UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CLEARCORRECT OPERATING LLC,

Petitioner

v.

ALIGN TECHNOLOGY INC.,
Patent Owner.

IPR2025-00814
U.S. Patent No. 10,456,217

Declaration of Dr. Sumit Yadav
in Support of Petition for *Inter Partes* Review of U.S. Patent No. 10,456,217

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X. Claims 1-20 of the ’217 Patent Are Unpatentable 56

A. Chishti-511, Chishti-876, Sachdeva, and Becker Render Obvious Claims 1-20 57

1. Independent Claim 1 57

a. [1(pre)] A method comprising: 57

b. [1(a)] selecting a movement pattern from a plurality of movement patterns for moving dental objects from an initial arrangement toward a final arrangement, the dental objects being based on output of a scanning device, the movement pattern defining a schedule of movement of the dental objects during treatment stages as each of the dental objects moves from a respective initial position toward a respective final position; 57

c. [1(b)] calculating, by a computer processor, a respective treatment path for each of the dental objects between its respective initial and final positions; 64

d. [1(c)] identifying, by a computer processor, a collision between a first of the dental objects and a second of the dental objects based at least on one of the respective treatment paths; and 65

e. [1(d)] performing, by a computer processor, a first modification of the schedule of movement in response to the identifying, the first modification comprising: 68

f. [1(e)] round-tripping the first dental object. 74

2. Dependent Claim 2: The method of claim 1, wherein the movement pattern is selected by a user. 79

3. Dependent Claim 3: The method of claim 1, wherein the selecting comprises analyzing, by a computer processor, the dental objects in their respective initial and final positions. 80

4. Dependent Claim 4: The method of claim 3, wherein the analyzing comprises determining, by a computer processor, a respective distance needed to move each of the dental objects from its respective initial position to its respective final position. 83

5. Dependent Claim 5.....86

a. [5(a)] The method of claim 1, further comprising: determining, by a computer processor, that the first modification does not avoid a collision between the first and second dental objects; and.....86

b. [5(b)] performing, by a computer processor after the determining, a second modification of the schedule of movement, the second modification comprising slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages in which the first dental object moved. 91

6. Dependent Claim 6.....98

a. [6(a)] The method of claim 5, further comprising: determining, by a computer processor, that the second modification does not avoid a collision between the first and second dental objects; and 98

b. [6(b)] performing, by a computer processor after determining that the second modification does not avoid a collision, a third modification of the schedule of movement, the third modification comprising round-tripping the first dental object.....99

7. Dependent Claim 7.....101

a. [7(a)] The method of claim 1, further comprising: determining, by a computer processor, that the first modification does not avoid a collision between the first and second dental objects; and.....101

b. [7(b)] performing, by a computer processor after the determining, a second modification of the schedule of movement, the second modification comprising round-tripping the first dental object. 101

8. Dependent Claim 8: The method of claim 1, further comprising producing a series of orthodontic appliances based at least on the modified schedule of movement, wherein each of the orthodontic appliances corresponds to a respective one of the treatment stages. 102

9. Dependent Claim 9.....105

a. [9(a)] The method of claim 8, wherein the producing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and 105

b. [9(b)] thermoforming a respective one of the orthodontic appliances over each of the respective positive molds. 106

10. Dependent Claim 10 109

a. [10(a)] The method of claim 1, further comprising: performing, by a computer processor, a second modification of the schedule of movement in response to the identifying, the second modification comprising one or more of: 109

b. [10(b)] delaying initial movement of the first dental object; and 110

c. [10(c)] slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages during which the first dental object moved. 112

11. Independent Claim 11 113

a. [11(pre)] A non-transitory computer-readable medium comprising instructions that, when

executed by one or more computer processors,
cause at least one of the one or more processors to: 113

12. Dependent Claims 12-20.....116

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I. Introduction

1. I, Dr. Sumit Yadav, submit this declaration to state my opinions on the matters described below.

2. I have been retained on behalf of Petitioner ClearCorrect Operating LLC as an independent expert for the above-identified *inter partes* review proceeding involving U.S. Patent No. 10,456,217 (the "'217 patent") (Ex-1001). Although I am being compensated for my time in connection with this IPR at my standard hourly consulting rate of $500 per hour, and reimbursed for reasonable out-of-pocket expenses, no part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my technical review, analysis, insights, and opinions regarding the '217 patent, the prior art references that form the basis for the invalidity ground set forth in the Petition for *Inter Partes* Review of the '217 patent, and any other prior art publications cited in this declaration.

II. Qualifications

4. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational and work experience summarized below. My *curriculum vitae* records my education, experience, and publications in greater detail. Ex. 1029.

5. I received a Bachelor of Dental Surgery in 2002, and a Master of Dental Surgery in Orthodontics in 2006, both from India. I received a Ph.D. in Oral Biology from Indiana University – Purdue University, Indianapolis in 2010, and a Clinical Certificate in Orthodontics from University of Connecticut ("UCONN") Health Center in 2013. I am also a Diplomat of the American Board of Orthodontics. In addition, I received my MBA from Northwestern University, Kellogg School of Management, in 2022. My qualifications and experience are also described in my *curriculum vitae* (Ex-1029).

6. I have authored or co-authored more than 140 articles in peer-reviewed journals. These publications span a range of topics, including: clear aligner treatment, orthodontic tooth movement, bone remodeling and modeling, orthodontic anchorage, mini-implant and bone integration, mechanical vibration and orthodontic tooth movement, mechanical vibration and root resorption, mechanical vibration and orthodontic retention, canine impaction, aligner orthodontics, and loading and unloading of the mandibular condylar cartilage of the temporomandibular joint (TMJ). I currently serve on the Editorial Board of Angle Orthodontist, and I am a reviewer for the American Journal of Orthodontics and Dentofacial Orthopedics, The Angle Orthodontist, the European Journal of Orthodontics, PLoS One, Progress in Orthodontics, the Journal of Dental Research, the Journal of Molecular Histology, Tissue Engineering, and the Journal of Applied Oral Science.

7. I have over 22 years of experience as a clinician and 17 years of experience as a research scientist. I am a Professor and Chairman at UNMC College of Dentistry. Since 2012, my research has been funded either through foundation grants (American Association of Orthodontic Foundation and National Institute of Health).

8. I have extensive expertise in orthodontic tooth movement both as a clinician and as a research scientist. I utilize basic biomechanics principles to maximize orthodontic tooth movement with minimal adverse effects in patients. Furthermore, I have worked extensively on optimizing orthodontic tooth movement with Clear Aligner Therapy (CAT) in patients. My research on clear aligners is focused on both the adolescent and adult patients. My research has focused on clear aligners and orthodontic tooth movement (M. Chaluparambil, S. Abu Arqub, C.-L. Kuo, L. Da Cunha Godoy, M. Upadhyay, S. Yadav, *Age-stratified assessment of orthodontic tooth movement outcomes with clear aligners*, Progress in Orthodontics 25:43 (Nov. 2024), https://doi.org/10.1186/s40510-024-00542-2). In this research, we compared the predicted versus achieved tooth movement between adults and adolescent patients. Our data has shown significant differences between adult and teenagers with CAT. Mandibular central and lateral incisors showed significantly greater over-correction in adults in the horizontal plane. The accuracy of rotations and vertical movements was comparable.

9. I also worked on comparing different aligner systems and their differential effect on orthodontic tooth movement. In this study, we compared treatment efficacy for specific tooth movement between two different clear aligner systems (M.T. Harandi, S. Abu Arqub, E. Warren, C.-L. Kuo, L. Da Cunha Godoy, S. Mehta, J. Feldman, M. Upadhyay, S. Yadav, *Assessment of clear aligner accuracy of 2 clear aligners systems*, American Journal of Orthodontics and Dentofacial Orthopedics, Vol. 164, No. 6, pp. 793-804 (Dec. 2023)). The achieved tooth movement was significantly different than predicted for both aligner systems. We concluded that the efficacy of clear aligner therapy systems in treating mild and moderate malocclusions was comparable. Deviation of the achieved movements from the predicted was greatest for rotational and vertical movements.

10. I have also worked on peripheral nerve regeneration using novel ionically conducting polymers. Nerve defects, particularly those larger than several millimeters, require use of allografts, autografts, or synthetic grafts for nerve regeneration. Allografts/autografts have the limitations of availability, morbidity, and disease transmission. Furthermore, current graft biomaterials are limited in part by slow deterioration of conductivity. We are working on developing a novel ionically conducting polymer that will be electronically stable and will stimulate nerve progenitor cells to heal the nerve defects. Our research has been funded by a UCONN convergence grant to the amount of $50,000.

11. The objective of my National Institute of Health-funded projects is to understand TMJ degeneration and regeneration and to accelerate orthodontic tooth movement. The long-term goal of the applicant (PI) is to understand the mechanism regulating the growth and differentiation of mandibular condylar cartilage (MCC). Temporomandibular joint disorders (TMDs) affect over 15 million Americans, and it is estimated that the United States spends billions of dollars each year on TMDs. Bone Morphogenic Proteins (BMPs) signaling is crucial for the development and postnatal maintenance of MCC, while overexpression of BMP signaling has been associated with degenerative disorders of the cartilage. Despite a wealth of literature on BMPs signaling in articular cartilage of the knee, little is known about BMPs role in postnatal growth, adaptive remodeling, and pathogenesis of MCC. In our MCC loading model, we found increased cartilage thickness, increased matrix synthesis and mineralization, as well as increased hypertrophic differentiation of chondrocytes. Moreover, conditional deletion of BMP2 in MCC showed decreased synthesis and mineralization of extracellular matrix and decreased hypertrophic differentiation of chondrocytes. These data suggest that BMP2 regulates MCC growth and differentiation. However, the mechanisms underlying the regulatory effects of BMP2 in the matrix synthesis and hypertrophic differentiation of chondrocytes in MCC remain unknown. Our global hypothesis is that BMP2 is required for postnatal growth and adaptive remodeling of the MCC. Our

understanding is that BMP2 is the master regulator of extracellular matrix synthesis, matrix mineralization, and hypertrophic differentiation of chondrocytes.

