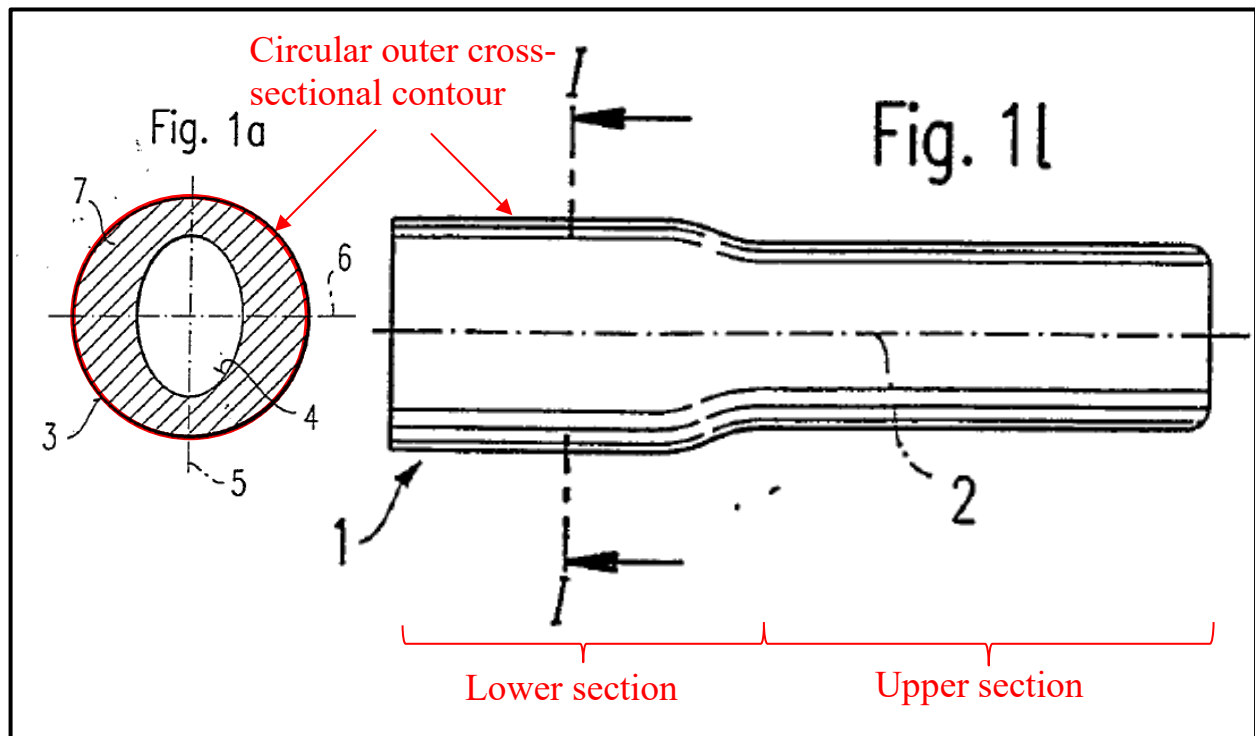
79. Moechnig further discloses that “a segment of the lower section” of the steerer tube body 100 is adapted to be joined to a crown of a front fork of the bicycle because Moechnig discloses that the steerer tube may be secured to or formed integrally with fork crown 32. Moechnig, [0002], [0027], FIGS. 1-3. Fork crown 32 is “a crown of a front wheel fork of the bicycle” because fork legs 34 extend from opposite sides of the fork crown and support a front wheel assembly 36 of the bicycle. Moechnig, [0002], [0026]-[0028].

80. Based on Moechnig’s teaching, a POSITA would have understood that Denk’s tube body, when mounted on a bicycle frame as a steerer tube, would have “a segment of the upper section adapted to be joined to a bicycle handlebar” and “a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle,” which was conventional and known at the time of the purported invention. *See* AAPA.

d. 1[c]: “outer surfaces of the upper and lower sections of the body being circular in cross section”

81. Denk’s tubular component has a circular outer cross-sectional contour 3 throughout the length of the tube and an elliptical inner cross-sectional contour 4 in

the lower section, as shown below. Denk, col. 6, Fig. 1a. Denk also discloses that a circular outer cross-sectional contour is preferred for visual and technical reasons and that the wall thickness distribution is defined by the inner cross-sectional contour. Denk, col. 3 (“The invention may be implemented using different cross-sectional shapes of the outer cross section and of the inner cross section. **A circular ring-shaped outer cross-sectional contour is to be preferred for visual and possibly also technical reasons, resulting in a lightweight component in which the different wall thickness distribution is defined by the inner cross-sectional contour.** Since for such a tube the distribution of the wall cross section is not visible from the outside, markings or the like are preferably applied here during manufacture to ensure the correct installation position of the tube.” (emphasis added)).

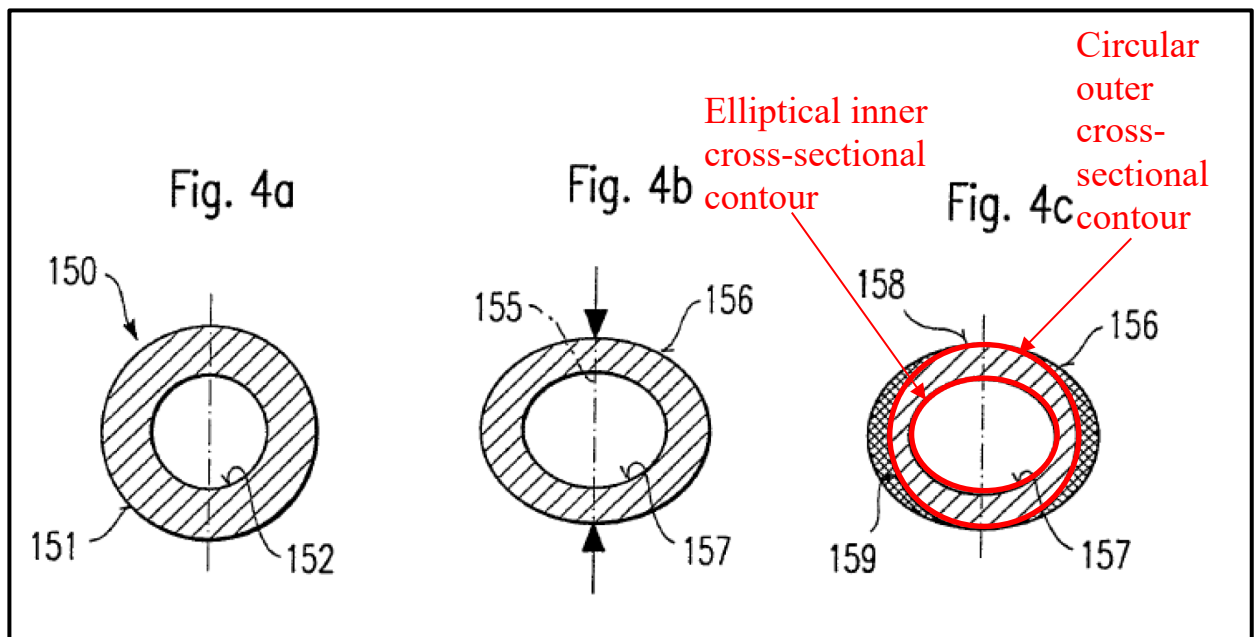


Denk, Figs. 1a, 1l (annotations added).

82. Based on Denk's express disclosure, a POSITA would have understood that the outer surface of Denk's elongated tubular body is circular in cross-section in both the upper and lower sections. *See* Denk, col. 3. Although Denk only shows a cross-section at section line I-I in the lower section of the embodiment shown in Figure 1l, a POSITA would have understood that the outer surface of the upper section would also be circular in cross-section because a circular outer cross-sectional contour is preferred for visual and technical reasons. Denk, col. 3.

83. Denk further discloses how to shape a circular outer cross-sectional contour during a machining process. Denk, cols. 10, 13. As shown below, Denk discloses

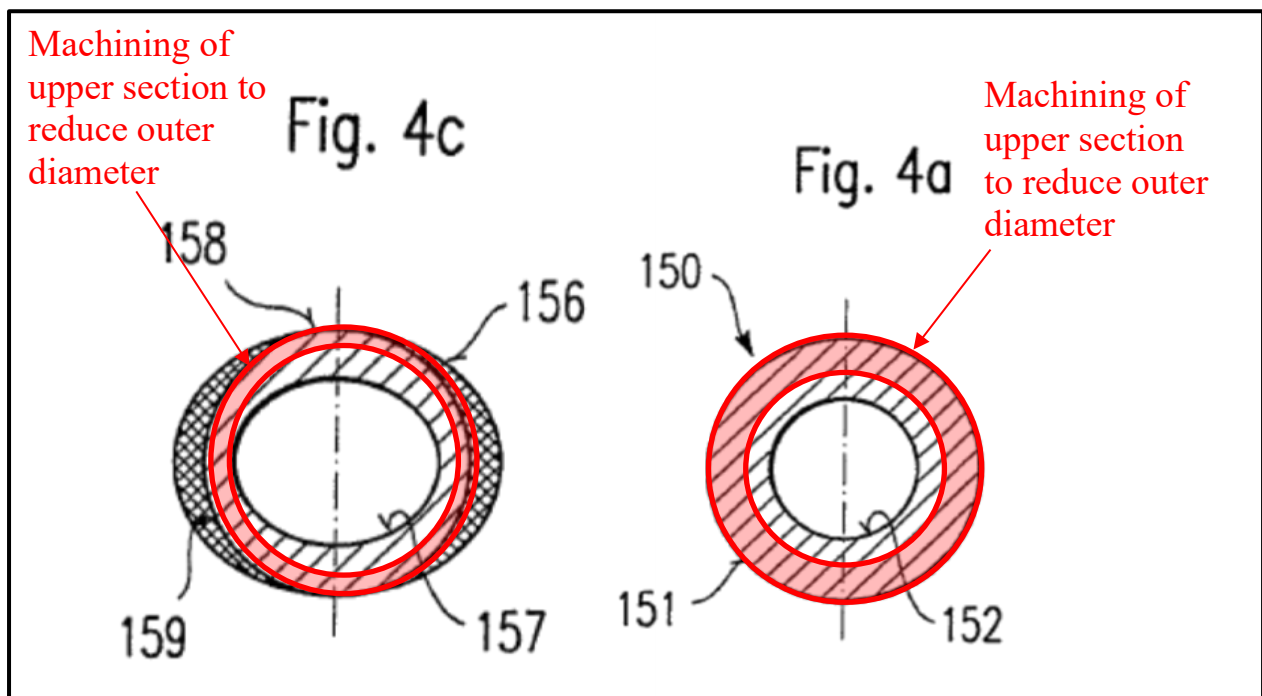
starting with a tube 150 that is cylindrical overall and has a circular outer cross-sectional contour 151 and a circular inner cross-sectional contour 152. Denk, cols. 9, 13, Fig. 4a. In a first step, the tube is pressed to form an elliptical outer cross-sectional contour 156 and an elliptical inner cross-sectional contour 157. Denk, col. 9, 13, Fig. 4b. Outer cross-sectional contour 156 is subsequently shaped into a circular outer cross-sectional contour 158 using a machining process while elliptical inner cross-sectional contour 157 is retained. Denk, cols. 9, 13, Fig. 4c.



Denk, Figs. 4a-4c (annotations added).

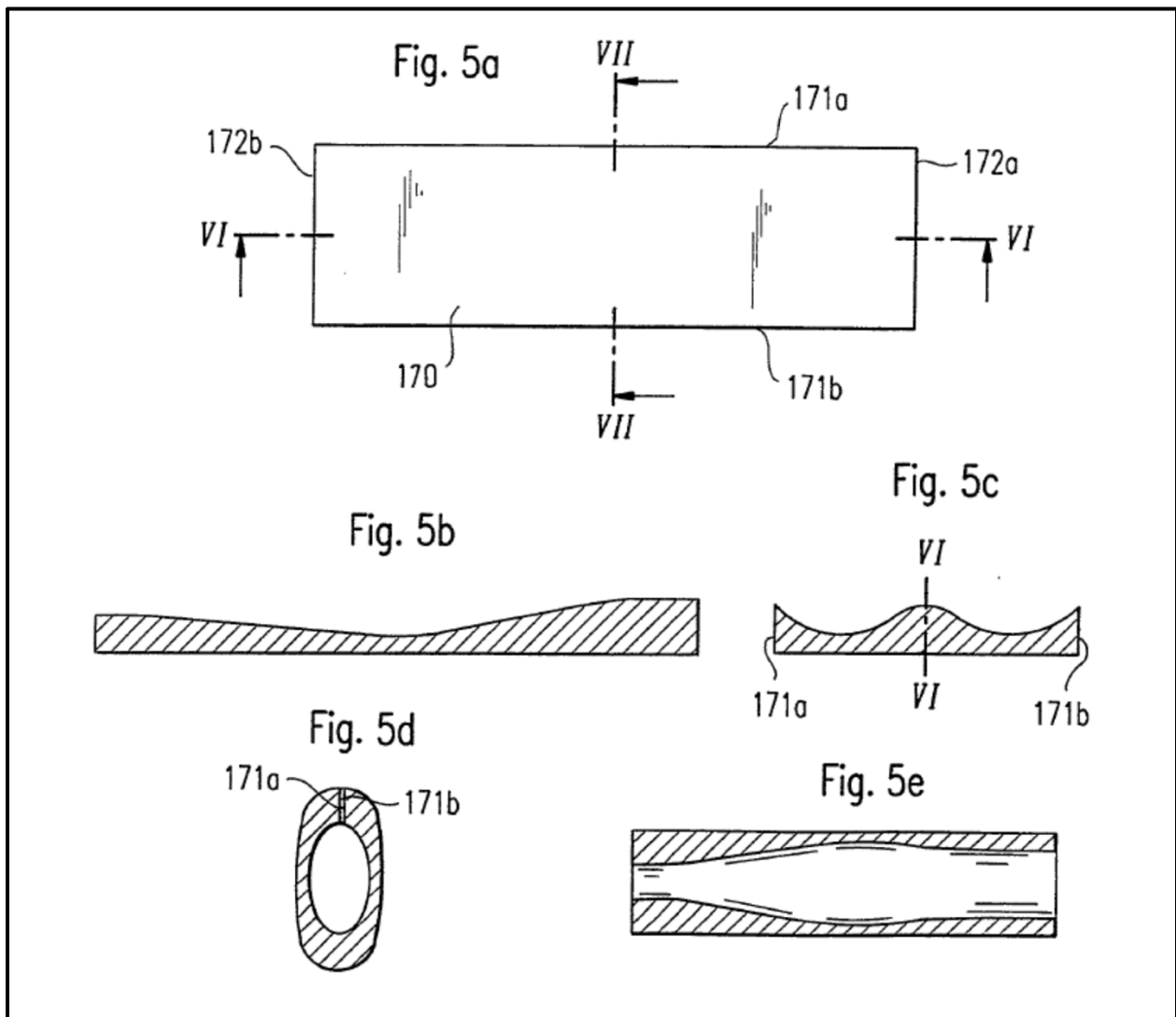
84. While Denk shows that the outer diameter of the upper section is smaller than the outer diameter of the lower section (Denk, Fig. 11), Denk does not expressly disclose how to shape the upper section to have a smaller outer diameter. But a POSITA would have understood how to shape the two sections to have two different

outer diameters using ordinary skill and known methods. For instance, as shown in the annotated Figure 4c below, the outer surface of the upper section could have been further machined to reduce its outer circular diameter. Alternatively, as shown in the annotated Figure 4a below, the upper section of the original tube could have been left unpressed and then machined to have a smaller circular outer diameter than the circular outer diameter of the lower section. Denk also discloses other suitable methods for manufacturing the tube, such as casting, injection molding, and rolling, all of which would have been suitable for achieving the desired outer surface contour as shown in Fig. 11. Denk, cols. 4, 9-10.



Denk, Figs. 4c, 4a (annotations added).

85. This is further seen in Denk's Figures 5a, 5b, 5c, and 5e, which imply to a POSITA looking at the outer circular cross-section that the inner cross-section may also be a circle with varying diameter along the length of the tube, or it may be an ellipse with varying minor and major diameters at different cross-sections along the length of the tube. The diameters would have been designed according to the optimal structure determined by the designer for the loads to be encountered by the bicycle. Indeed, an ellipse is the most general form of a circle, and a circle is just an ellipse with equal minor and major axes.



Denk, Figs. 5a-e.

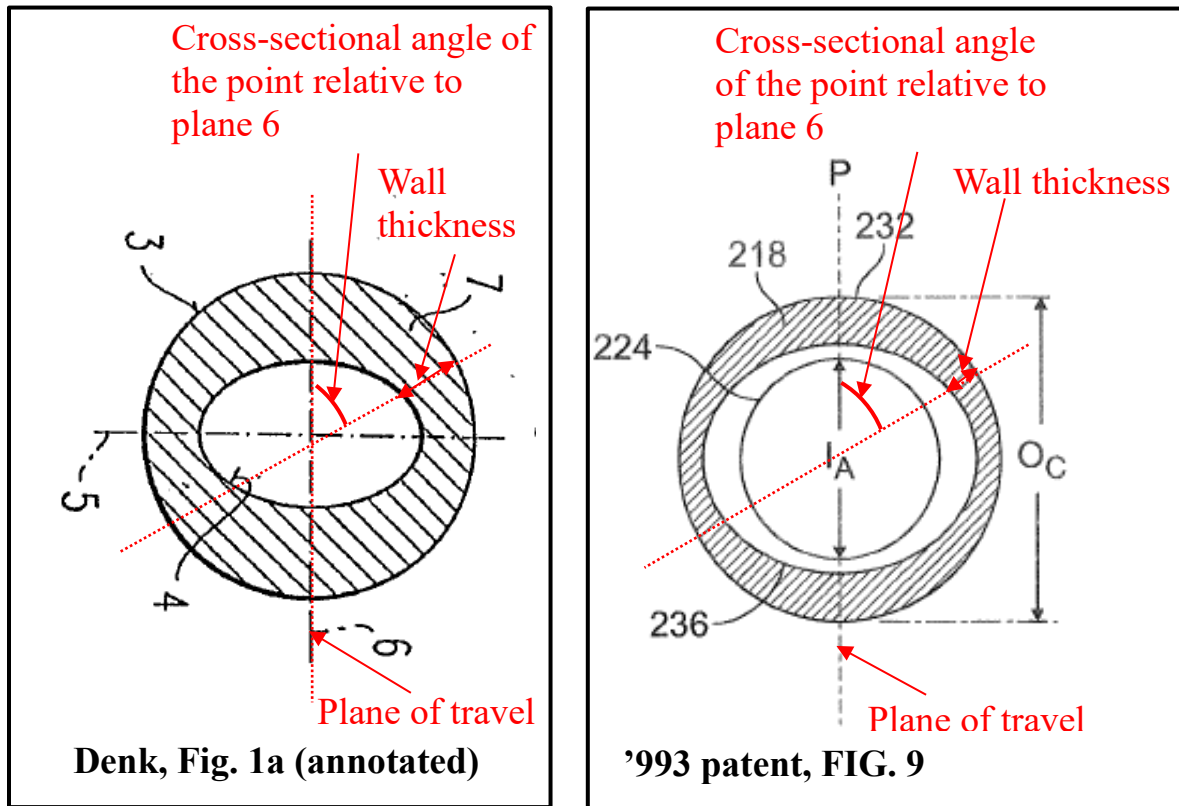
86. Indeed, Denk expressly discloses adapting the wall thickness of the tube body to the required strength and rigidity properties in the longitudinal direction. Denk, cols. 3, 9. A POSITA would have reduced the outer diameter of the upper section of the tube body, as shown in Denk's Figure 11, to reduce the wall thickness, and thereby to lower weight while meeting the strength and rigidity requirements of the

upper section. *See* Valat, 1:44-51, 1:70-78 (teaching that the lower end of the steerer tube bears greater loads than the upper end of the steerer tube and, thus, the lower end should have a greater wall thickness). A POSITA would have understood that such a design would provide a superior steerer tube that has improved mechanical strength and lower weight. *See* Schroeder, 6:16-26, FIGS. 1B-2.

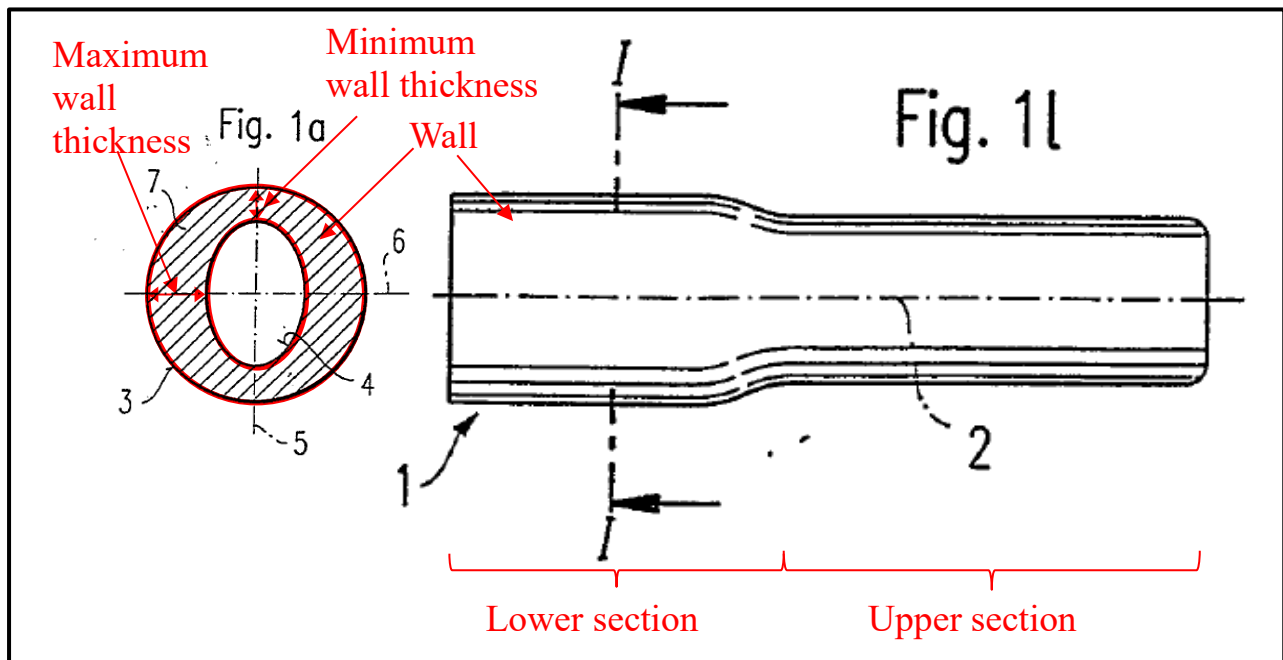
- e. **1[d]: “the body formed by a wall, a thickness of the wall at any point in the lower section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel, the wall thickness being at a maximum in the plane of travel of the bicycle.”**

87. Denk’s tubular body has a wall formed between the elliptical inner cross-sectional contour 4 and circular outer cross-sectional contour 3, resulting in the wall thickness over the cross-section being at a maximum in a plane 6 and a minimum in a plane 5 perpendicular to plane 6, as shown below. *See* Denk, col. 6, Figs. 1a, 11. Specifically, Denk teaches that an inner surface of the upper section may be circular in cross-section (as shown in Figure 1b), an inner surface of the lower section may be elliptical in cross-section (as shown in Figure 1a), and the elliptical inner contour of the lower section may transition gradually into the circular cross-section of the upper section. Denk, col. 8 (“Within the scope of the invention, it is likewise possible to change the cross-sectional shape along the tube length. For example, **the cross-sectional shape in one region of the tube may correspond to the cross-sectional**

shape according to Fig. 1a, and in one region may correspond to the cross-sectional shape according to Fig. 1b. In addition, in particular for the exemplary embodiments according to Fig. 1a it is possible for the elliptical inner cross-sectional contour to continually transition into a circular inner cross-sectional contour in a certain area of the tube, for example in a middle area or in an end area.” (emphasis added)), Figs. 1a and 1l (depicted below). Thus, in Denk’s tube having an elliptical inner cross-sectional contour in the lower section (as shown in Figure 1a), a POSITA would have understood that the wall thickness of the tubular body at any point in the lower section varies as a function of the cross-sectional angle of the point relative to plane 6, the maximum thickness being in plane 6.



88. A POSITA would also have understood the “lower section” of the Denk tube body to have varying wall thickness because Denk expressly discloses varying wall thickness in the cross-section along a section line I-I in the “lower section” of the tube body, as shown below:



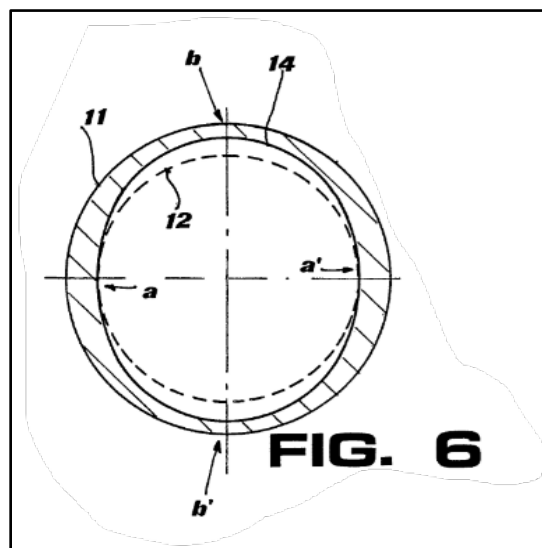
Denk, Figs. 1a, 1l (annotations added) (Fig. 1a shows cross-section taken at section line I-I (Denk cols. 5-6))

89. Denk discloses that the wall thickness “is not constant along its cross section, and the inner cross-sectional contour and the outer cross-sectional contour of the component are designed in such a way that the change in the wall thickness along the cross section takes place essentially continually.” Denk, Abstract, col. 8, Fig. 1a. Denk further discloses that the continuous change in the wall thickness should be adapted to meet the requirements of strength and rigidity while reducing weight. Denk, cols. 1-2, 9. Finally, Denk discloses that high loads occur in the vertical plane of a bicycle frame, and so force absorption capability of bicycle components should be greater in the vertical plane. Denk, col. 2. Accordingly, it would have been

obvious to a POSITA to align plane 6 of Denk's tube 1 with the plane of travel, i.e., put the areas of maximum wall thickness (resulting from the elliptical inner contour and circular outer contour) in the plane of travel of the bicycle because the loads on the steerer tube are maximum in the plane of travel, and to have the areas of minimum thickness orthogonal to the plane of travel to improve lightness of the steerer tube in areas of lesser loads. Indeed, Denk teaches that "the approach according to the invention has the significant advantage that the profile of the wall thickness over the cross section may be optimally adapted to the actual requirements with regard to strength and rigidity. **A consideration of the load on a bicycle frame, for example, shows that particularly high loads occur in the vertical plane of the frame, since the weight of the rider acts essentially in the vertical direction, and the impact loads acting on the front and rear wheel likewise essentially occur within a vertical plane. . . .** The design according to the invention now allows **the cross section of the tubular portion of the lightweight component to be designed in such a way that the force absorption capability of the components of a bicycle frame in the vertical frame direction is greater than in an arbitrary orientation perpendicular to this plane. As a result, for the same overall strength and rigidity, the weight may be reduced, or for the same weight, the**

strength and rigidity may be significantly increased in the load direction specified by the design.”). Denk, col. 2 (emphases added).

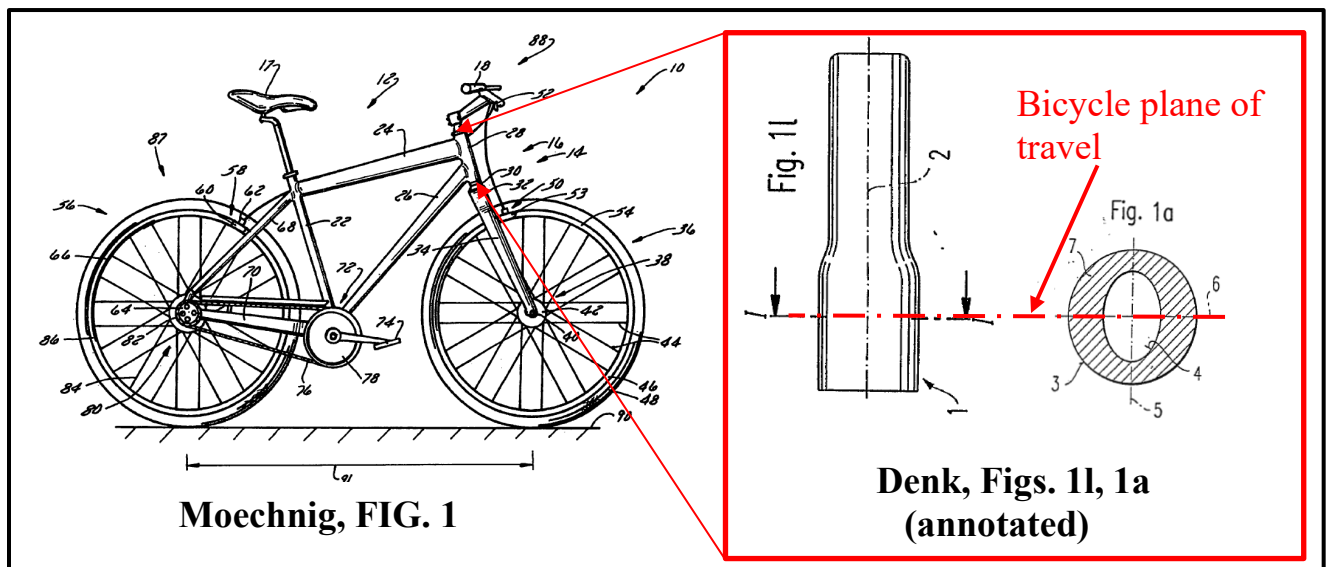
90. Moreover, it was well known to have bicycle frame elements, i.e., bicycle tube structures, of variable thickness walls to improve stiffness and strength while ensuring lightness. Campagnolo, 1:23-29, 2:32-3:7, 3:17-25. For example, Campagnolo teaches a bicycle tube having “two areas a and a' of maximum thickness and two areas b and b' of minimum thickness of the tube wall, these two areas being connected by arcs of an ellipse 14, centered within the circle 11 which outwardly defines the section. . . . It is evident that the structure will be apt to stand higher stresses in two areas a and a' positioned symmetrically.” Campagnolo, 7:2-9, FIG. 6 (depicted below).



Campagnolo, FIG. 6.

91. Thus, when mounting Denk's tubular component as a steerer tube, a POSITA would have known to place the areas of maximum wall thickness (resulting from the elliptical inner contour and circular outer contour) in the plane of travel of the bicycle, i.e., plane 6, because the loads on the steerer tube are maximum in the plane of travel, and to have the areas of minimum thickness in the plane orthogonal to the plane of travel (which experiences lesser loads) to improve lightness of the steerer tube in areas of lesser load. Denk, col. 2.

92. In sum, based on Denk's and Moechnig's teachings, a POSITA would have known to position the areas of maximum thickness of Denk's tube in the vertical plane of travel where the loads are highest, as illustrated below:



3. Claim 61

93. Denk in view of Moechnig renders claim 61 obvious.

- a. **61[pre]: “A steerer tube for a bicycle, the steerer tube comprising:”**

94. The preamble of claim 61 is identical to the preamble of claim 1. *See* discussion of 1[pre], above, at ¶¶63-64.

- b. **61[a]: “an elongate hollow body arranged around a steering axis located in a vertical plane of travel of the bicycle,”**

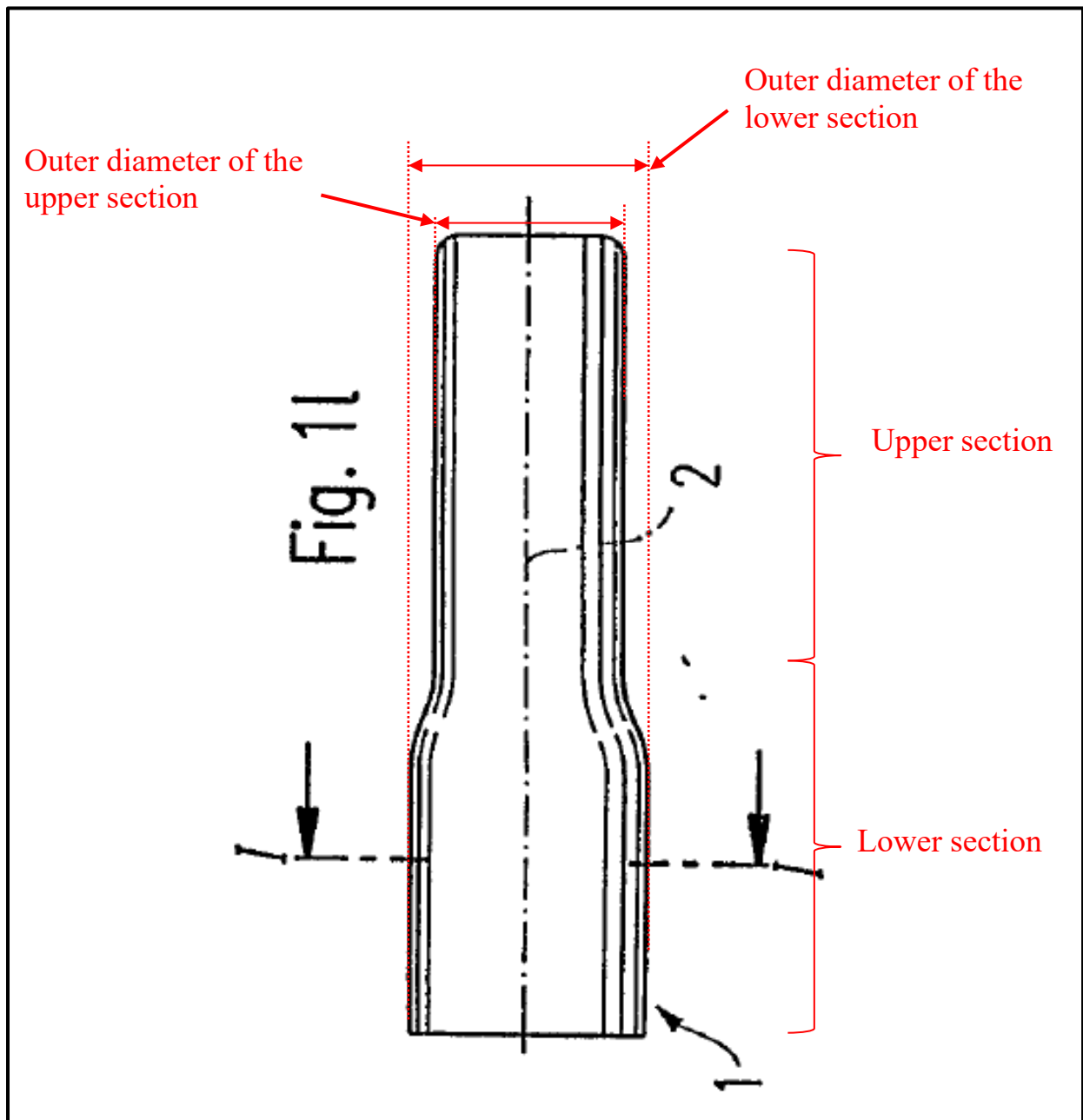
95. Claim term 61[a] is identical to claim term 1[a]. *See* discussion of 1[a], above, at ¶¶65-72.

- c. **61[b]: “the body having upper and lower sections, a segment of the upper section adapted to be joined to a bicycle handlebar, a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle, the lower section joined to the upper section,”**

96. Claim term 61[b] is identical to claim term 1[b]. *See* discussion of 1[b], above, at ¶¶73-80.

- d. **61[c]: “an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body, and”**

97. As discussed above with regard to claim term 1[b] and as shown below, a POSITA would have understood that the elongate body of Denk’s tube has an upper section and a lower section. *See also* Moechnig, FIG. 3.



Denk, Fig. 11 (annotations added).

98. And as discussed above with regard to claim term 1[c], a POSITA would have understood that the outer surfaces of the upper and lower sections of Denk's tube body have circular cross-sections. A POSITA would also have understood that an

outer diameter of the cross-section of the lower section of the body is greater than an outer diameter of the cross-section of the upper section of the body, as shown above. Denk, Fig. 11. A POSITA would have understood that such a shape allows for added reinforcement, such as a thicker wall, in the lower section, which is subjected to more loads or stresses compared to the upper section. *See* Valat, 1:44-51; *see also* Denk, col. 3.

- e. **61[d]: “the body formed by a wall, a thickness of the wall at any point in the lower section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel, the wall thickness being at a maximum in the plane of travel of the bicycle.”**

99. Claim term 61[d] is identical to claim term 1[d]. *See* discussion of 1[d], above, at ¶¶87-92.

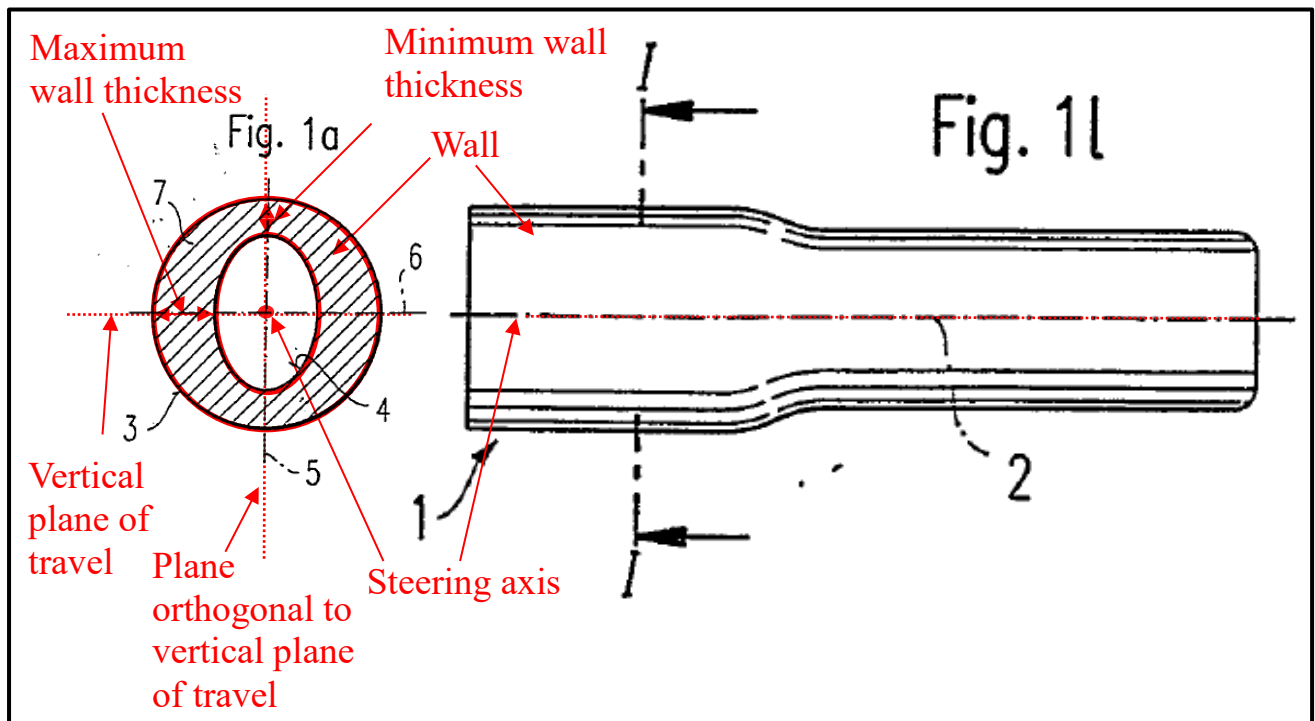
- 4. **Claim 15 (“wherein the wall thickness is at a minimum in a plane containing the steering axis and orthogonal to the plane of travel of the bicycle.”)**

100. Claim 15 depends from claim 1 and recites “wherein the wall thickness is at a minimum in a plane containing the steering axis and orthogonal to the plane of travel of the bicycle.”