III. Materials Considered

12. In forming my opinions, I have reviewed the following documents and any other documents cited in this declaration:

Exhibit No.	Description
Ex-1001	U.S. Patent No. 10,456,217 to Kitching et al. ("'217 patent")
Ex-1002	Prosecution History of U.S. Patent No. 10,456,217
Ex-1004	U.S. Patent No. 6,471,511 to Chishti et al. ("Chishti-511")
Ex-1005	U.S. Patent No. 6,729,876 to Chishti et al. ("Chishti-876")
Ex-1006	Adrian Becker, *The Orthodontic Treatment of Impacted Teeth* (Martin Dunitz Ltd. 1998) ("Becker")
Ex-1007	U.S. Patent No. 6,250,918 to Sachdeva et al. ("Sachdeva")
Ex-1008	*ClearCorrect Operating LLC v. Align, Inc.*, IPR2017-01829, Decision Denying Institution, Paper 10 (PTAB Feb. 5, 2018)
Ex-1009	Speaker Profile of Rohit Sachdeva, retrieved from: https://www.emedevents.com/speaker-profile/rohit-sachdeva
Ex-1010	LinkedIn Profile of Ruedger Rubbert, retrieved from: https://www.linkedin.com/in/ruedger-rubbert-6136b119
Ex-1011	LinkedIn Profile of Ian Kitching, retrieved from: https://www.linkedin.com/in/ian-kitching-3961333
Ex-1012	LinkedIn Profile of Alexander Dmitriev, retrieved from: https://www.linkedin.com/in/alexander-dmitriev-5145991

Exhibit No.	Description
Ex-1013	*Align Technology, Inc. v. ClearCorrect Operating, LLC, et al.*, Case No. 6:24-cv-00187-ADA-DTG, Dkt. 142, Joint Claim Construction Statement (W.D. Tex. Jan. 3, 2025)
Ex-1014	Harold D. Kesling, *The Diagnostic Setup with Consideration of the Third Dimension*, Am. J. Orthodontics, Vol. 42, No. 10, pp. 740-48 (Oct. 1956)
Ex-1015	H.D. Kesling, *Coordinating the Predetermined Pattern and Tooth Positioner with Conventional Treatment*, presented at the meeting of the Southern Society of Orthodontists, pp. 285-93 (Jan. 28-29, 1946)
Ex-1016	Orhan C. Tuncay (ed.), *The Invisalign System* (Quintessence Publishing Co., Ltd. 2006)
Ex-1017	Declaration of Dr. Paul C. Clark
Ex-1018	U.S. Patent No. 6,702,575 to Hilliard
Ex-1019	U.S. Patent No. 6,309,215 to Phan et al.
Ex-1020	Declaration of Kelley M. Hayes Greenhill Regarding Ex-1006
Ex-1021	Declaration of Kelley M. Hayes Greenhill Regarding Ex-1016
Ex-1022	Stanley A. Alexander, *Levels of root resorption associated with continuous arch and sectional arch mechanics*, Am. J. Orthodontics and Dentofacial Orthopedics, Vol. 110, No. 3, pp. 321-24 (Sept. 1996)
Ex-1023	DeAngelis, Vincent, *The Amalgamated Technique, a Mechanically and Biologically Efficient Method for Controlled Tooth Movement* (1980)
Ex-1024	Hyo-Sang Park et al., *Group Distal Movement of Teeth Using Microscrew Implant Anchorage*, Angle Orthodontist, Vol. 75, No. 4, pp. 602-09 (2005)

Exhibit No.	Description
Ex-1028	*ClearCorrect Operating, LLC v. Align Technology, Inc.*, IPR2017-01829, Petition for *Inter Partes* Review of U.S. Patent No. 8,038,444, Paper 1 (PTAB July 20, 2017)

IV. Relevant Legal Standards

13. In preparing this declaration and forming my opinions, I am relying on certain legal principles that counsel explained to me. My understanding of these concepts is summarized below.

14. I have been asked to provide my opinions regarding whether claims 1-20 ("the Challenged Claims") of the '217 patent would have been obvious to a person having ordinary skill in the art at the time of the alleged invention, in light of the prior art. I have been advised and understand that prior art includes all analogous art, and that two separate tests define the scope of analogous prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed; and (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved. It is my opinion that the Challenged Claims would have been obvious to a person having ordinary skill in the art at the time of the alleged invention.

15. In forming my opinions expressed below, in addition to my knowledge and experience based upon my work in the fields of computer architecture design, including fault-tolerant computer architecture design, I have considered the documents listed in the Table in Section III above.

16. I have been advised and understand that a dependent claim is a patent claim that refers back to another patent claim. I have been informed and understand that a dependent claim includes all of the limitations of the claim to which it refers.

A. Validity

17. I have been advised and understand that there are two ways in which prior art may render a patent claim unpatentable. First, the prior art can "anticipate" the claim. Second, the prior art can make the claim "obvious" to a person of ordinary skill in the art. I understand that for an invention claimed in a patent to be patentable, it must not be anticipated and must not be obvious based on what was known before the invention was made.

18. I have been advised and understand that a patent claim is unpatentable as anticipated under 35 U.S.C. § 102 if each element of that claim is present either explicitly or inherently in a single prior art reference. I have also been advised and understand that, to be an inherent disclosure, the prior art reference must necessarily disclose the limitation. The fact that the reference might practice or contain a claimed

limitation is insufficient to establish that the reference inherently teaches the limitation.

19. I have been advised and understand that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. I have also been advised and understand that the obviousness analysis takes into account factual inquiries, including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

20. I have further been advised and understand that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include the following: (a) combining prior art elements according to known methods to yield predictable results; (b) simple substitution of one known element for another to obtain predictable results; (c) use of a known technique to improve a similar device (method, or product) in the same way; (d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (e) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and (f) some teaching, suggestion, or motivation

in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

21. When considering the issue of obviousness, I have been advised and understand that I should consider (1) the scope and content of the prior art; (2) the differences between the prior art and the claims at issue; (3) the level of ordinary skill in the art; and (4) evidence of secondary indicia of nonobviousness. I have been informed that secondary indicia of nonobviousness include (i) "long-felt need" for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) "copying" of the claimed invention by others.

22. I have further been advised and understand that in connection with identifying a reason or motivation that would have led a person of ordinary skill in the art (POSITA) to combine or modify the relevant teachings in the prior art to obtain the claimed invention, a POSITA must have had a reasonable expectation of success in doing so. The reason to select and combine features, the predictability of the results of doing so, and a reasonable expectation of success may be found in the teachings of the prior art references themselves, in the nature of any need or problem in the field that was addressed by the patent, in the knowledge of a POSITA at the time, as well as in common sense or the level of creativity exhibited by a POSITA.

B. Level of Ordinary Skill

23. In rendering the opinions set forth in this declaration, I have been asked to consider the ’217 patent’s claims and the prior art through the eyes of a person of ordinary skill in the art. I understand that a person of ordinary skill in the art is determined by considering (1) the type of problems encountered in the art, (2) prior art solutions to those problems, (3) the rapidity with which innovations are made, (4) the sophistication of the technology, and (5) the educational level and years of experience level of those working in the pertinent field.

24. I understand that I must evaluate the ’217 patent from the perspective of a person of ordinary skill in the art. That is, the ’217 patent must be evaluated through the eyes of a person of ordinary skill in the art at the time of the alleged invention of this patent as of its earliest priority date—August 30, 2006. It is my opinion that such a person of ordinary skill in the art as related to the ’217 patent would have been part of an interdisciplinary team. This team would have included members with an advanced degree related to dentistry (e.g., BDS, MDS, DDS, DMD) with experience in orthodontics, including 1-3 years of orthodontic training or equivalent experience, and experience using clear aligners. The team may have also included members with a degree in a technical area related to software, graphics, computers, or a related discipline. Ex-1017, ¶ 24. This technical team member would have had 1-3 years of experience in software development. Ex-1017, ¶ 24. For all

team members, more education could substitute for experience and vice versa. Ex-1017, ¶ 24.

25. Based on my educational background and experience, such as my experience with orthodontics (*see* paragraphs 4-11), I am qualified as at least a person of ordinary skill in the art with respect to the ’217 patent. In particular, by August 30, 2006, I had my Bachelor’s in Dental Sciences and Master’s in Dental Sciences in Orthodontics. I had been treating orthodontic patients since October 2003 and had 2-3 years of experience using clear aligners by 2006. To the extent that it is argued that a Doctorate related to dentistry is required to qualify as a POSITA, I also received a Ph.D. in Oral Biology from Indiana University – Purdue University, Indianapolis in 2010. I am also familiar with the knowledge that such a degree holder would have had in 2006, through my further familiarity with research and literature in the field.

26. Thus, I am familiar with the knowledge of the person of ordinary skill in the art at the time of the alleged invention. I am able to opine on how a person of ordinary skill in the art would have understood the disclosure and claims of the ’217 patent, the disclosures of the prior art, the motivation to combine the prior art, and what combinations would have been obvious and not have been obvious to one of ordinary skill in the art.

27. I understand that ClearCorrect previously filed a petition for *inter partes* review against U.S. Patent No. 8,038,444 (the "'444 patent"), which is related to the '217 patent (IPR2017-01829), where ClearCorrect proposed that a person having a doctorate in dental science and three to five years of training and practical experience in orthodontics would qualify as a person having ordinary skill in the art. Ex-1028, 13. While I believe such a person would qualify as having at least ordinary skill in the art, it is not my experience that this particular education and experience would be requirements. In my experience, a doctorate in dental science is generally attained by a lower percentage of dentists, and so would be typical of a person with a greater than ordinary skill in the art. In 2006, there were many trained professionals with experience in orthodontics and treatment planning that did not have a doctorate in dental science.

28. For example, it appears that at least two inventors of the '217 patent (Ian Kitching and Alexander Dmitriev) have backgrounds in computer science, but no dental degree. *See* Ex-1011; Ex-1012. Similarly, Sachdeva—a highly relevant prior art reference not previously considered by the Office—includes two inventors: Rohit Sachdeva and Rudger Rubbert. Ex-1007. They exemplify the interdisciplinary team discussed above because Rohit Sachdeva is an orthodontist (*see* Ex-1009), and Rudger Rubbert is an engineer with a background in mechanical engineering (*see* Ex-1010).

C. Claim Construction

29. I have been informed that in an *inter partes* review proceeding, claim terms should be construed under the same standard applied in federal district court cases. Under this standard, I have been informed that claim terms are generally given their ordinary and customary meaning as understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claim terms are generally not limited by the embodiments described in the specification.

30. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I understand that the specification is highly relevant to the claim construction analysis and can be the single best guide to the meaning of a disputed term. I have been informed that the specification acts as a dictionary when it expressly defines terms used in the claims or when it defines terms by implication. I have been informed that this additional evidence is often less significant and less reliable than the claims, specification, and prosecution history.

31. I have been informed that claims should only be construed to the extent necessary to resolve any controversy. For all claim terms, I have considered and applied their plain and ordinary meaning as they would have been understood by one

skilled in the art at the time of the alleged invention and consistent with the specification.

32. I have also been informed that in the parallel district court proceeding, the parties agreed to the meanings below for the following terms:

Claim Term	Construction
round[-]tripping / round-trip '217 patent, cls. 1, 6, 7, 11, 16, 17	[moving / move] a first tooth out of the path of a second tooth, and once the second tooth has moved sufficiently, [moving / move] the first tooth back to its previous position before proceeding to a desired final position of that first tooth
slowing / slow '217 patent, cls. 5, 10, 15, 20	[having / have] one or more teeth scheduled to move at a rate less than the rate of other teeth, or even [stopping / stop] using interim key frames, so that collisions and/or obstructions do not occur

Ex-1013, 8.

33. These constructions mirror Applicant's definitions of "round[-]tripping" and "slowing" recited in the '217 patent's specification and are applied in the grounds presented herein. *See* Ex-1001, 13:3-11.

34. I note that, generally in orthodontics and treatment planning, the term "round-tripping" is a category of tooth movement that can have different implementations. At its highest level, round-tripping is sometimes used to refer to any movement where a tooth moves in a direction other than toward its desired position. Depending on the status of the patient, different implementations of round-

tripping can be used to treat the patient. I have applied the ’217 patent’s definition of round-tripping as reflected in the parties’ agreed construction throughout my analysis.

V. The ’217 Patent

A. Overview of the ’217 Patent

35. The ’217 patent claims priority to August 30, 2006. Ex-1001, p. 2, (60).

36. The ’217 patent describes computerized systems and methods for staging the movement of teeth during an orthodontic treatment. Ex-1001, Title, Abstract, 2:10-12, 8:28-35. The ’217 patent uses a computing device to schedule the movement of teeth from an initial position to a final position, according to various movement patterns and orthodontic techniques. Ex-1001, 2:10-22, 6:15-28, Figs. 2B, 3-9.

37. The system receives a scan of the patient’s teeth in an initial state. Ex-1001, 5:25-29, 2:45-53. Based on this scan, the computer generates a digital model of the patient’s teeth. Ex-1001, 5:45-53. A digital model of the patient’s teeth at a final position is then defined. Ex-1001, 3:54-60, 5:30-32. Using the final position of the patient’s teeth, the computer determines a path of movement for each of the patient’s teeth from initial position to final. Ex-1001, 3:54-4:3, 5:32-41.

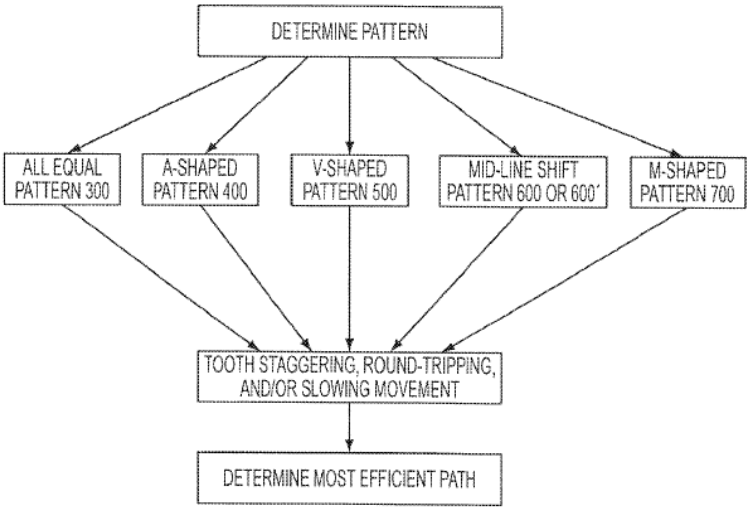


FIG. 2B

Ex-1001, Fig. 2B.

38. As shown above, one of various teeth movement patterns is selected to be used by the system. Ex-1001, 5:42-45, 5:55-6:3, 6:61-7:3, 7:63-8:7, 9:31-42, 10:41-50, 11:63-12:3, Figs. 3-9. For example, Figures 5 and 6B, below, are diagrams depicting the timing of the movement of teeth in a V-shaped and mid-line shift pattern, respectively. The ’217 patent admits that selecting an orthodontic treatment pattern was disclosed in Chishti-876. Ex-1001, 6:8-14.

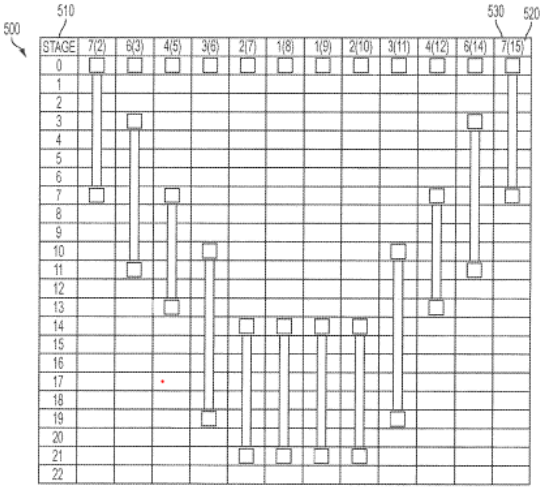


FIG. 5

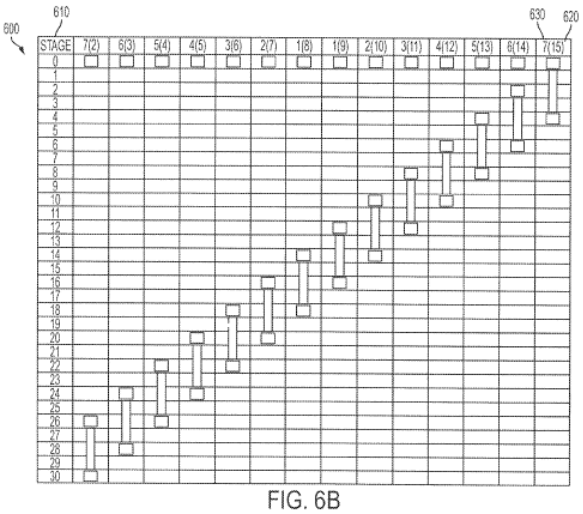


FIG. 6B

V-Shaped Pattern Mid-Line Shift Pattern

39. After selecting the movement pattern, the system determines whether the specified teeth movement would result in collisions between teeth. Ex-1001, 6:41-45. If a collision is detected, the system may modify the treatment plan to include well-known techniques for avoiding collision of the teeth, such as"[s]taggering," "[r]ound-tripping," or "[s]lowing down." Ex-1001, 12:66-13:11. The '217 patent admits that Chishti-876 discloses techniques for automated computer program determination of whether a collision is likely. Ex-1001, 6:45-52.

40. The system then determines whether the specified teeth movement would result in collisions between teeth. Ex-1001, 6:41-45. The '217 patent admits that collision detection was known in Chishti-876. Ex-1001, 6:45-52. If a collision is detected, the system automatically modifies the treatment plan by incorporating

well-known techniques for avoiding collision of the teeth, such as "[s]taggering," "[s]lowing down," and "[r]ound-tripping." Ex-1001, 12:66-13:11. "Round-tripping" is defined as "the technique of moving a first tooth out of the path of a second tooth, and once the second tooth has moved sufficiently, moving the first tooth back to its previous position before proceeding to a desired final position of that first tooth." Ex-1001, 12:51-55, 13:7-11. "Staggering" is defined as "delaying one or more teeth from moving one or more stages where it would otherwise move in order to prevent another tooth from colliding with and/or obstructing the path of the delayed tooth." Ex-1001, 12:66-13:3. "Slowing down" is defined as "having one or more teeth scheduled to move at a rate less than the rate of other teeth, or even stopping using interim key frames, so that collisions and/or obstructions do not occur." Ex-1001, 13:3-7. The '217 patent states that staggering, slowing down, and/or round-tripping can be applied "alone or in combination, and in any order." Ex. 1001, 13:11-13. But in the only exemplary embodiment incorporating all three techniques, the '217 patent describes using staggering first, followed by "slowing-down," and only then using "round-tripping ***as a last resort***." Ex-1001, 13:11-17 (emphasis added).

41. While the '217 patent describes a specific manner of round-tripping (i.e., movement of one tooth out of the path of a second tooth and then back to its previous position before proceeding to a desired final position) (Ex-1001, 12:51-55), its brief description does not purport to have invented this form (or any form of)

round-tripping. Nor does the ’217 patent identify any benefits (known or unknown) from this form (or any form) of round-tripping. Instead, as noted above, round-tripping is described in the ’217 patent as “a last resort,” which indicates that despite the risks associated with it, round-tripping may be a clinically necessary and acceptable technique in some circumstances. Ex-1001, 12:61-62.

B. Prosecution History

42. U.S. Application No. 15/834,608 (the “’608 application”) issued as the ’217 patent. I understand that during prosecution, the Office initially rejected all claims as anticipated and/or obvious over two publications to Chishti—Chishti-511 and U.S. Patent Publication No. 2004/0137400 to Chishti et al. (Chishti-400)—and one to Phan (U.S. Patent No. 6,309,215). Ex-1002, 129-43. In response to the prior-art rejections, Applicant submitted an IDS listing the Board’s decision denying institution of IPR2017-01829 (the “’444 IPR”) challenging U.S. Patent No. 8,038,444 (the “’444 patent”), a parent of the ’608 application, where Chishti-511 and Chishti-876 were relied on, and argued that the pending claims were allowable under the Board’s interpretation in the ’444 IPR. *See* Ex-1002, 207-27.

43. I understand that while the Office largely maintained its rejections based on the Chishti references, it allowed certain claims reciting “round-tripping,” explaining that the allowability of the claims was “limited to the definition of [round-tripping] found [in] the specification”—i.e., “the technique of moving a first tooth

out of the path of a second tooth, and once the second tooth has moved sufficiently, moving the first tooth back to its previous position before proceeding to a desired final position of that first tooth." Ex-1002, 246. The claims were eventually allowed after the Applicant authorized an Examiner's amendment that positively recited round-tripping in the independent claims. Ex-1002, 302-08.

C. Procedural History

44. I understand that the '217 patent is a member of a family (the "Treatment Planning Patents") stemming from two provisional patent applications filed by Align on August 30, 2006. Align filed the first of the Treatment Planning Patents, the "'444 patent, in 2007. Following allowance of the '444 patent, Align filed follow-on applications, including the parent application of the '217 patent, U.S. Patent No. 10,420,631 (the "'631 patent"). While the '631 patent application was pending, ClearCorrect filed IPR2017-01829, challenging the patentability of the '444 patent claims in view of Chishti-876 alone and in combination with Chishti-511. The Board declined to institute *inter partes* review based on, among other things, the definition of "round-tripping" appearing in the specification of the '444 patent, which it determined was not explicitly disclosed in the Chishti references. *See generally* Ex-1008.

45. Relying on the Board's denial of institution in the '444 IPR during prosecution of the '217 patent, Align amended the claims to recite "round-tripping,"

and the Office issued a Notice of Allowance. Ex-1002, 207-27, 302-08. The Office never considered the Becker reference, which discloses the specific type of "round-tripping" defined in the common Treatment Planning Patent specifications.

VI. Overview of the Prior Art

A. Chishti-511 (Ex-1004)

46. I understand that Chishti-511 is a U.S. patent that issued on October 29, 2002, more than one year before the earliest priority date of the '217 patent. Thus, I understand that Chishti-511 qualifies as prior art to the '217 patent under at least 35 U.S.C. § 102(b).

47. Chishti-511 is titled "Defining Tooth-Moving Appliances Computationally" and discloses methods and systems for segmenting an orthodontic treatment plan into a sequence of steps for repositioning a patient's teeth from an initial position to a final position. Ex-1004, Title, Abstract. The process involves generating a digital model of the patient's teeth and analyzing the model to define a series of treatment steps to be used with aligners, where the steps incrementally move the teeth from an initial position towards a final position. Ex-1004, Fig. 1, 3:32-5:6. A high-level outline of this process is shown below:

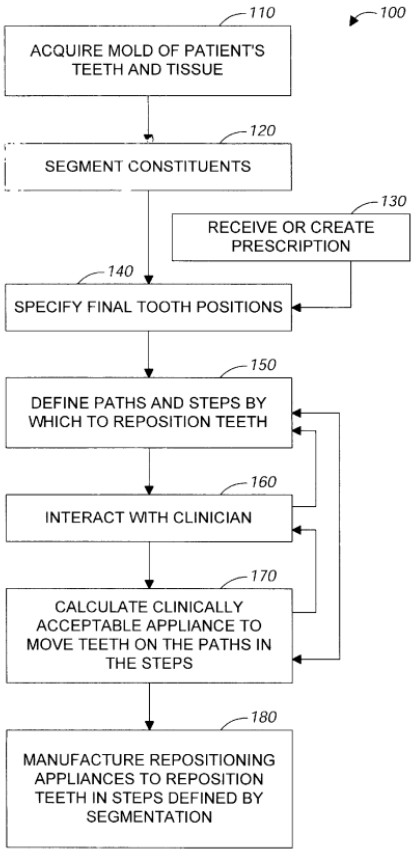


FIG. 1

Id.