101. Denk in view of Moechnig renders claim 15 obvious.

102. Denk discloses that “[t]he exemplary embodiment according to Fig. 1a shows a cross section 2 of a tube having a circular outer cross-sectional contour 3 and an

elliptical inner cross-sectional contour 4 that is arranged symmetrically with respect to a center line or center plane 5.” Denk, col. 6. Denk further explains that “the optimal rigidity vector is perpendicular to the plane of symmetry 5,” i.e., in the plane of travel 6. Denk, col. 6. And as discussed above with regard to claim term 1[d] and as shown below, Denk in view of Moechnig discloses that the steerer tube body has maximum thickness along plane 6, i.e., “the plane of travel of the bicycle,” and minimum thickness along center plane 5 perpendicular to plane 6, i.e., “a plane . . . orthogonal to the plane of travel of the bicycle.” Thus, when Denk’s tube is implemented as a steerer tube, the wall thickness is at a minimum in center plane 5, which is orthogonal to the plane of travel of the bicycle (plane 6). This coincides with the neutral axis of the steerer tube where bending stresses in the tube section are the least. Moreover, plane 5 contains the steering axis because planes 5 and 6 intersect orthogonally at the steering axis, as shown below in Denk, Fig. 1a. A POSITA would also have understood that the steering axis of Denk’s tube (when implemented as a steerer tube) would align with center plane 5. *See* Moechnig, [0035], FIGS. 2-3.



Denk, Figs. 1a, 1l (annotations added).

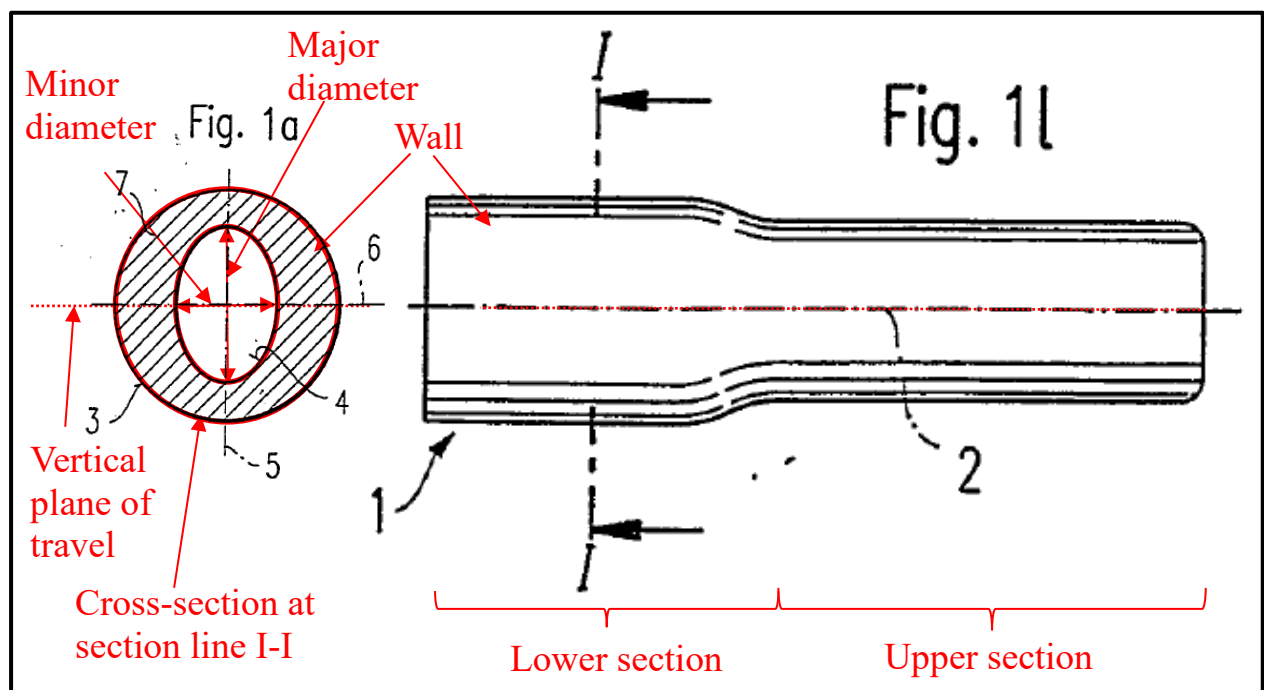
5. **Claim 34 (“wherein an inner surface of the wall within the lower section of the body is formed as an ellipse in cross section, a major diameter of the ellipse formed to be perpendicular to the plane of travel, a minor diameter of the ellipse formed to be in the plane of travel of the bicycle.”**

103. Claim 34 depends from claim 15 and recites “wherein an inner surface of the wall within the lower section of the body is formed as an ellipse in cross section, a major diameter of the ellipse formed to be perpendicular to the plane of travel, a minor diameter of the ellipse formed to be in the plane of travel of the bicycle.”

104. Denk in view of Moechnig renders claim 34 obvious.

105. As discussed above with regard to claim terms 1[b] and 1[d] and as shown below, Denk in view of Moechnig renders obvious that the steering tube body has

an upper section, a lower section, and a wall of the lower section having varying thickness formed between the inner elliptical cross-sectional contour 4 and outer circular cross-sectional contour 3 (as evident from the cross-section taken at a section line I-I in the lower section of Denk's tube body). Denk, cols. 3, 5-6, Figs 1a, 1l.



Denk, Figs. 1a, 1l (annotations added).

106. Because of the inner elliptical cross-sectional contour 4, an inner surface of the wall in the lower section of the Denk tube body is formed as “an ellipse in cross section.” Denk, Fig. 1a. The ellipse formed by contour 4 has “a major diameter” positioned to be perpendicular to the plane of travel 6 and “a minor diameter”

positioned to be in the plane of travel 6 of the bicycle, such that the tube has maximum wall thickness in the plane of travel where the loads are higher compared to the plane that is orthogonal to the plane of travel. Denk, col. 2; *see* discussion of wall thickness design in claim term 1[d].

6. Claim 35 (“wherein outer surfaces of the upper and lower sections of the body are circular in cross section.”)

107. Claim 35 depends from claim 34 and recites a limitation that is identical to claim term 1[c]. Denk in view of Moechnig renders it obvious for the reasons discussed above with regard to claim term 1[c] and claim 34. *See* Sections IX.A.2.d and IX.A.5, above.

7. Claims 14, 33, and 53 (“wherein the body is formed from a material selected from the group consisting of steel, carbon fiber reinforced composite, aluminum, titanium and magnesium.”)

108. Claims 14, 33, and 53 depend from claims 1, 15, and 34, respectively. All of these claims recite “wherein the body is formed from a material selected from the group consisting of steel, carbon fiber reinforced composite, aluminum, titanium and magnesium.”

109. Denk in view of Moechnig renders claims 14, 33, and 53 obvious.

110. Specifically, Denk discloses that lightweight components for bicycle tubes may be made of steel, aluminum or titanium alloy, or plastic material reinforced with carbon fibers. Denk, cols. 1, 5. A POSITA would have understood that Denk’s

lightweight component when used as a steerer tube would have been made of any of these materials because Denk teaches that such lightweight component is “suitable for practically all tubular components, i.e., top tube, down tube, seat tube, head tube, fork tubes, rear wheel stay, seat posts, handlebars, handlebar stem, and the like.”

Denk, col. 4.

111. Moechnig also discloses that a steerer tube is made of aluminum or carbon fiber materials. Moechnig, [0003], [0014]. A POSITA would have found it obvious to use these materials for Denk’s tube when used as a steerer tube. Indeed, it was well known and conventional to use aluminum or titanium alloy, or carbon fiber reinforced materials, for tubular components of bicycles.

8. Claims 2, 16, 27, 36, and 47 (“wherein an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body.”)

112. Claim 2 depends from claim 1; claims 16 and 27 depend from claim 15; claim 36 depends from claim 35; and claim 47 depends from claim 34. All of these claims are identical to claim term 61[c], which recites “an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body.” Denk in view of Moechnig render these claims obvious for the reasons discussed above with regard to claim term 61[c]. *See* Section IX.A.3.d, above.

9. Claims 3, 17, 28, 37, 48, and 62 (“wherein the lower section of the body has first and second portions, the first portion adjoining the upper section of the body, an outer diameter

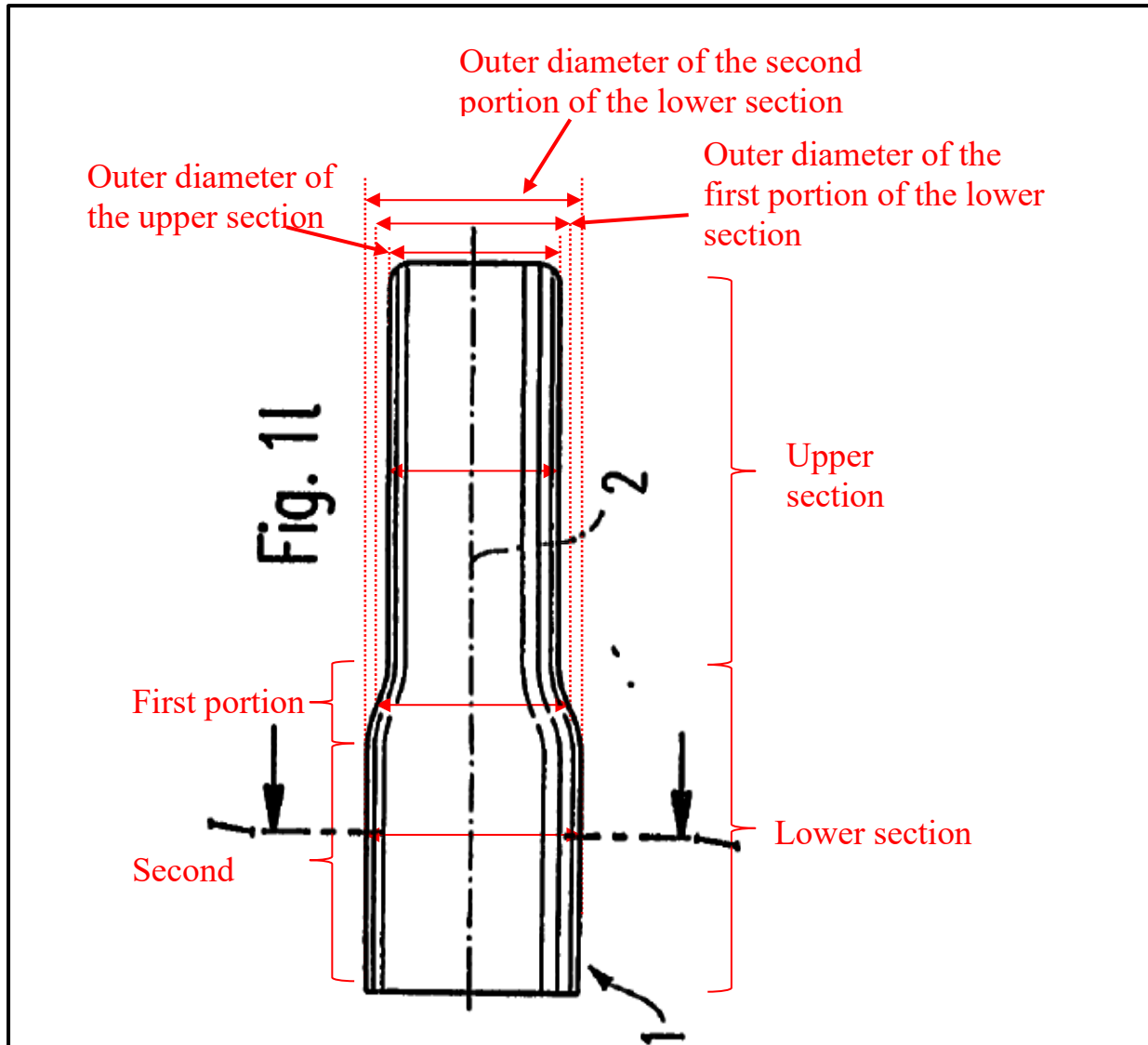
of the first portion of the lower section being greater than an outer diameter of the upper section and less than an outer diameter of the second portion of the lower section.”)

113. Claims 3, 17, 28, 37, 48, and 62 depend from claims 2, 16, 27, 36, 47, and 61, respectively. All these claims recite “wherein the lower section of the body has first and second portions, the first portion adjoining the upper section of the body, an outer diameter of the first portion of the lower section being greater than an outer diameter of the upper section and less than an outer diameter of the second portion of the lower section.”

114. Denk in view of Moechnig render claims 3, 17, 28, 37, 48, and 62 obvious.

115. As discussed with regard to claim term 1[b] and as shown below, Denk discloses that the elongated tubular body has a lower section joined to an upper section. The tapering region of the lower section forms a “first portion” of the lower section adjoining the upper section, and the rest of the lower section forms the “second portion.” As discussed above with regard to claim terms 1[c] and 61[c], the outer surfaces of the upper and lower sections are circular in cross-section with corresponding outer diameters. While the outer diameters of the upper section and the “second portion” of the lower section remain constant, the outer diameter of the “first portion” tapers gradually from the “second portion” of the lower section to the upper section, as shown below. Denk, Fig. 11. This results in *an* outer diameter of the “first portion” of the lower section to be greater than *an* outer diameter of the

upper section and less than *an* outer diameter of the “second portion” of the lower section.



Denk, Fig. 11 (annotations added).

- 10. Claims 4, 18, 29, 38, 49, and 63 (“wherein the outer diameter of the first portion of the lower section gradually**

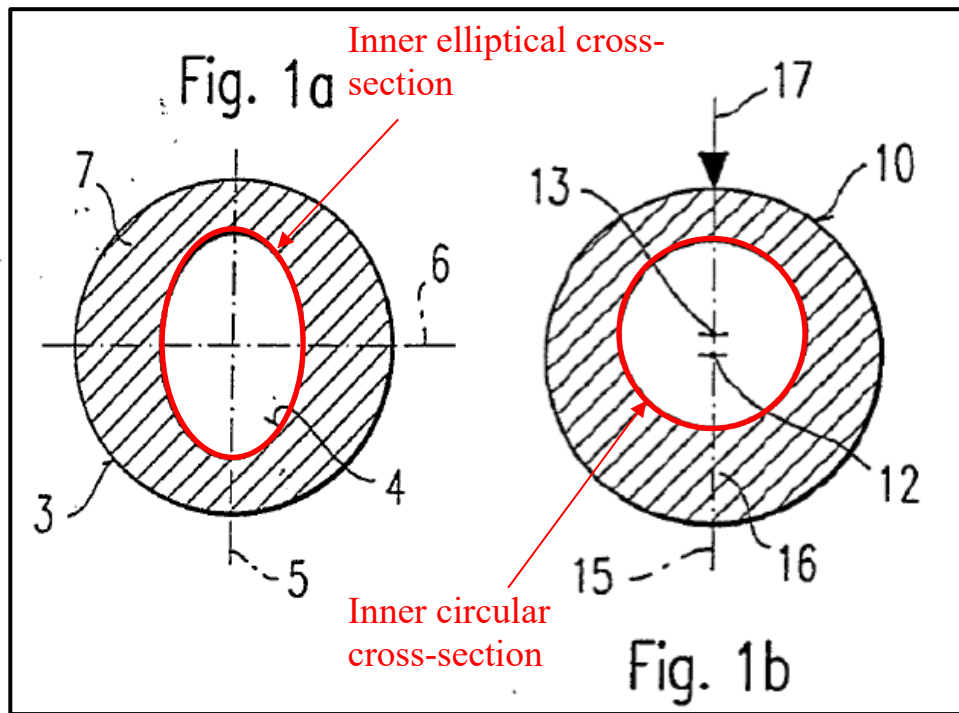
tapers from the second portion of the lower section to the upper section of the body.”)

116. Claims 4, 18, 29, 38, 49, and 63 depend from claims 3, 17, 28, 37, 48, and 62, respectively. All these claims recite “wherein the outer diameter of the first portion of the lower section gradually tapers from the second portion of the lower section to the upper section of the body.” Denk teaches this claim limitation as discussed above with regard to claims 3, 17, 28, 37, 48, and 62 (Section IX.A.9).

11. Claims 6, 10, 20, 24, 40, and 44 (“wherein an inner surface of the upper section is circular in cross section.”)

117. Claims 6, 10, 20, 24, 40, and 44 depend from claims 4, 1, 18, 15, 38, and 34, respectively. All these claims recite “wherein an inner surface of the upper section is circular in cross section.” Denk in view of Moechnig render these claims obvious.

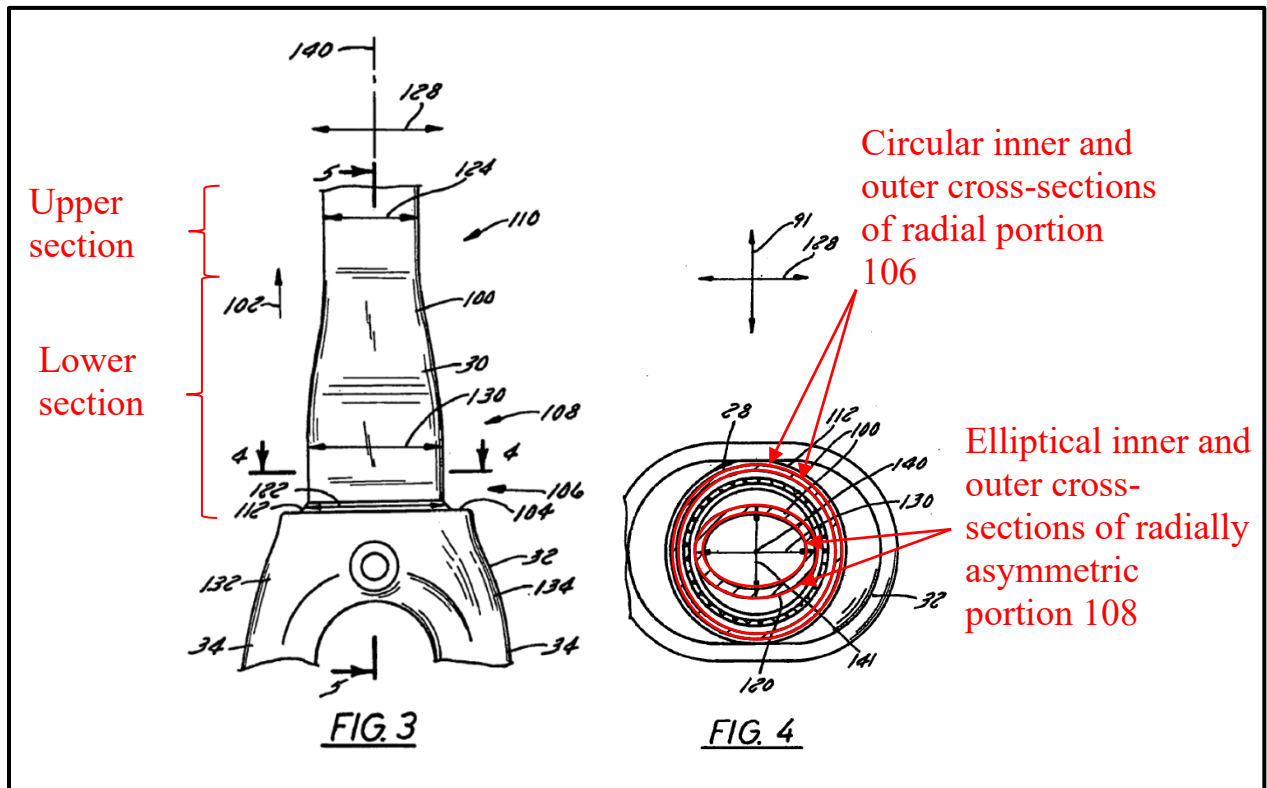
118. Denk discloses that the inner cross-sectional shape of the tube can change along the tube length, and that the inner cross-sectional shape in one region of the tube may be elliptical as shown in Figure 1a and may be circular in another region as shown in Figure 1b. Denk, cols. 6, 8, Figs. 1a-1b (reproduced below with annotations). Denk further discloses that for the embodiment of Figure 1a, “it is possible for the elliptical inner cross-sectional contour to continually transition into a circular inner cross-sectional contour in a certain area of the tube, for example in a middle area or in an end area.” Denk, col. 8. Therefore, Denk suggests that an inner surface of the upper section of Denk’s tube is circular in cross-section.



Denk, Figs. 1a-1b (annotations added).

119. As discussed with regard to claim term 1[b] and as shown below, Moechnig discloses a steerer tube that has an upper radial portion 110 that forms an “upper section,” and a radial portion 106 and a radially asymmetric portion 108 that collectively forming a “lower section.” Moechnig, [0035], FIGS. 2-3. Moechnig discloses that the cross-section of radial portion 106 has a diameter 124 and has circular inner and outer cross-sections, and that the cross-section of radially asymmetric portion 108 has a lateral diameter 130 and a longitudinal diameter 120 and has elliptical inner and outer cross-sections. Moechnig, FIGS. 1, 2-4, [0035]-[0036], [0038]. Moechnig further shows that the inner and outer cross-sections of radial portion 106 are circular in both lateral and longitudinal directions in the cross-

sectional view of Figure 4. A POSITA would have understood that upper radial portion 110 (“upper section”) would have circular inner and outer cross-sections, like radial portion 106, because Moechnig indicates both of these portions as “radial.”



Moechnig, FIGS. 3-4 (annotations added).

120. Based on the teachings of Denk and Moechnig, it would have been obvious to have the inner surface of the upper section in Denk’s tube be circular in cross-section as shown in Fig. 1b, an inner surface of the lower section be elliptical in cross-section as shown in Fig. 1a, and the elliptical inner contour of the lower section “continually transition” into the circular cross-section of the upper section as taught by Moechnig

and suggested by Denk. Denk, col. 8; Moechnig, [0038]. A POSITA would have found such design desirable because it allows for added reinforcement, such as greater wall thickness, in the lower section where loads or stresses are greater (particularly in the vertical travel plane) as compared to the upper section (*see, e.g.*, Denk, cols. 2-3; Valat, 1:35-51, 1:70-78; Schroeder, 6:16-26, FIGS. 1B-2), but reduces weight by have thinner wall with circular inner and outer cross-sections in the upper section (*see, e.g.*, Denk, col. 2; Moechnig, [0045], [0049]; Schroeder, 6:1-25, FIGS. 1A-2; Campagnolo, 1:23-26).

121. Indeed, steerer tubes having circular inner cross-sections in the upper section were conventional and well known in the art at the time of the purported invention. *See* Valat, Figs. 1-2; Schroeder, FIGS. 1A-2, 6:1-25.

12. Claims 8, 12, 22, 26, 42, and 46 (“wherein a ratio of an inner diameter of the upper section of the body to an outer diameter of the upper section of the body is within the range of 0.75 to 0.95, inclusive.”)

122. Claims 8, 12, 22, 26, 42, and 46 depend from claims 6, 10, 20, 24, 40, and 44, respectively. All these claims recite “wherein a ratio of an inner diameter of the upper section of the body to an outer diameter of the upper section of the body is within the range of 0.75 to 0.95, inclusive.” As explained above in Sections IX.A.2.d and IX.A.11, Denk in view of Moechnig discloses that the inner surface of the upper section is circular in cross-section and the outer surface of the upper section is

circular in cross-section. A POSITA would have known that a ratio of an inner diameter to an outer diameter of the upper section of the steerer tube body being in the range of 0.75 to 0.95 is an obvious design choice and obvious-to-try based on multiple considerations, as explained below.

123. A POSITA would have known to select a suitable wall thickness in the upper section based on the outer diameter of the upper section, the strength and lightness of the material of the steerer tube, and the strength and rigidity requirements of the upper section of the tube. A POSITA would have known to keep the thickness of the steerer tube wall low in the upper section in order to have a lightweight steerer tube and thereby a lighter weight bicycle. Moechnig, [0045] (“Steerer tube 30 includes an optional cavity 206 formed in body 100. Optional cavity 206 can extend a majority of the length of steerer tube 30 and **provides a lighter steerer assembly** 16. Such a construction forms a steerer tube wall 208 that has a thickness that is selected to withstand . . . the loaded interaction between steerer tube 30 and head tube 28.” (emphasis added)); Denk (discussing “lightweight component” in Title, Abstract, and throughout the specification); Schroeder, 6:16-26 (disclosing a steerer tube having an upper section with a thinner wall than the lower section provides an advantageous steerer tube with improved mechanical strength and reduced weight). A POSITA would have known that both the strength and rigidity as well as the

weight of the upper section of the steerer tube is affected by the wall thickness, i.e., a ratio of the inner diameter to the outer diameter. For instance, a tube made with aluminum may need to be thicker—i.e., have a smaller ratio of inner diameter to outer diameter—than a tube of the same outer diameter made of steel because aluminum has less strength and rigidity than steel. Given a certain outer diameter of the upper section of the steerer tube, a POSITA would have known to determine the ratio of the inner diameter to the outer diameter of the upper section of Denk's steerer tube body through routine experimentation to optimize strength and rigidity of the steerer tube while maintaining light weight.

124. For example, it was known that a typical steerer tube size is on the order of 1" OD x 7/8" ID. In other words, a 1-inch steerer tube would have an inner diameter of 22.2 mm and an outer diameter of 25.4 mm, resulting in a ratio of 0.874, which is in the range of 0.75 to 0.95. A POSITA would have known that this ratio would result in a wall thickness of 1.6 mm, which would be suitable for a steerer tube made of a certain material such as a high strength low alloy (HSLA) steel with a yield strength 2-3x that of mild steel. A POSITA would have adjusted this ratio or thickness for another material and/or the actual strength and rigidity requirements of a certain type of bicycle (e.g., a road bike has less strength and rigidity requirements than a mountain bike). For example, I created a spreadsheet *Steering_Tube_strength.xls*

(Ex. 1016), a portion of which is reproduced below, to show the types of basic calculations a POSITA would do. For these calculations, a typical outer diameter of 28.6 mm at the upper section of the tube, as taught by Moechnig [0040], was used. The '993 patent also notes an outer diameter of 28.5 mm at the upper section. Ex. 1001, 3:44-49. A POSITA would have found it obvious to determine the ratio of the inner diameter to the outer diameter of the upper section of Denk's steerer tube body through routine experimentation and calculations (as shown in Ex. 1016) to optimize strength and rigidity of the steerer tube while maintaining light weight.

Steering_Tube_strength.xls		
By Alex Slocum 8 January 2024		
Inputs in BLACK , Outputs in RED		
Upper section 110 (ala Moechnig) Circular OD and ID tube		
OD (mm)	28.6	
ID (mm)	22.6	
ID/OD	0.79	
wall thickness (mm)	3.00	
Wall thickness/OD ratio	10.49%	
Moment of inertia I (mm ⁴)	20037	
I/radius	1401	
Design safety factor	3	
	6061-T6 AL	HSLA Steel
Yield strength	240	960
Allowable bending moment		
N-mm	336,279	1,345,116
lb-ft	2,975	11,901
Assumed typical distance steering tube where eminates from head tube to end of fork (in, mm)	16	406
Force in plane P to reach allowable moment		
N	827	3,310
lbf	186	744

Ex. 1016.

13. Claim 57 (“wherein a ratio of the major diameter to the minor diameter taken at a lower end of the lower section is within the range of 1.05 to 1.3, inclusive.”); claim 58 (“wherein the ratio is within the range of 1.10 to 1.25, inclusive.”)

125. Claim 57 depends from claim 34 and recites “wherein a ratio of the major diameter to the minor diameter taken at a lower end of the lower section is within the range of 1.05 to 1.3, inclusive.” Claim 58 depends from claim 57 and recites “wherein the ratio is within the range of 1.10 to 1.25, inclusive.”

126. Denk in view of Moechnig renders claims 57 and 58 obvious because a POSITA would have known that a ratio of the major diameter to the minor diameter taken at a lower end of the lower section being within the range of 1.05 to 1.3 (or the range of 1.10 to 1.25, inclusive) is an obvious design choice and is obvious-to-try based on multiple considerations, as explained below.

127. As discussed above with regard to claim term 1[d] and claim 34 (Sections IX.A.2.e and IX.A.5, respectively), the wall thickness of the lower section of Denk’s tube is defined between the outer *circular* cross-section and the inner *elliptical* cross-section, and the inner elliptical cross-section has a major diameter in the plane perpendicular to the plane of travel and a minor diameter in the plane of travel. The inner elliptical cross-section and outer circular cross-section cause the wall thickness in the lower section of the tube to vary over a cross-section. Denk, col. 8. A POSITA would have designed the wall thickness of the lower end of the lower section based

on multiple factors (e.g., the particular outer diameter and material of the lower section of the steerer tube, type of connection to the fork crown, and type of bicycle) through routine experimentation to optimize the strength and rigidity of the lower end of the lower section while keeping the tube lightweight, as suggested by Denk. *See* Denk, col. 3; *see* Section IX.A.12 (claim 8).

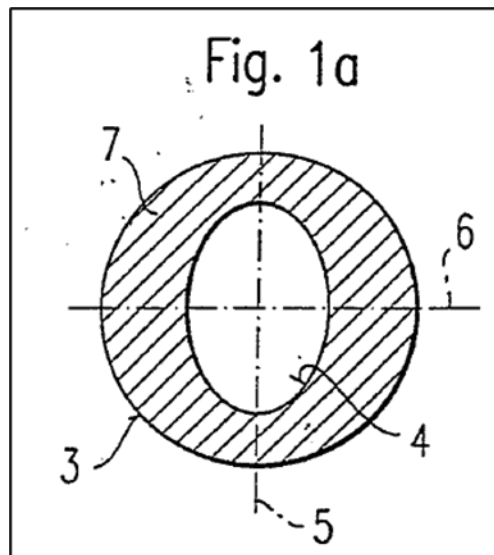
128. Indeed, the strength and rigidity properties in the plane of travel in the lower section of the steerer tube are directly affected by the thickness of the wall in the plane of travel, and as such, the strength and rigidity properties in the plane of travel in the lower section are directly affected by the minor diameter of the elliptical inner contour of the lower section. Similarly, the weight of the steerer tube is directly affected by the major diameter of the elliptical inner contour of the lower section. That is, the larger the major diameter of the lower section, the thinner the wall in parts of the lower section and consequently lower the weight of the tube.

129. A POSITA would have understood that changing the wall thickness distribution over a cross-section in the lower section (while the outer circular contour remains the same) would have changed the ratio of the major diameter to the minor diameter of the inner cross-sectional contour. For example, increasing the wall thickness in the area of the major axis in the plane perpendicular to the plane of travel while maintaining the wall thickness in the area of the minor axis in the plane

of travel would reduce the ratio of the major diameter to the minor diameter, and vice versa.

130. Denk discloses adapting the wall thickness of the tube body to the strength and rigidity properties along the tube length while reducing weight. Denk, cols. 1, 3. Based on Denk's teaching, a POSITA would have known to have an elliptical cross-sectional contour in a lower end of the lower section of the tube body, such as adjacent to section line I-I in Denk's Figure 11 where it is connected to the fork bridge—i.e., an end area—to be capable of absorbing the additional stress as compared to other portions of the lower section. *See* Denk, Fig. 11. A POSITA would also have optimized the ratio of the major diameter to the minor diameter taken at a lower end of the lower section through routine optimization and experimentation to identify an optimum ratio that meets the strength and rigidity requirements in the lower end of the steerer tube while keeping the weight of the tube low.

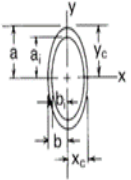
131. Moreover, in Figure 1a of Denk (shown below), the ratio of the major diameter to the minor diameter at section I-I of the lower section of Denk's tube is about 1.57. A POSITA would have known that the gradual transition of the elliptical inner contour to a circular inner contour within the lower section would result in the ratio of the major diameter to the minor diameter to gradually change from about 1.57 to 1, including ratios such as 1.3, 1.25, or 1.1.



Denk, Fig. 1a.

132. I created a spreadsheet *Steering_Tube_strength.xls* (Ex. 1016), a portion of which is reproduced below, which represents the type of calculations a POSITA would do in order to compare design options and compare how they affect performance. Note that the formulas come from a handbook (Ex. 1017) well known to POSITAs. Here, I have included an image of the page that shows the formulas for an elliptical tube with varying wall thickness:

TABLE A.1 Properties of sections (Continued)

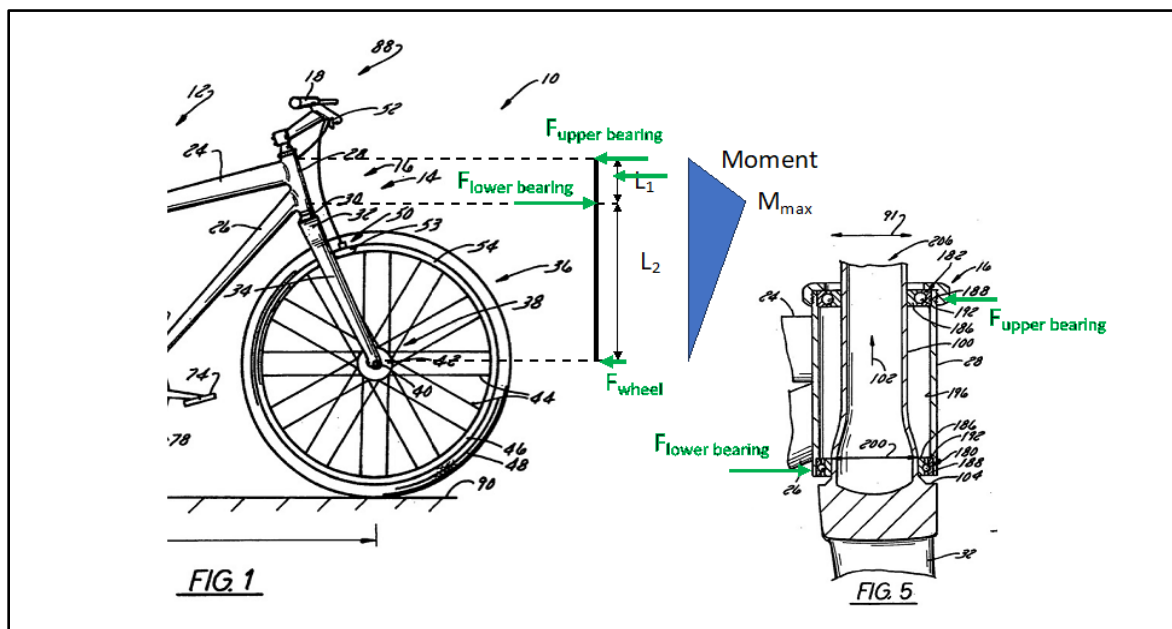
Form of section	Area and distances from centroid to extremities	Moments and products of inertia and radii of gyration about central axes	Plastic section moduli, shape factors, and locations of plastic neutral axes
25. Hollow ellipse 	$A = \pi(ab - a_i b_i)$ $y_c = a$ $x_c = b$	$I_x = \frac{\pi}{4}(ba^3 - b_i a_i^3)$ $I_y = \frac{\pi}{4}(ab^3 - a_i b_i^3)$ $r_x = \frac{1}{2} \sqrt{\frac{ba^3 - b_i a_i^3}{ab - a_i b_i}}$ $r_y = \frac{1}{2} \sqrt{\frac{ab^3 - a_i b_i^3}{ab - a_i b_i}}$	$Z_x = 1.333(a^2 b - a_i^2 b_i)$ $Z_y = 1.333(b^2 a - b_i^2 a_i)$ $SF_x = 1.698 \frac{a^3 b - a_i^3 b_i}{a^2 b - a_i^2 b_i}$ $SF_y = 1.698 \frac{b^3 a - b_i^3 a_i}{b^2 a - b_i^2 a_i}$
Note: For this case the inner and outer perimeters are both ellipses and the wall thickness is not constant. For a cross section with a constant wall thickness see case 26.			

Ex. 1017, 5.

Steering_Tube_strength.xls						
By Alex Slocum 8 January 2024						
Inputs in BLACK , Outputs in RED						
Upper section 110 (ala Moechnig) Circular OD and ID tube						
OD (mm)	28.6					
ID (mm)	22.6					
ID/OD	0.79					
wall thickness (mm)	3.00					
Wall thickness/OD ratio	10.49%					
Moment of inertia I (mm^4)	20037					
I/radius	1401					
Design safety factor	3					
	6061-T6 AL	HSLA Steel				
Yield strength	240	960				
Allowable bending moment						
N-mm	336,279	1,345,116				
lb-ft	2,975	11,901				
Assumed typical distance steering tube where eminates from head tube to end of fork (in, mm)	16	406				
Force in plane P to reach allowable moment						
N	827	3,310				
lbf	186	744				
Lower end 202 (ala '993) Circular outside at base, Elliptical inside at base						
Geometry	993 Fig. 9	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
OD (mm)	36.00	42.90	42.90	42.90	42.90	42.90
ID if round and same wall thickness as at top	30	36.9	36.9	36.9	36.9	36.9
Ratio OD lower end / Upper section	1.26	1.50	1.50	1.50	1.50	1.50
Major diameter/Minor diameter	1.20	1.14	1.57	1.30	1.25	1.00
Major axis	30.00	34.32	36.04	36.04	36.04	36.04
Ratio Major axis/OD	83.33%	80.00%	84.00%	84.00%	84.00%	84.00%
wall thickness (mm)	3.00	4.29	3.43	3.43	3.43	3.43
Wall thickness/OD ratio	8.3%	10.0%	8.0%	8.0%	8.0%	8.0%
Minor axis	25.00	30.03	22.95	27.72	28.83	36.04
Ratio Minor axis/OD	0.69	0.70	0.54	0.65	0.67	0.84
wall thickness (mm)	5.5	6.44	9.97	7.59	7.04	3.43
Wall thickness/OD ratio	15.3%	15.0%	23.2%	17.7%	16.4%	8.0%
Cross sectional areas						
Top Round tube at top (mm^2)	241	241	241	241	241	241
Base Circular outside, elliptical inside (mm^2)	429	636	796	661	630	426
compare to circular ID						
ID = major axis, area (mm^2)	311	520	426	426	426	426
ID = minor axes, area (mm^2)	527	737	1032	842	793	426
Wall thickness same as at top section, area (mm^2)	311	376	376	376	376	376
Moments of Inertia, maximum in plane P						
Top Round tube at top (mm^4)	20037	20037	20037	20037	20037	20037
Base Circular outside, elliptical inside (mm^4)	59438	120641	144874	128586	123882	83486
compare to circular ID						
ID = major axis, area (mm^4)	42687	98162	83486	83486	83486	83486
ID = minor axes, area (mm^4)	63273	126344	152640	137281	132358	83486
ID with top wall thickness (mm^4)	42687	75257	75257	75257	75257	75257
Structural efficiency (I/A) (mm^4/mm^2)						
Top Round tube at top (mm^2)	83	83	83	83	83	83
Base Circular outside, elliptical inside (mm^2)	139	190	182	195	197	196
compare to circular ID						
ID = major axis, area (mm^2)	137	189	196	196	196	196
ID = minor axes, area (mm^2)	120	171	148	163	167	196
ID with top wall thickness (mm^2)	137	200	200	200	200	200

Ex. 1016.

The figure I created below further shows how the forces on a bicycle front wheel create the greatest bending moment (force times distance along a beam, where the moment is zero at the ends of a simple beam, even though a force may be present there) on the steering tube at the lower bearing near the crown, and hence, here is where the larger moment of inertia is desired to withstand the greatest bending moment. The stress is proportional to the product of the bending moment and the steering tube outer radius, divided by the moment of inertia at that location. A POSITA would have known this and would have designed the steerer tube accordingly through routine experimentation and optimization to have the optimum ratio of the major diameter to the minor diameter taken at a lower end of the lower section to be able to handle the greater bending moments or loads near the crown.



Moechnig, FIGS. 1, 5 (modified, annotated).

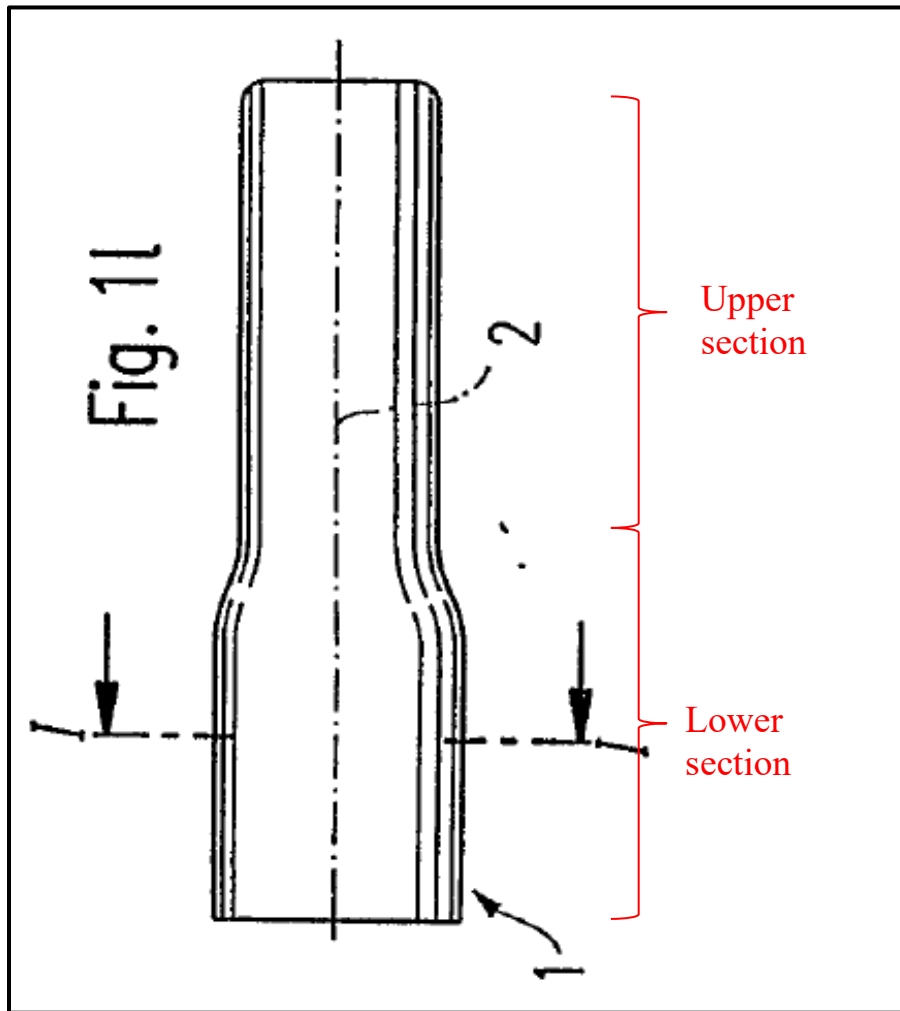
133. Moreover, Moechnig teaches that the widest major diameter (lateral diameter 130), i.e., the major diameter in the lower end of the lower section (106, 108), is 1.559 inches, and that the smallest minor diameter (longitudinal diameter 120), which is not less than radial diameter 124 of the upper portion 110, is 1.125 inches. Moechnig, [0040] (“[E]ach cross-section 141 [of oblong portion 108] includes a lateral diameter 130 that is larger than a longitudinal diameter 120. Preferably, longitudinal diameter 120 is not less than a diameter associated with upper radial portion 110. Although upper radial portion 110 could be provided in any of a number of sizes, upper radial portion 110 preferably has a diameter of about 1.125 inches or about 28.6 mm. Similarly, although lateral diameter 130 tapers from lower radial portion 106 to upper radial portion 110, and could be provided in a number of sizes, at its widest portion, lateral diameter 130 is approximately 1.559 inches or 39.6 mm . . .”). Therefore, a POSITA would have known that the widest minor diameter (longitudinal diameter 120) in the lower end of the lower section (106, 108) is greater than 1.125 inches but less than 1.559 inches. A POSITA optimizing the ratio of the major and minor diameters in a lower end of the steerer tube would have considered the ratio of the major and minor diameters taught by Moechnig because it is in the same field of art, and would have even used the ratio taught by Moechnig as a starting point for further optimization. Accordingly, a POSITA would have

easily known that a ratio of the major diameter to the minor diameter in Denk's steerer tube would be in the range of 1.05 and 1.3. A POSITA would also have been able to arrive at a ratio within the range of 1.10 to 1.25 through routine experimentation to optimize the strength and rigidity of the steerer tube while minimizing weight.

14. Claim 56 (“wherein the minor diameter decreases as a function of proximity to the upper section of the body.”); Claim 59 (“wherein the major diameter of the lower section tapers from the second portion of the lower section to the first portion of the lower section.”)

134. Claim 56 depends from claim 34 and recites that “the minor diameter [of the lower section] decreases as a function of proximity to the upper section of the body.” Claim 59 depends from claim 34 and recites that “the major diameter of the lower section tapers from the second portion of the lower section to the first portion of the lower section.” Denk in view of Moechnig renders claims 56 and 59 obvious.

135. As discussed with respect to claim 1, Denk discloses that the tube body has an upper section and a lower section, which are joined by a gradually tapering neck region, as shown in Denk's Figure 11 (annotated below). Denk teaches that the elliptical inner cross-sectional contour of the lower section of the steerer tube “continually transition[s]” into a circular inner cross-sectional contour. Denk, col. 8. Moechnig further teaches that such transition occurs over a tapering region in its steerer tube. *See* Moechnig, [0035], [0038]-[0039], FIGS. 2-3.

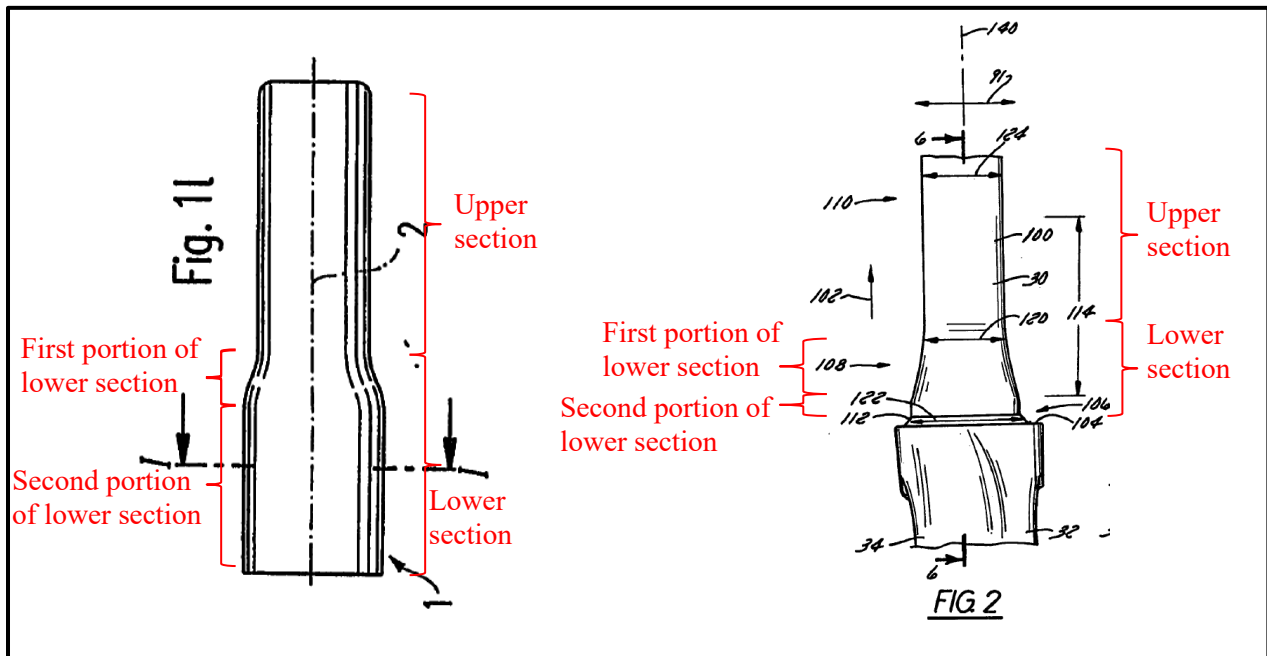


Denk, Fig. 11 (annotations added).

136. As discussed above, the lower section of the tube has an elliptical inner cross-section, with a first portion that is formed by a tapering region and a second portion. *See* Sections IX.A.2.e, IX.A.9. Although Denk does not explicitly disclose that a minor diameter of the elliptical inner contour of the lower section of the tube decreases as a function of proximity to the upper section of the body, a POSITA would have known and understood that both the major and the minor diameters in

the tapering neck region of the tube body decrease as a function of proximity to the upper section of the body.

137. Additionally, Moechnig explicitly teaches that the minor diameter (longitudinal diameter 120) of the lower section of the steerer tube body decreases (i.e., tapers) as a function of proximity to the upper section of the body (upper radial portion 110) along the tapering next region (radially asymmetrical portion 108). Moechnig, FIG. 2 (showing longitudinal diameter 120 decreasing along the radially asymmetrical portion 108 as a function of proximity to the radial upper portion 110), [0038] (“Both longitudinal and lateral diameters 120, 130 transition from lower radial portion 106 to upper radial portion 110.”). Accordingly, a POSITA would have known that Denk’s steerer tube (in view of Moechnig’s teaching) would also have the minor diameter of the lower section of the tube decrease as a function of proximity to the upper section of the tube and have the major diameter taper from the second portion of the lower section to an end region of the first portion of the lower section.



Denk, Fig. 1l (annotations added); Moechnig, FIG. 2 (annotations added).

138. Moechnig further discloses that the major diameter (lateral diameter 130) decreases (i.e., tapers) from the second portion of the lower section (lower radial portion 106) of the steerer tube to the first portion of the lower section (radially asymmetric portion 108) as a function of proximity to the upper section of the tube (upper radial portion 110). Moechnig, FIG. 3 (showing lateral diameter 130 decreasing along the radially asymmetrical portion 108 as a function of proximity to the radial upper portion 110), [0038] (“Both longitudinal and lateral diameters 120, 130 transition from lower radial portion 106 to upper radial portion 110.”); *see also* Moechnig, [0039]-[0040] (teaching that the lateral diameter 130 and longitudinal diameter 120 gradually reduce in the tapering region). Accordingly, a POSITA

would have known based on the teachings of Moechnig that Denk's tube, which has a tapering neck region as in Moechnig's steerer tube, would also have a major diameter of the lower section taper from the second portion of the lower section to an end region of the first portion of the lower section.

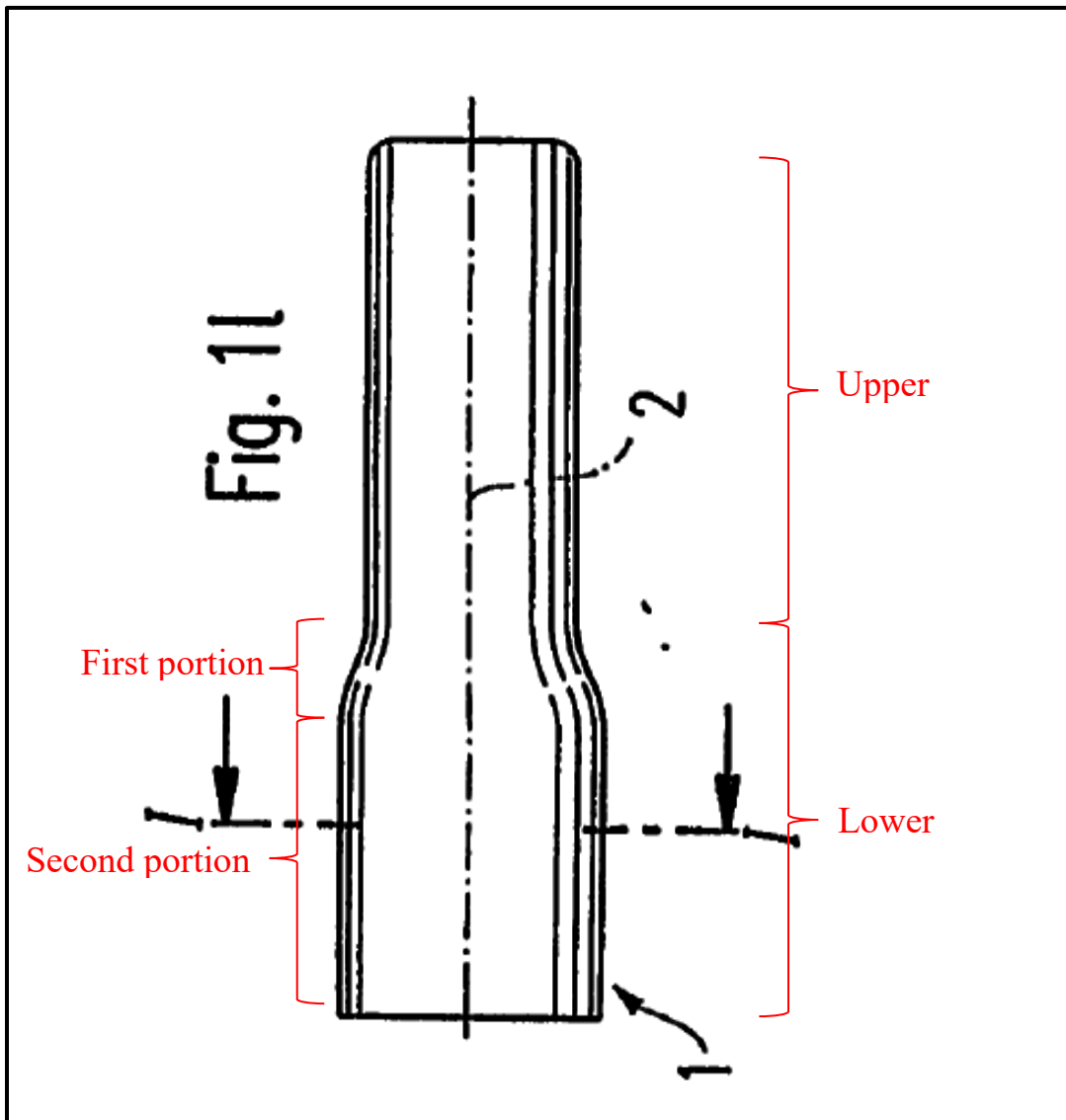
15. Claim 60 (“wherein a ratio of the major diameter to the minor diameter decreases as a function of proximity to the upper section of the body.”)

139. Claim 60 depends from claim 34 and recites “wherein a ratio of the major diameter to the minor diameter decreases as a function of proximity to the upper section of the body.”

140. Denk in view of Moechnig renders claim 60 obvious.

141. For the reasons discussed in claims 56 and 59 (Section IX.A.14), above, Denk teaches that the elliptical inner cross-sectional contour of the lower section of the steerer tube “continually transition[s]” into a circular inner cross-sectional contour. Denk, col. 8. Moechnig further teaches that such transition occurs over a tapering region in its steerer tube. *See* Moechnig, [0035], [0038]-[0039], FIGS. 2-3. It would have been obvious to a POSITA that as the inner cross-sectional contour of the tapering upper portion of the tube's “lower section,” as shown in the annotated Figure 11 of Denk below, transitions gradually from an ellipse to a circle, the ratio of the major diameter to the minor diameter gradually decreases. A POSITA would have understood that the decrease of the ratio of the major diameter to the minor

diameter in the tapering region of the tube would have resulted in the ratio decreasing as a function of proximity to the upper section of the body and that the ratio at the upper end of the tapering region (where the elliptical inner contour transitions into the circular inner contour) would be approximately 1.



Denk, Fig. 11 (annotations added).

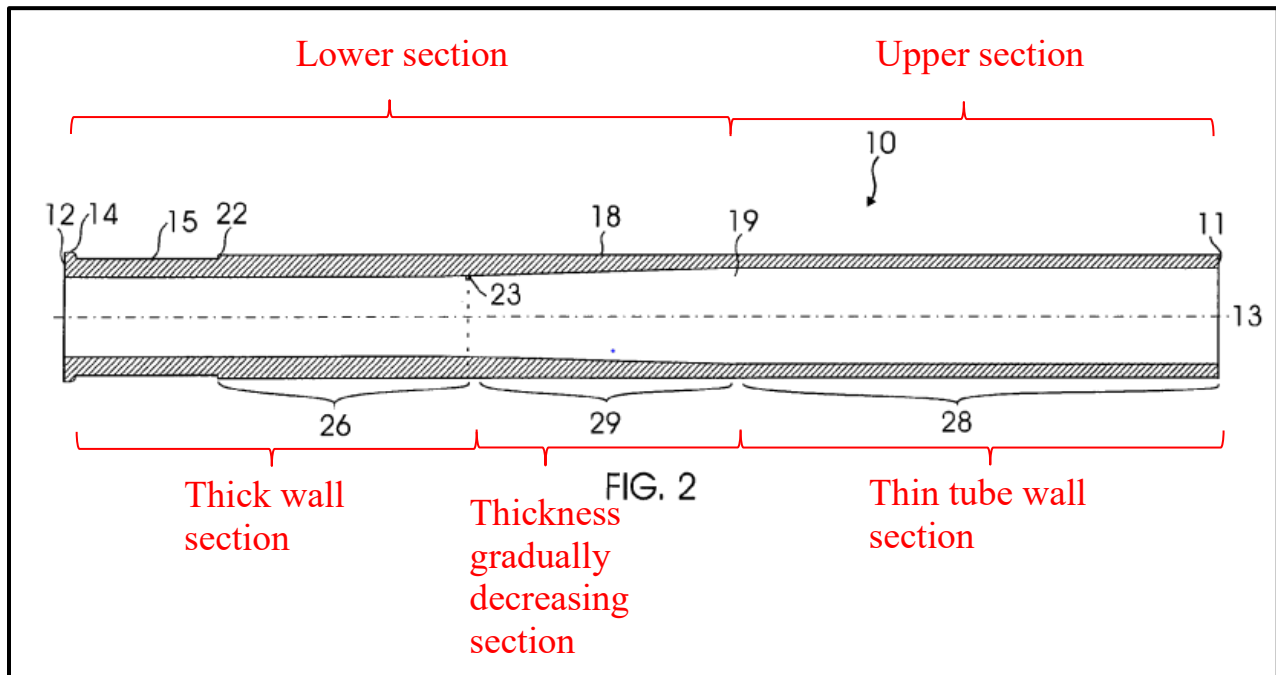
B. [Ground 2] Claims 31, 51, and 64 Are Rendered Obvious by Denk in View of Moechnig and Further in View of Schroeder

1. A POSITA would have been motivated to combine Denk, Moechnig, and Schroeder, and would have reasonably expected success in doing so

142. Claims 31 and 51 and claim term 64[c] require that “the body [be] formed of a material different from the crown of the front wheel fork.” Based on the disclosure of Schroeder, a POSITA would have been motivated to use two different materials for the steerer tube body and the fork crown in the Denk and Moechnig steerer tube combination to improve durability and shock absorption capabilities of the steerer tube and fork.

143. Like Denk, Moechnig, and the '993 patent, Schroeder discloses a steerer tube 10 connected to a crown 30 of a bicycle fork. Schroeder, 4:8-12, 6:1-4, FIGS. 1A-2. As shown below, Schroeder's steerer tube 10 includes a first proximal end 11, a second distal end 12, and a central bore 13. Schroeder, 6:5-9, FIGS. 1B-2. Steerer tube 10 has a thick tube wall section 26 from second distal end 12 to a location 23 of the tube, a thin tube wall section 28 extending from first proximal end 11 to another location 19, and a section 29 between the positions 19 and 23 where the thickness of the tube wall gradually decreases from the distal to the proximal location. Schroeder, 6:15-21, FIG. 2. Schroeder discloses that a steerer tube designed

in accordance with this configuration has the advantage of reduced weight and improved mechanical strength. Schroeder, 6:16-26.



Schroeder, FIG. 2 (annotations added).

144. Schroeder also discloses in general that aluminum is a preferred material for manufacturing the fork crown (likely because aluminum is less expensive and lighter), and that the steerer tube is made of uncured resin blended with carbon fiber composites. Schroeder, 4:19-26, 4:48-53, 5:21-25, 5:63-67, 7:20-44, 8:8-17, 9:39-49. Indeed, Schroeder explicitly teaches molding together a steerer tube and fork crown made of different materials. *See, e.g.*, Schroeder, Title, 4:22-26 (“It has been discovered, according to the present invention, that **if a bicycle fork assembly is comprised of a steering tube made of resin having carbon fiber composites**

molded into a crown made of aluminum, the bicycle fork will possess[] durability and shock absorbing capabilities.” (emphasis added)). A POSITA would have been motivated to use the generally preferred aluminum for the fork crown and a different material for the body of the steerer tube—such as the uncured resin blended with carbon fiber composites, which is subsequently molded to a desired shape and then cured—to improve durability and shock absorption capabilities of the steerer tube and fork. Schroeder, 4:22-26.

145. A POSITA would have readily known how to connect the steerer tube and the fork crown formed of different materials because it would have only required conventionally known manufacturing techniques, such as bonding or molding, as disclosed in Denk, Moechnig, and Schroeder. Denk, col. 3; Moechnig, [0002]; Schroeder, 7:31-42, 8:8-17, 9:66-10:9.

2. Claim 64

146. Denk in view of Moechnig and Schroeder renders claim 64 obvious.

a. Claim terms 64[pre]-64[b] and 64[d]

147. The claim limitations in 64[pre]-64[b] and 64[d] are identical to 1[pre]-1[b] and 1[d], respectively. Denk in view of Moechnig renders obvious 64[pre]-64[b] and 64[d] for the reasons discussed above in 1[pre]-1[b] and 1[d]. *See* Section IX.A.2, above.

- b. 64[c]: “the segment of the lower section of the body is joined to the crown of the front wheel fork, the body formed of a material different from the crown of the front wheel fork”**

148. Denk in view of Moechnig and further in view of Schroeder renders claim 64[c] obvious.

149. As discussed with regard to claim term 1[b] (Section IX.A.2.c), Denk in view of Moechnig shows that a segment of the lower section of the steerer tube body is joined to a crown of a front wheel fork. And as discussed above, Schroeder discloses that the body of the steerer tube is formed of a material different from that of the fork crown. Schroeder, Title, 4:19-26, 4:48-53, 5:21-25, 5:63-67, 7:20-44, 8:8-17, 9:39-49. A POSITA would have been motivated to modify the Denk and Moechnig steerer tube to be formed of a material different from Moechnig’s fork crown to improve durability and shock absorption capabilities, as disclosed in Schroeder. Schroeder, Title, 4:19-26, 4:48-53, 5:21-25, 5:63-67, 7:20-44, 8:8-17, 9:39-49.

3. Claims 31 and 51

150. Claims 31 and 51 depend from claims 15 and 34, respectively. Both claims are identical to the limitation in claim term 64[c].

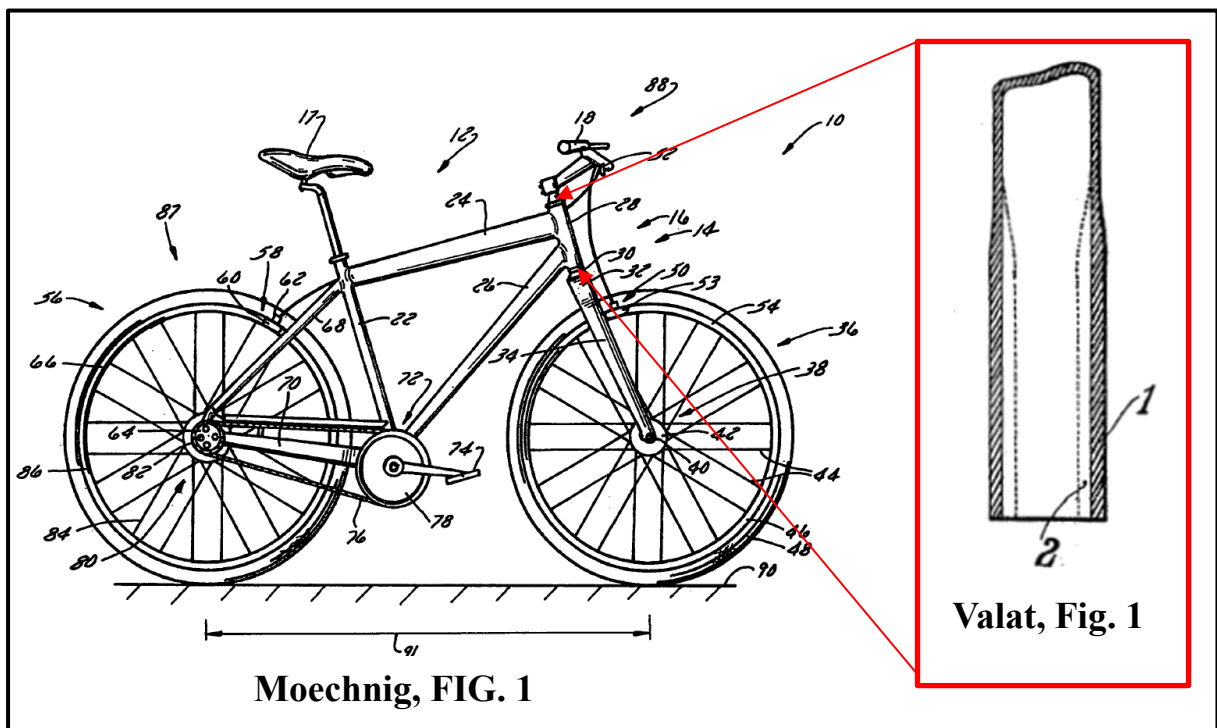
151. Denk in view of Moechnig and further in view of Schroeder renders claims 31 and 51 obvious for the reasons discussed above in claims 1, 15, and 34 and claim term 64[c]. *See* Sections IX.A.2, IX.A.4, IX.A.5, and IX.B.2.b, above.

X. VALAT-BASED GROUNDS

A. [Ground 3] Claims 1-4, 6, 8, 10, 12, 14-18, 20, 22, 24, 26-29, 33-38, 40, 42, 44, 46-49, 53, and 56-63 Are Obvious over Valat in View of Moechnig and Denk

1. A POSITA would have been motivated to combine Valat, Moechnig, and Denk, and would have reasonably expected success in doing so

152. A POSITA would have found it obvious to mount Valat's steerer tube on a bicycle frame in a conventional manner, as disclosed in Moechnig and as shown below.



Moechnig, FIG. 1, Valat, Fig. 1 (annotations added).

153. As discussed above in Ground 1 (Section IX.A.1), a POSITA would have understood that Valat's steerer tube would have been mounted on the bicycle frame

to connect to the handlebar and fork crown to steer the bicycle as disclosed in Moechnig, and which was also admitted as conventional in the AAPA. Moreover, a POSITA would have expected success in mounting Valat's steerer tube on a bicycle frame in a conventional manner as disclosed in Moechnig, for the same reasons as discussed above for Denk's tube in Ground 1 (Section IX.A.1).

154. A POSITA would have been motivated to improve the Valat design by having the internal cross-sectional contour of the lower section of the tube be an ellipse, as taught by Denk and shown in Denk Figure 11, instead of the reinforcement ribs. A POSITA would have known that such modification would allow the transition in wall thickness around the internal wall perimeter to be smooth, continuous, and without any sharp turns/corners that could add more stresses or failure points. *See* Denk, col. 3 (teaching continually change of inner cross-section contour avoids a jump in rigidity and thus stress concentration). A POSITA would also have known that, at the time of the purported invention, it would have been easier to manufacture a steerer tube with an elliptical inner wall in a portion thereof as compared to a steerer tube with reinforcement ribs on the inner wall. For example, in a molding process, additional helical structures would be required in the mold, and in a machining process, additional machining would be required on the inner wall surface

to create the helical structures, which would be more difficult for a steerer tube with smaller inner diameters.

155. A POSITA would have understood that modifying Valat's steerer tube to incorporate Denk's teaching of an elliptical inner cross-sectional contour in the lower part of the steerer tube would have provided the following benefits expressly recognized by the references: (1) improve the strength and rigidity (or load-bearing) properties of Valat's steerer tube in the vertical plane of the bicycle where higher loads or stresses occur (Denk, cols. 1-2); and (2) reduce the weight of the steerer tube to provide "a lighter weight machine" (Valat, 1:10-14; Denk, Abstract, cols. 1-2, 9).

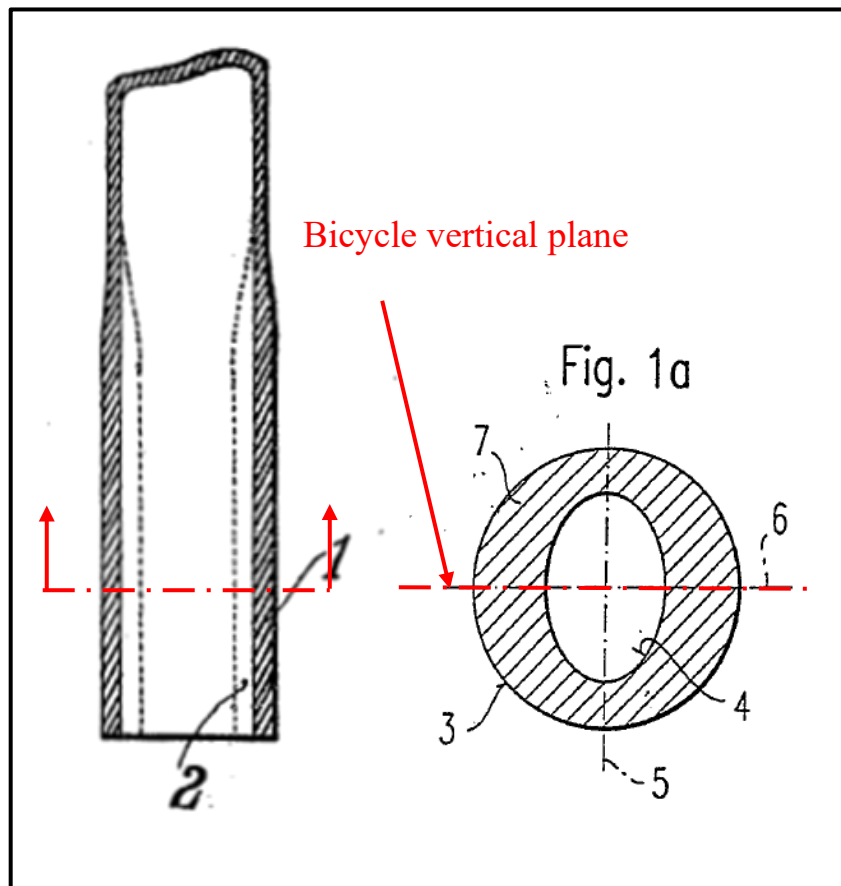
156. A POSITA would have known how to incorporate Denk's elliptical inner wall contour into Valat's steerer tube because the references expressly teach how to make such a modification. Valat discloses that the lower part *a* of the steerer tube bears the greatest loads and would benefit from reinforcement structures, such as parallel or helical ribs. Valat, 1:35-51, 1:70-78. A POSITA would have been motivated to modify the lower part *a* of Valat's steerer tube that has the reinforcement structures (Valat, 1:44-51, 1:70-78) to have the elliptical inner cross-sectional contour, as disclosed in Denk, instead of the ribs. Either form of reinforcement—ribs or elliptical contour—would provide varying wall thickness across a cross-section. But

as discussed above, an elliptical inner contour would provide smoother and consistent transition in wall thickness to reduce stress and would be easier to manufacture.

157. Moreover, Denk discloses that higher impact loads occur in the vertical plane of travel of the bicycle frame. Denk, cols. 2, 9. Thus, a POSITA would have known to incorporate Denk's varying wall thickness to the lower part *a* of Valat's steerer tube by positioning the maximum thickness areas in the vertical plane of travel as disclosed in Denk. Denk, cols. 2, 9; *see also* Campagnolo, 7:29-8:3 (teaching the tube should be mounted corresponding to the real needs and should take into account the actual stresses involved and their possible variations). A POSITA would have understood that the minimum wall thickness would be in the plane perpendicular to the vertical plane of travel and designed to have a thickness that meets the lower strength requirement of that plane while minimizing the weight of the steerer tube. This is because this plane is the neutral axis for bending caused by forward motion loads on the bicycle, and at the neutral axis, bending stresses are smaller or essentially zero as compared to the vertical plane. A POSITA also would have understood that such modification would have allowed Valat's lightweight steerer tube to have a "particularly favorable ratio of strength properties and rigidity properties with regard to the weight" by reinforcing the areas of higher loads and

reducing material (and thus weight of the steerer tube) at areas of lower loads at the lower part *a* of Valat's steerer tube where reinforcements are preferred. Denk, col. 1; Valat, 1:35-43, 1:79-90, 1:102-105.

158. Incorporating Denk's elliptical inner contour to the lower part *a* of Valat's steerer tube would have required only conventional manufacturing techniques and ordinary skill in the art. For instance, Denk discloses ways, such as machining, tube rolling, casting, or injection molding, to form the profile of the varying wall thickness. Denk, cols. 4, 9-10, Figs. 4a-5d. Denk also discloses that any desired cross-sectional shape can be achieved at any cross-section along the length of the tube. Denk, col. 10. Based on Denk's teaching, a POSITA would have known how to modify Valat's steerer tube and would have expected success in achieving the structure as shown in the figure below.



Valat, Fig. 1 (modified, annotated); Denk, Fig. 1a (annotated).

159. A POSITA would have understood that the combination of Valat, Moechnig, and Denk would have meant mounting Valat's steerer tube (as modified with Denk's elliptical inner wall contour) on a bicycle frame in a conventional manner as disclosed in Moechnig. Moechnig, [0002]. A POSITA would have expected success in combining the teachings of Valat, Moechnig, and Denk because it would simply require combining known prior art elements according to their established functions and would have yielded the expected, predictable result of a lightweight steerer tube

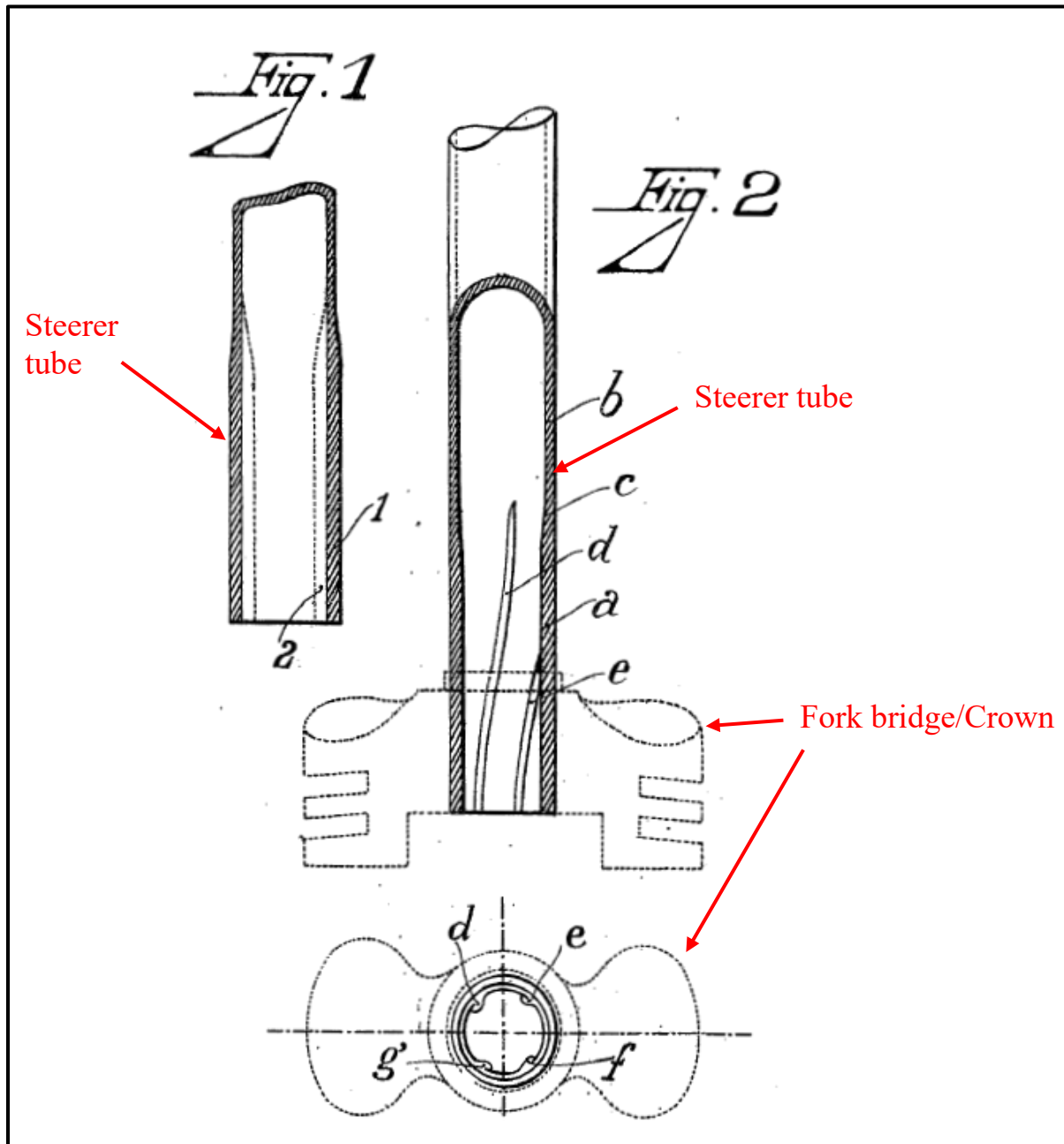
that meets the strength and rigidity requirements in the lower end of the steerer tube where reinforcement is beneficial.

2. Claim 1

160. Valat in view of Moechnig and Denk renders claim 1 obvious.

a. 1[pre]: “A steerer tube for a bicycle, the steerer tube comprising:”

161. Valat discloses 1[pre]. As shown below, Valat discloses a steerer tube for a bicycle connected to a fork bridge/crown. Valat, 1:44-63, Figs. 1-2.



Valat, Figs. 1-2 (annotations added).

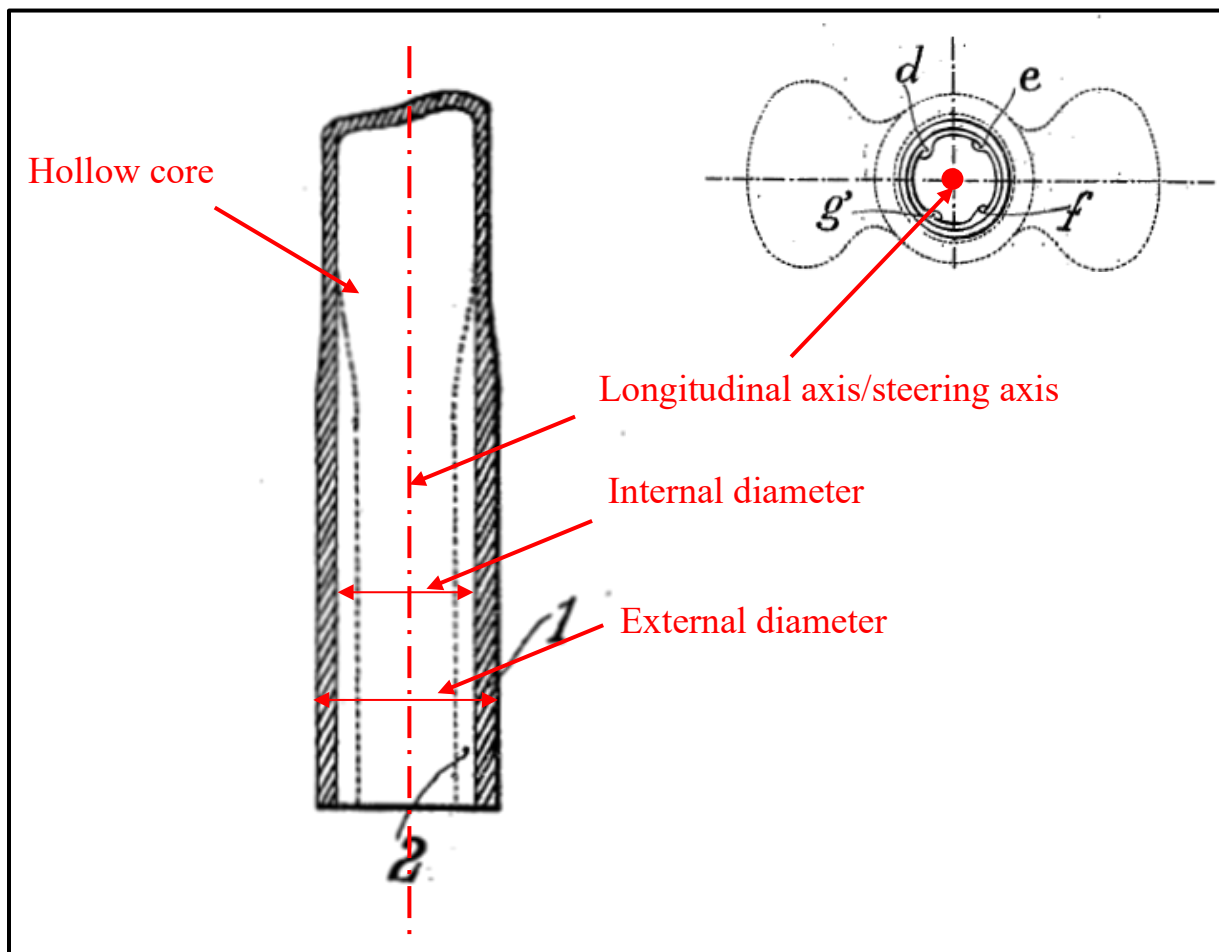
162. Moechnig also discloses a steerer tube for a bicycle. Moechnig, Title, Abstract, [0001].