48. Chishti-511 explains that after the initial and final positions for each tooth is determined, "the process next defines a tooth path for the motion of each tooth," and that "tooth paths are optimized in the aggregate so that the teeth are moved in the quickest fashion with the least amount of round-tripping to bring the teeth from their initial positions to their desired final positions." Ex-1004, 4:7-12. Chishti-511 explains that while round-tripping first moves a tooth in a "direction

other than directly toward the desired final position," it "is sometimes necessary to allow teeth to move past each other." Ex-1004, 4:13-16.

49. Chishti-511 also discloses that each path segment should "constitute a clinically viable repositioning" such that "moving from one point to the next in the sequence does not result in a collision of teeth." Ex-1004, 4:7-22. After the tooth paths are defined, each tooth path is segmented, and the segmented tooth paths are "used to calculate clinically acceptable appliance configurations (or successive changes in appliance configuration) that will move the teeth on the defined treatment path in the steps specified by the path segments." Ex-1004, 4:51-56. Chishti-511 further discloses that the proposed path for each tooth is compared against certain clinical constraints, and if there is a discrepancy that exceeds a certain threshold, the treatment plan can be modified. Ex-1004, 6:57-62, 7:9-22, 8:22-35. Clinical constraints include, for example, a maximum allowable force on the teeth and acceptable rates of displacement. Ex-1004, 1:59-67, 2:30-40, 6:51-7:8.

50. As shown below, Chishti-511 emphasizes that the process for calculating tooth paths and aligner shapes is an iterative process. Ex-1004, 4:27-50, 5:21-43, 8:42-66, Figs. 1, 2. If the proposed aligner shape does not satisfy the requisite criteria, or changes are made, the subprocess of defining the segmented paths is repeated (*see* "After the treatment path has been redefined, the outer loop of the overall process is executed again (step **632**)"). Ex-1004, 4:27-35, 8:42-66; Ex-

1017, ¶¶ 35-39. This allows for repeated modifications "to redefine those parts of the treatment path having unacceptable aligners." Ex-1004, 8:42-66.

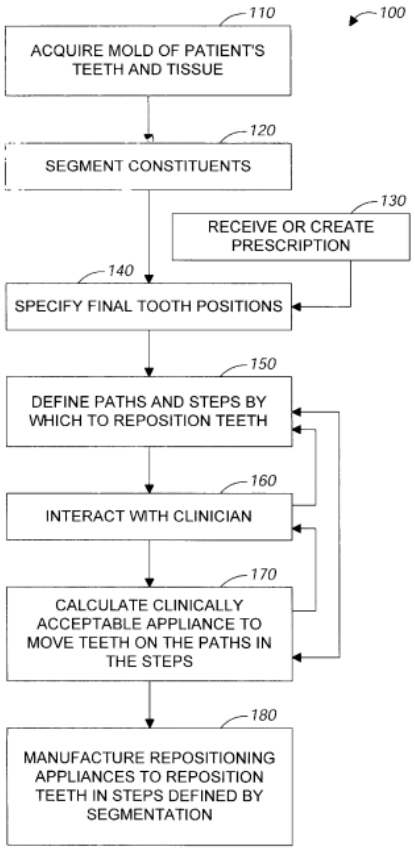


FIG. 1

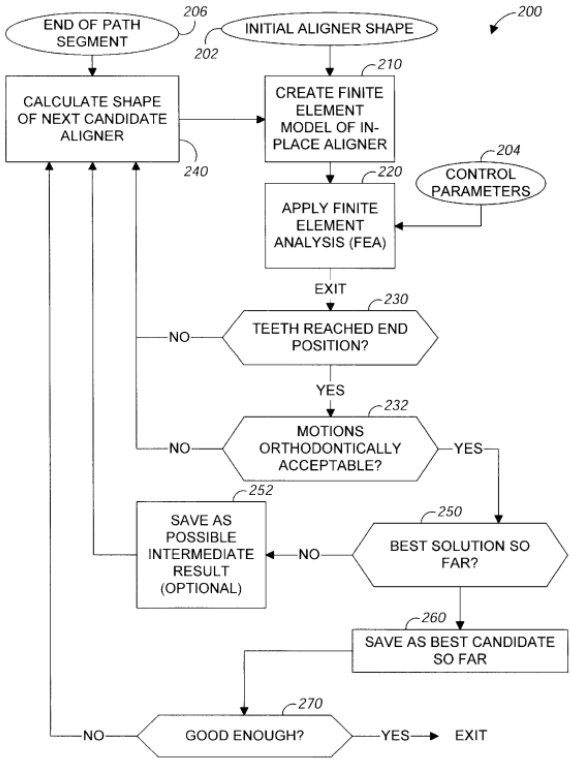


FIG. 2

51. With reference to Figure 1, Chishti-511 explains that "segments are calculated so that each tooth's motion within a segment stays within threshold limits of linear and rotational translation." Ex-1004, 4:15-18. However, after attempting to calculate appliances based on the defined paths, the "limit values can also be updated based on the result of an appliance-calculation (step 170, described later)." Ex-1004,

4: 27-35. And in particular, "[w]ith this information, the subprocess defining segmented paths (step 150) can recalculate the paths or the affected subpaths." *Id.*

52. In calculating the aligners (referring to Figure 2), Chishti-511 explains that the "analysis runs until an exit condition is reached, at which time the process evaluates whether the teeth have reached the desired end position for the current path segment, or a position sufficiently close to the desired end position (step 230)," and "[i]f an acceptable end position is not reached by the teeth, the process calculates a new candidate aligner shape (step 240)." Ex-1004, 5:21-27. Chishti-511 also discloses that a new aligner may be calculated even if an acceptable endpoint is reached, explaining that "[i]f an acceptable end position is reached, the motions of the teeth calculated by the finite elements analysis are evaluated to determine whether they are orthodontically acceptable (step 232). If they are not, the process also proceeds to calculate a new candidate aligner shape (step 240)." Ex-1004, 5:27-32.

53. Additionally, Chishti-511 explains that "[a]ligners may be unacceptable for a variety of reasons." Ex-1004, 8:42-43. And in those circumstances, "the process transfers control to a path definition process (such as step 150, FIG. 1) to redefine those parts of the treatment path having unacceptable aligners (step 630)" if they did not require impossible movements. Ex-1004, 8:54-58. Chishti-511 further explains that "[t]his step can include both changing the

increments of tooth motion, i.e., changing the segmentation, on the treatment path, changing the path followed by one or more teeth in the treatment path, or both." Ex-1004, 8:58-61.

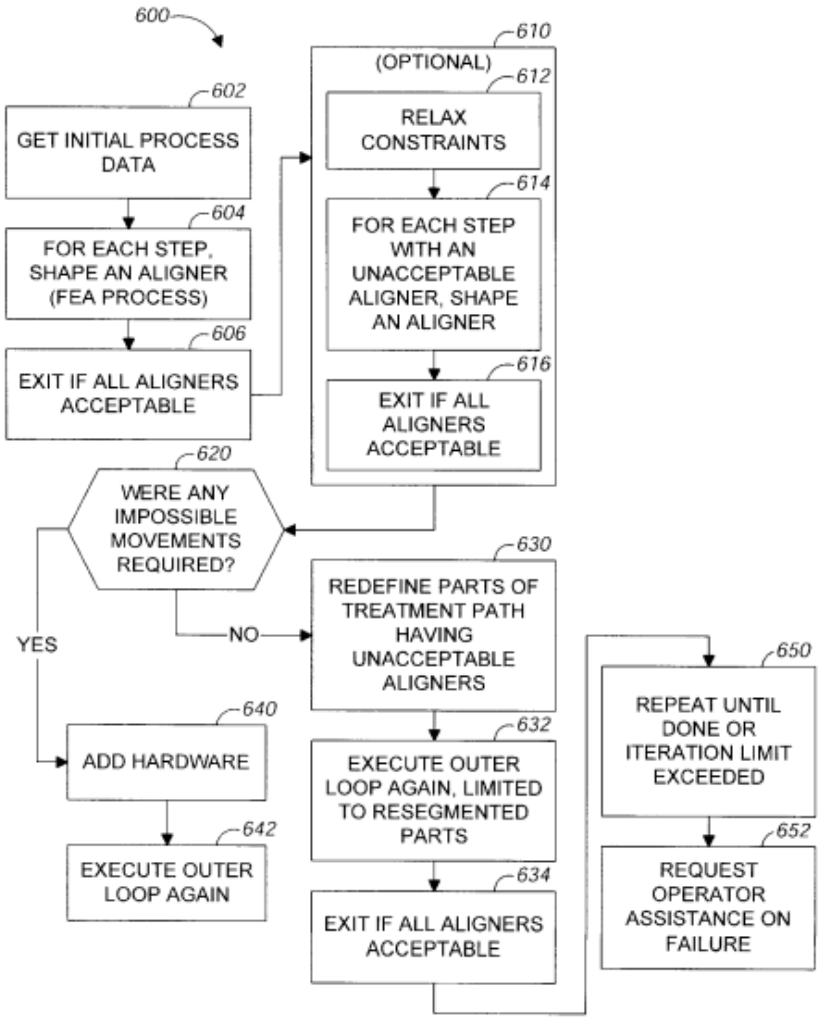


FIG. 6

Id., Fig. 6.

B. Chishti-876 (Ex-1005)

54. I understand that Chishti-876 is a U.S. patent that issued on May 4, 2004, more than one year before the earliest priority date of the ’217 patent. Thus, I understand that Chishti-876 qualifies as prior art to the ’217 patent under at least 35 U.S.C. § 102(b).

55. Chishti-876 is titled “Tooth Path Treatment Plan” and discloses systems and methods for preparing a treatment plan that involves selecting a tooth treatment pattern from a library of predetermined movement patterns and implementing the selected pattern in the treatment plan. Ex-1005, Title, Abstract, 2:15-19. Chishti-876 discloses that its algorithm “schedules treatment paths by drawing upon a database of preferred treatments for exemplary tooth arrangements,” and that “[t]his database can be constructed over time by observing various courses of treatment and identifying the treatment plans that prove most successful with each general class of initial tooth arrangements.” Ex-1005, 14:63-15:1. Thus, the database is based on prior successful treatments. The algorithm can “create several alternative paths and present each path graphically to the user.” Ex-1005, 15:1-3.

56. Chishti-876 further discloses the well-known and routine method of manufacturing aligners by thermoforming over a positive mold, where each aligner corresponds to a stage of the treatment plan. Ex-1005, 7:54-64. Chishti-876 also discloses variations in how a tooth may move.

57. Chishti-876 also discloses that "[a] set of rules can be applied to detect any collisions that will occur as the patient's teeth move along the treatment paths" (Ex-1005, 4:11-13), and that "[i]f any collisions are detected, the program alters the path of at least one tooth in each colliding pair by selecting a new position for one of the intermediate steps. . . . The program then samples the new path (1604) and again applies the collision detection algorithm (1606). The program continues in this manner until no collisions are detected" (Ex-1005, 13:35-45).