- b. 1[a]: “an elongate hollow body arranged around a steering axis located in a vertical plane of travel of the bicycle”

163. Valat alone or in view of Moechnig discloses claim term 1[a].

164. Valat discloses that the steerer tube has “an elongate hollow body” because Valat’s steerer tube is arranged around a longitudinal axis and has an internal diameter and an external diameter, thus forming a hollow core, as shown below.

Valat, 1:22-26, 1:70-78, 1:86-90, 2:22-25.



Valat, Figs. 1-2 (modified, annotated).

165. A POSITA would have understood that Valat's longitudinal axis is the "steering axis located in a vertical plane of travel of the bicycle."

166. When Valat's steerer tube is mounted on a bicycle, a POSITA would have understood its longitudinal axis to be "a steering axis" because the longitudinal axis of a steerer tube is the axis about which the front wheel rotates to change travel direction and steer the bicycle. A POSITA also would have understood that the steering axis would have been "in a vertical plane of travel of the bicycle" because the vertical plane of travel is aligned with the fore-aft traveling direction of the bicycle, and rotating the front wheel about the steering axis in the vertical plane of travel would steer the front wheel out of the vertical plane of travel. *See also* AAPA; discussion of a steering axis in a vertical plane of travel in claim term 1[a] in Ground 1 (Section IX.A.2.b).

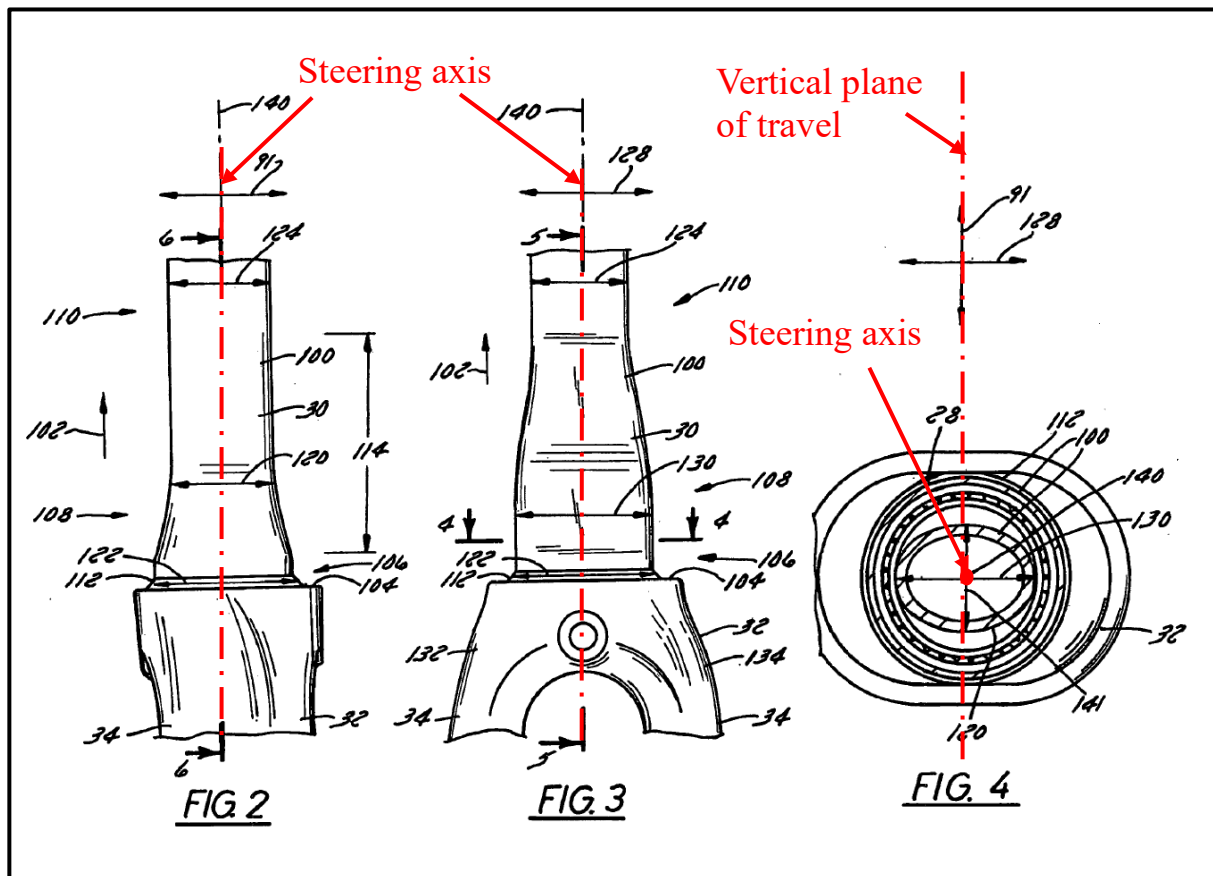
167. Further, Valat in view of Moechnig renders obvious a steerer tube having "an elongate hollow body arranged around a steering axis located in a vertical plane of travel of the bicycle."

168. Specifically, Moechnig discloses a steerer tube having an elongate hollow body arranged around a steering axis (longitudinal axis 140) located in a vertical plane of travel of the bicycle. Moechnig, FIGS. 2 and 3 (showing steerer tube 30 having an elongate body 110 arranged around longitudinal axis 140), [0035]

(“Radially asymmetric portion 114 tapers inward relative to **a longitudinal axis 140**, indicated by the intersection of longitudinal and lateral diameters 120, 130 as shown in FIG. 4, of body 100 as it extends from lower radial portion 106 toward upper radial portion 110.” (emphasis added)).

169. Moechnig also discloses that body 100 may be hollow. Moechnig, FIG. 4 (showing body 100 being hollow), [0045] (“Steerer tube 30 includes **an optional cavity 206 formed in body 100. Optional cavity 206 can extend a majority of the length of steerer tube 30 and provides a lighter steerer assembly 16**. Such a construction forms a steerer tube wall 208 that has a thickness that is selected to withstand the loaded interaction between steerer tube 30 and head tube 28.” (emphasis added)).

170. As shown below, Moechnig discloses a longitudinal direction or axis 91 of the bicycle frame that is aligned with a vertical plane of travel of the bicycle. Moechnig, [0005], [0032]. A POSITA would have understood that the vertical plane, as shown in Moechnig’s Figure 1, is aligned with the fore-aft direction of travel, and that longitudinal axis 91 of the bicycle frame would be in “a vertical plane of travel of the bicycle,” similar to the plane of travel disclosed in the ’993 patent. *See also* AAPA, Ex. 1001, FIG. 1.



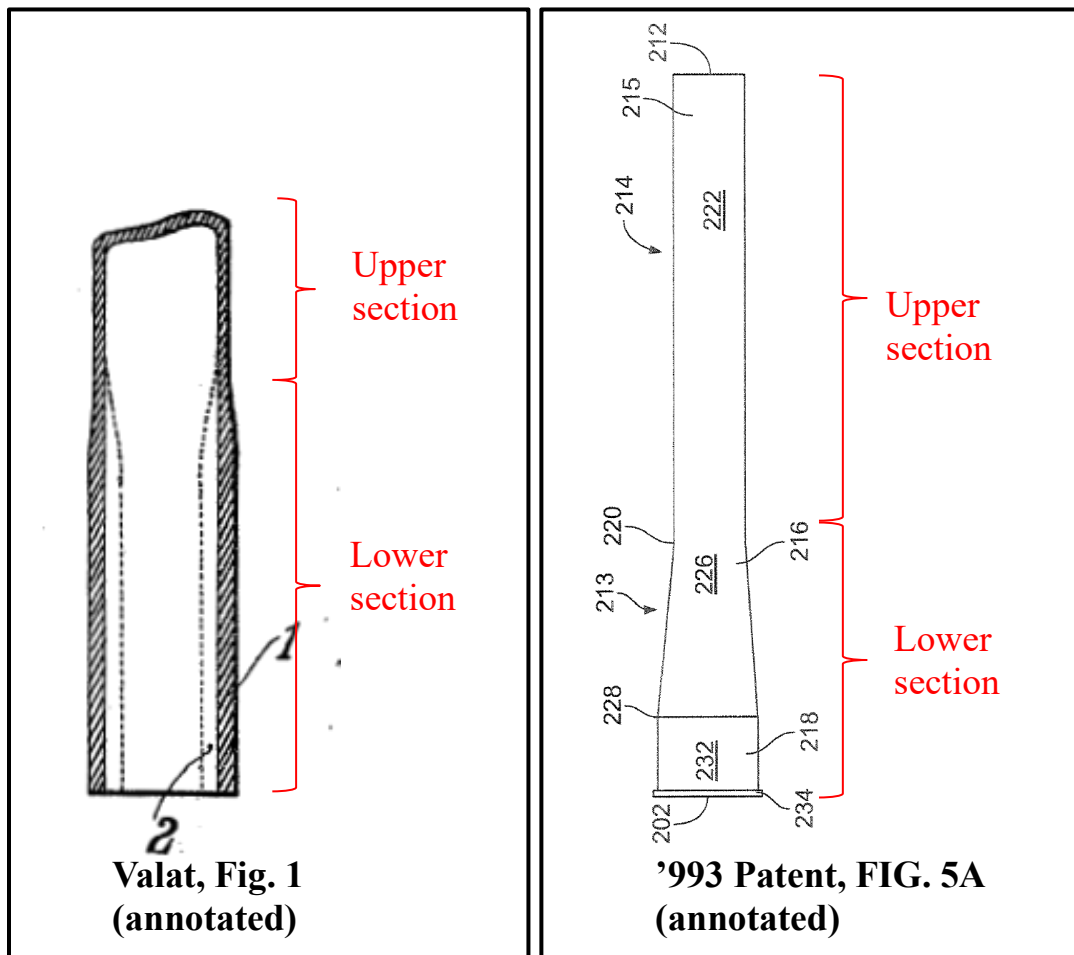
Moechnig, FIGS. 2-4 (annotations added).

171. A POSITA would have understood that Moechnig's longitudinal axis 140 is "a steering axis" because the steerer tube rotates about it to enable turning of the bicycle, and that Moechnig's longitudinal axis 140 is located "in a vertical plane of travel of the bicycle." Moechnig, FIG. 1. Based on Moechnig's teachings, a POSITA would have known that the elongated hollow body of Valat's steerer tube when mounted on a bicycle frame would be arranged around a steering axis in a vertical plane of travel of the bicycle, which was conventional and known at the time of the purported claimed invention. *See* AAPA.

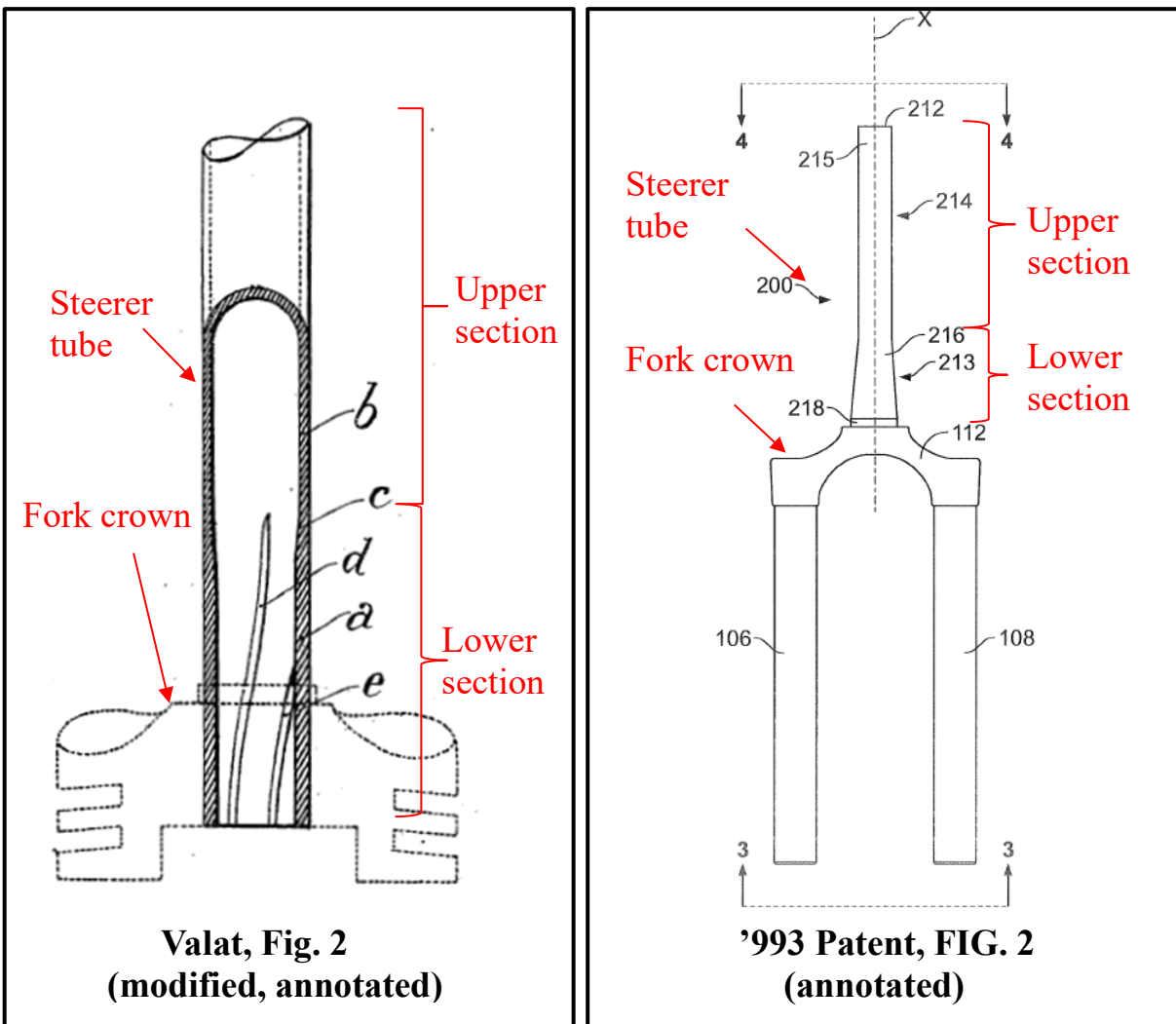
- c. **1[b]: “the body having upper and lower sections, a segment of the upper section adapted to be joined to a bicycle handlebar, a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle, the lower section joined to the upper section, and”**

172. Valat alone or in view of Moechnig discloses 1[b].

173. In one embodiment of Valat, the elongate hollow body of the steerer tube has a lower part *a* and an upper part *b* joined to the lower part via a tapering region *c*. Valat, 1:70-78, Figs. 1-2. Like the '993 patent, lower part *a* and tapering region *c* collectively form the “lower section” and upper part *b* forms the “upper section” that is joined to the “lower section,” as shown below.



174. Like the '993 patent, Valat discloses that a segment of the lower part *a* is adapted to be joined to a fork bridge, as shown below. Valat, 1:44-51, 1:61-63. A POSITA would have known that a fork bridge of a bicycle is equivalent to “a crown of a front wheel fork of the bicycle” because it was known and conventional that the front wheel of a bicycle is suspended between two fork legs connected by a crown or a bridge. *See* AAPA.

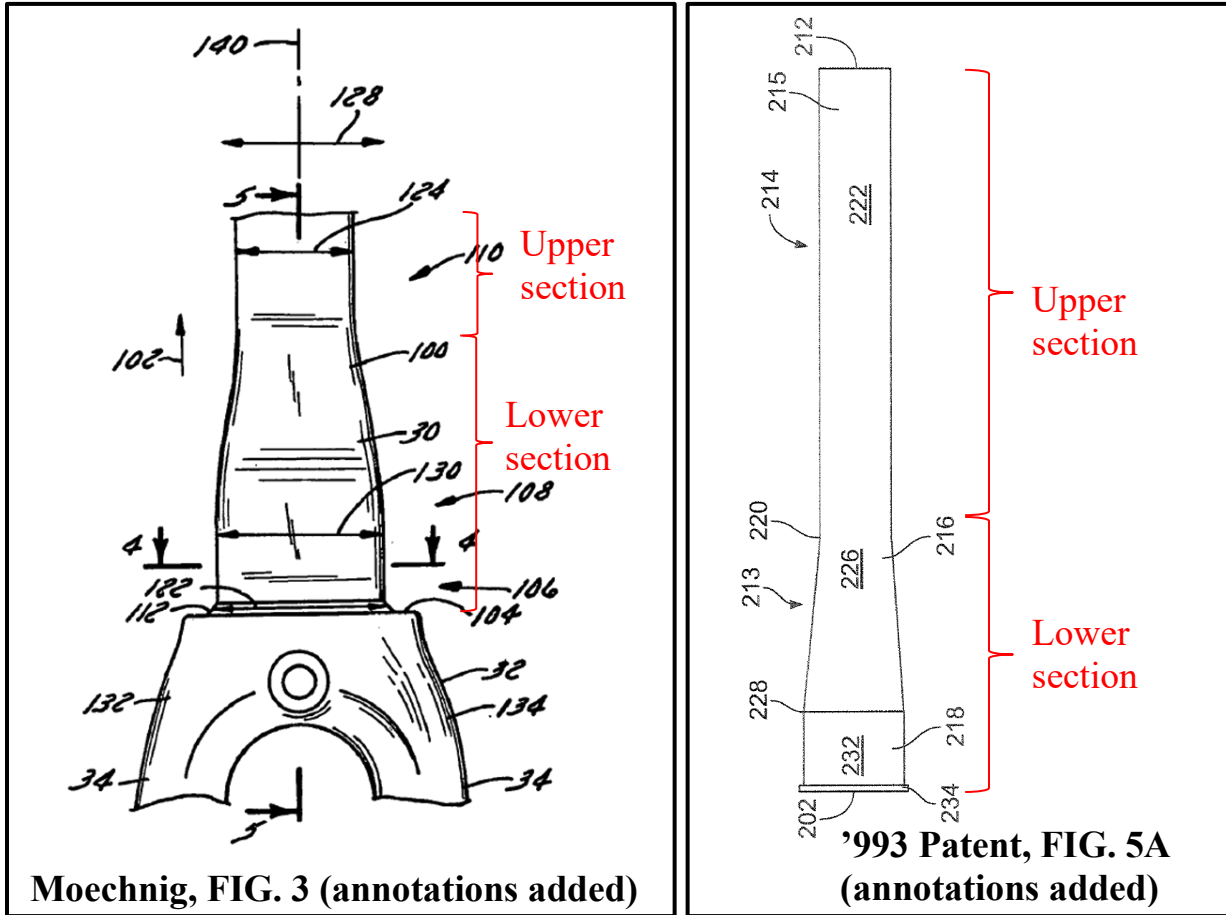


175. Although Valat does not explicitly disclose that a segment of the upper section is adapted to be joined to a bicycle handlebar, a POSITA would have understood that when mounted on a bicycle frame, the top end of the upper section of the steerer tube would have been joined to a handlebar such that manipulation of the handlebar would allow for steering of the front wheel of the bicycle, thereby changing the travel

direction of the bicycle. *See* AAPA; *see* discussion in Ground 1, above, 1[b] (IX.A.2.c).

176. Further, Valat in view of Moechnig renders obvious “a segment of the upper section adapted to be joined to a bicycle handlebar, a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle.”

177. Moechnig discloses a steerer tube 30 having a body 100, which includes a first or lower radial portion 106 and a radial asymmetric portion 108, which collectively form a “lower section.” Moechnig, [0035]. The “lower section” is joined to a second or upper radial portion 110 (“upper section”), as shown below. Moechnig, [0035], FIGS. 2, 3.



178. Moechnig discloses that “a segment of the upper section” of body 100 is adapted to be joined to a bicycle handlebar because the stem of Moechnig’s handlebar 18 engages with steerer tube 30. Moechnig, [0001], [0026], FIG. 1.

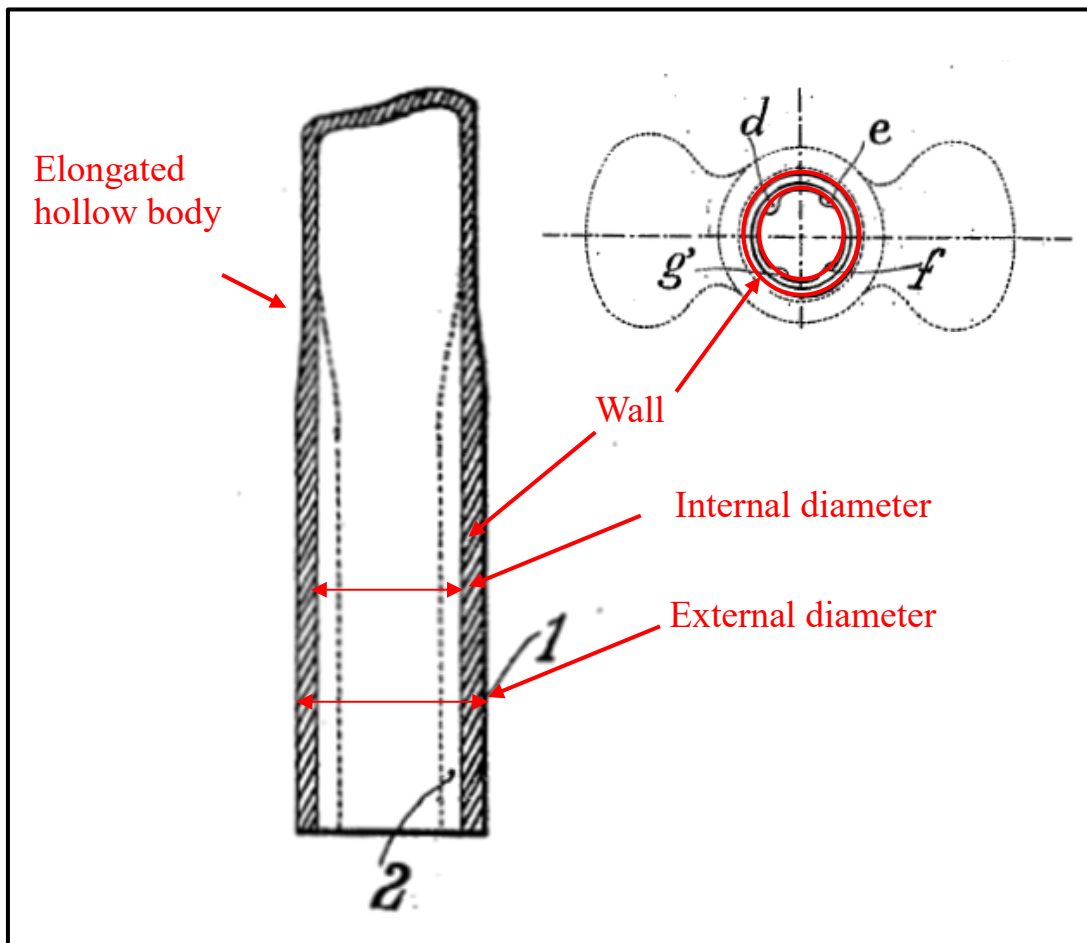
179. Moechnig further discloses that “a segment of the lower section” of the steerer tube body 100 is adapted to be joined to a crown of a front fork of the bicycle because Moechnig discloses that the steerer tube may be secured to or formed integrally with fork crown 32. Moechnig, [0002], [0027], FIGS. 1-3. Fork crown 32 is “a crown of a front wheel fork of the bicycle” because fork legs 34 extend from opposite sides

of the fork crown and support a front wheel assembly 36 of the bicycle. Moechnig, [0002], [0026]-[0028].

180. Based on Moechnig's teaching, a POSITA would have understood that Valat's steerer tube would have "a segment of the upper section adapted to be joined to a bicycle handlebar" and "a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle," which was conventional and known at the time of the purported invention. *See* AAPA.

d. 1[c]: "outer surfaces of the upper and lower sections of the body being circular in cross section, and"

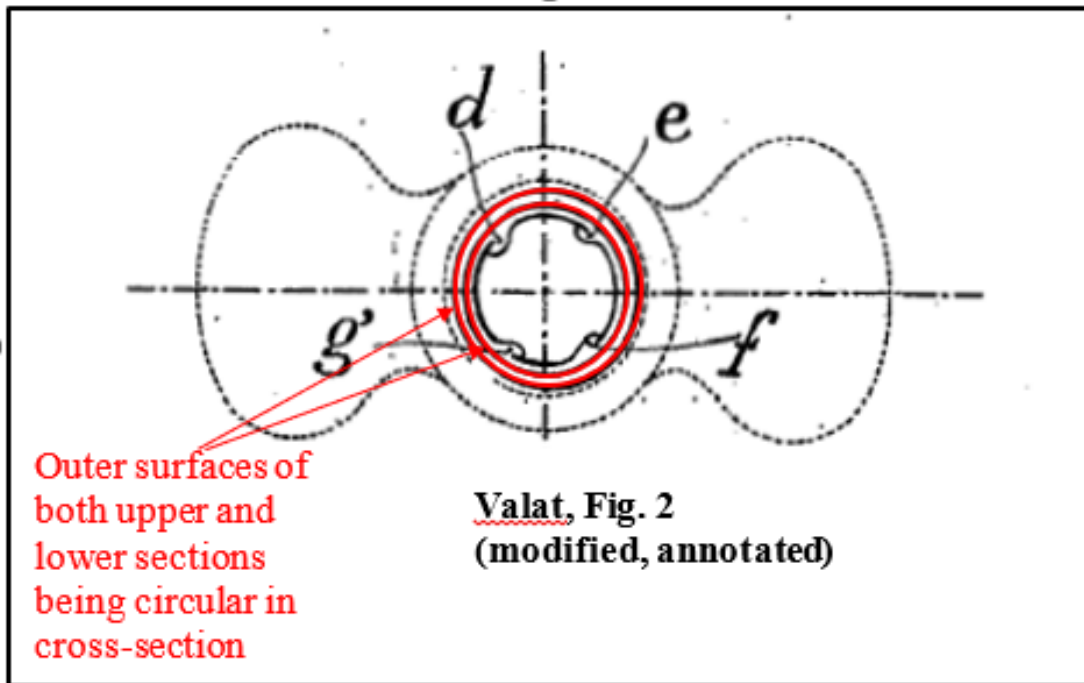
181. Valat discloses 1[c]. Specifically, Valat discloses that its steerer tube body has an external diameter. Valat, 1:70-90, 1:102-105, Figs. 1-2. Valat also discloses that, in one embodiment, the external diameter is greater at lower part *a* and taper *c* (together, the "lower section") where the reinforcements are formed, compared to the upper part *b*, as shown below. Valat, 1:70-78, 1:102-105, Fig. 1.



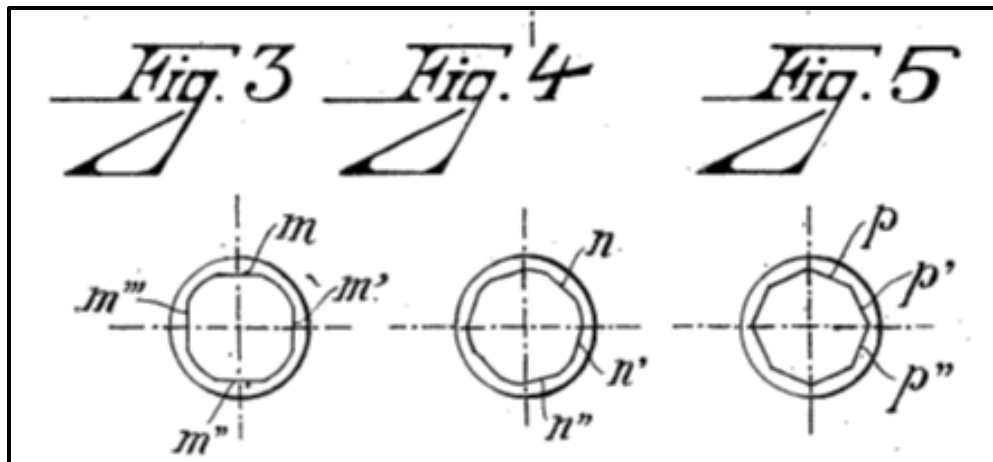
Valat, Fig. 1 (annotations added).

182. Because a “diameter” refers to the line passing through the center of a circle, unless modified with the term “major” or “minor” to signify an ellipse, a POSITA would have understood that the cross-sections of the outer surface of upper part *b* (“upper section”) and the outer surface of lower part *a* and taper *c* (together, the “lower section”) would be circular. Indeed, like the ’993 patent, Valat shows that the outer surfaces of the upper and lower sections are circular in a cross-sectional view perpendicular to the steering axis, as shown below with regard to the second

embodiment. Valat, 1:70-77, Fig. 2; *see also* Valat, Figs. 3-5 (showing outer surface of the entire elongate body is circular in cross-section).



Valat, Fig. 2 (annotations added).



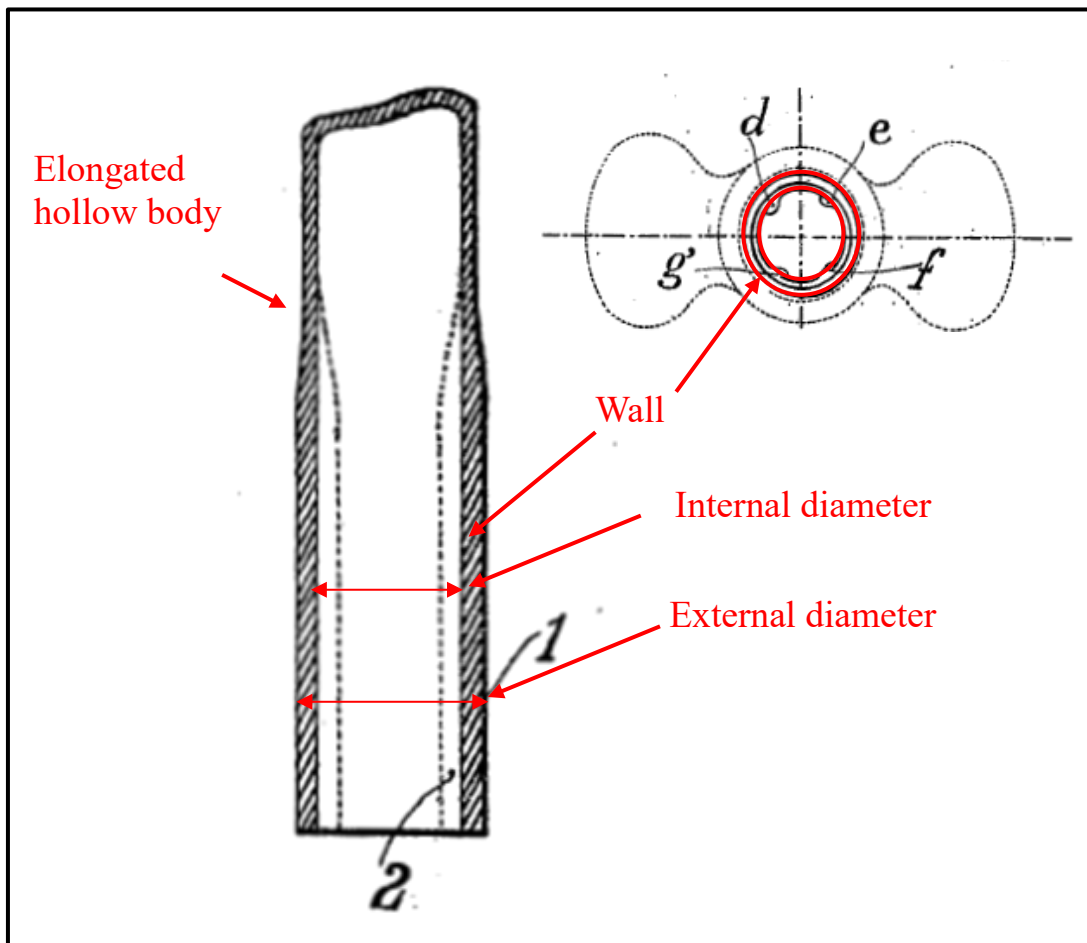
Valat, Figs. 3-5.

183. Accordingly, a POSITA would have understood that Valat discloses that the outer surfaces of the upper and lower sections of the elongated steerer tube body are circular in cross-section, like the '993 patent.

- e. **1[d]: “the body formed by a wall, a thickness of the wall at any point in the lower section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel, the wall thickness being at a maximum in the plane of travel of the bicycle.”**

184. Valat in view of Denk and Moechnig discloses 1[d].

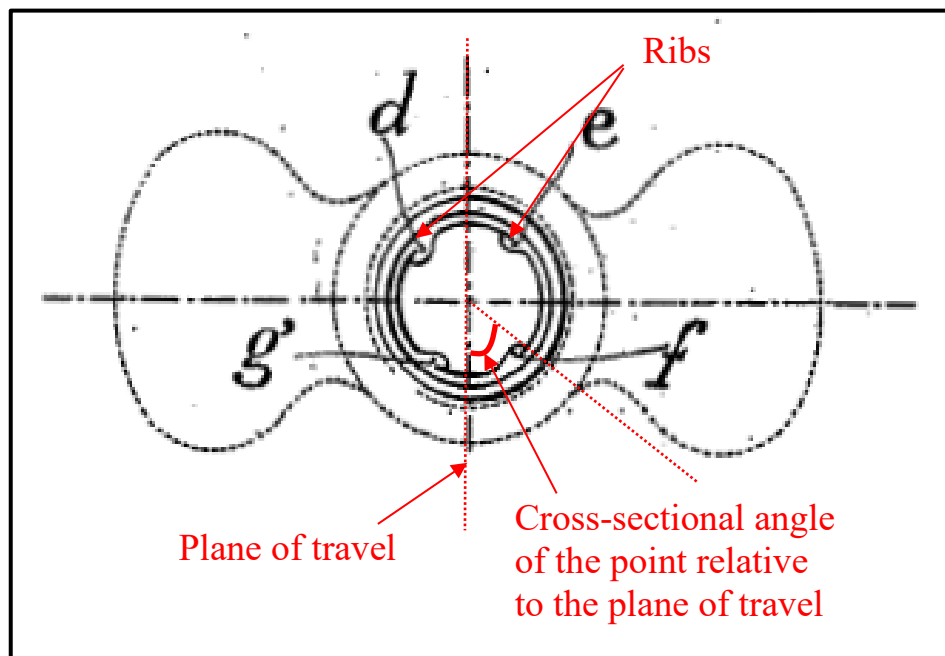
185. Valat's steerer tube body is formed by a wall that extends between the internal diameter and external diameter, as shown below.



Valat, Figs. 1-2 (modified, annotated).

186. Valat discloses that the wall thickness at any point in the lower section of the body—lower part *a* and taper *c*—varies as a function of the cross-sectional angle of the point relative to the plane of travel. Specifically, lower part *a*, where the loads are greatest, has a greater thickness than upper part *b* by having either a smaller internal diameter or a greater external diameter. Valat, 1:70-78, 1:102-105, Figs. 1-2. Valat further discloses that the steerer tube includes interior reinforcements, such as parallel or helical ribs, over the whole length of the tube or confined to those parts

that are subject to shear when in use. Valat 1:35-43, Fig. 2. For example, Valat discloses that reinforcements are provided in lower part *a* that taper towards the change in the internal diameter of the tube at taper *c*. Valat, 1:86-90, Figs. 2-5. Accordingly, as shown below, the wall thickness at any point in the lower section of the body—lower part *a* and taper *c*—depends on whether the point is in a region with reinforcement.

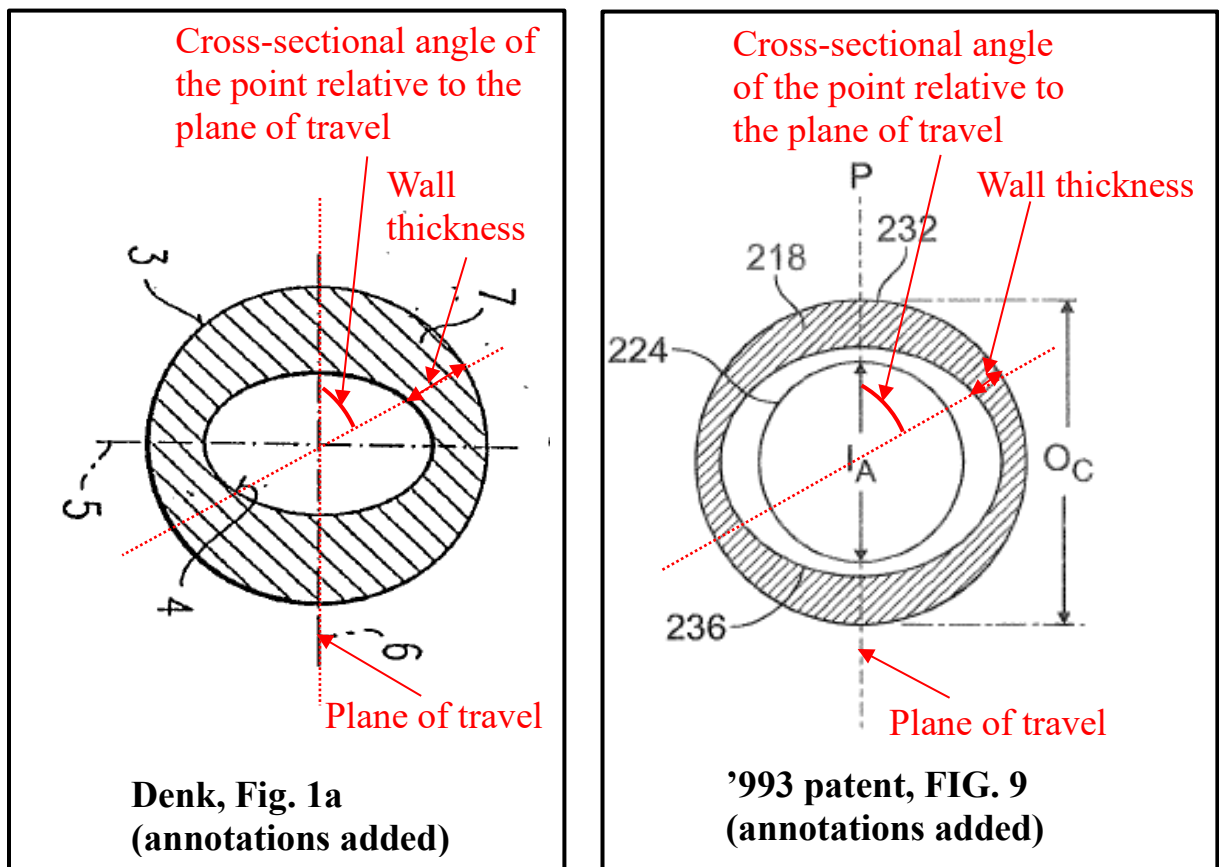


Valat, Fig. 2 (modified, annotated).

187. As illustrated above, the wall thickness of Valat's tube at any point on the wall, e.g., a point on the internal reinforcement rib, varies as a function of the cross-sectional angle of the point relative to the vertical plane ("the plane of travel") of the

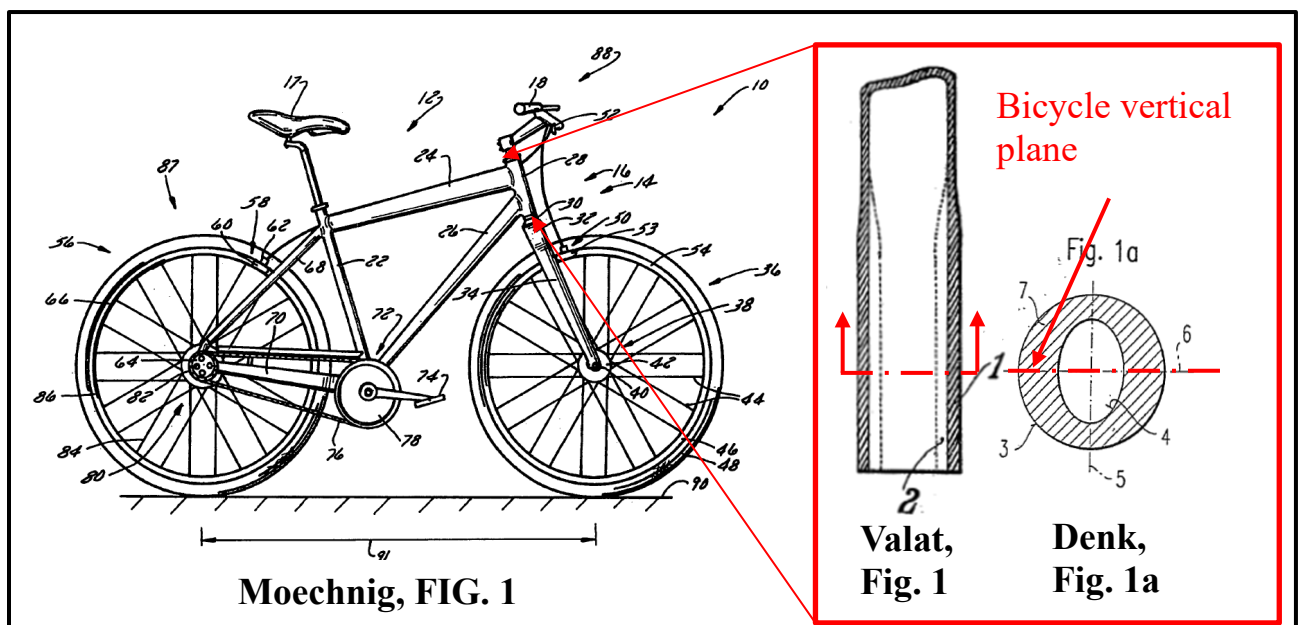
bicycle because the wall thickness changes based on the angular position of the point on the wall.