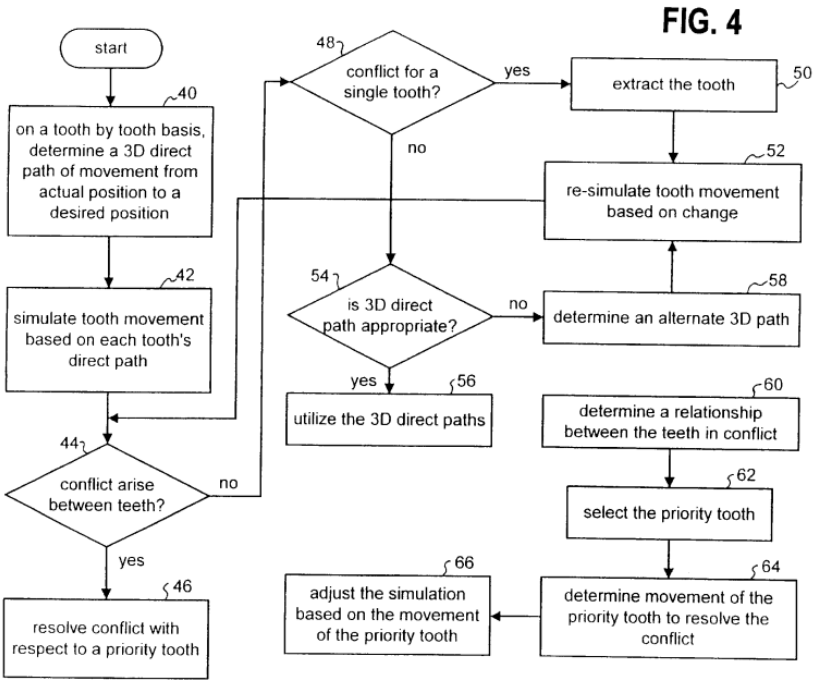
C. Sachdeva (Ex-1007)

58. I understand that Sachdeva is a U.S. patent that issued on June 26, 2001, more than one year before the earliest priority date of the '217 patent. Thus, I understand that Sachdeva qualifies as prior art to the '217 patent under at least 35 U.S.C. § 102(b).

59. Sachdeva is titled "Method and Apparatus for Simulating Tooth Movement for an Orthodontic Patient" and discloses using three-dimensional digital models for orthodontic treatment planning. Ex-1007, Title, Abstract, 4:50-5:8. Sachdeva discloses a process that includes comparing a digital representation of a patient's current dental structure with a three-dimensional model of a desired orthodontic structure to determine a three-dimensional direct path of movement. Ex-1007, 3:36-41. Then, the process simulates the tooth movement and determines whether a "conflict" arises between two teeth. Ex-1007, Abstract, 4:50-5:8.

Sachdeva explains that a "conflict" arises when "the movement of one tooth interferes with the direct path movement of another tooth[,] causing a particular tooth to not be able to obtain its desired position." Ex-1007, 5:5-8. If a conflict is detected, the computer automatically resolves the conflict by modifying the scheduled tooth movement and adjusting the simulation. Ex-1007, 3:43-48, 4:50-5:5, 5:27-32.

60. Sachdeva further discloses resolving a conflict between two teeth by delaying one tooth movement while moving another tooth. For example, "[i]f the lower tooth protrudes preventing the upper tooth from moving back, the lower tooth must be moved before the upper tooth can be positioned. Conversely, if the upper tooth is interfering with the lower tooth from being moved out, the upper tooth must first be moved." Ex-1007, 5:22-26.



Ex-1007, Fig. 4.

D. Becker (Ex-1006)

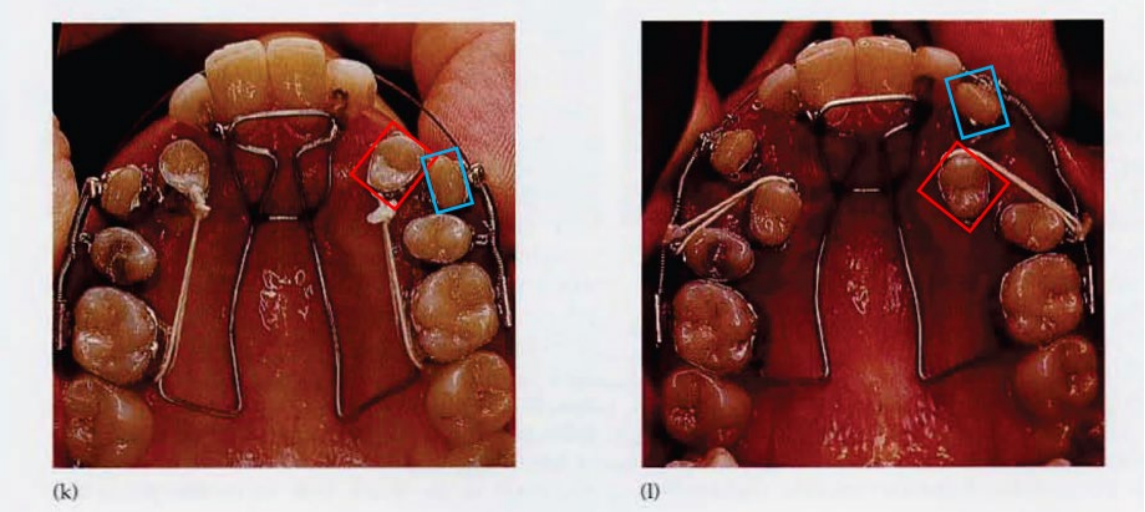
61. I understand that Becker is a textbook that published in 1998, more than one year before the earliest priority date of the ’217 patent. Ex-1020, ¶¶ 11-20. Thus, I understand that Becker qualifies as prior art to the ’217 patent under at least 35 U.S.C. § 102(b).

62. Becker is titled *The Orthodontic Treatment of Impacted Teeth* and discloses a method of repositioning a tooth using a round-tripping technique to avoid collisions between teeth. Ex-1006, Title, 5. Becker explains that where a patient’s teeth are “transposed,” the “preferred line of treatment” includes “retranspos[ing]

[the teeth] to their ideal positions" rather than "align[ing] the teeth in their transposed positions." Ex-1006, 5. In my opinion, a POSITA would have understood that tooth transposition refers to a dental anomaly where a tooth is located in the position normally occupied by a different tooth. In my opinion, a POSITA would have understood that is often referred to as an ectopic tooth.

63. Becker discloses a method of treatment for this type of malocclusion. Below are before and after images showing a patient, where a more lingual tooth (i.e., a tooth closer to the tongue in red) is transposed with a more buccal tooth (i.e., a tooth closer to the cheek in blue).[1]

[1] Becker describes the tooth shown in the upper dental arch as a "lingual" tooth and describes movement of that tooth to the center of the mouth as "lingual" movement (i.e., toward the tongue). Ex-1006, 5. But in my opinion, a POSITA would understand that when referencing teeth in the upper arch, movement to the center of the mouth is generally described as "palatal" movement, and that "lingual" movement is used when referencing teeth in the lower arch. I use the "lingual" terminology from Becker in my declaration to describe teeth in the upper arch (and movement thereof), but in my opinion, a POSITA would recognize that Becker's technique applies to teeth in either the upper or lower dental arch (lingual and palatal movement).



Ex-1006, 7 (Figs. 8.6(k), (l) (annotated)).

64. The more buccal tooth should be in the position shown on the right, but the lingual tooth is blocking the direct path of the more buccal tooth between its position shown on the right and its position shown on the left. Becker discloses using round-tripping, as described in the '217 patent, to correct the transposition of the teeth. Becker specifically describes "slid[ing]" the more buccal tooth toward the midline (i.e., "in the mesio-distal plane"). Ex-1006, 5. To allow for this, the more lingual tooth "must be moved further lingually" in order "to allow its partner to pass by." Ex-1006, 5. Finally, the more lingual tooth "must be moved ***in the opposite mesio-distal direction and back in the line of the arch***." *Id.* (emphasis added). Becker further explains that "[w]hen moving teeth mesio-distally along an archwire with a multibracketed fixed appliance, the establishment of interproximal contacts between the teeth enables a high degree of control of individual tooth position. Once

this has been achieved, uprighting and torqueing movements may be carried out, with care being taken to see that the spaces do not reopen. The desired treatment result includes closed contacts." *Id.*; *see also* Ex-1006, 7 (Figs. 8.6(k), (l)).

65. In my opinion, a POSITA would have understood that Figures 8.6(k) and (l) demonstrate that the more lingual tooth is moved, which allows the more buccal of the transposed teeth to move along the dental arch to the opposite side of the more lingual tooth. Ex-1006, Figs. 8.6(k), (l); Ex-1006, 5. The figures also show that after the more buccal tooth has "pass[ed] by," force is applied to the more lingual tooth to move it "in the opposite mesio-distal direction and back in the line of the arch." Ex-1006, 5. Moving the more lingual tooth in the "opposite" direction and "back in the line of the arch" would return the tooth to its previous position, after which the tooth would proceed toward a desired final position. *Id*. Indeed, Figure 8.6(m) shows the more lingual tooth after it further moved to its final position.

Ex-1006, 8 (Fig. 8.6(m) (annotated)).

E. General Overview of Round-Tripping in the Prior Art

66. Round-tripping—both as a general concept of moving a tooth in a direction other than directly towards its final position, and as the specific type of movement described in the ’217 patent where a tooth moves in one direction and then back to its original position before moving to its final position—was a well-known technique at the time of the invention for avoiding collisions between teeth. Through such indirect movements, clinicians create sufficient space for a second tooth to move towards its final position while avoiding a collision between the two teeth. Round-tripping was understood to be sometimes necessary in cases involving crowding or impacted teeth, like Becker, where direct movement of either the first tooth or second tooth is not otherwise possible without causing a collision.

67. A clinician presented with a patient where direct movement of a tooth towards its final position is not possible without causing a collision would consider various indirect tooth movement techniques in order to avoid a collision. In my opinion, a POSITA also would have understood that when determining whether to use an indirect movement technique, including round-tripping, to avoid a collision, a clinician would consider both the risks of round-tripping movement (such as root resorption, loss of periodontal support, and prolonged treatment time caused by the round-tripping movement), as well as the benefit of achieving proper alignment while avoiding a collision.

68. Although it was understood that round-tripping should be avoided if possible, it was also understood to be a necessary option for some patients. Chishti-511 explains that moving a tooth in a "direction other than directly toward the desired final position," "***is sometimes necessary*** to allow teeth to move past each other." Ex-1004, 4:9-16 (emphasis added) (describing optimization of tooth paths with the "least amount" of indirect movement). In some instances, the only alternative to round-tripping might be extraction, which could be even less desirable. This is consistent with the '217 patent's disclosure that round-tripping may be used "as a last resort" (Ex-1001, 13:11-17), and with a POSITA's understanding that while it is preferable to avoid ***unnecessary*** indirect movement techniques, for some patients, some indirect movement may be necessary.

69. Other publications also confirm that round-tripping was well known. As discussed previously, Becker discloses that the "preferred line of treatment" may include the type of round-tripping specifically required in the '217 patent. Ex-1006, 5. Becker discloses that a tooth is moved out of the way for another tooth to "pass by" before it is moved to its previous and then final positions. *Supra* Section VI.D; *infra* Section X.A.1.f. Similarly, Park (Ex-1024) discloses a known movement technique whereby anterior teeth are moved to a forward position and then "retracted back after creating space with the distal movement of the molars and premolars." Ex-1024, 5-6. DeAngelis also discloses a known movement technique where a tooth is tipped such that the root apex moves "from point *a* to point *b*'," and then is "brought back through point *a* to the desirable end-point *b*." Ex-1023, 2; *see also* Ex-1023, Fig. 1B.

70. Finally, the prior art discloses that some of the reasons clinicians tended to avoid round-tripping may have been based on only anecdotal evidence and were not supported by more rigorous research. *See* Ex-1022, 3 ("It is generally accepted that some level of root resorption will occur in patients undergoing orthodontic treatment. . . . Although many treatment factors have been related to this phenomenon, the presence of 'jiggling' movements or 'round tripping' have anecdotally been stated as a cause for resorption without any hard evidence."); *id.* at 1 ("Both treatment groups exhibited the same levels of resorption indicating that the

side effect of treatment may be due to individual variation and not to the 'round tripping' of teeth so often assumed.").

71. In short, the '217 patent's disclosure regarding round-tripping is neither novel nor nonobvious but rather reflects a widespread consensus at the time of the '217 patent that round-tripping was an option to be considered, with advantages and disadvantages, and that round-tripping would be used as necessary if it was the best (or potentially only) available treatment option.

VII. Analogous Art

72. In my opinion, each of Chishti-511, Chishti-876, Sachdeva, and Becker is analogous art to the '217 patent and to each other. The '217 patent states that the "present invention is related generally to the field of orthodontics, and more particularly to staging a path of movement for correcting the position of one or more teeth." Ex-1001, 1:21-23. Like the '217 patent, each of Chishti-511, Chishti-876, Sachdeva, and Becker is in the same field of endeavor, as each is directed to orthodontic treatment for repositioning misaligned teeth in patients. *See* Ex-1004, Abstract (discussing "orthodontic treatment path into clinically appropriate substeps for repositioning the teeth of a patient"); Ex-1005, Abstract ("prepar[ing] a malocclusion treatment plan"); Ex-1007, Abstract (discussing that "simulating tooth movement for an orthodontic patient include[s] processing that begins by

determining, on a tooth by tooth basis, a three-dimensional direct path of movement"); Ex-1006, 5 (discussing movement of teeth).

73. In my opinion, Chishti-511, Chishti-876, Sachdeva, and Becker are also analogous art because they are reasonably pertinent to the problem that the '217 patent purports to solve. In particular, the '217 patent discusses planning a path for correcting the position of teeth and addressing the problem of avoiding potential collisions of teeth along that path. Ex-1001, 1:21-23, 6:41-52 (the system "is configured to determine[] if the pattern should be modified to accommodate the teeth movement of the current patient to avoid collision"), 6:53-60 (discussing methods of avoiding collisions).

74. Chishti-511, Chishti-876, Sachdeva, and Becker are reasonably pertinent to this same problem. Chishti-511 discloses "defin[ing] a tooth path for the motion of each tooth" that "constitute[s] a clinically viable sequence of tooth positions, so that moving from one point to the next in the sequence does not result in a collision of teeth." Ex-1004, 4:7-9, 4:18-22. Chishti-876 similarly relates to generating a "malocclusion treatment plan," which includes "determining a tooth path [which] includes finding a collision[-]free shortest path." Ex-1005, 2:21-30. To help accomplish that goal, Chishti-876 discloses the use of "treatment pattern[s]" that "can be selected from one or more clinical treatment prescriptions." *Id.* Sachdeva similarly discloses "determining, on a tooth by tooth basis, a three-

dimensional direct path of movement" as well as "determin[ing] whether a conflict arises between at least two teeth" and resolving that conflict. Ex-1007, Abstract. Finally, Becker shows a known round-tripping technique used in a patient's orthodontic treatment and demonstrates and explains how to resolve and avoid potential collision of teeth using that technique. Ex-1006, 5.

VIII. Motivation to Combine

75. In my opinion, a POSITA would have been motivated to combine the Ground 1 references with a reasonable expectation of success.

76. In my opinion, a POSITA would have been motivated to use Sachdeva's and Becker's collision identification and avoidance techniques to supplement Chishti-511's treatment planning system. Chishti-511 already discloses that its system is intended to result in "a clinically viable sequence of tooth positions." Ex-1004, 4:18-22. Chishti-511 further recognizes that, to accomplish a clinically viable sequence, its system must achieve a treatment such that "moving from one point to the next in the sequence does not result in a collision of teeth." Ex-1004, 4:18-22. In light of this express disclosure, in my opinion, a POSITA would have been motivated to look to teachings regarding the identification and avoidance of collisions.

77. Sachdeva provides one such very teaching. Like Chishti-511, Sachdeva recognizes that collisions are undesirable and may cause issues with treatment. *See*

Ex-1007, 5:5-8 ("A conflict may arise in that the movement of one tooth interferes with the direct path movement of another tooth[,] causing a particular tooth to not be able to obtain its desired position."). Sachdeva further teaches a process for identifying collisions as well as methods for resolving them. *See* Ex-1007, 5:3-26, Fig. 4. For example, Sachdeva discloses that a conflict can be resolved by giving one tooth priority to move it before another tooth (delaying one tooth), and it further explains how the changes will cause adjustments in the simulated treatment. Ex-1007, 5:3-32.

78. In my opinion, a POSITA would have recognized that integrating Sachdeva's automated collision identification, avoidance, and adjustments features into Chishti-511 would provide implementation details for the features disclosed in Chishti-511 and would help achieve the "clinically viable sequence of tooth positions" sought by Chishti-511—that is, preventing the undesirable result of producing a set of aligners that might otherwise cause a collision. Indeed, in my opinion, a POSITA would have understood that the type of collision avoidance disclosed by Sachdeva (delaying an initial movement of a tooth) was a well-known treatment technique at the time of the invention. *See, e.g.*, Ex-1014, 6, Howard D. Kesling, *The Diagnostic Setup with Consideration of the Third Dimension* (describing a scenario wherein a patient's canine teeth are repositioned after "the central and lateral incisors are repositioned"); Ex-1015, 5, H.D. Kesling,

Coordinating the Predetermined Pattern and Tooth Positioner with Conventional Treatment ("Treatment of both arches can be carried on together, bearing in mind that the mandibular teeth should advance toward the predetermined pattern and stationary anchorage somewhat ahead of the maxillary teeth."); Ex-1016, 124 & Fig. 12-10a (describing a "[h]igh-anchorage pattern" used when "crowding on the anterior teeth requires that the space is created by the distal movement of the posterior teeth," where the anterior teeth are only moved after the posterior teeth have moved)[2]. In my opinion, a POSITA would also have understood that such a system would improve patient results by avoiding unacceptable collisions and increase efficiency by reducing the time needed for a clinician to manually identify potential collisions.

79. I understand A POSITA would have had a reasonable expectation of success in combining Chishti-511 with Sachdeva's collision identification and avoidance features. Ex-1017, ¶¶ 55-61 (citing Ex-1004, 5:7-59; Ex-1007, 4:39-49). A POSITA would understand that a collision between teeth is not "orthodontically acceptable" and that acceptable end positions are unlikely to be reached when there are collisions. A POSITA would thus recognize the applicability of Sachdeva's collision-related features to Chishti-511's system. *See* Ex-1004, 8:22-65, 4:7-22; Ex-

[2] I understand that Tuncay (Ex-1016) was publicly available at least by August 17, 2006. Ex-1021, ¶¶ 21-37.

1007, 5:3-32. I understand such a combination would have required little more than software modifications, and a POSITA would have had a reasonable expectation of success in combining these teachings. Ex-1017 ¶¶ 55-61.

80. In my opinion, a POSITA similarly would have been motivated to combine Chishti-511 with Becker's teachings regarding round-tripping. As discussed above, Chishti-511 already discusses the need to have collision-free treatment paths (Ex-1004, 4:15-22), and thus, a POSITA would have been motivated to look to techniques for avoiding collisions during treatment. In my opinion, a POSITA would have recognized that different patients may require different treatments, and thus would have been motivated to include, in Chishti-511's treatment planning system, multiple treatment methods to resolve and avoid potential collisions. For example, Becker provides one such teaching, illustrating how round-tripping—as specifically discussed in the '217 patent—can be used to avoid collisions in cases of patients with transposed teeth. Ex-1006, 5-7. For example, in transposition cases involving canines, in my opinion, a POSITA would have understood that a treatment plan might include repositioning the canine to its proper position, and that for some patients, round-tripping one or more teeth might be preferable over a different treatment (e.g., extracting the tooth) because canine teeth play a critical role in preventing collapse of the dental arch.

81. While the treatment shown for Becker's patient is one example, A POSITA would have understood that, depending on the specifics of a patient's malocclusion, there are different ways to implement the concept of round-tripping disclosed in Becker, of moving a first tooth away from the path of a second tooth and then moving it back to its previous position before proceeding to a desired final position. For example, a POSITA would have understood that, after the first tooth has been moved to its previous position, the first tooth would be free to move to a different, desired final position, depending on the needs of the patient. Similarly, a POSITA would have also understood that if only minor tooth movement is required to avoid collision with a path of a second tooth, aligners alone may be used to move the first tooth out of the path of a second tooth sufficiently to avoid a collision and then moving the first tooth back to its previous position before moving it towards its final position. In that case, depending on the initial malocclusion of the patient, the "first tooth" may not need to move as far to be "out of the path" of the second tooth to avoid a collision. *Id.*

82. A POSITA would also recognize that in other cases, where more significant tooth movement is needed to avoid a collision may utilize aligners with attachments, such as attachments shown in Becker, to achieve the desired movement. In my opinion, a POSITA would understand that use of such attachments was well known in the art at the time of the invention. For example, Chishti-511 describes

that its process for computing the shape of an aligner will also take into account hardware attachments if necessary to create the tooth motion. *See* Ex-1004, 8:47-53 ("process 600 proceeds to execute a module that calculates the configuration of a hardware attachment to the subject tooth to which forces can be applied to effect the required motion"). Similarly, when discussing manufacturing of its aligners, Chishti-511 recognize that this will account for "the position and selection of attachments, and the addition or removal of material (e.g., adding wires or creating dimples) to change the structure of the aligner." *Id.*, 10:1-6; *see also id.*, 6:21-24. State of the art confirms that use of attachments, as shown in Becker, with aligners were well known at the time of the invention. For example, it was known that attachments may be used with Essix aligners to accomplish various types of movement, including labial and lingual movement, lateral movement, torque, rotation, and to adjust arch relationships. *See* Ex-1016, 26, 30-38. As one example, a button may be constructed on the aligner to which an elastic may be attached. Ex-1016, 34, 35 (Fig. 2-24c). Alternatively, a "facial window" may be cut into the clear aligner in the area where a button is bonded to the surface for a tooth, where the button serves as "the base for [an] elastic vector." Ex-1016, 37; *see also* Ex-1018, Abstract, 11:45-65; Ex-1019, Abstract, 3:21-48. Thus, a POSITA would have understood that depending on the type of malocclusion, aligners may be used either alone or with attachments to achieve the type of round-tripping disclosed in Becker.

83. Although round-tripping can have disadvantages, a POSITA would have recognized that for some patients, there may be no other option other than to round-trip one or more teeth, particularly if the patient or clinician wishes to avoid extracting one or more teeth. Indeed, Chishti-511 expressly discloses that round-tripping—understood more broadly as any motion of a tooth in any direction other than directly toward the desired final position—is "sometimes necessary to allow teeth to move past each other." Ex-1004, 4:13-15. Chishti-511, Becker, and the '217 patent are thus all consistent in understanding that round-tripping—whether understood more broadly or as specifically defined in the '217 patent—may be required to treat certain patients, even if it is, in the words of the '217 patent, "a last resort." Ex-1004, 4:9-12; Ex-1001, 13:11-17. Accordingly, a POSITA would have been motivated to include round-tripping as one feature in a system with robust software for generating treatment plans for a broad range of different patients with different needs. Adding a well-known feature such as round-tripping to make Chishti-511's treatment planning software more robust thus would have been obvious, even if those features are only used in rare cases or as a last resort for patients that might otherwise not be able to be treated.