188. Further, as discussed in Ground 1, claim term 1[d] (Section IX.A.2.e) and shown below, Denk discloses an elongated tubular body that includes a wall formed between the inner elliptical and outer circular cross-sectional contours and the wall thickness at any point in the lower section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel. Denk, cols. 1-2, 9.



189. A POSITA would have been motivated to modify Valat's lower part *a* and taper *c* (together, the "lower section") to have an elliptical inner contour as disclosed

in Denk to improve the strength and rigidity properties of Valat's steerer tube in the vertical plane of the bicycle while maintaining light weight, as expressly disclosed in Denk and explained above in Section X.A.1 (motivation to combine). The wall thickness at any point on the wall of Valat's steerer tube (modified in view of Denk to have an elliptical inner contour in the lower part) would vary as a function of the cross-sectional angle of the point relative to the vertical plane of the bicycle. Based on Denk and Moechnig's teaching, a POSITA would have known to position the areas of maximum thickness of the elliptical inner wall contour of Valat's steerer tube (as modified in view of Denk) in the vertical plane of travel where the loads are highest, as illustrated below:



Moechnig, FIG. 1, Valat, Fig. 1 Denk, Fig. 1a (annotations added).

3. Claim 61

190. Valat in view of Moechnig and Denk renders claim 61 obvious.

- a. **61[pre]: “A steerer tube for a bicycle, the steerer tube comprising:”**

191. The preamble of claim 61 is identical to the preamble of claim 1. *See* discussion of 1[pre], above, at ¶¶161-162.

- b. **61[a]: “an elongate hollow body arranged around a steering axis located in a vertical plane of travel of the bicycle,”**

192. Claim term 61[a] is identical to claim term 1[a]. *See* discussion of 1[a], above, at ¶¶163-171.

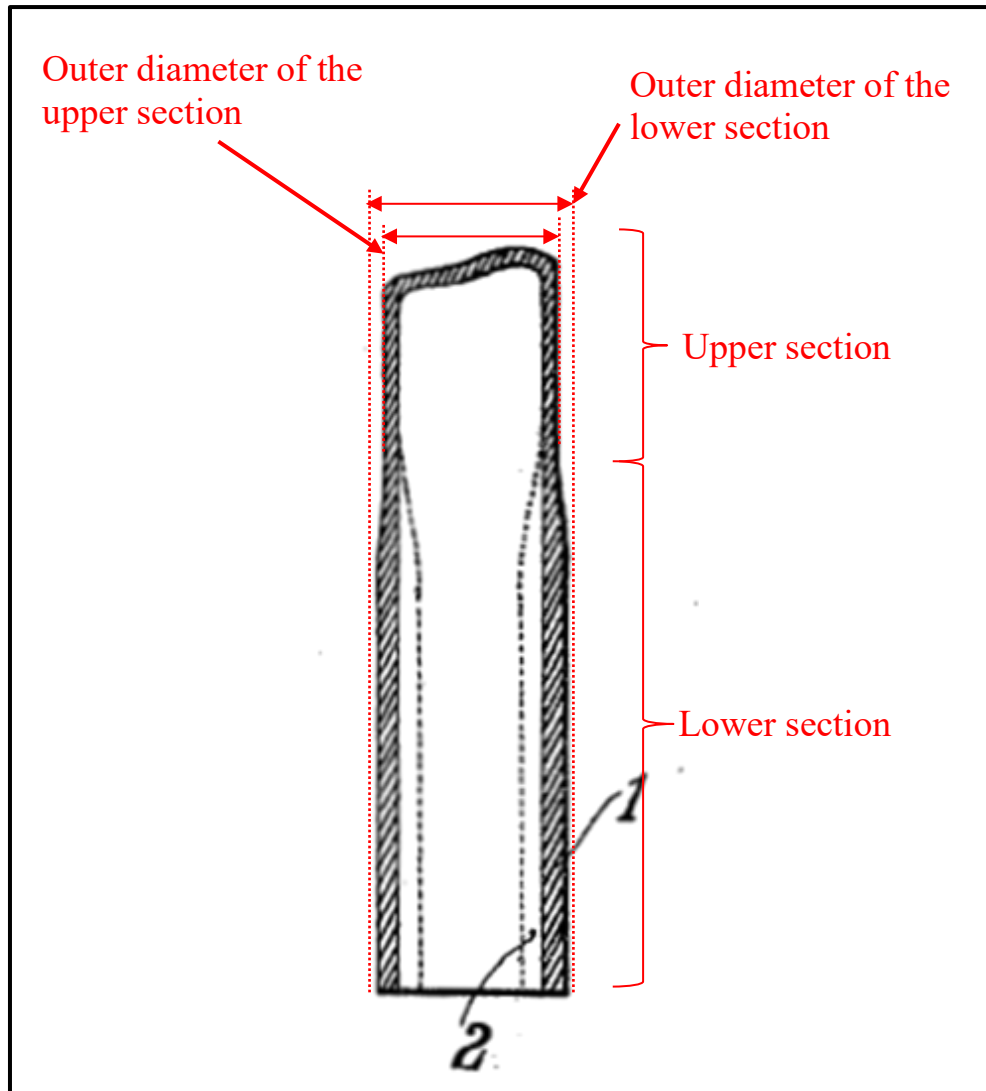
- c. **61[b]: “the body having upper and lower sections, a segment of the upper section adapted to be joined to a bicycle handlebar, a segment of the lower section adapted to be joined to a crown of a front wheel fork of the bicycle, the lower section joined to the upper section,”**

193. Claim term 61[b] is identical to claim term 1[b]. *See* discussion of 1[b], above, at ¶¶172-180.

- d. **61[c]: “an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body, and”**

194. Valat in view of Moechnig and Denk discloses claim term 61[c].

195. As discussed above with regard to claim term 1[b] and as shown below, Valat discloses that its steerer tube has an upper section and a lower section. *See* Valat, Fig. 1, 1:70-78, 1:102-105.



Valat, Fig. 1 (annotations added).

196. And as discussed above with regard to claim term 1[c] (§§181-183), Valat discloses that the outer surfaces of the upper and lower sections of the body have

circular cross-sections. Valat further discloses that the outer diameter of the lower section where reinforcements are added is greater than the outer diameter of the upper section, as shown above. *See* Valat, Fig. 1, 1:70-78, 1:102-105.

- e. **61[d]: “the body formed by a wall, a thickness of the wall at any point in the lower section of the body varying as a function of the cross-sectional angle of the point relative to the plane of travel, the wall thickness being at a maximum in the plane of travel of the bicycle.”**

197. Claim term 61[d] is identical to claim term 1[d]. *See* discussion of 1[d], above, at ¶¶184-189.

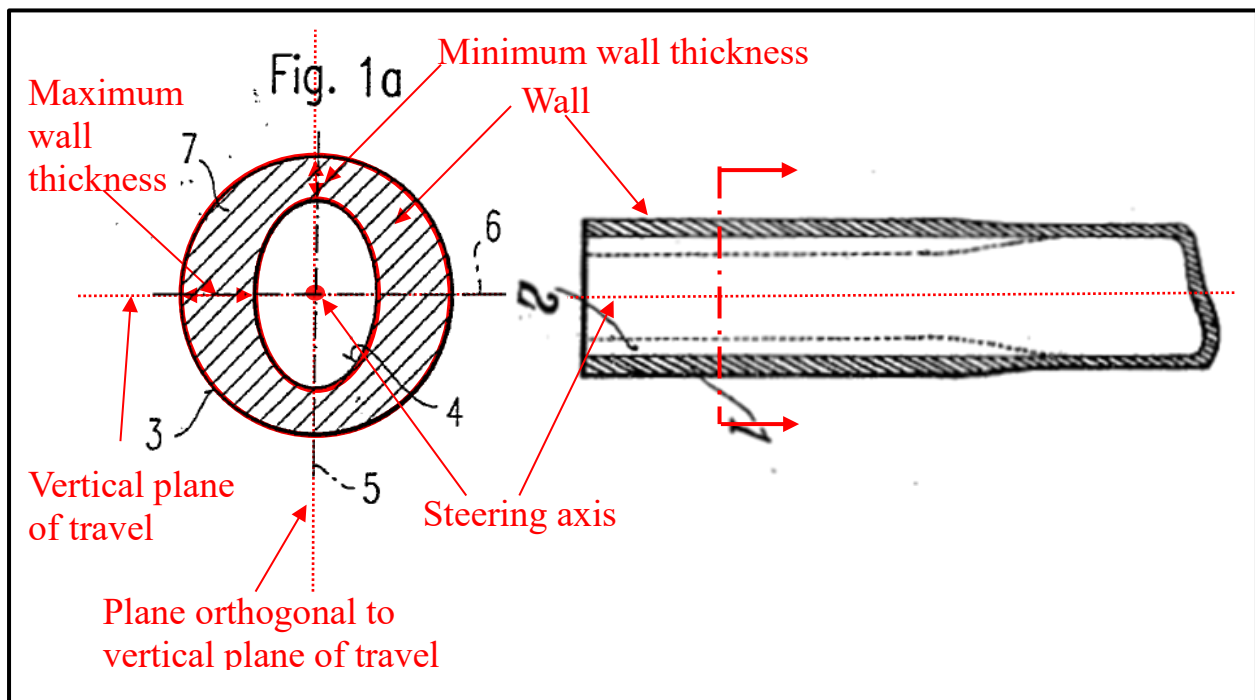
- 4. **Claim 15 (“wherein the wall thickness is at a minimum in a plane containing the steering axis and orthogonal to the plane of travel of the bicycle.”)**

198. Claim 15 depends from claim 1 and recites “wherein the wall thickness is at a minimum in a plane containing the steering axis and orthogonal to the plane of travel of the bicycle.”

199. Valat in view of Moechnig and Denk renders claim 15 obvious.

200. As discussed above with regard to claim terms 1[a] and 1[d] and as shown below, Valat in view of Moechnig and Denk discloses that the steerer tube body of Valat (modified in view of Denk to have an elliptical inner wall contour in the lower section (instead of reinforcement ribs)) is arranged around a steering axis located in a vertical plane of travel of the bicycle, and that the wall of the elongated hollow

body has maximum thickness in “the plane of travel of the bicycle” (e.g., Denk’s plane 6) and minimum thickness in a plane perpendicular to the plane of travel, i.e., “a plane . . . orthogonal to the plane of travel of the bicycle” (e.g., Denk’s plane 5). Both planes intersect orthogonally at the steering axis, as shown below, so the “plane orthogonal to the plane of travel of the bicycle” includes the steering axis. A POSITA would have known that the steering axis of Denk’s tube would align with the center line or center plane 5.



Denk, Fig. 1a; Valat, Fig. 2 (modified, annotated).

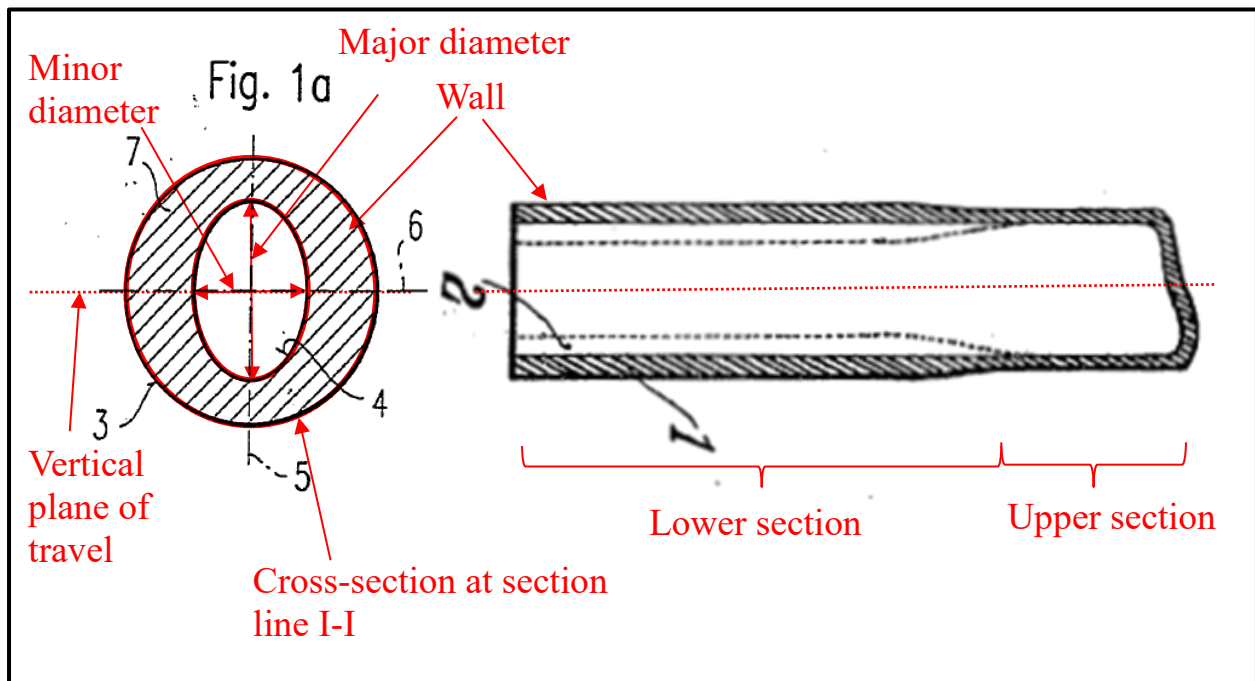
5. **Claim 34 (“wherein an inner surface of the wall within the lower section of the body is formed as an ellipse in cross section, a major diameter of the ellipse formed to be**

perpendicular to the plane of travel, a minor diameter of the ellipse formed to be in the plane of travel of the bicycle.”)

201. Claim 34 depends from claim 15 and recites “wherein an inner surface of the wall within the lower section of the body is formed as an ellipse in cross section, a major diameter of the ellipse formed to be perpendicular to the plane of travel, a minor diameter of the ellipse formed to be in the plane of travel of the bicycle.”

202. Valat in view of Moechnig and Denk renders claim 34 obvious.

203. As discussed above with regard to claim terms 1[b] and 1[d] and as shown below, Valat’s steerer tube body (modified in view of Denk) has an upper section, a lower section, and a wall of the lower section has varying thickness formed between the inner elliptical cross-sectional contour 4 and outer circular cross-sectional contour 3 (as evident from the cross-section taken at a section line I-I in the lower section of Denk’s tube body).



Denk, Fig. 1a (annotations added); Valat, Fig. 1 (annotations added).

204. Inner elliptical cross-sectional contour 4 in the lower section of the body is formed as “an ellipse in cross section.” The ellipse formed by contour 4 has “a major diameter” positioned to be perpendicular to the plane of travel and “a minor diameter” positioned to be in the plane of travel of the bicycle such that the tube has maximum wall thickness in the plane of travel where the loads are higher compared to the plane that is orthogonal to the plane of travel, as disclosed in Denk. Denk, col. 2; *see* discussion of wall thickness design in claim term 1[d] (Section X.A.2.e).

6. Claim 35 (“wherein outer surfaces of the upper and lower sections of the body are circular in cross section.”)

205. Claim 35 depends from claim 34 and recites a limitation that is identical to claim term 1[c]. Valat in view of Denk and Moechnig renders claim 35 obvious for

the reasons discussed above with regard to claim term 1[c] and claim 34. *See* Sections X.A.2.d and X.A.5, above.

7. Claims 14, 33, and 53 (“wherein the body is formed from a material selected from the group consisting of steel, carbon fiber reinforced composite, aluminum, titanium and magnesium.”)

206. Claims 14, 33, and 53 depend from claims 1, 15, and 34, respectively. All of these claims recite “wherein the body is formed from a material selected from the group consisting of steel, carbon fiber reinforced composite, aluminum, titanium and magnesium.”

207. Valat in view of Moechnig and Denk renders claims 14, 33, and 53 obvious.

208. Specifically, Denk discloses that lightweight components for bicycle tubes may be made of steel, aluminum or titanium alloy, or plastic material reinforced with carbon fibers. Denk, cols. 1, 5. A POSITA would have understood that any of these materials would have been suitable for Valat’s steerer tube because Denk teaches that such lightweight component is “suitable for practically all tubular components, i.e., top tube, down tube, seat tube, head tube, fork tubes, rear wheel stay, seat posts, handlebars, handlebar stem, and the like.” Denk, col. 4.

209. Moechnig also discloses that a steerer tube is made of aluminum or carbon fiber materials. Moechnig, [0003], [0014]. A POSITA would have found it obvious to use these materials for Valat’s steerer tube. Indeed, it was well known and

conventional to use aluminum or titanium alloy, or carbon fiber reinforced materials for tubular components of bicycles because they provide suitable mechanical properties and weight.

8. Claims 2, 16, 27, 36, and 47 (“wherein an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body.”)

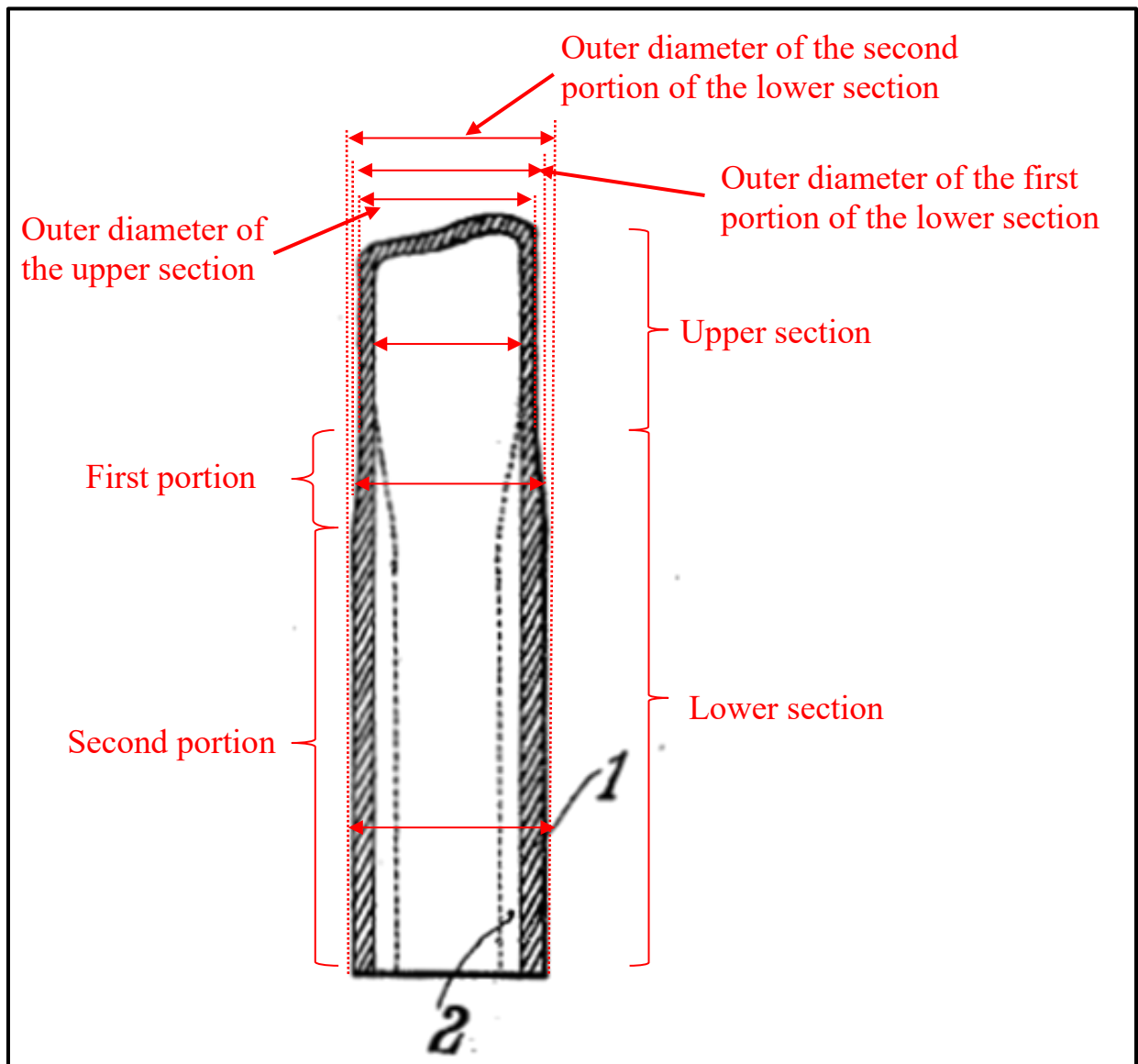
210. Claim 2 depends from claim 1; claims 16 and 27 depend from claim 15; claim 36 depends from claim 35; and claim 47 depends from claim 34. All of these claims are identical to claim term 61[c], which recites “wherein an outer diameter of the lower section of the body is greater than an outer diameter of the upper section of the body.” Valat in view of Moechnig and Denk renders them obvious for the reasons discussed above with regard to claim term 61[c]. *See* Section X.A.3.d.

9. Claims 3, 17, 28, 37, 48, and 62 (“wherein the lower section of the body has first and second portions, the first portion adjoining the upper section of the body, an outer diameter of the first portion of the lower section being greater than an outer diameter of the upper section and less than an outer diameter of the second portion of the lower section.”)

211. Claims 3, 17, 28, 37, 48, and 62 depend from claims 2, 16, 27, 36, 47, and 61, respectively. All these claims recite “wherein the lower section of the body has first and second portions, the first portion adjoining the upper section of the body, an outer diameter of the first portion of the lower section being greater than an outer

diameter of the upper section and less than an outer diameter of the second portion of the lower section.” Valat discloses this limitation.

212. As discussed with regard to claim term 1[b] (Section X.A.2.c) and shown below, Valat discloses that the elongated tubular body has a lower part and a taper, collectively forming “a lower section,” and an upper part forming “an upper section.” The taper forms a “first portion” of the lower section joining the upper section, and the lower part forms the “second portion” of the lower section. As discussed above with regard to claim terms 1[c] and 61[c] (Sections X.A.2.d and X.A.3.d), the outer surfaces of the upper and lower sections are circular in cross-section with corresponding outer diameters. The outer diameter of the tubular body tapers gradually from the “second portion” of the lower section to the upper section over the “first portion” of the lower section. This results in *an* outer diameter of the “first portion” of the lower section being greater than *an* outer diameter of the upper section and less than *an* outer diameter of the “second portion” of the lower section.



Valat, Fig. 1 (annotations added).

10. Claims 4, 18, 29, 38, 49, and 63 (“wherein the outer diameter of the first portion of the lower section gradually tapers from the second portion of the lower section to the upper section of the body.”)

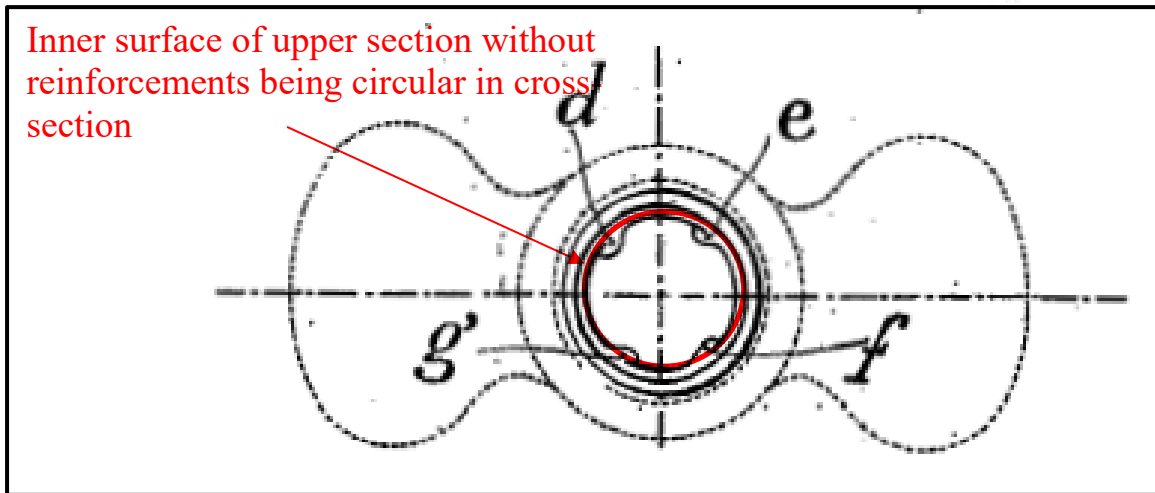
213. Claims 4, 18, 29, 38, 49, and 63 depend from claims 3, 17, 28, 37, 48, and 62, respectively. All these claims recite “wherein the outer diameter of the first portion

of the lower section gradually tapers from the second portion of the lower section to the upper section of the body.” Valat discloses this claim limitation for the same reasons discussed above with regard to claims 3, 17, 28, 37, 48, and 62 (Section X.A.9).

11. Claims 6, 10, 20, 24, 40, and 44 (“wherein an inner surface of the upper section is circular in cross section.”)

214. Claims 6, 10, 20, 24, 40, and 44 depend from claims 4, 1, 18, 15, 38, and 34, respectively. All these claims recite “wherein an inner surface of the upper section is circular in cross section.” Valat discloses this claim limitation.

215. Valat discloses that its steerer tube body has an internal diameter. Valat, 1:86-90, Figs. 1-2. Valat shows in a cross-sectional view perpendicular to the steering axis that the inner surface of the lower section is circular with reinforcements *d*, *e*, *g*, *f*, as shown below. Valat, Fig. 2, 1:79-86. Valat also shows and explains that the reinforcements *d*, *e*, *g*, *f* in the lower section taper away towards the upper section. Valat, Fig. 2, 1:58-63, 1:79-90. A POSITA would have understood that the inner surface of the upper section would also be circular in cross-section with an internal diameter and without the reinforcements.



Valat, Fig. 2 (modified, annotated).

216. Additionally, Denk discloses that the cross-sectional shape can continually transition along the tube length from the elliptical inner cross-sectional contour into a circular inner cross-sectional contour in a certain area of the tube. Denk, cols. 6, 8, Figs. 1a-1b. A POSITA would have understood that in Valat's steerer tube modified in view of Denk, the transition of the inner cross-sectional contour would occur over taper c, such that the upper section of the steerer tube has a circular inner cross-section. Such a modification would allow Valat's steerer tube's lower part (lower section) to be reinforced with Denk's elliptical inner contour for improved mechanical property while maintaining light weight. *See* Section X.A.1; Valat, 1:10-14; Denk, Abstract, cols. 1-2, 9; *see also* Schroeder, 6:22-26 (disclosing a steerer tube having a lower thick tube wall section transitioned to an upper thin tube wall

section advantageously reduce weight and improve mechanical strength of the steerer tube).

12. Claims 8, 12, 22, 26, 42, and 46 (“wherein a ratio of an inner diameter of the upper section of the body to an outer diameter of the upper section of the body is within the range of 0.75 to 0.95, inclusive.”)

217. Claims 8, 12, 22, 26, 42, and 46 depend from claims 6, 10, 20, 24, 40, and 44, respectively. All these claims recite “wherein a ratio of an inner diameter of the upper section of the body to an outer diameter of the upper section of the body is within the range of 0.75 to 0.95, inclusive.”

218. As explained above with regard to claim term 1[c] (Section X.A.2.d) and claims 6, 10, 20, 24, 40, and 44 (Section X.A.11), Valat discloses that the inner and outer surfaces of the upper section are circular in cross-section. Accordingly, a POSITA would have understood that a cross-section of the upper section of the tubular body of Valat’s steerer tube would have an inner diameter and an outer diameter. A POSITA would also have known that a ratio of an inner diameter to an outer diameter of the upper section of the steerer tube body being in the range of 0.75 to 0.95 is an obvious design choice and obvious-to-try for Valat’s steerer tube based on multiple considerations, as explained above in Ground 1, claims 8, 12, 22, 26, 42, and 46 (Section IX.A.12). Specifically, a POSITA would have known that both the strength and rigidity as well as the weight of the upper section of the steerer

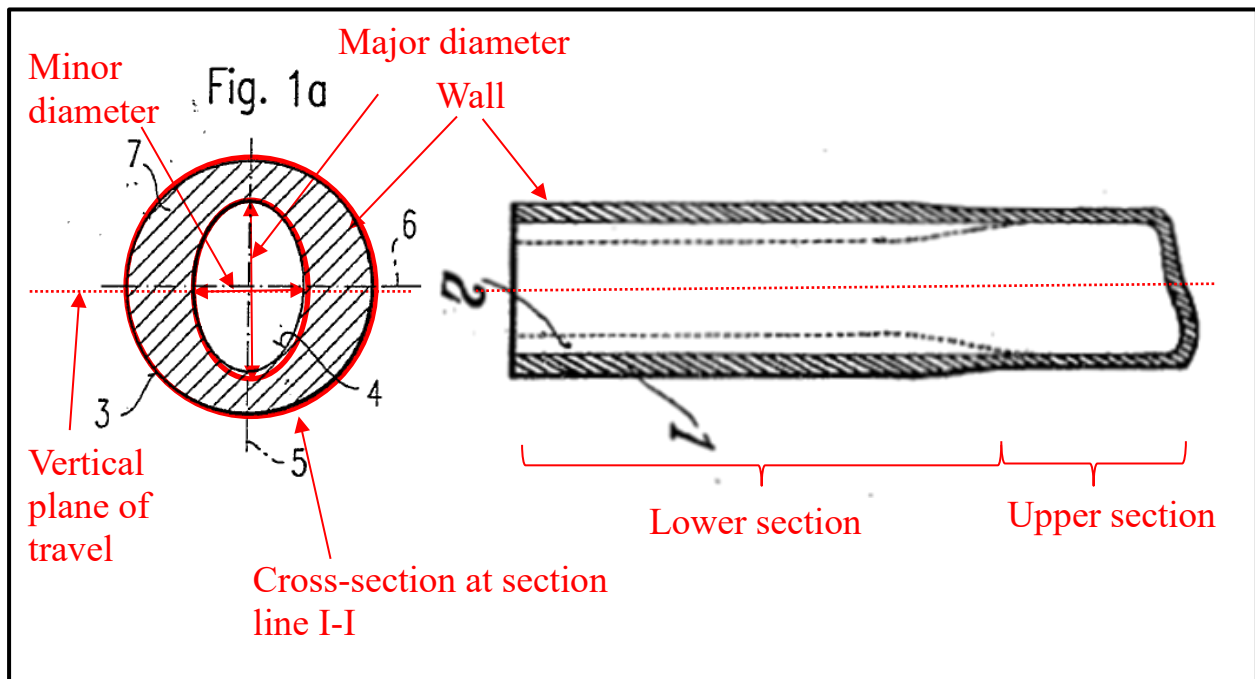
tube is affected by the wall thickness, i.e., a ratio of the inner diameter to the outer diameter. Given a certain outer diameter of the upper section of the steerer tube, a POSITA would have known to determine the ratio of the inner diameter to the outer diameter of the upper section of Denk's steerer tube body through routine experimentation to optimize strength and rigidity of the steerer tube while maintaining light weight. *See generally* discussion in ¶¶123-124, above.

13. Claim 56 (“wherein the minor diameter decreases as a function of proximity to the upper section of the body.”)

219. Claim 56 depends from claim 34 and recites “wherein the minor diameter decreases as a function of proximity to the upper section of the body.”

220. Valat in view of Moechnig and Denk renders claim 56 obvious.

221. As discussed above in claim term 1[d] and claim 34 (Sections X.A.2.e and X.A.5), Valat in view of Denk discloses that an inner surface of the wall within the lower section has an elliptical cross-section having a major diameter positioned to be perpendicular to the plane of travel and a minor diameter positioned to be in the plane of travel of the bicycle. Valat also discloses that the steerer tube body has a greater wall thickness in the lower part *a* of the lower section, where loads are greatest, than the upper part *b* of the upper section, and shows that the wall thickness tapers from lower part *a* to upper part *b* via taper *c* of the lower section. Valat, 1:70-78, Figs. 1-2.



Denk, Fig. 1a; Valat, Fig. 1 (annotations added).

222. And as in claim 6 (Section X.A.11) a POSITA would have understood that in Valat's steerer tube (configuration 1 shown in Fig. 1 of Valat) modified in view of Denk, the elliptical inner cross-sectional contour in the lower section would transition into a circular cross-sectional contour in the upper section over the taper. Thus, a POSITA would have understood that in Valat combined with Denk's elliptical inner contour in the lower section, the major and minor diameters would decrease from lower part *a* to upper part *b* over taper *c*. Indeed, in Valat modified with Denk's elliptical contour in the lower section, the tapering wall thickness from a thicker lower section to a thinner upper section would advantageously improve mechanical property of the steerer tube in the lower section and reduce weight.

Schroeder, 6:16-26, FIGS. 1B-2. A POSITA would have understood that such modification would allow improved mechanical strength (as disclosed in Valat) and in the vertical plane of travel (as disclosed in Denk) while reducing weight. *See* Schroeder, 6:16-26.

223. A POSITA would have understood that the decrease of the minor diameter of the inner elliptical cross-section from the lower section to the upper section would result in the minor diameter “decreas[ing] as a function of proximity to the upper section of the body” because the minor diameter would decrease based on the closeness of a cross-section of the lower section to the upper section. Additionally, Moechnig explicitly discloses that the major and minor diameters of its lower section decrease (i.e., taper) as a function of proximity to the upper section of the body. Moechnig, [0038] (“Both longitudinal and lateral diameters 120, 130 transition from lower radial portion 106 to upper radial portion 110.”). Accordingly, a POSITA would have known that Valat’s steerer tube (modified in view of Moechnig and Denk) would also have a minor diameter of the lower section decrease from the second portion of the lower section to an end region of the first portion of the lower section. *See also* discussion regarding teachings regarding the taper causing the decreasing of minor and major diameters in view of Moechnig in ¶¶137-138.

14. Claim 57 (“wherein a ratio of the major diameter to the minor diameter taken at a lower end of the lower section is

within the range of 1.05 to 1.3, inclusive.”); claim 58 (“wherein the ratio is within the range of 1.10 to 1.25, inclusive.”)

224. Claim 57 depends from claim 34 and recites “wherein a ratio of the major diameter to the minor diameter taken at a lower end of the lower section is within the range of 1.05 to 1.3, inclusive.” Claim 58 depends from claim 57 and recites “wherein the ratio is within the range of 1.10 to 1.25, inclusive.”

225. Valat in view of Moechnig and Denk renders claims 57 and 58 obvious because a POSITA would have known that a ratio of the major diameter to the minor diameter taken at a lower end of the lower section being within the range of 1.05 to 1.3 (or the range of 1.10 to 1.25, inclusive) is an obvious design choice and is obvious-to-try based on multiple considerations, as explained below. *See* discussion in Ground 1, claims 57-58 at ¶¶130-132.

226. As discussed with regard to claim 34 (Section X.A.5), in Valat’s steerer tube modified in view of Denk’s elliptical inner contour in the lower section, the wall thickness of the lower section of the tube is defined between the outer circular cross-section and the inner elliptical cross-section, and the inner elliptical cross-section has a major diameter in the plane perpendicular to the plane of travel and a minor diameter in the plane of travel. The inner elliptical cross-section and outer circular cross-section cause the wall thickness in the lower section of the tube to vary over a cross-section. Denk, col. 8. A POSITA would design the wall thickness based on

multiple factors (e.g., the particular outer diameter and material of the lower section of the steerer tube, type of connection to the fork crown, and type of bicycle) through routine experimentation to optimize the strength and rigidity of the lower end of the lower section while keeping the tube lightweight, as suggested by Denk. *See* Denk, col. 3.

227. Indeed, the strength and rigidity properties in the plane of travel in the lower section of the steerer tube are directly affected by the thickness of the wall in the plane of travel, and as such, the strength and rigidity properties in the plane of travel in the lower section are directly affected by the minor diameter of the elliptical inner contour of the lower section. Similarly, the weight of the steerer tube is directly affected by the major diameter of the elliptical inner contour of the lower section. That is, the larger the major diameter of the lower section, the thinner the wall in the lower section and consequently lower the weight of the tube.

228. A POSITA would have understood that changing the wall thickness distribution over a cross-section in the lower section (while the outer circular contour remains the same) would have changed the ratio of the major diameter to the minor diameter of the inner cross-sectional contour. For example, increasing the wall thickness in the area of the major axis in the plane perpendicular to the plane of travel while maintaining the wall thickness in the area of the minor axis in the plane

of travel would reduce the ratio of the major diameter to the minor diameter, and vice versa.

229. Denk discloses adapting the wall thickness of the tube body to the strength and rigidity properties over the tube length while reducing weight. Denk, cols. 1, 3. Denk also discloses that the wall thickness “in the end areas of the tube” would be increased to absorb additional stress from welded, clamped, or soldered connections. Denk, cols. 1, 3, 9; *see also* Valat, 1:44-51 (teaching that fractures frequently occur in the region of the steerer tube connecting to the fork bridge). Based on Denk’s teaching, a POSITA would have known to have an elliptical cross-sectional contour in a lower end of the lower section of the tube body, such as adjacent to section line I-I in Denk’s Figure 11 where it is connected to the fork bridge—i.e., an end area—to be capable of absorbing the additional stress as compared to other portions of the lower section. *See* Denk, Fig. 11. A POSITA would also have optimized the ratio of the major diameter to the minor diameter taken at a lower end of the lower section through routine optimization and experimentation to identify an optimum ratio that meets the strength and rigidity requirements in the lower end of the steerer tube while keeping the weight of the tube low.

230. Denk further suggests that the elliptical inner cross-sectional contour at the lower end of the tube continually transitions to a circular inner cross-sectional

contour along the tube length. Denk, col. 8. Based on Denk's figures, the ratio of the major diameter to the minor diameter at section I-I of the lower section of Denk's tube is about 1.57. A POSITA would have known that the gradual transition of the elliptical inner contour to a circular inner contour within the lower section would result in the ratio of the major diameter to the minor diameter continually changing from 1.57 to 1, including ratios such as 1.3, 1.25, or 1.1. *See* discussion in Ground 1, claims 57-58, ¶¶130-132.

231. Moreover, Moechnig teaches that the widest major diameter (lateral diameter 130), i.e., the major diameter in the lower end of the lower section (106, 108), is 1.559 inches, and that the smallest minor diameter (longitudinal diameter 120), which is not less than radial diameter 124 of the upper portion 110, is 1.125 inches. Moechnig, [0040] (“[E]ach cross-section 141 [of oblong portion 108] includes a lateral diameter 130 that is larger than a longitudinal diameter 120. Preferably, longitudinal diameter 120 is not less than a diameter associated with upper radial portion 110. Although upper radial portion 110 could be provided in any of a number of sizes, upper radial portion 110 preferably has a diameter of about 1.125 inches or about 28.6 mm. Similarly, although lateral diameter 130 tapers from lower radial portion 106 to upper radial portion 110, and could be provided in a number of sizes, at its widest portion, lateral diameter 130 is approximately 1.559 inches or 39.6

mm . . .”). Therefore, a POSITA would have known that the widest minor diameter (longitudinal diameter 120) in the lower end of the lower section (106, 108) is greater than 1.125 inches but less than 1.559 inches. A POSITA optimizing the ratio of the major and minor diameters in a lower end of the steerer tube would have considered the ratio of the major and minor diameters taught by Moechnig because it is in the same field of art, and would have even used the ratio taught by Moechnig as a starting point for further optimization. Accordingly, a POSITA would have easily known that a ratio of the major diameter to the minor diameter in Valat’s steerer tube (modified in view of Denk and Moechnig) would be in the range of 1.05 and 1.3. A POSITA would also have been able to arrive at a ratio within the range of 1.10 to 1.25 through routine experimentation to optimize the strength and rigidity of the steerer tube while minimizing weight. *See generally* ¶¶125-133, above.

15. Claim 59 (“wherein the major diameter of the lower section tapers from the second portion of the lower section to the first portion of the lower section.”)

232. Claim 59 depends from claim 34 and recites “wherein the major diameter of the lower section tapers from the second portion of the lower section to the first portion of the lower section.”

233. Valat in view of Moechnig and Denk renders claim 59 obvious.

234. For reasons discussed above in claim 56 (Section X.A.13), a POSITA would have modified Valat’s tube by decreasing the major and minor diameters of the inner

cross-sectional contour from lower part *a* to upper part *b* over taper *c* to benefit from the advantages of the wall thickness configurations of both Valat and Denk.

235. A POSITA would have understood that the decrease of the major diameter of the inner elliptical cross-section over taper *c* would result in “the major diameter of the lower section [to] taper[] from the second portion of the lower section to the first portion of the lower section” because the major diameter gradually changes from a point of the second portion (the common point of lower part *a* and taper *c*) to a point of the first portion (the common point of taper *c* and upper part *b*). Additionally, Moechnig explicitly discloses that the major and minor diameters of its lower section decrease (i.e., taper) to the upper section of the body. Moechnig, [0038] (“Both longitudinal and lateral diameters 120, 130 transition from lower radial portion 106 to upper radial portion 110.”). Accordingly, a POSITA would have known that Valat’s steerer tube (modified in view of Moechnig and Denk) would also have a major diameter of the lower section taper from the second portion of the lower section to an end region of the first portion of the lower section. *See also* discussion regarding teachings in Moechnig in ¶¶137-138.

16. Claim 60 (“wherein a ratio of the major diameter to the minor diameter decreases as a function of proximity to the upper section of the body.”)

236. Claim 60 depends from claim 34 and recites “wherein a ratio of the major diameter to the minor diameter decreases as a function of proximity to the upper section of the body.” Valat in view of Moechnig and Denk renders claim 60 obvious.

237. As discussed in Section X.A.11 (claims 6 and 10), Valat discloses that an inner surface of the upper section is circular in cross-section, and as discussed in Section X.A.2.e (claim 1[d]), a POSITA would have understood that in Valat as combined with Denk, the inner elliptical cross-sectional contour in lower part *a* would “continually transition” into an inner circular contour in upper part *b* over taper *c* to allow Valat’s steerer tube’s lower part *a* to be reinforced with Denk’s elliptical inner contour for improved mechanical property while maintaining light weight. *See* Valat, 1:10-14; Denk, Abstract, cols. 1-2, 9; *see also* Schroeder, 6:22-26. Thus, in Valat combined with Denk, the inner surface contour of the steerer tube would “continually transition” from an ellipse to a circle, causing the ratio of the major diameter to the minor diameter to decrease gradually from the lower part *a* of the lower section up to upper part *b* of the upper section. A POSITA would have understood that such decrease of the ratio of the major diameter to the minor diameter would result in the ratio “decreas[ing] as a function of proximity to the upper section of the body” because the ratio would decrease based on the closeness

of a point in the lower section to the upper section. A POSITA would also understand that the ratio at the upper end of the tapering region (where the elliptical inner contour transitions into the circular inner contour) would be approximately 1.

B. [Ground 4] Claims 31, 51, and 64 Are Rendered Obvious by Valat in View of Moechnig, Denk, and Schroeder

1. A POSITA would have been motivated to combine Valat, Moechnig, Denk, and Schroeder, and would have reasonably expected success in doing so

238. Claims 31 and 51 and claim term 64[c] require that “the body [be] formed of a material different from the crown of the front wheel fork.” Based on the disclosure of Schroeder, a POSITA would have been motivated to use two different materials for the steerer tube body and the fork crown of Valat to improve durability and shock absorption capabilities of a bicycle fork and would have reasonably expected success for the reasons explained in Section IX.B.1 (Ground 2).

239. In summary, Schroeder discloses that aluminum is a preferred material for manufacturing the fork crown (likely because aluminum is less expensive and lighter), and that its steerer tube is made of uncured resin blended with carbon fiber composites. Schroeder, 4:19-26, 4:48-53, 5:21-25, 5:63-67, 7:20-44, 8:8-17, 9:39-49. Indeed, Schroeder explicitly teaches molding together a steerer tube and fork crown made of different materials. *See, e.g.,* Schroeder, Title, 4:22-26. A POSITA would have been motivated to use the generally preferred aluminum for forming the

fork crown of the bicycle fork and a different material suitable for forming the body of the steerer tube—such as the uncured resin blended with carbon fiber composites, which is subsequently molded to the desired shape and then cured—to improve durability and shock absorption capabilities of the steerer tube and fork. Schroeder, 4:22-26.

240. A POSITA would have readily known how to connect the steerer tube with the fork crown formed of different materials because it would have only required conventionally known manufacturing techniques, such as bonding or molding, as disclosed in Denk, Moechnig, and Schroeder. Denk, col. 3; Moechnig, [0002]; Schroeder, 7:31-42, 8:8-17, 9:66-10:9.

2. Claim 64

241. Valat in view of Moechnig, Denk, and Schroeder renders claim 64 obvious.

a. Claim terms 64[pre]-64[b] and 64[d]

242. The claim limitations in 64[pre]-64[b] and 64[d] are identical to 1[pre]-1[b] and 1[d], respectively. Valat in view of Denk and Moechnig renders obvious 64[pre]-64[b] and 64[d] for the reasons discussed above in 1[pre]-1[b] and 1[d]. *See* Section X.A.2, above.

- b. 64[c]: “the segment of the lower section of the body is joined to the crown of the front wheel fork, the body formed of a material different from the crown of the front wheel fork”**

243. Valat in view of Denk and Moechnig and further in view of Schroeder renders claim term 64[c] obvious.

244. As discussed in claim term 1[b] (Section X.A.2.c), Valat discloses that a segment of the lower section of the steerer tube body is joined to a crown of a front wheel fork. And as discussed above, Schroeder discloses that the body of the steerer tube is formed of a material different from the fork crown, and a POSITA would have been motivated to modify Valat’s steerer tube to be formed of a material different from the fork crown to improve durability and shock absorption capabilities, as disclosed in Schroeder. Schroeder, 4:19-26, 4:48-53, 5:21-25, 5:63-67, 7:20-44, 8:8-17, 9:39-49.

3. Claims 31 and 51

245. Claims 31 and 51 depend from claims 15 and 34, respectively. Both claims are identical to the limitation in claim term 64[c].

246. Valat in view of Denk and Moechnig and further in view of Schroeder renders claims 31 and 51 obvious for the reasons discussed above in claims 1, 15, and 34, and claim term 64[c]. *See* Sections X.A.2, X.A.4, X.A.5, and X.B.2.b, above.

XI. CONCLUSION

247. For the reasons explained in detail above, every element of the Challenged Claims of the '993 patent is disclosed by Denk in view of Moechnig with or without Schroeder, or Valat in view of Moechnig and Denk with or without Schroeder. Moreover, it would have been obvious to a POSITA to combine the teachings of Denk and Valat with those of Moechnig and Schroeder to arrive at the purported invention recited in the '993 patent. A POSITA would have been motivated to make the modifications and/or combinations; doing so would have required only routine engineering skill and knowledge, as I have demonstrated above; and the modifications and/or combinations would have yielded predictable results.

248. Moreover, I am not aware of any secondary indicia of non-obviousness tied to the claimed invention that would alter my opinion that the Challenged Claims would have been obvious to a POSITA at the time of the purported invention.

249. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, 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 that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Respectfully submitted,

A handwritten signature in black ink, consisting of several loops and a long horizontal stroke extending to the right.

Dated: January 29, 2024

By: _____
Alexander H. Slocum, Ph.D.

EXHIBIT A

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

School of Engineering Faculty Personnel Record

Date: 1 December 2022 Full Name: Alexander H. Slocum
Department: Mechanical Engineering

1. Date of Birth: on file

2. Citizenship: U.S.

3.	<u>School</u>	<u>Degree</u>	<u>Date</u>
	M.I.T.	S.B., M.E	June 1982
	M.I.T.	S.M., M.E	Jan. 1983
	M.I.T.	Ph.D., M.E.	June 1985

4. Title of Thesis for Most Advanced Degree:
Sensor System Design to Determine Position and Orientation of Articulated Structures

5. Principle Field of Interest:
Precision Engineering

6. Name and Rank of Other Department Faculty in the Same Field:
David Trumper, Professor
Martin Culpepper, Professor
Sangbae Kim, Associate Professor
Amos Winter, Associate Professor

7. Name and Rank of Faculty in Other Departments in Same Field:
Jeff Lang, Professor, Electrical Engineering

8.	Non-MIT Experience:			
	<u>Employer</u>	<u>Position</u>	<u>Beginning</u>	<u>End</u>
	NIST	Mechanical Engineer	June 1982	Sept. 1986
	Cranfield Inst. Tech.	Visiting Professor	Oct. 1989	Oct. 1990

9. History of M.I.T. Appointments:

<u>Rank:</u>	<u>Beginning</u>	<u>End</u>
Assistant Professor (CE)	Sept. 1985	July 1989
Assistant Professor (ME)	July 1991	July 1992
Associate Professor (ME)	July 1992	July 1995
Associate Professor (ME, tenured)	July 1995	July 1998
Professor	July 1998	?

10. Department and Institute Committees, Other Assigned Duties:

<u>Activity</u>	<u>Beginning</u>	<u>End</u>
Inst. Comm. on Design in UG Education	Feb. 1987	June 1988
Inst. UG Admissions Folder Reader	Jan. 1987	Present
Inst. Committee on the Hobby Shop	July 1989	June 1997
Chairman, Inst. Committee -- Hobby Shop	June 1997	Present
Dept. Committee on Graduate Curricula	Oct. 1992	June 2004
Dept. Support Staff Cost Committee	Mar. 1994	May 1994
Pi Tau Sigma Faculty Advisor	May 1994	Jan. 2002
Dept. Faculty Search Committee	Jan. 1995	June 1995
Leader, OME 2nd Summer Design Program	Jan. 1996	Jan. 2008
MIT Educational Council	June 1996	Present
ME Strategic Planning Committee	Sept. 1996	June 1998
ME Design Faculty Search Committee	Jan. 1997	June 1998
Designated Course Professors Committee	Sept. 1997	June 2004
ME Design Faculty Search Committee	Jan. 1998	Nov. 1998
Space Committee	Jan. 2000	Sept. 2003
CalTech/MIT Voting Commission	Jan. 2001	June 2001
ME Council	Jan 2004	June 2005
Director: Experimental Study Group	Sept. 2004	June 2012
Research Administration Improvement Initiative	July. 2005	
co-chair of the Class of 1982 Reunion Gift Fund	Spring 2007	
Energy Education Task Force	Dec. 2008	June 2012
Institute Committee on Student Life	Aug. 2009	June 2012
Energy Minor Oversight Committee	Feb. 2009	June 2012
Daper Advisory Board	Aug. 2009	June 2016
Institute Committee on Student Life, Chair	June 2010	June 2012
Department Awards Committee	Spring 2011	June 2018
ME Design Faculty Search Committee	Fall 2017	June 2018
Institute Committee on Intellectual Property	Fall 2019	Fall 2022

11. Professional Service:

<u>Activity</u>	<u>Dates</u>
Office of Secretary of Defense, Foreign Strategic Trade	June 1990-June 2005
Department of Justice, Bearing Tariffs	Jan.1992-Dec.1992
NIST, Technology Assessment	June 1986-Aug. 1997
International Scientific Committee of the European Union Society for Precision Engineering and Nanotechnology	Feb. 2004-present
Session Chair "Education" 4th. Intl. Conf. Advanced Engineering Design, Glasgow, Scotland,	Sept. 5-8, 2004
Vice Chair, ASME Design Education Committee	2005
Associate Editor ASME Jou. Mechanical Design	2007-2012
Department of Energy: BP Gulf Oil Spill response team	May 2010-Sept. 2010
Assistant Director for Advanced Manufacturing, Executive Office of the White House	June 2013- May 2014

12. Awards or Honors Received:

1. U.S. DoC Development of an Advanced Robot Gripper Feb. 1984
2. U.S. DoC Outstanding Performance Rating Mar. 1985
3. SME Outstanding Contribution to FMS Feb. 1986
4. U.S. DoC Outstanding Performance Rating Mar. 1986
5. U.S. DoC Outstanding Performance Rating Mar. 1986
6. U.S. DoC Development of Robotic Micromanipulator June 1986
7. U.S. DoC Robot End Effector Patent July 1986
8. U.S. DoC Robotic Micromanipulator Patent July 1986
9. SME Outstanding Contribution to Robotics Aug. 1986
10. U.S. DoC Bronze Medal Award for Federal Service Dec. 1986
11. NSF Presidential Young Investigator June 1987
12. Royal Society Visiting Scholar Fellowship Aug. 1988
13. Oak Ridge Offsite Research Fellowship Aug. 1988
14. SME Earl E. Walker Outstanding Young Manufacturing Engineer Award, June 1993
15. ASCE 1994 Thomas Fitch Rowland Prize
16. 1994 R&D 100 Award, one of 100 best new technical products of the year (ShearDamper™)
17. 1994 International Machine Tool Show “Best of Show” award for development of Weldon Machine Tool’s 1632 Gold Cylindrical Grinder (it used Slocum’s hydrostatic bearings and ShearDamper technology).
18. 1994 R&D 100 Award, one of 100 best new technical products of the year (HydroGuide™)
19. 1995 R&D 100 Award, one of 100 best new technical products of the year (HydroSpindle™)
20. 1996 R&D 100 Award, one of 100 best new technical products of the year (TurboTool™ Ultra-High Speed Spindle)
21. SME 1997 SME Frederick W. Taylor Research Medal
22. 1997 R&D 100 Award -one of 100 best new technical products of the yr. (Machining Variation Analysis)
23. 1997 R&D 100 Award-- one of 100 best new technical products of the yr. (ShieldBeam™ Contactor)
24. 1997 R&D 100 Award, one of 100 best new technical products of the yr. (Kinematic Docking System)
25. 1998 R&D 100 Award, one of 100 best new technical products of the yr. (Q-Tool™)
26. Who’s Who in America Science and Engineering
27. Martin Luther King Jr. Leadership Award, January 1999.
28. MacVicar Faculty Fellow, January 1999.
29. 1999 R&D 100 Award, one of 100 best new technical products of the yr. (Quasi Kinematic Coupling for Engine Assembly)
30. Massachusetts Professor of the Year Award, November 2000
31. ASME Leonardo da Vinci Award, 2004
32. 100K Competición Winner (2007, Team Robopsy)
33. ASME Machine Design Award, 2008
34. 2008 R&D 100 Award, one of 100 best new technical products of the yr. (Saber Furnace)
35. 2009 R&D 100 Award, one of 100 best new technical products of the yr. (Micro-ESR with Active Spectrum, Inc).
36. 2010 Arthur Smith Faculty Achievement Award
37. Best Paper Award: O. Yaglioglu, R Martens, A. Cao, A. H. Slocum, “Compliant Carbon Nanotube-Metal Contact Structures”, Proc. of 57th IEEE Holm Conference on Electrical Contacts, 2011
38. 2014 ASME Thar Energy Award
39. 2014 Association of Manufacturing Technology Charlie Carter Award
40. 2015 Best Paper Award: J.M. Kluger, T.P. Sapsis, and A.H. Slocum, Combined offshore wind-wave-storage system power and cost predictions, NAWEA Symposium, Blacksburg, VA, June 8, 2015.

41. 2016 Best Paper Award: M.N. Haji, C. Delmy, J. Gonzalez, A.H. Slocum , “Uranium Extraction from Seawater Using Adsorbent Shell Enclosures Via a Symbiotic Offshore Wind Turbine Device”, ISOPE-2016 Best Student Paper Award, Twenty-sixth (2016) International Offshore and Polar Engineering Conference, Rhodes, Greece, June 26 – July 1, 2016.
 42. 2017 Member National Academy of Engineering
 43. 2017 Capers and Marion MacDonald Award for Excellence in Mentoring and Advising
 44. 2018 ASME Ruth and Joel Spira Outstanding Design Educator Award
 45. 2020 Elected Fellow of the American Society for Precision Engineering (inaugural year of the Fellows program).
13. Current Organization Membership:
- American Society of Mechanical Engineers, Fellow
 American Society for Precision Engineering, Fellow
 Society of Manufacturing Engineers, Member
 National Academy of Engineering, Member
14. Patents
1. US4606696, Slocum, Alexander, H. Mechanism To Determine Position And Orientation In Space, 8/19/1986
 2. US4676002, Slocum, Alexander, H. “Mechanisms To Determine Position And Orientation In Space”, 6/30/1987
 3. US4685661 Slocum, Alexander, H. | Peris, James, P. Method And Mechanism For Fixturing Objects, 8/11/1987
 4. US4694230 Slocum, Alexander, H. | Peris, James, P. Micromanipulator System, 9/15/1987
 5. US4765754 Slocum, Alexander, H. Inclined Contact Recirculating Roller Bearing, 8/23/1988
 6. US4765668 Slocum, Alexander, H. | Jurgens, Peter, A., Robot End Effector, 8/23/1988
 7. US4821436 Slocum, Alexander, H., Plow System, 4/18/1989
 8. US4836042 Slocum, Alexander, H., System To Convert Rotary Motion To Linear Motion, 6/6/1989
 9. US4838145 Slocum, Alexander, H. | Peris, James, P., Multiple Actuator Hydraulic System And Rotary Control Valve Therefor, 6/13/1989
 10. US4878002 Heatzig, Eric | Slocum, Alexander | Thurston-Slocum, Debra, Multi-Axis Dsp-Based Parallel Processing Servo Controller For Machine Tools And Robots, 10/31/1989
 11. US4987526 Slocum, Alexander, H. | Thurston, Debra, System To Provide High Speed, High Accuracy Motion, 1/22/1991
 12. US5023528 Saidin, Zain | Slocum, Alexander, H., Method Of Three-Phase Winding Motor Control Of Rotary Motor-Driven Linear Actuators, Linear Motor-Actuated Carriages, And Similar Systems, And Apparatus For Practicing The Same, 6/11/1991
 13. US5090265 Slocum, Alexander, H., System To Convert Rotary Motion To Linear Motion, 2/25/1992
 14. US5104237 Slocum, Alexander, H., Self-Compensating Hydrostatic Linear Motion Bearing, 4/14/1992
 15. US5281032 Slocum, Alexander H. Self-Compensating Hydrostatic Bearings For Supporting Shafts And Spindles And The Like For Rotary And Translational Motion And Methods Therefor, 1/25/1994
 16. US5472367 Slocum, Alexander, H. | Olsen, John, H., Machine Tool Apparatus And Linear Motion Track Therefor, 12/5/1995
 17. US5466071 Slocum, Alexander H. High Speed Hydrostatic Spindle Design, 11/14/1995
 18. US5484208 Kane, Nathan, R. | Slocum, Alexander, H., Elastically Supported Self-Compensating Flow Restrictors For Optimizing Hydrostatic Bearing Performance, 1/16/1996
 19. US5533814 Slocum, Alexander, H., Low Profile Self-Compensated Hydrostatic Thrust Bearing, 7/9/1996
 20. US5667204 Slocum, Alexander, Henry, Slit-Tube Replicated In-Place Constrained Layer Damper And Method, 9/16/1997

21. US5674032 Slocum, Alexander, H. | Wasson, Kevin, Tooling System And Method With Integral Hydrostatic Bearings And Turbine Power Source, 10/7/1997
22. US5678944 Slocum, Alexander, H. | Muller, Luis | Braunstein, Daniel, Flexural Mount Kinematic Couplings And Method, 10/21/1997
23. US 5683118 Slocum, Alexander, H., Kinematic Coupling Fluid Couplings And Method, 11/4/1997.
24. US5682795 Solomon, Todd, R. | Slocum, Alexander, H., Robotic Joint Using Metal Bands, 11/4/1997
25. US5700046 Van, Doren, Matthew, J. | Sauer, Don | Slocum, Alexander, H. | Rocki, David, Pap | Tam, Johann | Gerszewski, Larry, Wafer Gripper, 12/23/1997
26. US5700092 Wasson, Kevin, Lee | Slocum, Alexander, Henry, Integrated Shaft Self-Compensating Hydrostatic Bearing, 12/23/1997
27. US5711647 Slocum, Alexander, H., Method Of And Apparatus For Locating And Orientating A Part On A Gripper And Transferring It To A Tool While Maintaining Location And Orientation On The Tool, 1/27/1998
28. US5733096 Van, Doren, Matthew, J. | Slocum, Alexander, H. | Sauer, Don, Multi-Stage Telescoping Structure, 3/31/1998
29. US5733024 Slocum, Alexander, H. | Van, Doren, Matthew, J. | Ziegenhagen, Ii, Rodney, Scott | Sauer, Don, Modular System, 3/31/1998
30. US5743326 Slocum, Alexander, H., Method Of And Apparatus For Damping Bending Vibrations While Achieving Temperature Control In Beams And Related, 4/28/1998
31. US5758776 Slocum, Alexander, H. | Ziegenhagen, Ii, R., Scott | Slocum, Iii, Richard, W. | Muller, Luis, A., Integrated Circuit Tray With Flexural Bearings, 6/2/1998
32. US5769554 Slocum, Alexander, H., Kinematic Coupling Method And System For Aligning Sand Mold Cores And The Like And Other Soft Objects And Surfaces, 6/23/1998
33. US5778730 Solomon, Todd, R. | Slocum, Alexander, H., Robotic Joint Using Metallic Bands, 7/14/1998
34. US5784756 Slocum, Alexander, H. | Culpepper, Martin, L., Debris Cleaner With Compound Auger And Vacuum Pickup, 7/28/1998
35. US5799924 Slocum, Alexander, H. | Marsh, Eric, R. | Smith, Douglas, H., Replicated-In-Place Internal Viscous Shear Damper For Machine Structures And Components, 9/1/1998
36. US5821764 Slocum, Alexander, H. | Chiu, Michael, A., Interface Apparatus For Automatic Test Equipment, 10/13/1998
37. US5834410 Slocum, Alexander, H., Surface Textured Cleansing Device And Method With Massaging Effect, 11/10/1998
38. US5839769 Slocum, Alexander, H. | Ziegenhagen, Ii, R., Scott, Expanding Gripper With Elastically Variable Pitch Screw, 11/24/1998
39. US5848869 Slocum, Alexander, H. | Meskoe, John, William Container Restraining Mechanism And Method 12/15/1998
40. US5858050 Slocum, Alexander, H. | Roberts, Douglas, J. | Lovell, Walter, E. | Borbone, Joseph, A. | Pinkerton, Steven, J. | Mungovan, John, P. | Voisine, Gary, R., I.S. Machine, 1/12/1999
41. US5865868 Slocum, Alexander, H. | Lovell, Walter, E. | Borbone, Joseph, A. | Pinkerton, Steven, J. | Roberts, Douglas, J. | Mungovan, John, P. | Voisine, Gary, R. Mold Carrier Assembly For An I. S. Machine Mold Opening And Closing Mechanism, 2/2/1999
42. US5888114 Slocum, Alexander, H. | Ho, Christopher, M., Modular Storage System, Components, Accessories, And Applications To Structural Systems And Toy Construction Sets And The Like, 3/30/1999
43. US5887450 Slocum, Alexander, H. | Lovell, Walter, E. | Borbone, Joseph, A. | Pinkerton, Steven, J. | Roberts, Douglas, J. | Mungovan, John, P. | Voisine, Gary, R., Mold Opening And Closing Mechanism For An I.S. Machine, 3/30/1999
44. US5915678 Slocum, Alexander, H. | Braunstein, Daniel, Kinematic Coupling System For Thin Plates And Sheets And The Like, 6/29/1999
45. US5921786 Slocum, Alexander, H. | Ziegenhagen, Ii, Rodney, Scott, Flexible Shielded Laminated Beam For Electrical Contacts And The Like And Method Of Contact Operation, 7/13/1999

46. US5924003 Slocum, Alexander, H., Method Of Manufacturing Ball Grid Arrays For Improved Testability, 7/13/1999
47. US5931048 Slocum, Alexander, H. | Hochmuth, Carsten, A. | Levy, David, H. | Kiani, Sepehr | Vallance, R., Ryan, Manipulator For Automatic Test Equipment Test Head, 8/3/1999
48. US5938809 Mungovan, John, P. | Voisine, Gary, R. | Lovell, Walter, E. | Borbone, Joseph, A. | Pinkerton, Steven, J. | Roberts, Douglas, J. | Slocum, Alexander, H., I.S. Machine, 8/17/1999
49. US5964242 Slocum, Alexander, H., Method Of And Apparatus For Substance Processing With Small Opening Gates Actuated And Controlled By Large Displacement Members Having Fine Surface Finishing, 10/12/1999
50. US5971156 Slocum, Alexander, H. | Gessel, David, J. Semiconductor Chip Tray With Rolling Contact Retention Mechanism, 10/26/1999
51. US5973394 Slocum, Alexander, H. | Ziegenhagen, Ii, R., Scott | Richard, Robert, A., Small Contactor For Test Probes, Chip Packaging And The Like, 10/26/1999
52. US5971614 Kane, Nathan, R. | Slocum, Alexander, H., Modular Hydrostatic Bearing With Carriage Form-Fit To Profile Rail, 10/26/1999
53. US5982182 Chiu, Michael, A. | Levy, David, H. | Slocum, Alexander, H., Interface Apparatus For Automatic Test Equipment With Positioning Modules Incorporating Kinematic Surfaces, 11/9/1999
54. US6024526 Slocum, Alexander, H. | Muller, Luis, A., Integrated Prober, Handler And Tester For Semiconductor Components, 2/15/2000
55. US6036023 Pfahnl, Andreas, C. | Slocum, Alexander, H. | Lienhard, V, John, H., Heat-Transfer Enhancing Features For Semiconductor Carriers And Devices, 3/14/2000
56. US6097201 Slocum, Alexander, H., System To Simultaneously Test Trays Of Integrated Circuit Packages, 8/1/2000
57. US6104202 Slocum, Alexander, H. | Chiu, Michael, A., Interface Apparatus For Automatic Test Equipment, 8/15/2000
58. US6150740 Slocum, Alexander, H., Linear Motion Carriage System And Method With Bearings Preloaded By Inclined Linear Motor With High Attractive Force, 11/21/2000
59. US6193430 Culpepper, Martin | Slocum, Alexander, H., Quasi-Kinematic Coupling And Method For Use In Assembling And Locating Mechanical Components And The Like, 2/27/2001
60. US6280126 Slocum, Alexander, H. | Wasson, Kevin, Damped Tool Holder And Method, 8/28/2001
61. US6352389 Rines, Justice, C. | Slocum, Alexander, H., Method Of Construction, Deploying And Operating Submersible And Refloatable Underwater Tubular Platform Structures And The Like, As For Underwater Illumination And Target Detection, And Improved Underwater Platform Structures Therefor, 3/5/2002
62. US6418774 Brog.Ang.Rdh, Torgny | Jerreg.Ang.Rd, Henrik | Robertson, Alec | Slocum, Alexander | Willoughby, Patrick, Device And A Method For Calibration Of An Industrial Robot, 7/16/2002
63. US6448575 Slocum, Alexander, H. | Pfahnl, Andreas, C. | Walker, Ernest, P. | Sartschev, Ronald, A., Temperature Control Structure, 9/10/2002
64. US6446560 Slocum, Alexander, H., Single Carriage Robotic Monorail Material Transfer System, 9/10/2002
65. US6497581 Slocum, Alexander, H. | Ziegenhagen, R., Scott, Robust, Small Scale Electrical Contactor, 12/24/2002
66. US6550440 Vrsek, Gary, Allan | Tobis, Bruce, Joseph | Shaikh, Furqan, Zafar | Fedeson, Ken, Steven | Tallio, Kevin, V. | Slocum, Alexander, Acoustic Suppression Arrangement For A Component Undergoing Induced Vibration, 4/22/2003
67. US6688183 Awtar, Shorya | Slocum, Alexander, H., Apparatus Having Motion With Pre-Determined Degrees Of Freedom, 2/10/2004
68. US6886651 Slocum, Alexander, H. | Awtar, Shorya | Hart, Anastasios, John, Material Transportation System, 5/3/2005
69. US6911891 Qiu, Jin | Slocum, Alexander, H. | Lang, Jeffrey, H. | Struempfer, Ralf | Brenner, Michael, P. | Li, Jian, Bistable Actuation Techniques, Mechanisms, And Applications, 6/28/2005

70. US6914785 Slocum, Alexander, H. | Lang, Jeffrey | White, James, R. | Ma, Hong | Yang, Xueen, Variable Electronic Circuit Component, 7/5/2005
71. US7004235 Slocum, Alexander, H. | Pfahnl, Andreas, C., Method Of Providing Direct Impingement Temperature Control Of A Device, 2/28/2006
72. US7025324 Slocum, Alexander, H. | White, James, R. Gating Apparatus And Method Of Manufacture, 4/11/2006
73. US7040949 Slocum, Alexander, H., Flexible Connector, 5/9/2006
74. US20070071652 A1 J. Cherng, M. Cima, J. Gonzalez-Zugasti, N. Kane, A. Lemmo, C. Moore, A. Slocum, "Method And Apparatus For Manipulating And Measuring Solids", March 29, 2007
75. US7285968 Eldridge, Benjamin, N. | Grube, Gary, W. | Hobbs, Eric, D. | Mathieu, Gaetan, L. | Shinde, Makarand, S. | Slocum, Alexander, H. | Sporck, A., Nicholas | Watson, Thomas, N., Apparatus And Method For Managing Thermally Induced Motion Of A Probe Card Assembly, 10/23/2007
76. US7368930 Hobbs, Eric, D. | Mccoy, Christopher, D. | Porter, Jr., James, M. | Slocum, Alexander, H., Adjustment Mechanism, 5/6/2008
77. US7370645 Freeman, David, C. | Slocum, Alexander, H. | Kabat, Daniel, Variable Stiffness Flow Control Valve, 5/13/2008
78. US7471094 Hobbs, Eric, D. | Eldridge, Benjamin, N. | Ma, Lunyu | Mathieu, Gaetan, L. | Murphy, Steven, T. | Shinde, Makarand, S. | Slocum, Alexander, H., Method And Apparatus For Adjusting A Multi-Substrate Probe Structure, 12/30/2008
79. US7592821 Eldridge, Benjamin, N. | Grube, Gary, W. | Hobbs, Eric, D. | Mathieu, Gaetan, L. | Shinde, Makarand, S. | Slocum, Alexander, H. | Sporck, A., Nicholas | Watson, Thomas, N., Apparatus And Method For Managing Thermally Induced Motion Of A Probe Card Assembly, 9/22/2009
80. US7622935 Hobbs, Eric, D. | Slocum, Alexander, H. | Eldridge, Benjamin, N. | Breinlinger, Keith, J. | Powell, Shawn, Probe Card Assembly With A Mechanically Decoupled Wiring Substrate, 11/24/2009
81. US7671614 Eldridge, Benjamin, N. | Hobbs, Eric, D. | Mathieu, Gaetan, L. | Shinde, Makarand, S. | Slocum, Alexander, H., Apparatus And Method For Adjusting An Orientation Of Probes, 3/2/2010
82. US7682082 Kane, Nathan, R. | Sihler, Joachim | Slocum, Alexander, H. | Walter, Mark, Compact Surface Self-Compensated Hydrostatic Bearings, 3/23/2010
83. US7746089 Hobbs, Eric, D. | Slocum, Alexander, H., Method And Apparatus For Indirect Planarization, 6/29/2010
84. US7789443 Gillespie, Joseph | Slocum, Alexander, H. | Weed, Allan, Workpiece Gripping Device, 9/7/2010
85. US7845072 Hobbs, Eric, D. | Eldridge, Benjamin, N. | Ma, Lunyu | Mathieu, Gaetan, L. | Murphy, Steven, T. | Shinde, Makarand, S. | Slocum, Alexander, H., Method And Apparatus For Adjusting A Multi-Substrate Probe Structure, 12/7/2010
86. US7863897 Slocum, Jr., Alexander, H. | Gupta, Rajiv | Jones, Stephen, E. | Slocum, Sr., Alexander, H., Method And Apparatus For Characterizing The Temporal Resolution Of An Imaging Device, 1/4/2011
87. US7938107 Freeman, David, C. | Slocum, Alexander, H. | Kabat, Daniel, Variable Stiffness Flow Control Valve, 5/10/2011
88. US7976815 Hart, Anastasios, John | Slocum, Alexander, Henry, Shape Controlled Growth Of Nanostructured Films And Objects, 7/12/2011
89. US8075863 Hart, Anastasios, J. | Slocum, Alexander, H., Methods And Devices For Growth And/Or Assembly Of Nanostructures, 12/13/2011
90. US8130007 Eldridge, Benjamin, N. | Gritters, John, K. | Martens, Rodney, I. | Slocum, Alexander, H. | Yaglioglu, Onnik, Probe Card Assembly With Carbon Nanotube Probes Having A Spring Mechanism Therein, 3/6/2012
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92. US8157024 F. Neves, A.H. Slocum, I.D. Thomas, Ball Piston Steering Devices And Methods Of Use, 4/17/ 2012.
93. US8212563 White, James, Robert | White, Christopher, John | Elliott, Colin, T. | Slocum, Alexander, H., Method And Apparatus For In-Situ Measurement Of Soot By Electron Spin Resonance (Esr) Spectrometry, 7/3/2012
94. US8272262 Cabrera, Ramon | Grozev, Zhivko | Kovachev, Alexander | Slocum, Daryl, B. | Jackson, Adam | Osiecki, Daniel, Underwater Sensor Apparatus, 9/25/2012
95. US8292004 S. E. Buchanan, A. Walkingshaw, A.H. Slocum, G. Erol, Downhole Marking Apparatus And Methods, 10/23/2012.
96. US8291768 Spiegel, Joan, E. | Slocum, Alexander, H. | Watral, Adrienne | Duffley, Samuel, Pressure Measuring Syringe, 10/23/2012
97. US8308681 Slocum, Alexander | Carvey, Matthew, R. | Salamini, Alexey | Walker, Daniel, G. | Wang, Ying-Chih | Murray, Martha, M., Device For Mixing And Delivering Fluids For Tissue Repair, 11/13/2012
98. US8337979 Wardle, Brian, L. | Hart, Anastasios, John | Garcia, Enrique, J. | Slocum, Alexander, Henry, Nanostructure-Reinforced Composite Articles And Methods, 12/25/2012
99. US8372470 Hart, Anastasios, John | Slocum, Alexander, Henry | Van, Laake, Lucas, Carolus, Apparatus And Methods For Controlled Growth And Assembly Of Nanostructures, 2/12/2013
100. US8394015 Dibiasio, Christopher | Durand, Keith | Hopkins, Jonathan, Brigham | Traina, Zach | Slocum, Alexander | Nayfeh, Samir | Del, Nido, Pedro, J. | Vasilyev, Nikolay, V., Instrument Port For Minimally Invasive Cardiac Surgery, 3/12/2013
101. US8397577 Slocum, Sr., Alexander, Henry | Slocum, Jr., Alexander, Henry, Rolling Diaphragm Pressure Sensor, 3/19/2013
102. US8776606 Slocum, Sr., Alexander, Henry | Slocum, Jr., Alexander, Henry Unrolling tube pressure sensor, 07/15/2014
103. US8496410 Winter, V, Amos, Greene | Hosoi, Anette, E. | Slocum, Alexander, Henry, Method And Apparatus For Penetrating Particulate Substrates, 7/30/2013
104. US8587331 Berry, Tommie, E. | Breinlinger, Keith, J. | Hobbs, Eric, D. | Loranger, Marc | Slocum, Alexander, H. | Wilson, Adrian, S., Test Systems And Methods For Testing Electronic Devices, 11/19/2013
105. USd694595 Slocum, Alexander, Henry, Cutting Board with A Heart-Shaped Cut-Out Handle, 12/3/2013
106. US8618810 Suto, Anthony, J. | Slocum, Alexander, H. | Ziegenhagen, R., Scott, Identifying Fuel Cell Defects, 12/31/2013
107. US8668230 Slocum, Alexander, Henry | Gutierrez, Luis, Javier, Apparatus and Methods for Splicing Conduits And Hoses Subsea, 3/11/2014
108. US8698338 Slocum, Alexander, H. | Fennell, Gregory, E. | Greenlee, Alison, S., Offshore Energy Harvesting, Storage, And Power Generation System 4/15/2014
109. US8707789 Spiegel, Joan, E. | Slocum, Alexander, H. | Watral, Adrienne | Duffley, Samuel | Slocum, Jr., Alexander, Pressure Measuring Syringe, 4/29/2014
110. US8720153 Smith, Eric | Slocum, Alexander, Tapered Spiral Welded Structure, 5/13/2014
111. US8776606 Slocum; Alexander H., "Unrolling tube pressure sensor", 07/15/2014
112. US8867037 Slocum, Alexander | Hoehl, Melanie | Lu, Peter Apparatus and method for detecting glycol, 10/21/2014
113. US8881594 Slocum, Alexander | Slocum, Jr. Alexander, "Tapered spiral bellows pressure sensor", 11/11/2014
114. US8920388 Slocum, Alexander | Bassett, Erik | Karp, Jeffery M. | Langer, Robert S. | Farokhzad, Omid C., Methods and Devices For Sensing Tissues And Tissue Compartments 12/30/2014
115. US9036326 Lee, William David, Et-Al, Gas Bearing Electrostatic Chuck, 5/19/2015
116. US 9157287 Slocum; Alexander, Nelson; Keith, Gabler; Irene, Bayless; James, "System and method for conveying", 10/13/2015
117. US9178200 Bazzarella, Ricardo | Slocum, Alexander | Doherty, Tristan | Cross, James Electrochemical cells and methods of manufacturing the same, 11/03/2015

118. US 9181639 Hart; Anastasios John, Wardle; Brian L., Garcia; Enrique J., Slocum; Alexander Henry, "Continuous process for the production of nanostructures including nanotubes", 11/10/2015
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122. US9289055, Slocum, Alexander| Slocum, Jonathan, "Force Sensitive Toothbrush", 3/22/2016
123. US9302303 Smith, Eric| Takata, Rosalind| Slocum, Alexander| Nayfeh, Samir, "Tapered structure construction", 04/05/2016
124. US9382960, Kluger, Jocelyn Maxine | Sapsis, Themistoklis Panagiotis | Alexander H Slocum, "Beam-Based Nonlinear Spring", 07/05/2016
125. US9394175, Garcia, Enrique J, Hart, Anastasios J., Slocum, Alexander H, Wardle, Brian L., "Continuous Process for The Production of Nanostructures Including Nanotubes", 07/19/2016
126. US 9401501 Bazzarella; Ricardo, Slocum; Alexander H., Doherty; Tristan, Cross, III; James C., "Electrochemical cells and methods of manufacturing the same", 07/26/2016
127. US9475153 Smith, Eric| Slocum, Alexander, "Tapered spiral welded structure", 10/25/2016
128. US9488386 Slocum, Alexander| Codd, Daniel| Paxson, Adam, "Concentrated solar power system receiver", 11/08/2016
129. US9546970 White, James| White, Christopher| Elliott, Colin| Slocum, Alexander Method of and apparatus for in-situ measurement of soot by electron spin resonance (ESR) spectrometry, 01/17/2017
130. US9599180, Jocelyn Maxine Kluger, Alexander Henry Slocum, Themistoklis Panagiotis Sapsis, Beam-Based Nonlinear Spring, 03/21/2017
131. US9617145 Breinlinger, Keith| Malleo, Daniele| Mathieu, Gaetan| Nevill, Tanner| Slocum, Alexander| White, Mark| Exporting a selected group of micro-objects from a micro-fluidic device, 04/11/2017
132. US 9719331 Slocum; Alexander H., Rojas; Folkers Eduardo, "Method and apparatus for bringing under control an uncontrolled flow through a flow device", 08/01/2017
133. US9812674 Bazzarella; Ricardo, Slocum; Alexander H., Doherty; Tristan, Cross, III; James C., "Electrochemical cells and methods of manufacturing the same", 11/7/2017
134. US9839575 Slocum, Alexander| Rojas, Folkers | Massaging device, 12/12/2017
135. US9844394 Pedro Del Nido, Christopher Di Biasio, Keith Vaughn Durand, Jonathan B Hopkins, Samir A Nayfeh, Alexander H Slocum, Zachary Traina and Nikolay Vasilyev | Instrument Port for Minimally Invasive Cardiac Surgery, 12/19/2017
136. US10053798 Slocum, Alexander, et al., | Methods and Systems for Manufacturing a Tablet, 8/21/2018
137. US 10060149 Smith; Eric D., Slocum; Alexander H., "Tapered spiral welded structure" 08/28/2018
138. US10131023 Werner, Jr.; Charles H., Gjovik; Erik J., Slocum; Alexander H., "Adjustable fixture", 11/20/2018
139. US10,188,964 Witt; Daniel P., Wilde; William J., Lowe; Adrian, Shamashkin; Michael, Rezac; Peter, Slocum; Alexander, Ward; Travis, "Chromatography columns", 01/29/2019
140. US 10,189,064 Takata; Rosalind K., Smith; Eric D., Bridgers; Loren Daniel, Ainge; Daniel, Slocum; Alexander H., "Control system and method for tapered structure construction", 01/29/2019
141. US10195653 Smith; Eric D., Takata; Rosalind K., Slocum; Alexander H., Nayfeh; Samir A., "Tapered structure construction", 02/05/2019
142. US 10201655 O'Cearbhaill; Eoin D., Laulich; Bryan, Slocum; Alexander H., Langer; Robert S., Farokhzad; Omid C., Karp; Jeffrey M., "Methods and devices for inserting a needle", 02/12/2019