84. Moreover, I also understand that a POSITA would have had a reasonable expectation of success in combining these teachings. Ex-1017, ¶ 62. Like Sachdeva's technique, a POSITA would have been motivated to integrate Becker's

round-tripping technique as an option in Chishti-511's algorithm for calculating new aligners, such as when it is determined that the aligner is unacceptable (e.g., the treatment plan results in a collision). Ex-1004, 5:25-32, 8:42-61, Fig. 6; Ex-1017, ¶ 62. If a collision is detected, the combined system would have Becker's technique as an option for use in Chishti-511's path redefinition process, which already incorporates other types of changes to tooth movement, to resolve the collision. I understand that adding the option for the system to use Becker's technique to round-trip one or more teeth as part of generating a treatment plan would have involved a software modification related to Chishti-511's algorithm for calculating new aligners (similar to that discussed for Sachdeva) would have yielded predictable results and had a reasonable expectation of success. Ex-1017, ¶ 62. To the extent that it is argued that the prior art teaches away from the proposed combination, I disagree because the prior art discloses at least as much as the '217 patent itself for the round-tripping limitation. Chishti-511 recognizes there may be some disadvantages of round-tripping and recommends avoiding such movement when possible, but it also recognizes that round-tripping may be necessary in some circumstances. Ex 1004, 4:9-16. This is analogous to the '217 patent's disclosure, which refers to round-tripping as a matter of "last resort" when the collision cannot be resolved by other collision avoidance techniques. Ex-1001, 13:13-17.

85. In my opinion, a POSITA also would have been motivated to combine Chishti-876's teachings regarding the use of movement patterns and the generation of schedules of movement with Chishti-511's treatment planning system. Chishti-511 already discloses the importance of tailoring the generated treatment plan according to a clinician's preferences and of proposing treatment plans for a clinician's approval, and the use of predetermined movement patterns would facilitate interactions with a clinician by providing repeatable, known treatment techniques. *See, e.g.*, Ex-1004, 3:59-64 (discussing receiving prescription and constraints from clinicians and allowing clinician interaction through a client), 2:45-53, 4:36-50. A POSITA would have understood that such a modification would improve efficiency by allowing a technician to generate a treatment plan more quickly. It would also improve treatment quality by applying treatment techniques that had been used successfully for similar patients, implement clinician preferences, and improve patient flexibility by providing the type of treatment appropriate for each patient's needs. It would also potentially decrease the number of requested modification or refinements necessary to achieve the desired result. I also understand that a POSITA would have had a reasonable expectation of success in combining Chishti-876's teachings in Chishti-511's system. Ex-1017, ¶¶ 63-65.

86. For the various features of Chishti-876, Sachdeva, and Becker discussed in this declaration, in my opinion those various features would not have

interfered with one another when combined with Chishti-511's system. *See also* Ex-1017, ¶ 79.

IX. Ground of Unpatentability

87. Based on my review of the materials set forth above, including my application of the knowledge of a person of ordinary skill in the art, it is my opinion that the Challenged Claims of the '217 patent would have been obvious to one of ordinary skill in the art at the time of the purported invention (August 30, 2006). In particular, it is my opinion that the Challenged Claims of the '217 patent would have been obvious to one of ordinary skill in the art based on the ground shown below:

Ground	Claims Challenged	35 U.S.C.	References
1	1-20	§ 103	Chishti-511, Chishti-876, Sachdeva, and Becker

X. Claims 1-20 of the '217 Patent Are Unpatentable

88. In my opinion, claims 1-20 of the '217 patent would have been obvious based on the teachings of Chishti-511, Chishti-876, Sachdeva, and Becker for the reasons I have provided below in the asserted ground of unpatentability.

A. Chishti-511, Chishti-876, Sachdeva, and Becker Render Obvious Claims 1-20

89. In my opinion, Chishti-511 in view of Chishti-876, Sachdeva, and Becker renders obvious claims 1-20.

1. Independent Claim 1

90. In my opinion, Chishti-511 in view of Chishti-876, Sachdeva, and Becker discloses or renders obvious each limitation of claim 1.

a. [1(pre)] A method comprising:

91. In my opinion, to the extent the preamble is limiting, Chishti-511 discloses a "method[]" for orthodontic treatment planning. Ex-1004, Abstract (providing for "[m]ethods and corresponding apparatus for segmenting an orthodontic treatment path into clinically appropriate substeps for repositioning the teeth of a patient."); *see also* Ex-1004, 1:33-39, 2:34-39.

b. [1(a)] selecting a movement pattern from a plurality of movement patterns for moving dental objects from an initial arrangement toward a final arrangement, the dental objects being based on output of a scanning device, the movement pattern defining a schedule of movement of the dental objects during treatment stages as each of the dental objects moves from a respective initial position toward a respective final position;

92. In my opinion, Chishti-511 in view of Chishti-876 renders obvious this limitation. Chishti-511 discloses a schedule of movement of the dental objects during treatment stages as each of the dental objects moves from a respective initial

position toward a respective final position. In this schedule of movement, Chishti-511 bases the dental objects on outputs from a scanning device. Indeed, as an initial step, Chishti-511 gathers data by acquiring "a mold ***or a scan*** of [a] patient's teeth," in order to create "a digital data set" representative of the patient's initial arrangement of dental objects. Ex-1004, 3:40-50 (emphasis added); *see also* Ex-1004, 3:51-58.

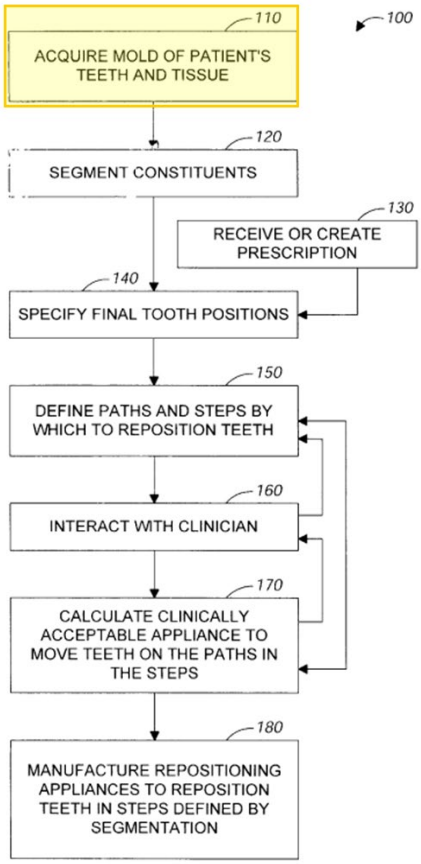


FIG. 1

Ex-1004, Fig. 1 (annotated).

93. Chishti-511 discloses that the system will then receive the "desired final position of the teeth." Ex-1004, 3:59-4:6. For example, Chishti-511 discloses that the "desired final position of the teeth" can be "calculated from basic orthodontic principles" or "extrapolated computationally from a clinical prescription" or received from a clinician. *Id.* Once the beginning and final positions are established for each tooth, the process "defines a tooth path for the motion of each tooth." Ex-1004, 4:7-22. The teeth are moved along this tooth path toward the desired final tooth positions without exceeding safety or discomfort thresholds. Ex-1004, 2:59-67, 3:41-50, 4:16-22.

94. To achieve this, "[t]he tooth paths are segmented," such that the "end points of each path segment" represent a "clinically viable repositioning," and "the aggregate of segment endpoints constitute[s] a clinically viable sequence of tooth positions." Ex-1004, 4:7-22. Moreover, the segments are "optimized in the aggregate . . . to bring the teeth from their initial positions to their desired final positions." *Id.* The segmented tooth paths are then "used to calculate clinically acceptable appliance configurations." Ex-1004, 4:51-67. Each appliance configuration "represents a step along the treatment path" (treatment stages) and is designed to apply "an orthodontically optimal amount of force on the patient's dentition" to "move the teeth on the defined treatment path in the steps" toward their respective final positions. *Id.* Thus, Chishti-511 discloses "a schedule of movement of the dental

objects during treatment stages as each of the dental objects moves from a respective initial position toward a respective final position," as claimed.

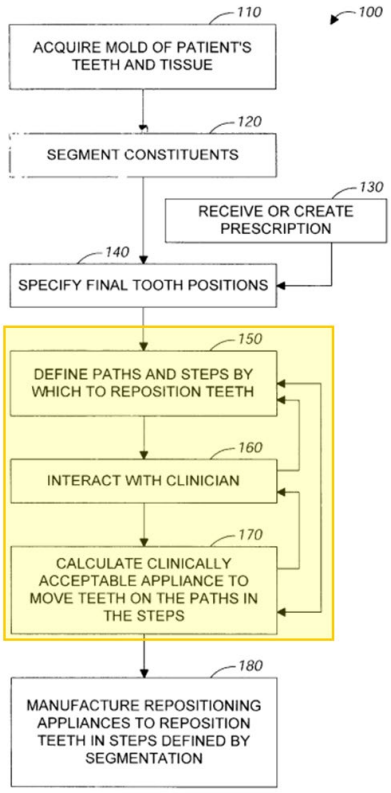


FIG. 1

Ex-1004, Fig. 1 (annotated).

95. While Chishti-511 does not provide selecting a movement pattern from a plurality of movement patterns for moving dental objects from an initial arrangement toward a final arrangement, Chishti-876 does and renders obvious this feature. For the reasons explained in Section VIII, a POSITA would have been motivated to modify Chishti-511 to include Chishti-876's teachings regarding

defining a schedule of movement by selecting a movement pattern from a plurality of movement patterns. The ’217 patent admits that Chishti-876 disclosed movement patterns. Ex-1001, 6:8-14. Chishti-876 explains that its algorithm draws upon a library of predetermined tooth treatment patterns and its system allows for the selection of “one teeth treatment pattern from a plurality of predetermined teeth treatment patterns.” Ex-1005, Abstract, 2:63-3:5, 3:24-33. Each of the proposed treatment patterns presents a “transformation curve” applied to each tooth in order “to move th[at] tooth from its initial position to its final position.” Ex-1005, 12:38-43. As a Chishti-876 explains that its system “generat[es] the malocclusion treatment plan in accordance with the selected treatment pattern.” Ex-1005 2:63-3:5, 2:20-24. And Chishti-876 provides several exemplary movement patterns, including details on how the schedule of movement will be generated based on the selected pattern. Ex-1005, 2:44-62, 3:6-10, 3:24-27, 3:38-40, 3:49-51, 16:48-17:17, Figs. 10-13.

96. Chishti-876 also uses a similar system to Chishti-511 and discloses a similar system with “the movement pattern defining a schedule of movement” of the dental objects during each of the treatment stages. For example, it discloses that its system will “define or map the movement of selected individual teeth from the initial position to the final position over a series of successive steps.” Ex-1005, 9:13-19; *see also* Ex-1005, 7:13-19, Fig. 3. Chishti-876’s system “takes into consideration” “[m]ovement: a detailed, sequential description of how the patient’s teeth should be

moved in order to accomplish the desired goals for final placement," which is a section of the treatment plan that "specifies an order [of] moving the patient's teeth" and "break[s] the treatment down into discrete stages" to provide "control over which teeth the orthodontist wants to move and which teeth to anchor (not move)." Ex-1005, 9:33-45, 10:12-17. Using these teachings, "a plan is generated for moving teeth" (a "schedule of movement"). Ex-1005, 10:29-34. Chishti-876 further explains that its system "considers a set of movement constraints which affect the tooth path movement plan," and that such considerations include, for example: "[s]pace," "[t]eeth moving past each other," "[w]hich teeth are moving when?" and "[w]hich teeth need to be moved before others are moved?" Ex-1005, 11:32-65.