143. US10213960 Nikhil Padhye, David Parks, Alexander Slocum, Bernhard Trout | Plasticity Induced Bonding, 02/26/2019
144. US10230124 W. Craig Carter, Xinwei Chen, Yet-Ming Chiang, Frank Yongzhen Fan, Ahmed H Helal, Brandon James Hopkins, Zheng Li, Alexander H Slocum and Kyle C Smith | Gravity Induced Flow Cell Using Suspension-Based Flow Electrodes, 03/12/2019
145. US 10252907 Breinlinger; Keith J., Malleo; Daniele, Mathieu; Gaetan L., Nevill; J. Tanner, Slocum; Alexander H., White; Mark P., "Exporting a selected group of micro-objects from a micro-fluidic device", 04/09/2019
146. US10265683 Anastasios John Hart, Brian L. Wardle, Enrique J. Garcia, Alexander H. Slocum | Continuous Process for The Production Of Nanostructures Including Nanotubes, 4/23/2019
147. US 10266402 Yaglioglu; Onnik, Eldridge; Benjamin N., Slocum; Alexander, "Contactors devices with carbon nanotube probes embedded in a flexible film and processes of making such", 04/23/2019
148. US 10,399,316 Wardle; Brian L., Hart; Anastasios John, Garcia; Enrique J., Slocum; Alexander H., "Nanostructure-reinforced composite articles and methods", 09/23/2019
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150. US10513912 Slocum, Alexander | Rojas, Folkers, "Method and Apparatus For Bringing Under Control An Uncontrolled Flow Through A Flow Device", 12/24/2019
151. US10548809 Slocum, Alexander | Rojas, Folkers | Messaging device, 02/04/2020
152. US10566603 Slocum; Alexander H., Doherty; Tristan, Bazzarella; Ricardo, Cross, III; James C., Limthongkul; Pimpa, Duduta; Mihai, Disko; Jeffry, Yang; Allen, Wilder; Throop, Carter; William Craig, Chiang; Yet-Ming, "Stationary semi-solid battery module and method of manufacture", 02/18/2020
153. US10637038 Zagars; Raymond, Curhan; Jeffrey, Doherty; Tristan, Slocum; Alexander H., "Electrochemical cells having semi-solid electrodes and methods of manufacturing the same", 04/28/2020
154. US10703048 Padhye; Nikhil, Parks; David Moore, Trout; Bernhardt Levy, Slocum; Alexander H., "Plasticity induced bonding", 07/07/2020
155. US10800652 Breinlinger; Keith J., Malleo; Daniele, Mathieu; Gaetan L., Nevill; J. Tanner, Slocum; Alexander H., White; Mark P., "Exporting a selected group of micro-objects from a micro-fluidic device", 10/13/2020
156. US10886521 Zagars; Raymond, Curhan; Jeffrey, Doherty; Tristan, Slocum; Alexander H., "Electrochemical cells having semi-solid electrodes and methods of manufacturing the same", 01/05/2021
157. US10895088 Smith, Eric | Slocum, Alexander | Tapered spiral welded structure, 01/19/2021
158. US10906285, Wardle; Brian L., Hart; Anastasios John, Garcia; Enrique J., Slocum; Alexander H., "Nanostructure-reinforced composite articles and methods", 02/02/2021
159. US10925655 Alexander Slocum, James Connor Jr., Jacob Mooney, Nicholas Wing-Ping Kwok | "Bone Reduction Forceps", 02/23/2021
160. US10926418 Lu Lu; Xiaodong, Tang; Peter, Slocum; Alexander H., Chen; Rui, "Robotic devices and methods for fabrication, use and control of same", 02/23/2021
161. US 10974298 Smith; Eric D., Takata; Rosalind K., Slocum; Alexander H., Nayfeh; Samir A., "Tapered structure construction", April 13, 2021
162. US10,988,279, Alexander Slocum, Debra Thurston-Slocum, "Package Maker", April 27, 2021
163. US11,065,036, DiBiasio; Christopher, Durand; Keith, Hopkins; Jonathan, Traina; Zach, Slocum; Alexander, Nayfeh; Samir, del Nido; Pedro J., Vasilyev; Nikolay V., "Instrument port for minimally invasive cardiac surgery", 07/20/2021
164. US11,111,141 Jonathan Slocum, Alexander Slocum, "Storing Activated Aluminum", Sept. 7, 2021.
165. US11121437, Bazzarella; Ricardo, Slocum; Alexander H., Doherty; Tristan, Cross, III; James C., "Electrochemical cells and methods of manufacturing the same", 09/14/2021
166. US 11161579, Slocum; Alexander H., Slocum; Jonathan T., "Systems, modules, and submersible vehicles for collecting material from a seafloor", 09/23/2021

167. US11130557, Slocum; Alexander H., Slocum; Jonathan T., "Controlling lifting gas in inflatable structures", 9/28/2021
168. US11148947, Slocum; Jonathan T., Slocum; Alexander H., "Controlling hydrogen production from water-reactive aluminum", 10/19/2021
169. US11148840, Slocum; Jonathan T., Slocum; Alexander H., "Method of packaging water-reactive aluminum", 10/19/2021
170. US11,268,180 Slocum; Jonathan T., Slocum; Alexander H., "Structure inflation using activated aluminum", 3/8/2022
171. US11312466 Slocum; Jonathan T., Slocum; Alexander H., "Inflatable structure deployment", 4/26/2022
172. US11318437 Slocum; Jonathan T., Slocum; Alexander H., "Controlling contamination in hydrogen production from water-reactive aluminum" 5/3/2022
173. US11332366 Slocum; Jonathan T., Slocum; Alexander H., "Controlling reactivity of water-reactive aluminum" 05/17/2022
174. US11373549 Johnson, Hilary; Slocum Alexander, "Braille writing device", June 28, 2022

15. Professional Registration: None.

16. Major New Products, Processes, Designs, or Systems:

- SEMI E57 - Specification for Kinematic Couplings Used to Align and Support 300 mm Wafer Carriers. I proposed to SEMI/Sematech a new standard for locating 300 mm wafer cassettes, and then led the formulation and implementation of the standard, which is now in use by all companies for 300 mm semiconductor wafer cassettes and interfaces.
- OMAX Jet Machining Center (many different models). See: www.omax.com.
- Weldon 1632 Gold Grinder, International Machine Tool Show (IMTS: "Best of Show" award for development Weldon Machine Tool's 1632 Gold Cylindrical Grinder (it used Slocum's hydrostatic bearings and ShearDamper technology), Sept. 1994.
- ShieldBeam Contactor, manufactured by Teradyne, which won an R&D 100 Award for one of 100 best new technical products of the year, June 1997.
- K-Dock Kinematic Docking System, manufactured by Teradyne, which won an R&D 100 Award for one of 100 best new technical products of the year, June 1997.
- Executive Producer for inner-city kids' rap group Mental Block, their first CD entitled, "IF".
- Kinetrix, Inc. (a new startup I helped create) Apollo Semiconductor Device Sorter and Galileo Semiconductor Device Handler.
- Created web sites and programs for the Urban Design Corp (www.urbandesigncorp.org), and Paths-to-Peace (www.pathstopeace.org) to help teach kids to design and create and to promote better understanding between cultures.
- Advised 2nd Summer students as UROPs to pursue patenting their device "Ergonomic Cleaning Apparatus with Multiple Scrubbing Surfaces," US Patent # 5,915,869, June 1999.
- Worked with Overbeck Corp. of Long Island, NY to create the LT Grinding machine, which was featured as a cover article: "Get a Preload of This," American Machinist, December 2002.
- Executive Producer for "Journey of The Lost Souls" by Marc Graham (book of poems and rap CD).
- Dial Soap "Quest for the Best" consumer product search finalist for "Massagasoap".
- Massachusetts State Archives: Encasements for Documents of Freedom (cases to provide 20 years O₂ free enclosures to enable public viewing of original documents: Commonwealth of MA Charter of 1629, Charter of 1692, original copies provided to the 13 colonies of: US Declaration of Independence, Constitution, and Bill of Rights, all with combined value >\$80 million).
- OOSEH massaging balls (see www.roll2run.com)
- OOSEH finger splint

17. Teaching Experience:

<u>Term</u>	<u>Subject Number</u>	<u>Title</u>	<u>Role</u>
ST 1986	1.965	Special Studies in Civil Engineering	Lect. in Charge
FT 1986	1.964	Design for Construction Automation*	Lect. in Charge
ST 1987	1.13	Design for Construction Automation*	Lect. in Charge
FT 1987	1.08	Introduction to Robotics*	Lect. in Charge
FT 1987	1.502A	Freshman Seminar "Design of Machine Systems"	Lect. in Charge
ST 1988	1.13	Design for Construction Automation*	Lect. in Charge
FT 1988	2.70	Introduction to Design	Recitation
FT 1988	1.S04	Fr Freshman Seminar "Precision Machine Design"	Lect. in Charge
ST 1989	2.996	Precision Machine Design*	Lect. in Charge
FT 1991	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1991	2.731	Advanced Engineering Design	Co-lecturer
ST 1992	2.732	Advanced Engineering Design	Co-lecturer
ST 1992	2.840	Precision Machine Design*	Lect. in Charge
FT 1992	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1992	2.731	Advanced Engineering Design	Co-lecturer
ST 1993	2.732	Advanced Engineering Design	Co-lecturer
ST 1993	2.75	Precision Machine Design*	Lect. in Charge
FT 1993	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1993	2.72	Machine Elements	Co-lecturer
ST 1994	2.75	Precision Machine Design*	Lect. in Charge
FT 1994	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1994	2.73	Design	Co-Lect. in Charge
ST 1995	2.70	Introduction to Design	Lect. in Charge
FT 1995	2A08	Freshman Seminar: Design of Toys & Games*	Lect. in Charge
FT 1995	2.75	Precision Machine Design*	Lect. in Charge
IAP 1996	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1996	2.70	Introduction to Design	Lect. in Charge
FT 1996	2A08	Freshman Seminar: Design of Toys & Games*	Lect. in Charge
FT 1996	2.75	Precision Machine Design*	Lect. in Charge
IAP 1997	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1997	2.007	Design & Mfg I*	Lect. in Charge
IAP 1998	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1998	2.75	Precision Machine Design*	Lect. in Charge
ST 1998	2.007	Design & Mfg I*	Lect. in Charge
FT 1998	2.009	Product Design Section Instructor	
IAP 1999	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1999	2.007	Design & Mfg I*	Lect. in Charge
IAP 2000	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2000	2.007	Design & Mfg I*	Lect. in Charge
ST 2000	2.75	Precision Machine Design*	Lect. in Charge
IAP 2001	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2001	2.007	Design & Mfg I*	Lect. in Charge
FT 2001	2.75	Precision Machine Design*	Lect. in Charge
FT 2001	2.997	(J with 6.963 Medical Innovation)	Co-Lect. in Charge
IAP 2002	2.971	2nd Summer Intro. to Design*	Lect. in Charge
IAP 2002	2.996	Paths to peace*	Lect. in Charge
ST 2002	2.007	Design & Mfg I*	Lect. in Charge
FT 2002	2.996	Paths to peace*	Lect. in Charge
IAP 2003	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2003	2.007	Design & Mfg I*	Lect. in Charge
FT 2003	SP247	8.01 Physics with Sports*	Lect. in Charge
FT 2003	2.75	Precision Machine Design*	Lect. in Charge
IAP 2004	2.971	2nd Summer Intro. to Design*	Lect. in Charge

ST 2004	2.007	Design & Mfg I*	Lect. in Charge
FT 2004	SP247	8.01 Physics with Sports*	Lect. in Charge
FT 2004	2.75	Precision Machine Design*	Lect. in Charge
IAP 2005	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2005	2.007	Design & Mfg I*	Lect. in Charge
FT 2005	2.75	Precision Machine Design*	Lect. in Charge
ST 2006	2.007	Design & Mfg I*	Lect. in Charge
FT 2006	2.75	Precision Machine Design*	Lect. in Charge
ST 2007	2.007	Design & Mfg I*	Lect. in Charge
ST 2008	2.007	Design & Mfg I*	Lect. in Charge
FT 2008	2.75/2.750	Precision Machine Design*	Lect. in Charge
ST 2009	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2009	2.75/2.750	Precision Machine Design*	Lect. in Charge
FT2009	2.A38	Freshman Advisor Seminar*	Lect. in Charge
ST 2010	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2010	2.75/2.750	Precision Machine Design*	Lect. in Charge
FT2010	2.A38	Freshman Advisor Seminar*	Lect. in Charge
ST 2011	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2011	2.75/2.750	Precision Machine Design*	Lect. in Charge
ST 2012	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2012	2.75/2.750	Precision Machine Design*	Lect. in Charge
ST 2013	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2014	2.75/6.525, 2.750/6.025J	Design of Medical Devices	Co-Lect. In Charge
ST 2014	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2015	2.75/6.525, 2.750/6.025J	Design of Medical Devices	Co-Lect. In Charge
ST 2016	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
ST 2016	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2016	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2017	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2017	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2018	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2018	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2019	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2019	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2020	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2020	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2021	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge

* Indicates subject developed by Slocum

Publications of Alexander H. Slocum

18. Books:

- 1) Slocum, A. H., Precision Machine Design, © 1995, Society of Manufacturing Engineers, Dearborn, MI. (first published by Prentice Hall in 1992).
- 2) Handbook of Human-centered Design (Japanese), Section 7.3.
- 3) Slocum, A. H., FUNdaMENTALS of Design, and accompanying lecture videos and notes available on-line for free at (<http://pergatory.mit.edu/2.007/resources/FUNdaMENTALS.html>).
- 4) Ito, T., Ichikawa, T., Hanumara, N. C., Slocum, A. H., "Teaching Creativity in Design Through Project-Based Learning in a Collaborative Distributed Educational Setting," Chapter from Cloud-Based Design and Manufacturing (CBDM) , D. Schaefer (ed.) available on-line at (http://link.springer.com/chapter/10.1007/978-3-319-07398-9_9), Springer International Publishing Switzerland, 2014, pp. 231-282.

19. Papers in Refereed Journals:

- 1) McClintock, F. A., Slocum, A. H., "Predicting Fully Plastic Mode II Crack Growth from an Asymmetric Weld Defect," International Jrl. of Fracture Vol. 27, 1985, pp 49-62.
- 2) Slocum, A. H., "Design to Limit Thermal Effects on Linear Motion Bearing Components," Int. Jrl. Machine Tool Design, Vol. 27, No. 2, 1987, pp 239-245.
- 3) Slocum, A. H., Greenspan, L., Peris, J.P., "Design and Implementation of a Five Axis Robotic Micro-manipulator," Int. Jrl. Machine Tool Design, Vol. 28, No. 2, 1988, pp 131-141.
- 4) Slocum, A. H., "Development of a Six Degree-of-Freedom Position and Orientation Sensing Device: Design Theory and Testing," Int. Jrl. Machine Tool Design, Vol. 28, No. 2, 1988, pp 131-139.
- 5) Slocum, A. H. "Kinematic Couplings for Precision Fixturing - Part I - Formulation of Design Parameters," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 10, No. 2, April 1988, pp 85-91.
- 6) Slocum, A. H. and Donmez, A., "Kinematic Couplings for Precision Fixturing - Part II - Experimental Determination of Repeatability and Stiffness," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 10, No. 3, July 1988, pp 115-122.
- 7) *Slocum, A. H. and Schena, B., "Blockbot: A Robot to Automate Construction of Cement Block Walls," Robotics, Vol. 4, 1988, pp 111-129.
- 8) *Slocum, A. H. and Ziegler, A., "An Automated Shear Stud Welding System," Jrl. Robotics and Autonomous Systems, Vol. 6, 1990, pp 367-382.
- 9) Slocum, A. H. "Design of Three-Groove Kinematic Couplings," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 14, No. 2, April 1992, pp 67-76.
- 10) *Battles, A.E., Linder, B. M., Chang, K.W., Slocum, A.H., "The Design of a Precision Bilaminar Resonating Transducer Assembly Tool", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 15, No. 4, Oct. 1993, pp 248-257.
- 11) *Everett, J. G., and Slocum, A. H. "CRANIUM: Device for Improving Crane Safety and Productivity," ASCE Jrl. Construction Engineering and Management, 1994, 119 (1), pp 1-17. Received the ASCE 1994 Thomas Fitch Rowland Prize.
- 12) *Smith, M.H., Annaswamy, A.M., Slocum, A.H., "Adaptive Control Strategies for a Precision Machine Tool Axis," Precision Engineering, Vol. 17, No. 3, 1995, pp. 192-206.
- 13) *Slocum, A. H., Marsh, E.R., Douglas H. Smith, "A New Damper Design for Machine Tools and Components: "The Replicated Internal Viscous Damper," Precision Eng., Vol. 16, No. 3, June. 1994, pp 174-183.

- 14) *Slocum, A.H., Scagnetti, P.E., Kane, N.R., Brünner, C., "Design of Self Compensated Water-Hydrostatic Bearings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 17, No. 3, 1995, pp 173-185.
- 15) *Hale, L.C., Slocum, A.H., "Design of Anti-Backlash Transmissions for Precision Position Control Systems", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 16, No. 4, Oct. 1994, pp. 244-258.
- 16) *Van Doren, M. and Slocum, A. "Design and Implementation of a Precision Material Handling Robot Control System," International Journal of Machine Tools and Manufacture, Vol. 35, Issue 7, 1995, Pages 1003-1014, [https://doi.org/10.1016/0890-6955\(94\)00043-J](https://doi.org/10.1016/0890-6955(94)00043-J).
- 17) *Marsh, E.R., Slocum, A.H., "An Integrated Approach to Structural Damping," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 18, Nos. 2/3, 1996, pp 103-109.
- 18) Schmiechen, P., Slocum, A.H., "Analysis of Kinematic Systems: a Generalized Approach", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 19, No. 1, July 1996, pp. 11-18.
- 19) *Pfahnl, A. C., Lienhard V, J. H., Slocum, A.H., "Heat Transfer Enhancing Features for Handler Tray-Type Device Carriers", IEEE Transactions on Components, Packaging, and Manufacturing Technology Part C: Manufacturing, Vol. 21, No. 4, October 1998.
- 20) *Kotilainen, M., Slocum, A. "Manufacturing of Cast Monolithic Hydrostatic Journal Bearings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 25 (2001), pp. 235-244.
- 21) *Hale, L. and Slocum, A, "Optimal design techniques for Kinematic Couplings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, April 2001, vol. 24, number 2, pp. 114-127.
- 22) *Balasubramaniam, M., Dunn, H., Golaski, E., Son, S., Sriram, K., Slocum, A., "An Anti Backlash Two-Part Shaft Coupling with Interlocking Elastically Averaged Teeth", Precis Eng., Volume 26, July 2002, No. 3 pp. 314-330, 2002.
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- 24) *Kane, N. R., Sihler, J., Slocum, A.H., "A hydrostatic rotary bearing with angled surface self-compensation", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Volume 27, Issue 2, April 2003, Pages 125-139.
- 25) *O'Sullivan, D., Q., "Slocum, A.H., "Design of Two-Dimensionally Curved Panels for Sandwich Cores", Journal of Sandwich Structures and Materials, Vol. 05 Issue 01, 1 January 2003, pp 77.
- 26) *Slocum, A., Basaran, M., Cortesi, R., Hart, A.J., "Linear Motion Carriage with Bearings Preloaded by Inclined Iron Core Linear Electric Motor", Jou. Int. Soc. of Precision Engineering and Nanotechnology, 27 (2003) 382-394.
- 27) *Slocum, A., Weber, Alexis, "Precision Passive Mechanical Alignment of Wafers", IEEE JMEMS, Dec. 2003, Vol. 12, No. 6, pp 826-834.
- 28) *Brenner M.P., Lang J. H., Li J., Qiu, J., Slocum A. H., "Optimal, design of a bistable switch", PNAS, August 19, 2003, Vol. 100, No. 17, 9663-9667.
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- 43) Bamberg E, Grippo CP, Wanakamol P, Slocum AH, Boyce MC, Thomas, EL, "A tensile test device for in situ atomic force microscope mechanical testing", Precision Engineering, 30 (2006), pp. 71-84.
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- 45) *Hart, A.J., Slocum, A.H., Royer, L., "Growth of High-Quality Single-Walled Carbon Nanotube Films on Bare and Microstructured Silicon Substrates", Carbon, 44(2):348-359, 2006.
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- 128) S.L. Figueredo, R. Guzman de Villoria, A.J. Hart, S. A. Steiner III, A.H. Slocum, B.L. Wardle, "Apparatus for Continuous Growth of Vertically Aligned Carbon Nanotubes", euspen annual mtg, San Sebastian, June 2008.
- 129) K. Durand, D. Zurovcik, A. Slocum, "Precision Hermetically Sealed Display Encasements for Historic Documents". euspen annual mtg, San Sebastian, June 2008.
- 130) Teruaki Ito, Alexander H. Slocum, "Virtual Cutter Path Display for Dental Milling Machine", IEEE RO-MAN2009, Toyama of Japan in Sep 27-Oct 2, 2009.
- 131) A. Seitel, C. J. Walsh, N. C. Hanumara, J. Shepard, A.H. Slocum, H. Meinzer, R. Gupta, L. Maier-Heina "Development and evaluation of a new image-based user interface for robot assisted needle placements with the Robopsy system", Proc. of SPIE Vol. 7261 72610X-1.
- 132) L. Maier-Hein, C. J. Walsh, A. Seitel, N. C. Hanumara, J. Shepard, A. M. Franz, F. Pianka, S. A. Muller, B. Schmied, A. H. Slocum, R. Gupta, H. Meinzer, "Human vs. robot operator error in a needle-based navigation system for percutaneous liver interventions", Proc. of SPIE Vol. 7261 72610Y-1.
- 133) M.B. Read, A.H. Slocum, J.H. Lang, and R. Martens, "Contact Resistance in Flat Thin Films," Proceedings of the 55th IEEE Holm Conference on Electrical Contacts, 2009, pp. 300-306.
- 134) A.Yui, S. Okuyama1, T. Kitajima1, E. Fujita, A.H. Slocum, G. Rothenhofer, "Study on Precision Machine Table Equipped with Constant-Flow Hydrostatic Water Bearings", Advanced Materials Research Vols. 76-78 (2009) pp 664-669, online at <http://www.scientific.net>
- 135) Chen, J., Greenlee, A., Cheung, K., Slocum, A., "Multi-turn, Tension-stiffening Catheter Navigation System", Proceedings of 2010 IEEE International Conference on Robotics and Automation, May 3-8, 2010, Anchorage, Alaska, USA.
- 136) Joan Spiegel, M.D., Alex Slocum, Jr., B.S., Alex Slocum, Sr., DPhil. "Measuring Endotracheal-Tube Cuff Pressure: An Integrated, In-Line Pressure-Measuring Syringe". Proceedings of the 105th Annual Meeting of the American Society Anesthesiologists, San Diego, California, October 16-20, 2010.
- 137) A.M. Al Hussein, H.J. Lee, J. Negrete, S. Powelson, A. Servi1, A.H. Slocum, J. Saukkonen, "Design and Prototyping of a Low-cost Portable Mechanical Ventilator", Proceedings of the 2010 Design of Medical Devices Conference, DMD2010, April 13-15, 2010, Minneapolis, MN, USA.
- 138) D. Da. Pozzo, M. Deterre, D. Eggenspieler, M. Lobovsky, A.H. Slocum, Frank Pigula, "Hydraulic Remotely Adjustable Pulmonary Artery Banding", Proc. of the 2010 Design of Medical Devices Conference, DMD2010, April 13-15, 2010, Minneapolis, MN, USA.
- 139) Y. Chen, J. H. Chang, A. S. Greenlee, K. C. Cheung, A. H. Slocum, R. Gupta, "Multi-turn, Tension-stiffening Catheter Navigation System", ICRA'10, Anchorage, Alaska, USA.
- 140) A. H. Slocum, Jr., S. C. Duffley, J. Moreu Gamazo1, A. Watral1, J.E. Spiegel, A. H. Slocum, "Design of a Pressure Measuring Syringe", Proc. of the 2010 Design of Medical Devices Conference, DMD2010, April 13-15, 2010, Minneapolis, MN, USA.
- 141) J.E. Petrzalka, D.M. Chatzigeorgiou, M.C. Menon, M.E. Lustrino, C.J. Stefanov-Wagner, A.H. Slocum, S.K. Agarwal, 2001, An Articulating Tool For Endoscopic Screw Delivery, Proc. of the 2010 Design of Medical Devices Conference, April 13-15, 2010, Minneapolis, MN, USA.
- 142) S.J. Anderson, J.C. Zimmermann, E.F. Houston, K.M. Farino, N.D. Begg, , Design of an Endoscopic Lens Shielding Device for use in Laparoscopic Procedures, Proc. of the 2010

Design of Medical Devices Conference, Minneapolis, MN, USA, Mar. 13-15, DMD2010-3849.

- 143) M. Read, R. Martens, J. Lang, and A. Slocum, "The Effects of Contact Radius and Scrub on Thin Film Contacts," Proc. of 56th IEEE Holm Conference on Electrical Contacts, Charleston, 2010.
- 144) D.S. Codd, A.H. Slocum, "Direct Absorption Volumetric Molten Salt Receiver With Integral Storage", Proceedings of ASME 2011 5th International Conference on Energy Sustainability & 9th Fuel Cell Science, Engineering and Technology Conference, ESFuelCell2011, August 7-10, 2011, Washington, DC, USA
- 145) *G. Rothenhöfer, A. Slocum, M. Paone, X. Lu, A. Yui, "Elements for the Design of Next Generation, High Stiffness and High Accuracy Precision Machines", 2011 euspen annual mtg, Como, Italy
- 146) *A. Slocum, R. Campbell, S. Ziegehgaen, W. Miskoe, D. V. Lorenzo Ippolito, N. De Blasio, "Design, Fabrication, and Testing of a Modular Concentrated Solar Power Trough System", 2011 euspen annual mtg, Como, Italy
- 147) O. Yaglioglu, R. Martens, A. Cao, A. H. Slocum, "Compliant Carbon Nanotube-Metal Contact Structures", Proc. of 57th IEEE Holm Conference on Electrical Contacts, 2011
- 148) D.S. Codd and A.H. Slocum, "Direct absorption volumetric molten salt receiver with integral storage," in ASME 5th International Conference on Energy Sustainability, ESFuelCell2011, August 7-10, 2011, Washington, DC, 2011.
- 149) Walsh, C., Slocum, A.H., "Design of a Telerobot for Percutaneous Instrument Distal Tip Repositioning", 33rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'11), Boston, MA, USA on August 30 - September 3, 2011.
- 150) Zurovcik, D., Slocum, A.H., "Development of Simplified Negative Pressure Wound Therapy Device for Low-Resource Settings", 2011 IEEE Global Humanitarian Technology Conference.
- 151) Graves C., Slocum, A.H., Gupta, R., Walsh, C., "Towards a Compact Robotically Steerable Thermal Ablation Probe ", submitted to 2012 IEEE International Conference on Robotics and Automation, May 14-18, 2012, RiverCentre, Saint Paul, Minnesota, USA
- 152) Slocum, A.H, Wong, A.R., "Hydrostatics on a Halfshell", 2011 ASPE annual meeting, Denver, CO.
- 153) Petrzela, J.E., Chatzigeorgiou, D.M., Menon, M.C., Lustrino, M.E., Stefanov-Wagner, C.J., Slocum, A.H., and Agarwal, S.K., "An Articulating Tool for Endoscopic Screw Delivery," Proceedings of the 2010 Design of Medical Devices Conference, Minneapolis, MN, 2010.
- 154) Agarwal, S.K., Petrzela, J.E., Menon, M.C., Stefanov-Wagner, C.J., Chatzigeorgiou, D.M., Lustrino, M.E., and Slocum, A.H. "Thoracoscopic Stabilization of the Chest Wall," Proceedings of the New England Surgical Society Annual Meeting, 2010.
- 155) Ito, T, Ichikawa, T., Hanumara, H., Slocum, A.H., "Expectation Management In A Global Collaboration Project Using Deterministic Design Approach", Proceedings of the ASME 2012 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2012, August 12-15, 2012, Chicago, IL
- 156) T. Koiwai, A. Honda, G. Okahata, T. Kitajima, A. Yui, S. Okuyama, H. Kobayashi, A. Slocum, "Development of Grinding Machine for 450mm Wafer - 1st report: Specification and Fundamental Performance of The Grinding Machine", JSME 9th Manufacturing & Machine tool Conference, Akita prefecture October 26-27 2012
- 157) A. Honda, A. Yui, T. Koiwai, S. Okuyama, G. Okahata, H. Kobayashi, T. Kitajima, A. Slocum, "Development of Grinding Machine for 450mm Wafer - 2nd Report: Numerical Analysis of Static Stiffness and Load Capacity of Water Hydrostatic Table", JSME 9th Manufacturing & Machine tool Conference, Akita prefecture October 26-27 2012
- 158) A. H. Slocum, M. A. Chiu, E. D. Hobbs, G. Rothenhöfer, A.Yui, "Kinematic and Elastically Averaged Joints: Connecting the Past, Present and Future", IUSPEN, Tokyo Japan, March 13, 14, 2013

- 159) A. Yui, A. Honda, S. Okuyama, T. Kitajima, G. Okahata, H. Saito, A. H. Slocum, "Development of a vertical-spindle rotary surface grinding machine for large scale silicon-wafers –Machine specifications and performance of rotary work table–", Proceedings of the 13th euspen International Conference, Berlin, May 2013
- 160) F.E. Rojas and Slocum, A.H., "Continuous Feed of an Occluding Medium into a Flow Stream," presented at ASPE Annual Meeting, St. Paul, MN, USA, October 21-25, 2013.
- 161) A.H. Slocum, "Addressing Big Challenges with Precision Symbiotic Systems Thinking," presented at ASPE Annual Meeting, St. Paul, MN, USA, October 21-25, 2013.
- 162) S.A. Lopez, et al., "Design Prototyping, and Evaluation of a Collapsible Device for Single-Operator Sheathing of Ultrasound Probes," Mechanical Sciences Guest Editorial, ms-2013-13, Special Issue, Design of Medical Devices: Creative Solutions by Young Researchers.
- 163) A.H. Slocum, "Symbiotic Offshore Energy Harvesting and Storage Systems," Proceedings of 2014 Offshore Energy & Storage Symposium, Windsor, Ontario, Canada, UWCAES Society, July 10-11, 2014.
- 164) M. N. Haji, C. Vitry, A. H. Slocum, "Design of a Symbiotic System to Extract Uranium from Seawater," Seawater Uranium Recovery Program Meeting, Oak Ridge, TN, January 12-13, 2015.
- 165) J.M. Kluger, T.P. Sapsis, and A.H. Slocum, "First order power estimation of a floating oscillating water column encircling an offshore wind turbine," NEEC Annual Meeting, NSWC Carderock, West Bethesda, VA. April, 2015.
- 166) J.M. Kluger, T.P. Sapsis, and A.H. Slocum, Combined offshore wind-wave-storage system power and cost predictions, NAWEA Symposium, Blacksburg, VA, June 8, 2015.
- 167) M. N. Haji, C. Delmy, J. Gonzalez, A. H. Slocum, "Design of a Symbiotic System to Extract Uranium from Seawater," Seawater Uranium Recovery Program Meeting, College Park, MD, August 6-7, 2015.
- 168) M. N. Haji, C. Delmy, J. Gonzalez, A. H. Slocum, "Extraction of Uranium from Seawater: Design and Testing of a Symbiotic System," NAKFI Advancing Nuclear Technologies Mid-Cycle Grant Meeting, Chicago, IL, July 9, 2015.
- 169) M. N. Haji, C. Vitry, and A. H. Slocum, "Decoupling the functional requirements of an adsorbent for harvesting uranium from seawater through the use of shell enclosures," In *Proceedings of the 2015 ANS Winter Meeting and Nuclear Technology Expo*, Washington, DC, November 8-12, 2015
- 170) F. Rojas, A. Slocum, "A BOP Back-Up System: The Hampering Active Wellbore Kit (HAWK)" □SPE Workshop: Downhole Tools, Tuesday, October 20th, 2015, Galveston, TX
- 171) M. E. Flicker Byers, M. N. Haji, E. A. Schneider, and A. H. Slocum, "A Higher Fidelity Cost Analysis of Wind and Uranium from Seawater Acquisition SymBiotic Infrastructure", In *Proceedings of the 2016 ANS Winter Meeting and Nuclear Technology Expo*, Las Vegas, NV, November 6-10, 2016.
- 172) M. N. Haji, C. Delmy, J. Gonzalez, A. H. Slocum, "Uranium extraction from seawater using adsorbent shell enclosures via a symbiotic offshore wind turbine device", *Proc. Twenty-sixth (2016) International Ocean and Polar Engineering Conference*, Rhodes, Greece, June 26-July 1, 2016 (Best Paper Award)
- 173) J.M. Kluger, T.P. Sapsis, and A.H. Slocum, "A reduced-order, statistical linearization approach for estimating nonlinear floating wind turbine response statistics," *Proceedings of the International Society of Offshore and Polar Engineers Conference*, Rhodes, pp. 8 (2016).
- 174) M. N. Haji, A. H. Slocum, "Design of a Symbiotic Device to Harvest Uranium from Seawater through the use of Shell Enclosures", In *Proceedings of the 2016 ANS Winter Meeting and Nuclear Technology Expo*, Las Vegas, NV, November 6-10, 2016.
- 175) J.M. Kluger, A.H. Slocum, T.P. Sapsis, "A first-order dynamics and cost comparison of wave energy converters combined with floating wind turbines," *Proceedings of the International Society of Offshore and Polar Engineers Conference*, San Francisco, CA, pp. 9 (2017).

- 176) A.H. Slocum, M. N. Haji, J.M. Kluger, T.P. Sapsis, "Mechanics and materials in the design of symbiotic offshore energy harvesting systems", 7th Intl Conf. Progress in Mechanics and Materials in Design, Albufeira Portugal, 11-15 June 2017.
- 177) M. N. Haji, M. E. Flicker Byers, E. A. Schneider, and A. H. Slocum, "Cost Analysis of Wind and Uranium from Seawater Acquisition symBiotic Infrastructure using Shell Enclosures", In Proceedings of the 2017 ANS Meeting, San Francisco, CA, June 11-15, 2017.
- 178) M. N. Haji, J. Drysdale, K. Buesseler, and A. H. Slocum, "Ocean Testing of a Symbiotic Device to Harvest Uranium from Seawater through the Use of Shell Enclosures", In Proceedings of the Twenty-seventh (2017) International Ocean and Polar Engineering Conference, San Francisco, CA, June 25-30, 2017.
- 179) T. Hamer, L. Zhou, V. Perez, A. Gil, D. Trumper, A.H. Slocum, N. Calvet, "Implementation of Thermal-Insulating and-Mixing Elements in a Concentrated Solar Power on Demand System", SOLAR PACES Conf, Sept. 2017, Santiago, Chile.
- 180) A. Slocum, Ronald Campbell, M. Giglio, A. Bernasconi, S. Cardamone, N. Parow, "Large monolithic curved panels and cylindrical torque tubes for concentrated solar power parabolic trough systems", euspen annual mtg, Venice, Italy, 2018
- 181) L. Gray, A. Slocum, "Cable Train: In-Situ Manufacturing of Trackside Underground Cable HVDC Transmission Systems", CIGRE US National Committee [http : //www.cigre.org](http://www.cigre.org) 2018 Grid of the Future Symposium Nov. 2018.
- 182) A.C. Duenner, A.H. Slocum, "Framework for Error Budgeting in Precision Machine Design" Proceedings - ASPE 2018 Annual Meeting. Las Vegas, NV; 2018.
- 183) M. Verma et. Al., "Development Of A Long-Acting Direct-Acting Antiviral System For Hepatitis C Virus Treatment In A Swine Model", 2020 DDW (Digestive Diseases Weekly) conference.
- 184) Johnson, H. A., Simon, K. P., and Slocum, A. H., 2020, "Improving the Design Life Cycle Efficiency of Wastewater Treatment Plant Inflow Pumps," Proceedings of Applied Energy Symposium: MIT A+B, ICAE, p. 5. <http://www.energy-proceedings.org/improving-the-design-life-cycle-efficiency-of-wastewater-treatment-plant-inflow-pumps/>
- 185) J. Oeding, S. Bockman, H. Chiu, C. Hua, J. Connor, A. Slocum, "Design of a Multi-Degree-of-Freedom Traction and Stabilization Device for Open Reduction and Internal Fixation of Distal Radius Fractures", BIOMED 2021; V001T13A007doi:<https://doi.org/10.1115/DMD2021-1047>
- 186) Doron, P., Karni, J., & Slocum, A. (2019), "A Generalized Approach for Selecting Solar Energy System Configurations for a Wide Range of Applications", MRS Energy & Sustainability, 6, E#. doi:10.1557/mre.2019.10
- 187) Gessel, D., Slocum, A., "Lifespan Analysis of Utility Scale Energy Storage Options", euspen special interest group mtg, 13-14 Oct. 2021.
- 188)

*Outgrowth of supervised student research.

21. Other Major Publications:

- 1) Slocum, A. H., (Executive Producer) for inner-city kids' rap group Mental Block, their first CD entitled "IF".
- 2) Slocum, A. H., (Executive Editor) for Marc Graham's book of poems and images entitled "JoTLS" (Journey of The Lost Souls) www.jotls.com .

22. Invited Lectures:

1. April 1986, "Flexible Automated Fixturing Systems," SME Conf. on Jigs and Fixtures, Cincinnati, OH.
2. Dec. 1986, "A Five Axis Robotic Micromanipulator," ASME Winter Annual Meeting, Anaheim, California.
3. Dec. 1986 "A Servo-Controlled Pneumatic Double Gripper with Changeable Fingers," ASME Winter Annual Meeting, Anaheim, CA.
4. Sept. 1989, *Precision Machine Design*, Short course for the American Society for Precision Engineering Annual Meeting in Monterey, CA.
5. Sept. 1990, *Precision Machine Design*, Short course for the American Society for Precision Engineering Annual Meeting in Rochester, NY.
6. Oct. 1991, *Precision Linear Motion Bearing Design*, Short course for the American Society for Precision Engineering Meeting in Santa Fe, NM.
7. Oct. 1991, *Error Budgeting and Machine Modeling*, Short course for the American Society for Precision Engineering Meeting in Santa Fe, NM.
8. Oct. 1992, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Orlando, FL.
9. Oct. 1992, *Applications of Ceramic Materials in Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Orlando, FL.
10. Nov. 1993, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Seattle, WA.
11. Nov. 1993, *Applications of Ceramic Materials in Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Seattle, WA.
12. Nov. 1993, *Design of Damping Systems for High Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Seattle, WA.
13. Nov. 1994, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Cincinnati, OH.
14. Nov. 1995, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Phoenix, AZ.
15. Oct, 2000, *Getting Students Psyched about Engineering and Science*, Robofesta Conf., Osaka, Japan
16. Nov. 2000, *Advances in Machine Tool Design*, ASME Winter Annual Meeting, Orlando, FL
17. July 2001, *Advances in Machine Elements*, keynote address, 10 International Conference on Precision Engineering, Yokohama, Japan.
18. Nov. 2002, *Mechanics of Designing Precision Machines*, Harvard University, Division of Engineering and Applied Science Dept. seminar
19. April. 2003, *The Nanogate*, Harvard University, Division of Engineering and Applied Science Dept. seminar
20. June 2003, *Characterization and Fabrication of the NanoGate for Nanoscale Fluidics, Wireless Communications, and ?*, NSF Workshop on Nanoscale Mechanical Engineering, Arlington, VA Nov. 2002
21. Nov. 2003, *Advances in Precision Machine Design*, keynote speaker, Mechatronics, Automation and Control Symposium of the COBEM 2003 Sao Paulo Brazil
22. Nov. 20, 2003, "Fundamentals of MEMS machines", Invited lecture, University of Florida
23. March 22, 2004, "Fundamentals of Precision Machine Design", invited lecture, Brigham Young University
24. March 22, 2004, "Applying Macro Machine Design Experience to Dinky Designs", invited lecture, Brigham Young University
25. May 17, 2004, "Fundamentals of Precision Machine Design", invited lecture, Ohio State University
26. June 2, 2004, "Magnetically Preloaded Friction Drive System", Invited keynote speaker, European Union Society for Precision Engineering & Nanotechnology annual meeting.
27. Sept. 6, 2004, "A design Environment to Teach Students about Optimal Transmission Ratios", 4th. Intl. Conf. Advanced Engineering Design, Glasgow, Scotland, Sept. 5-8, 2004.
28. Sept 14, 2006, "Design of Small Precision Machines", ICOMM Univ. of Illinois UC, keynote address

29. Oct. 16, 2007, "Water Hydrostatic Bearings for Precision Machine Tools and Industrial Machinery", invited talk, ASPE Annual Mtg
30. April 14, 2008 "A Fantasy Vision of how as a Giant Bio Nano Team We All Zoom Forward to Infinity and Beyond," 2008 Bio-Nano Manufacturing Grand Challenges for 2020 Workshop, Arlington, VA
31. Oct 21, 2010 "Precision Machines for Renewable Energy Harvesting and Storage", First IFToMM Asian Conference on Mechanism and Machine Science, Taipei, Taiwan
32. March 13-14, 2013 "Kinematic and Elastically Averaged Joints: Connecting the Past, Present and Future", IUSPEN, Tokyo Japan
33. July 10-11, 2014 "Symbiotic Offshore Energy Harvesting and Storage Systems," Offshore Energy & Storage Symposium, invited talk, UWCAES Society, Windsor, Ontario, Canada
34. July 25, 2014 "Big hydrostatic bearings for ships and offshore wind machines", invited keynote speech, Japan Society for Precision Engineering annual meeting, Komatsu Japan.
35. Nov 2014, "Symbiotic Systems for The Future of Energy, Water, and Food", Atlantic Council Energy and Economic Summit, Istanbul
36. March 24, 2015, "The Future of Energy, Generation, Demand & Supply", PEWA, Johannesburg, South Africa
37. Oct. 29, 2015, "Symbiotic Systems for The Future of Energy, Water, and Food", Dartmouth College, Visionaries in Technology Distinguished Lecture
38. Feb 16, 2016, "Symbiotic Systems for The Future of Energy, Water, and Food", Weizmann Institute of Science
39. June 2, 2016, "A Bright Future for Energy & the World", Frankfurter Allgemeine Forum, Berlin Germany.
40. Volo Foundation/ ClimateCorrec4on, "Symbiotic Systems for The Future of Energy, Water, and Food", Oct 11, Orlando, FL.
41. Dec. 11.2018, "Vision Speech: A Bright Future for Energy & the World", Future Energies Science Match 4 December 2018, Kiel Germany

Theses Supervised by Alexander H. Slocum

	<u>Total</u>	<u>Completed</u>	<u>In Progress</u>
S.B.	127	127	0
S.M.	85	84	1
Engineers	1	1	0
Doctoral Supervisor:	59	57	2
Doctoral Reader (committee member):	44	44	0

S.B. Theses:

1. Robinson, Darryl K., "Design of a Prototype Fastening System for the Trackbot Automated Construction Robot," May 1986.
2. Kang, Jiin, "Design of a Track Positioning Mechanism for an Interior Wall Construction Robot," June 1986.
3. Paulson, Bruce A., "Design of a Materials Handling System to Automate Interior Wall Construction," June 1986.
4. Thackston, III, George W., "Design of an Automatically Guided Vehicle for Use in Automated Drywall Construction," June 1986.
5. Gladwin, S. C., "Design and Assembly of a Construction Robot Subsystem to Fasten Drywall to Studs," June 1986.
6. Shiller, Andrew, "Kinematic Analysis of A Precision Slide," June 1987.
7. Gregory, Arthur, "Vacuum Gripper Design for Automated Assembly," June 1987.
8. Wurman, Peter, "Anechoic Chamber Design and Acoustical Analysis of Room 1-051," June 1987.
9. Heatzig, Eric, "Scafbot-A Servo Controlled Scaffolding Device," June 1987.
10. Huang, Stanley, "Design and Implementation of a Software Controller for a Wall Building Robot," June 1987, (Electrical Engineering and Computer Science).
11. Barrientos, Miguel, "Tools for Developing Countries," June 1993.
12. Mateo, Evan, "Semiconductor Wafer Gripper," June 1994.
13. Phillips, Alton, "Electrostatic Air Cleaner," June 1994.
14. Breinlinger, Keith J., "A Handbook to show 2.007 Students How to Better Utilize the Materials in the 2.007 Kit," February 1996
15. Percer, Adrian C., "2.007 Briggs and Stratton Lawnmower Engine Exercise," June 1996
16. Estan, Basak, "Modeling Methods Using Computer Aided Design," June 1996.
17. Goldstein, Evan D., "The Design Process as Employed in the Introduction to Design Class at MIT," June 2006.
18. Hicks, Robert J., "A Proposal for the 2.007 Book: Instrument to Design," February 1997
19. Youngbear, Kathy, "Optimization of Cross-Sectional Configuration of an Extruded Plastic Truss," June 1997.
20. Richkus, Rebecca, "Performance Limiters in the Clamping Mechanism of Injection Molding Machine," June 1997.
21. Schmidt-Lang, Michael P., "The Design of a Simple Wind Tunnel Test Stand for Measuring Lift to Drag Ratio," June 1997.
22. Pellegrini, Brian J., "Guide to the Design Process through the MIT 2.70 Contest," June 1997.
23. Melvin, Jason W., "Design of a Kinematic Coupling for Machine Tool Fixturing," June 1997.
24. Lehman, David M., "The Design Process: MIT 2.70 Contest," June 1997.
25. Burn III, Robert D., "Simulator Chair Design: Ergonomics and Vibration," June 1997.
26. Shah, Raj, "Creation of a Website for the Purposes of Archiving Course-Related Material," June 1997.
27. Allen, Holly, "Multimedia as a Teaching Tool in 2.007," June 1998.
28. Miller, John, "Design of an Anti-Backlash Transmission for Position Control Applications," June 1998.
29. Butville, Michael, "Driveshaft Design for a Dynamometer Utilizing Rotary Motion Flexural Bearings," June, 1998.
30. Durant, Lawrence C., "Administration of the Urban Design Corp. and the Implementation of Design in Hip Hop Production," February 1999.
31. Prieto, Rodrigo, "2.007 Contest Design and Machine Design," June 1999.

32. Cooperman, Seth J., "The History, Mechanics, and Psychology of Magic," June 1999.
33. Cortesi, Roger S., "Designing a Mechanical Engineering Contest," June 1999.
34. Sprunt, Alexander D., "A Three Axis CNC Router Design," February 2000.
35. Davis, Wallace B., "Design and Cost Optimization of a Cast Concrete Constrained Layer Vibration Damper," September 2000.
36. Loisel, Phillip J., "Thermal Stability of Kinematically Coupled Microscope Stack Structure," June 2001.
37. Moon, Daniel K., "Flexure Based Mounts for Sensitive Payloads: A Management and Engineering Stack Study (Course 2B)," June 2001.
38. Harper, Christopher, "Redesign of Industrial Pin Joint Test Apparatus," June 2001.
39. Chouinard, Natalie, "Design Process of a 2.007 Design and Manufacturing Contest Table," June 2001.
40. Arguelles, David, "Design and Manufacture of a BattleBot," June 2001.
41. Sanchez, Manuel A., "Plantez Business Plan and Preliminary Research," June 2001.
42. Kisai, Darul "Mechanical Design of Chassis and Drivetrain for an Autonomous Mobile Robot," June 2001.
43. Montgomery, Sean J., "An Analysis of the Dynamics of the 2001 2.007 Contest Table with an Overview of its Application to Table Design Choice," June 2001.
44. Harper, Kelly, "Redesign of Industrial Pin Joint Test Apparatus," June 2001.
45. Shur, Maiya, "Design and Manufacturing of a Device Prototype for Performing Combined Ultrasound and X-Ray Mammography," June 2002.
46. Bernstein, Oren, "Wireless Touch Pads for Competitive Swimming," June 2002.
47. Bravard, Marjory A., "Design and Implementation of an Electrical System for a Combined Ultrasound and X-ray Mammography Breast Imaging Device," June 2002.
48. Ferguson, Kevin M., "Design and Fabrication of the Testing Apparatus for the Characterization of the Z-axis Flexure in the MIT-PERG/UIUC-LFD High-Precision Microscope Project," June 2002.
49. Praster, Stephanie M., "Prototype Development of Linear Actuator System to Enable Breast Ultrasound," September 2002.
50. Roberts, Michael H., "Approximation of Air Bearings as Linear Point Springs: Verification of an Analytical Model for a New Five-Axis Machine Tool," June 2002.
51. Bloomsburgh, John G., "Sealing and Heat Transfer Analysis of Gas Flow through Alumina Tubes in a Tube Furnace," June 2003.
52. Jacobs, Alex T., "Development of a Right-Angle Gearbox Design Module for Use in Undergraduate Mechanical Design Curriculum," June 2003.
53. Varady, Eric J., "Design and Manufacture of the 2003 2.007 Wireless Control Boxes," February 2004.
54. Browne, Courtney, "Design of a 2.007 machine with All-Terrain Suspension," June 2004.
55. Read, Melissa, "Designing a Better Hair Straightener," June 2004.
56. Kahn, Christopher, "Solution for Modular Die-Level Anodic Bonder," June 2004.
57. James, Richard, "Design of an Aluminum Differential Housing and Driveline Component for High Performance Application Abstract," June 2004.
58. Figueroa, Victor A., "Designing a Mechanism to Cleave Silicon Wafers," September 2004.
59. Mukaddam, Kabir, "Design of a Silicon Wafer Fracturing Instrument," February 2005.
60. Gomez III, Nicasio, "PCV Valve Flutter: Vibration Characterization through Pressure and Flow," June 2005.
61. Held, David, "Modeling and Control of a Silicon Substrate Heater for Carbon Nanotube Growth Experiments," June 2005.
62. Fonder, Gregory Paul, "The Back Stroke Buddy," June 2005.
63. Bonas, Calvin, "Re-Usability of Plastics," June 2005.
64. Jonnalagadda, Aparna S., "Passive Microfluidic Interconnects," June 2005.
65. Shu, Yuan, "Tabletop Robot to Aid in Arm Rehabilitation of Stroke Patients," June 2005.
66. Su, Benjamin W., "Wheelchair Exercise Roller Product Design," June 2005.
67. Johnson, Philip Tyler, "Development and Design of an Adjustable Elastic Support System for Ensuring Safety While Learning Physical Skills," June 2005.

68. Nelson, Alexandra T., "Press Fit Design: Force and Torque Testing of Steel Dowel Pins in Brass and Nylon Samples," June 2005.
69. Trangle, Etan S., "SmartBat: A Baseball Swing Analysis and Training Product," June 2005.
70. Smith, Benjamin D., "HandSkates: An Apparatus for physically Intelligent Exercise," June 2005.
71. McKenney, Kyle S., "The Design and Development of Aquatic Exercise Shoe Flags," June 2005.
72. Hatton, Ross L, "Plant Design for Deterministic Control of STEMs and Tape-Springs," June 2005.
73. Breinlinger, Joshua E., "Design and Construction of a Linear Induction Powered LEGO Roller Coaster," June 2006
74. Fuertes, Amilcar, "Read and Do with the Animaroos," June 2006.
75. Shull, Craig M., "Fundamentals of the 2.007 Design Process," June 2006.
76. Lin, Wey-Jiun, "Product Realization of the 2.007 Control Box," June 2006.
77. Yang, Tiffany, "The Wall-Mill: The Design of a Flexible Machine for the In-Situe Architectural Machining of Surfaces," June 2006.
78. Tsai, Helan, "Swimming Fins for Strengthening the Inner Quadriceps Muscle," June 2007.
79. Juan Herrera, "Wall Miller," June 2007.
80. Colton, Shane, "Energy harvesting power electronics," June 2008.
81. Bosworth, Will, "Adjustable Kinematic Coupling," June 2008.
82. Schroll, Gregory, "Gyroscope Actuated Spherical Robot," June 2008.
83. Treadway, Shane, "Climbing knot fixture," June 2008.
84. Harrington, Jeremy, "Steerable Catheter," June 2009.
85. Paxton, Adam, "Air Window over Salt Reciever," June 2009.
86. Gil Amrita, "Multi Loop Heat Exchanger for Molten Salts," June 2009.
87. Koniski , Cyril, "Precision 4-Bar linkages," June 2009.
88. Nikandrou, Paul, " Dynamic Valuation Model For Wind Development In Regard to Land Value, Proximity to Transmission Lines, and Capacity Factor," June 2009.
89. Houston, Emily, "Design of an Endoscope Lens Shielding Device for Use in Laparoscopic Procedures," June 2010.
90. Lampe, Evan M, "Design of an Endoscope Lens Shielding Device for Use in Laparoscopic Procedures," June 2010.
91. Schantz, Jarred L, "Design of an Endoscope Lens Shielding Device for Use in Laparoscopic Procedures," June 2010.
92. Adames, Adrian, "Design Considerations of a 15KW Heat Exchanger for the CSPonD Project"
93. Chen, Xuefeng, "Instrument Guide for MRI-guided Percutaneous Interventions," June 2010.
94. Ding, Hao, "Characterization of a Pre-curved Stylet Distal Tip Manipulation Mechanism for use in Volume Targeting," June 2010.
95. Esmail, Adnan M, "Cannabis Sativa: An Optimization Study for ROI," June 2010.
96. Powelson, Stephen K, "Developing a Low-Cost Ventilator," June 2010.
97. Rodriguez Alvarado, Juan F, "Validation of a Numerical Model for the Analysis of Thermal-Fluid Behavior in a Solar Concentrator Vessel," June 2010.
98. Racz, Rastislav , "Design of Bicycle Testing Rig," June 2010.
99. Adames, Adrian A., Design considerations of a 15kW heat exchanger for the CSPonD Project," June 2010.
100. Cervantes , Thomas Michael, "Analysis and Design of an Adjustable Bone Plate for Mandibular Fixation," June 2011.
101. Correll, Eric Owen, "Design of a rapid, continuous, small-scale device for creating dry powders from concentrated suspensions containing active pharmaceutical ingredients," June 2011.
102. O'Rourke, Conor Rakis, "Mechanical Development of the Mounting and Actuation System of a Parabolic Solar Trough," June 2011.
103. Westwood, Mitchell, "Creation and Validation of a Numerical Model for the Analysis of Bending Patterns of a Flexural Laparoscopic Grasper," June 2011.
104. Hawthorne, Stephan, "Device for the Mechanization of Corneal Transplants," June 2011.
105. Marten-Ellis Graves, Carmen, "Drive Train Improvements and Performance Evaluation of a Robotically Steered Needle," June 2011
106. Reyda, Caitlin J., "Design of a Pressure Sensing Laparoscopic Grasper," June 2011.
107. Rees, Jennifer A., "Modeling the Solar Thermal Receiver for the CSPonD Project," June 2011.

108. Dündar, Gökhan, "Design and manufacture study of Ocean Renewable Energy Storage (ORES) prototype," June 2012.
109. Erickson, Andrew T., "Design and optimization of actuation mechanisms for rapid skin closure device," June 2012.
110. Khalifa, Sammy Mohsen, "Mechanics of jammed media used as a structural element," June 2012.
111. Mason IV, Alexander M., "Design, measurement, and analysis of oxygenated fluid pump system," June 2012.
112. Peña, Kristen Helen, "Characterization of an oxygen suspension used for intravenous infusion," June 2012.
113. Piazzarolo, Bruno Aiala, "Design optimization of oxygenated fluid pump," June 2012.
114. Jarboe, Jason Neal, "A Method for Infrared Temperature Measurements of Thin Im Materials with a Low, Unknown and/or Variable emissivity at Low Temperatures," June 2013.
115. Popovic, Katarina, "Design and Analysis of Hydraulically Driven Actuation System for a Parabolic Solar Trough," June 2013.
116. Carrillo, Juan Felipe, "Mechanical Development of an Actuation System for a Parabolic Solar Trough Collector," June 2013.
117. Flowers, Susan Caroline, "Design of a Laparoscopic Simulation Device for Testing and Training," June 2014.
118. Abiose, Kabir, "Improving The Concentrated Solar Power Plant Through Connecting The Modular Parabolic Solar Trough", June 2016.
119. Cao, Cyndia, "Exploration of Configurations of Wave Energy Converters to Mechanically Drive a Seawater Uranium Harvester", June 2017
120. Delmy, Cédric, "Making Haiti "The Pearl of the Antilles" again: What Can Be Done?" June 2018
121. Brown, Austin, "Axially Compliant Grinding Spindle for Robotic Grinding", June 2018
122. Gray, Luke, "Cable Train: A Platform for In-Situ Manufacturing of Underground Cable", June 2018
123. Bratten, Richard, "Cost Analysis and Profitability of the Cable Train: A Mobile Platform for Manufacturing Underground Cable Systems", June 2018
124. Leathrum, Travis, "Modular Auger Design to Prevent Clogging in Suction", June 2019
125. Wettermark, Susan Daly, "Modeling Flow Characteristics of a Low Specific-Speed Centrifugal Pump with Different Volute Shapes", June 2019
126. Le, Serena, "Design of a Load-Lock System for the Lyophilization of Unit-Dose Pharmaceuticals in a Continuous Manufacturing Machine", June 2019
127. Flores, Ryan, "Design of Load-lock Door for Unit Dose Continuous Lyophilization Process for Complex Biologics", June 2019

S.M. Theses:

- 1) Hou, William M., "Conceptual Design of an Automated System for Emplacement and Retrieval of Nuclear Waste," January 1987.
- 2) Schena, Bruce, "Design Methodology for Large Work Volume Robotic Manipulators: Theory and Application," Sept. 1987.
- 3) Gedney, Richard, "Sensor and Control System Design for Automated Testing of Structural Materials," January 1988.
- 4) Damazo, Bradford, "Mechanical, Sensor, and Control System Design of an Accelerometer Calibrator with One Part Per Million Accuracy," January 1988.
- 5) Ousterhout, Karl, "Design of a Force and Position Servo Controlled Robotic Gripper with a 50:1 Grip Force to Weight Ratio," January 1988.
- 6) Levy, David, "Studbot: A Construction Robot for the Automated Assembly of Steel-Stud Partition Walls," Sept. 1987.
- 7) Ziegler, Andrew, "Studwelder: A Construction Robot for In-Situ Automated Welding of Shear Studs," June 1988.
- 8) Heatzig, Eric, "Modular digital servo controller," June 1989 (Civil Engineering).
- 9) Hochmuth, Catrsten, "Design and Construction of a machine tool axis prototype for evaluation of adaptive and learning control systems," January 18, 1990.

- 10) Carey, John, "Methodologies of Controller Design for Precision Linear Motion Systems," June 1992.
- 11) Gaub, Heinz, "Hydrostatic Linear Motion Bearings for Precision Machine Tools," June 1992.
- 12) Schmeichen, Philip, "Design of Precision Kinematic Systems," Jan. 1993.
- 13) Bhatthana, Firdaus, "Mapped Control Systems for Precision Machines," (Co-supervisor with Prof. Lang), June 1993.
- 14) Mintz, David, "Models for the development of precision machine tools", June 1993.
- 15) Smith, Michael, "Adaptive Control Systems for Precision Machines," (Co-supervisor with Prof. Annaswamy), June 1993.
- 16) Br  nner, Christoph, "Self Compensating Hydrostatic Bearings for Grinding Machine Tables," January 1994.
- 17) Chiu, Michael, "Design of a Precision High Speed Tool Servo," January 1994.
- 18) Wasson, Kevin, "High Speed Hydrostatic Spindle Design," 1994.
- 19) Doubleday, Roland, "A control system for a testhead manipulator," June 1995.
- 20) Vallance, Ryan, "Design and prototype fabrication of a manipulator for semiconductor test equipment," June 1996.
- 21) Culpepper, Martin, "Design of Debris Cleaner Using a Compound Auger and Vacuum Pick Up," January 1997.
- 22) Scrivens, Jevin, "A Wireless Robot for Semiconductor Manufacturing Equipment," June, 1997.
- 23) Houdek, Phillip, "Design and Implementation Issues for Stewart Platform Configuration Machine Tools," June 1997.
- 24) Alden, John, "Active Kinematic Coupling," June 1997.
- 25) Ellahi, Farooq, "An Integrated Decanter Centrifuge-Pitot Pump," June 1997.
- 26) Brienlinger, Keith, "Hexapod Home Flight Simulator," August 1998.
- 27) Balakrishnan, Asha, "Planarized Ball Grid Arrays," June 1999.
- 28) Schmidt-Lange, Michael, "A graduate level treatment of the design of a machine for the 1999 2.007 Contest," June 1999.
- 29) Rohatgi, Gaurav, "Damped Tool Holder - Approaches for Chatter Reduction in Deep Cavity and Intricate Surface Milling," June 1998.
- 30) Cortesi, Roger, "An Easy to Manufacture Non-Contact Precision Linear Motion System and Its Applications," August 2000.
- 31) Sprunt, Alex, "Electrical Contact tester," June 2002.
- 32) Robertson, Alec, "Precision Aerostatic Spherical Joint," June 2003.
- 33) Montgomery, Sean, "Electronics Curriculum for 2.007," June 2003.
- 34) Werkmeister, Jaime, "Mesomill," June 2004.
- 35) Thompson, Kate, "MEMS Fluid Coupling," June 2004.
- 36) Abu-Ibrahim, Fadi, "Low-cost precision waterjet," June 2004.
- 37) Vanderpoel, Timothy, "Design of a Snowboard Simulating Exercise Device," June 2005.
- 38) Figueredo, Stacy, "Monolithic Plastic Biopsy Device," June 2006.
- 39) Durand, Keith, "Design of an Energy Efficient and Economical Actuator for Automobile Windows," June 2007.
- 40) Jonnalagadda, Aparna, "Automotive Energy Harvesting," Jan. 2007.
- 41) Trimble, Zachary, "Rotating Energy Harvesting Device," June 2007.
- 42) Rothenhofer, Gerald, "Hydrocline linear motion axis," June 2007.
- 43) Zurovcik, Danielle, "Negative Pressure Wound Therapy Device," June 2007.
- 44) Kuhn, David, "Desktop systems for manufacturing carbon nanotube films by chemical vapor deposition," June 2007.
- 45) Edinger, Sarah, "Multi Motion Door," Jan. 2008.
- 46) Bassett, Erik, "Linear clutch for needle insertion," June 2008.
- 47) Rojas, Folkers, "CSPonD Heat Exchanger," January 2011.
- 48) Zimmerman, Julia, "Single-use Lancet and Capillary Loading Mechanism for Complete Blood Count Point of Care Device," January 2011.
- 49) Fennell, Gregory, "Offshore Renewable Energy Storage System," June 2011.
- 50) Bosworth, William, "Design and Parametric Simulation of Radially Oriented Electromagnetic Actuators," June 2011.
- 51) Begg, Nikolai, "Bistable Flexure-based Trocar," June 2011.

- 52) Wong, Anthony, "Water Hydrostatic Bearings for Ships," June 2012.
- 53) Bridgers, Daniel, "Ex-Vivo Brain Holding Fixture for MRI Studies," June 2012.
- 54) Rosario, Matthew, "Characterization of Cardiac Lead Perforation Risk via a Dynamic Simulated Environment," January 2012.
- 55) Meredith, James. "Design, Construction and Testing of an Ocean Renewable Energy Storage Scaled Prototype," January 2012.
- 56) Gorbaty, Emily, "Development of an efficient off-grid pumping system and evaporation reduction strategies to increase access to irrigation for smallholder farmers in India," June 2013.
- 57) Carrasquillo, Omar, "Design of inflatable solar concentrator," June 2013.
- 58) Hopkins, Brandon James, "Mechanical design of flow batteries" June 2013.
- 59) Kluger, Jocelyn Maxine, "Nonlinear beam-based vibration energy harvesters and load cells" June 2014.
- 60) Bayless, Jacob, "A High-Speed Hysteresis Motor Spindle for Machining Applications" February 2014.
- 61) Sondej, Nicholas, "Direct Tablet Formation by Electrospinning and Compaction" June 2014.
- 62) Taylor, David Donald James, "Reducing Booster-Pump-Induced Contaminant Intrusion in Indian Water Systems with a Self-Actuated, Back-Pressure Regulating Valve" June 2014.
- 63) Simon, Kevin, "Low Cost Water Pump", June 2015
- 64) Abbott, Jonathan E., "Bee Care Technology" Jan 2016.
- 65) Mills, Nathan, "Pan Tilt Mechanism", June 2016.
- 66) O' Brien, Megan, "Design of a Mobile Torrefaction Reactor for In-Situ Conversion of Agricultural Waste to Solid Biofuel", June 2016.
- 67) Labib, Shahd, "Pill Forming Apparatus", June 2017
- 68) Beautyman, Michael, "Load Bearing Interface Design for a Pan-Tilt Mechanism for Severe Marine Environments", June 2017
- 69) Finley, Thomas, "Slip Clutch Design for Position Sensitive Systems in Marine Environments" , June 2017
- 70) Hamlet, Amanda, "Uranium Extraction from Seawater: Investigating Hydrodynamic Behavior and Performance of Porous Shells ", June 2017
- 71) Krol, Przemyslaw Michal, "Productization and Instrumented Testing of a Corrosion Fatigue Test Device", June 2017
- 72) Cervantes, Thomas "Thumb Ligament Stiffness Measurement Instrument", January 2018
- 73) Johnson, Hilary, "Braille Writer", January 2018
- 74) Leibowitz , Dalia, "Design of a Large-Dose Minimally Invasive Drug Delivery Device for Tuberculosis", June 2018
- 75) Carrus, Justin, "Brick Press for Africa", June. 2018
- 76) Huynh, Daniel, "Next Generation Probabilistic Prediction Model for Submarine Propulsion Shaft Life", June 2018
- 77) Yue, Brian, "Design of a Construction Saw Kickback Evaluation Machine for the Comparison of Kickback Energies in Pipe Cutting Applications", June 2019
- 78) Duenner, Andrew, "A Framework for Error Budgeting in Engineering Design", June 2019
- 79) Peng, Val, "Design and System Integration of a Low-Cost Packing Method for Profitable Utilization of Water Hyacinth (*Eichhornia crassipes*)", June 2019
- 80) Canning, Julia, "Gesture Sensing with Flexural Ultrasonic Transducers", June 2019
- 81) Burcat, Steven, "Development of a Benchtop Chainsaw Kickback Measurement Device for Manufacturing", June 2019
- 82) Gray, Luke, "Open Ocean Sargassum Sequestration", June 2019
- 83) Southerland, Sarah, "Utilization of High Contaminant Recycled HDPE in Concrete Aggregate and Investigation into Additional Industrial Applications", January 2021
- 84) O'Connell, Ellen, Lyophilization system vial supports, 2021
- 85) Flores, Ryan, Lyophilization system load lock, work started June 2020

Engineer Degree

- 1) Werkmeister, Jaime, "Development of Silicon Insert Molded Plastic (SIMP)", June 2005.

Doctoral Theses, Supervisor:

- 1) Demsetz, Laura, "Methodology for Formulating Designs of Task Specific Automated Construction Machinery," Jan. 1989. (Civil Engineering).
- 2) Everett, John, "Construction Automation: Basic Task Selection and Development of the Cranium," June 1991. (Civil Engineering).
- 3) Marsh, Eric, "Design of Precision Coordinate Measuring Machines," June 1994.
- 4) Van Doren, Matthew, "Precision Machine Design Methodology for Design of Semiconductor Processing Equipment," June 1995.
- 5) Scagnetti, Paul, "Design of Precision Grinding Machines for Ceramics," January 1996.
- 6) Ho, Chris, "Concurrent Development of a Rotationally-Symmetric Barb Joint for Modular Storage Systems through Product Innovation Research," June 1997.
- 7) Levy, David, "Portable Product Miniaturization and the Ergonomic Threshold," August 1997.
- 8) Braunstein, Daniel, "Precision Printed Circuit Board Manufacturing," August 1997.
- 9) Chiu, Michael, "High Precision Semiconductor Equipment Test Design," January 1998.
- 10) Nayfeh, Samir, "Design and Application of Damped Machine Elements," June, 1998.
- 11) Pfahnl, Andreas, "Design of Precision Temperature Controlled Precision Machine Tools," June 1998.
- 12) Hale, Layton, "Principles and Techniques for Designing Precision Machines," January 1999
- 13) Hochmuth, Carsten, "Platform Concept for Precision Machining Centers," January 1999
- 14) Kiani, Sephir, "Multi-connection vias for printed circuit boards," January 1999.
- 15) Vallance, Ryan, "Precision Miniature Mechanism Manufacture," June 1999.
- 16) Muller, Luis, "Modular Semiconductor Test, Assembly & Packaging Manufacturing Equipment Design," June 1999.
- 17) Kane, Nathan, "Surface Self-Compensated Modular Linear Hydrostatic Bearings," June 1999.
- 18) Kotilainen, Markku Sami Antero, "Design and Manufacture of Modular Self-compensating Hydrostatic Journal Bearings," June 2000.
- 19) Culpepper, Martin, "Design and Application of Compliant Quasi-Kinematic Couplings," January 2000.
- 20) Bamburg, Eberhard, "Principles of Rapid Machine Design," June, 2000.
- 21) O'Sullivan, Donald, "Structural Elements with Mathematically Defined Surfaces for Enhanced Structural and Acoustic Performance," August 2001.
- 22) White, James, "The Nanogate: Nanoscale Flow Control," June 2003.
- 23) Qiu, Jin, "An Electrothermally-Actuated Bistable MEMS Relay for Power Applications," June, 2003.
- 24) Brienlinger, Keith, "Three Dimensional Routed Manifolds with Externally Inserted Cables," June, 2003.
- 25) Sihler, Joachim, "A Low Leakage 3-Way Silicon Microvalve," January 2004.
- 26) Awtar, Shorya, "Synthesis and Analysis of Parallel Kinematic XY Flexure Mechanisms," January 2004.
- 27) Li, Jian, "Electrostatic Zipping Actuators and Their Application to MEMS," January 2004.
- 28) Willoughby, Pat, "Elastically Averaged Precision Alignment," June 2005.
- 29) Sprunt, Alexander, "A Variable Capacitor Made from Single Crystal Silicon Fracture Surface Pairs," August 2005.
- 30) Yang, Xueen, "MEMS LC Tunable Filter," June 2005.
- 31) Graham, Marc, "Product Development by Deterministic Design," June 2006.
- 32) Hart, Anastassios John, "Continuous Growth Nanotubes," August 2006.
- 33) Thompson, Mary Kate, "A Multi-Scale Iterative Approach for Finite Element Modeling of Thermal Contact Resistance," August 2007.
- 34) Yaglioglu, Onnik, "Carbon Nanotube Based Electromechanical Probes," June 2007.
- 35) Ma, Hongshen, "Electrochemical Impedance Spectroscopy using adjustable nanometer-gas electrodes," June 2007.
- 36) Freeman, David, "Resonator PCV Valve," January 2008.
- 37) Weber, Alexis, "MEMS relays for make-break power switching applications: {111} silicon etched planar electrical contacts," June 2008.
- 38) Read, Melissa, "Design of a Standard Method and Instrumentation for the Measurement and Characterization of MEMS Fabricated Electrical Contacts," January 2009.

- 39) Walsh, Conor, "Image-guided robots for dot-matrix tumor ablation," June 2010.
- 40) Rothenhofer, Gerald, "Elements for the Design of Precision Machine Tools with High Required Loop Stiffness and their Application to a Prototype 450 mm Si-Wafer Grinder," August 2010.
- 41) Durand, Keith, "Hermetically sealed encasements for historic document display and preservation," January 2011.
- 42) Trimble, A. Zachary, "Energy harvesting of random wide-band vibrations with applications to an electro-magnetic rotational energy harvester," June 2011.
- 43) Figueredo, Stacy, "Parabolic Trough Solar Collectors: Design for Increasing Efficiency," June 2011.
- 44) Codd, Daniel Shawn, "Concentrated Solar Power on Demand," June 2011.
- 45) Hanumara, Nevan Clancy, "Design of Efficient Precision Medical Robotics," August 2012.
- 46) Zurovcik, Danielle, "Negative Pressure Wound Therapy," August 2012.
- 47) Heberley, Brian, "Advances in hybrid water-lubricated journal bearings for use in ocean vessels," June 2013.
- 48) Rojas, Folkers, "Continuous Feed of an Occluding Medium into an Uncontrolled Well," February 2014.
- 49) Padhye, Nikhil, "Film based pharmaceutical tablet manufacturing," August, 2015.
- 50) Begg, Nikolai D., "Increasing the Safety and Precision of Medical Tissue Puncture," June 2014.
- 51) Wortman, Tyler, "LesionAir: A low-cost tool for automated skin cancer diagnosis and mapping" June 2016
- 52) Jonart, Douglas, "Methods and Devices for Corrosion Fatigue Testing without Acceleration," June 2016
- 53) Haji, Maha, "Extraction of Uranium from Seawater: Design and Testing of a Symbiotic System". June 2017
- 54) Kluger, Jocelyn Maxine, "Synergistic Design of a Combined FloatingWind Turbine -Wave Energy Converter", June 2017
- 55) Taylor, David Donald James, "Tools for Managing Intermittent Water Supplies", June 2018
- 56) Melanie Tretault-Friend, "Thermal-Fluid Characterization And Performance Enhancement Of Direct Absorption Molten Salt Solar Receivers" June 2018 (co-advisor with Prof. E Baglietto in NSE)
- 57) Simon, Kevin, "Low cost water pumps", January 2019
- 58) Johnson, Hilary, "Design and analysis of adaptive hydraulic geometry for centrifugal pumps", work initiated January. 2018
- 59) Burcat, Steven, "Lyophilization machine", work initiated June 2020.

Doctoral Theses, Reader:

- 1) Bausch, John J. III, "Kinematic Methods for Automated Fixture Design," Jan. 1990.
- 2) Trumper, Dave, "Magnetic Suspension Techniques for Precision Motion Control," Sept. 1990 (Electrical Engineering and Computer Science).
- 3) Chai, Jangbom, "Non-Invasive Diagnostics of Motor-Operated Valves," June 1993.
- 4) Mosleh, Mohsen, "The Role of Wear Particles in Geometrically Constrained Frictional Systems in Dry Sliding," June 1994.
- 5) Walczyk, Daniel, "A Complete Sheet Metal Forming System Incorporating a New Quick Prototyping Method for Dies," January 1996.
- 6) Frey, Daniel, "Using Product Tolerances to Drive Manufacturing System Design," June 1997.
- 7) Williams, Mark, "Precision Six Degree of Freedom Magnetically-Levitated Photolithography Stage," October 1997.
- 8) Pfahnl, Andy, "Design of a Thermal Control System for an IC Test-In-Tray Handler," June 1998.
- 9) Ludwick, Stephen, "High-Speed Lens Cutting Machine," MIT, Mechanical Engineering, June, 1999.
- 10) Hidrovo, Carlos, "Development of a Fluorescence Based Optical Diagnostics Technique and Investigation of Particle Ingestion and Accumulation in the Contact Region of Rotating Shaft Seals," Mechanical Engineering, June 2001.
- 11) Liebman, Michael, "Five-Axis Grinding Machine for Centimeter-scale Parts," MIT, Mechanical Engineering, June 2002.
- 12) Sweetland, Mathew, "Precision Thermal Control System for Semiconductor Devices Under test," MIT, Mechanical Engineering, June 2002.

- 13) Meggiolaro, Marco, "Achieving Fine Absolute Positioning Accuracy in Large Powerful Manipulators," Mechanical Engineering, June 2002.
- 14) Sujan, Vivek, "Compensating for Model Uncertainty in the Control of Cooperative Field Robots," June, Mechanical Engineering, 2002.
- 15) Konkola, Paul, "Phase Interference Gratings," Mechanical Engineering, June, 2003.
- 16) Savran, Cagri, "A Robust Micromechanical Sensor for Label-free Biomolecular Detection in Real-time," Mechanical Engineering, Jan. 2004.
- 17) Griffith, Saul, "Self Assembling 3D structures," Mechanical Engineering, June 2004.
- 18) Turner, Kevin, "Wafer Bonding: Mechanics-Based Models and Experiments," Mechanical Engineering, June 2004.
- 19) Wilhelm, Eric, "Printed Electronics and Micro-Electromechanical Systems," Mechanical Engineering, June 2004.
- 20) Hai Ning, "Building E-Education Platforms for Design-Oriented Learning," Civil Engineering, June 2004.
- 21) Sparks, Andrew, "Scanning Probe Microscopy with Inherent Disturbance Suppression Using Micromechanical Devices," Mechanical Engineering, Sept. 2004.
- 22) Wilson, Andrew, "Wafer Bonding," June 2004.
- 23) Varanasi, Kripa "Damping mechanisms," June 2004.
- 24) Hashemi, Fardod, "Nanotweezers," June 2005.
- 25) Montesanti, Rick, "High speed tool servo," June 2006.
- 26) Balakrishnan, Asha, "Development of Novel Dynamic Indentation Techniques for Soft Tissue Applications," August 2007.
- 27) Winter, Amos, "Burrowing Robots," August 2010.
- 28) Yamamoto, Namiko, "CNT reinforced composites," June 2010.
- 29) Kesner, Samuel (Harvard), "Robotic Catheters for Beating Heart Surgery," January 2012.
- 30) Phan, Long, "Thermal imaging of buildings," May 2012.
- 31) Amin-Shahidi, Darya, "High Force Density Piezoelectric Reticle Assist Device," May 2013.
- 32) Gilbertson, Mathew, "Electromechanical Systems to Enhance the Usability and Diagnostic Capabilities of Ultrasound Imaging," May 2014.
- 33) Greenblatt, Elliot, "The Impact of Pathological Ventilation on Aerosol Deposition Imaging, Insight and Interventions," January 2015.
- 34) Weinstein, Lee, "Improving solar thermal receiver performance via spectral and directional selectivity", August, 2017
- 35) Xu, Ruzie, "Low-Frequency, Low-Amplitude MEMS Vibration Energy Harvesting", Oct .2017
- 36) Bousquet, Gabriel, "Optimal wind energy extraction at interfaces: from Dynamic Soaring to the amphibious Sailplane", Dec. 2017
- 37) Hopkins, Brandon, "Stopping Self-Discharge in Metal-Air Batteries", June 2018
- 38) Mannai, Sebastien, "A Novel Framework for Acoustic Diagnostic of Artificial Lift System for Oil-Production", June 2018
- 39) K.S. Kung, Design and Validation of a Decentralized Biomass Torrefaction System", June 2017.
- 40) Fan, Dixia "Mapping the Hydrodynamic Properties of Flexible and Rigid Bodies Undergoing Vortex-Induced Vibrations", June 2019
- 41) Zhou, Lei, "Magnetically Levitated Hysteresis Motor Driven Linear Stage for In-Vacuum Transportation Tasks", June 2019
- 42) Justin Beroz "Precision pipetting and crack-free colloidal assembly" June 2019
- 43) Guillermo F. Diaz Lankenau, "Tractor design for resource limited small farms", Dec. 2019
- 44) Max Carlson, "Design of Fouling-Resistant Coatings for Energy Systems: Theory and Proof of Principle at Realistic Conditions", June 2021

Postdoctoral Associates and Fellows supervised by Alexander H. Slocum

- 1) Hart, A.J., Carbon Nanotubes (2007). Current employer and title: Associate Professor of Mechanical Engineering, MIT.

- 2) Ma, Hongshen, "Electrochemical Impedance Spectroscopy using adjustable nanometer-gap electrodes," 2007. Current employer and title: Assistant Professor, University of British Columbia, Department of Mechanical Engineering, Multi-scale Design Laboratory, Vancouver, BC, Canada.
- 3) Hanumara, Nevan Clancy, "Efficient design of precision medical robots," 2012 MIT Postdoctoral Associate Appointment: August 2012 – August 2014. Current employer and title: MIT Dept. mech. Engineering, Research Scientist.
- 4) Gil, Antoni, "Concentrated Solar Power on Demand", MIT Postdoctoral Associate Appointment: September 2014-2017. Current employer and title: Unknown.