97. Chishti-876 also describes "a two-dimensional array" that is "used to track specific movements for each tooth at a specific period of time." Ex-1005, 11:38-40. "One dimension of this array relates to teeth identification, while the second dimension relates to the time periods or stages." Ex-1005, 11:41-43. Chishti-876 further provides examples of its schedule of movement. For example, it provides a "diagram of the A type movement." Ex-1005, 17:1-7. With that movement type, "the next tooth starts to move when the current tooth reaches midway to the current tooth's goal position." *Id.* As shown in the annotated diagram, Chishti-876's schedule of movement shows for each treatment stage when each tooth is moving

(annotated green for the leftmost tooth) or not moving (annotated red for the leftmost tooth).

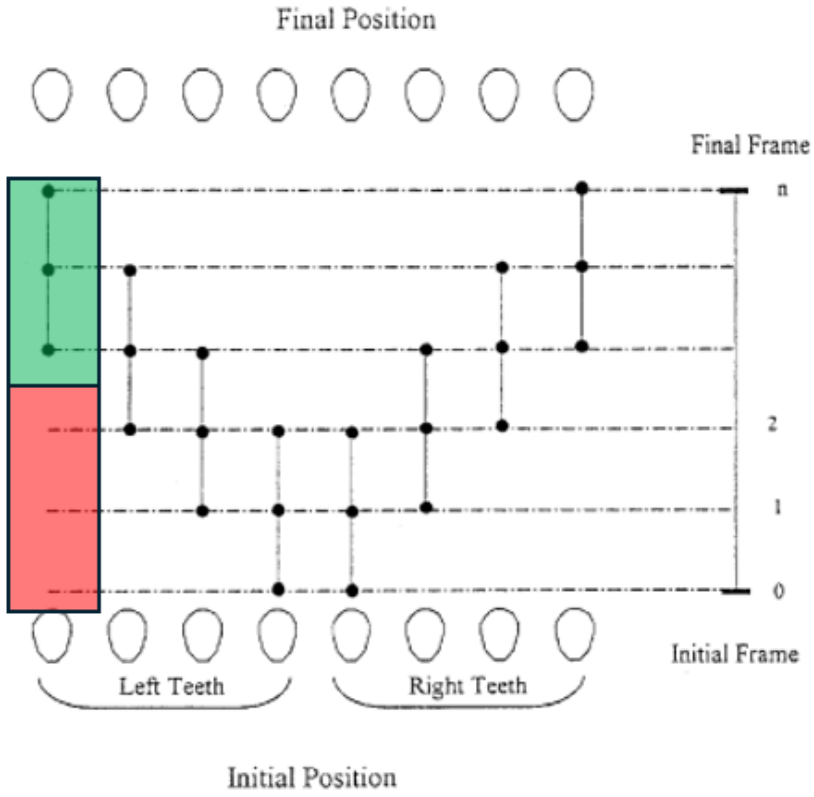


FIG. 11

Ex-1005, Fig. 11 (annotated), 17:1-7. Thus, in my opinion, Chishti-876's movement pattern defines a schedule of movement of the dental objects during treatment stages as each of the dental objects moves from a respective initial position toward a respective final position. *See* Ex-1005, 11:43-61 (discussing factors considered for

the schedule of movement, including "[w]hich teeth are moving when?" and "[w]hich teeth need to be moved before others are moved?").

c. [1(b)] calculating, by a computer processor, a respective treatment path for each of the dental objects between its respective initial and final positions;

98. In my opinion, Chishti-511 discloses this feature. In particular, Chishti-511 teaches that its computer program (Ex-1004, 2:34-39, 3:31-39, 10:19-51) "defines a tooth path" (calculates a respective treatment path) "for the motion of each tooth" (for each dental object), which includes "bring[ing] the teeth from their initial positions to their desired final positions" (between their respective initial position and respective final position). Ex-1004, 4:7-22. Chishti-511's program calculates these paths for each tooth such that "the teeth are moved in the quickest fashion" from start to finish. *Id.* This calculation further involves segmenting the tooth paths into defined steps of the overall treatment path. Ex-1004, 4:51-67 (explaining that the segmented tooth paths "are used to calculate clinically acceptable appliance configurations" that "will move the teeth on the defined treatment path in the steps specified by the path segments").

99. As Chishti-511 explains, "each segment [corresponds to] one aligner," allowing for a tooth to move in a desired direction from its initial position to its final position under "an orthodontically optimal amount of force" during each stage.

Ex-1004, 4:51-67, 9:15-35. Chishti-511's system further incorporates "a path definition module that calculates the paths taken by teeth as they are repositioned during treatment." Ex-1004, 1:62-67. Thus, Chishti-511's method includes calculating, and continuing to calculate, the treatment path for each tooth during each stage of treatment between their respective initial and final positions. *Id.* And as Chishti-511 explains, the steps of the method may be performed on a computer by a computer processor.[3] Ex-1004, 2:34-39, 3:31-39, 10:19-51 (explaining that the steps of the process can be implemented on a computer program, including for execution by a programmable processor).

d. [1(c)] identifying, by a computer processor, a collision between a first of the dental objects and a second of the dental objects based at least on one of the respective treatment paths; and

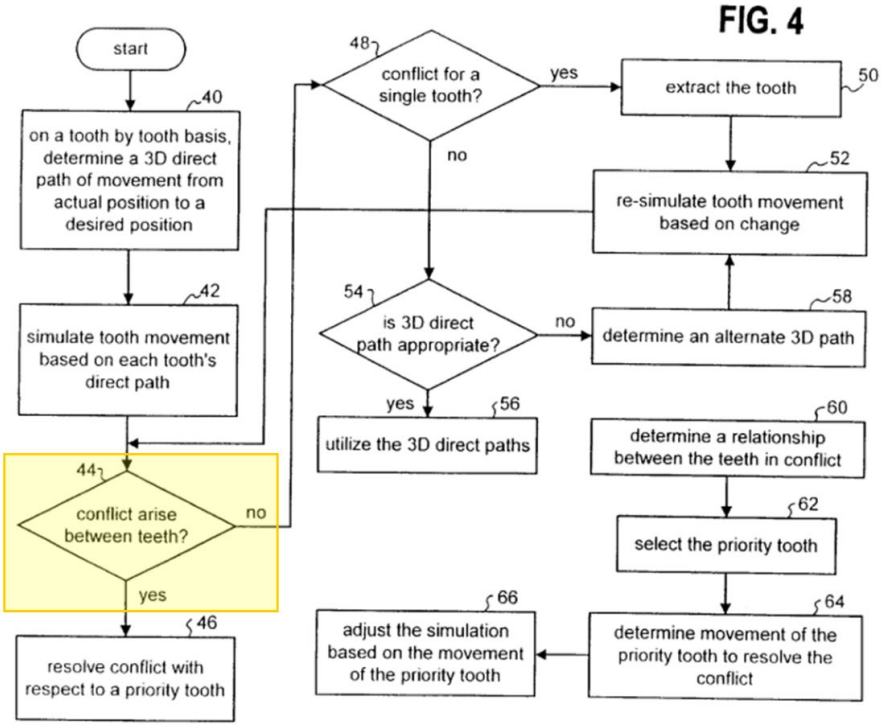
100. In my opinion, Chishti-511 discloses this limitation and renders it obvious both alone and in view of Sachdeva. Chishti-511 explains that tooth paths are calculated to achieve a successful result quickly and safely. Ex-1004, 4:7-22. Indeed, Chishti-511's solution seeks a "clinically viable sequence of tooth positions," moving from an initial position to a final position in stages that "do[] not result in a collision of teeth." *Id.* Chishti-511 further states that new aligners will be

[3] This applies equally to all remaining claim limitations that recite steps performed "by a computer processor."

calculated if the system determines teeth motion is not "orthodontically acceptable" or if "an acceptable end position is not reached by the teeth." Ex-1004, 5:25-32. In my opinion, a POSITA implementing Chishti-511 would have understood that a schedule of movement resulting in a collision would be unlikely to reach an acceptable end position and would be orthodontically unacceptable and require an alternative movement schedule. To ensure unacceptable movements are not used in the treatment plan, Chishti-511 explains that its method includes a "path definition process" to redefine portions of the treatment path that are unacceptable. Ex-1004, 8:42-9:14 (disclosing "[a]ligners may be unacceptable for a variety of reasons" and in those circumstances, "the process transfers control to a path definition process (such as step 150, FIG. 1) to redefine those parts of the treatment path having unacceptable aligners (step 630)."). Thus, during Chishti-511's treatment planning process, unacceptable movements including those resulting in a collision based on respective teeth paths, are identified, so that the schedule of movement can be redefined.

101. For the reasons discussed in Section VIII, in my opinion, a POSITA would have been motivated to modify Chishti-511 to include Sachdeva's automated collision identification teachings. Indeed, Sachdeva discloses a system for simulating tooth movement for an orthodontic patient, implemented by a computer processor, analogous to each of Chishti-511, Chishti-876, and the Challenged

Claims. Ex-1007, 4:39-49. During Sachdeva's treatment planning process, the computer determines the three-dimensional path of movement for each tooth between its actual position and its desired position. Ex-1007, 4:39-54. It then simulates each of these treatment paths to automatically determine if "[a] conflict in movement arose between at least two teeth." Ex-1007, 5:3-8, Fig. 4.



Ex-1007, Fig. 4 (annotated).

102. In my opinion, a POSITA would have understood that a conflict arises when there is a collision between two dental objects. Indeed, Sachdeva explains that a conflict may arise if the "movement of one tooth interferes with the direct path of another tooth" (i.e., a collision), thereby "causing a particular tooth to not be able to

reach its desired position." Ex-1007, 5:3-8. Thus, in my opinion, Sachdeva discloses its system identifying collision between a first of the dental objects and a second of the dental objects based at least on one of the respective treatment paths. Sachdeva explains that its process may be performed on a computer by a computer processor.[4] Ex-1007, 4:39-49.

e. [1(d)] performing, by a computer processor, a first modification of the schedule of movement in response to the identifying, the first modification comprising:

103. In my opinion, Chishti-511 alone or in view Sachdeva renders this limitation obvious. Chishti-511 discloses an iterative process for generating a schedule of movement, including performing modifications to that schedule. Ex-1004, 8:42-61 (noting that when aligners are unacceptable, "the process transfers control to a path definition process" "to redefine those parts of the treatment path having unacceptable aligners."), 4:23-50, 5:21-32, Figs. 1, 2, 6.

104. Indeed, Chishti-511 explains that its process and system will iteratively modify the segmentations until the system achieves an acceptable movement schedule. Ex-1004, 4:15-35, 4:51-5:43, 6:63-7:8, 8:29-9:2, Figs. 1, 2, 4, 6.

105. Chishti-511 also explains that this redefinition process involves modifying the schedule of movements, including "changing the increments of tooth

[4] This applies equally to all remaining claim limitations that recite steps performed "by a computer processor."

motion, i.e., changing the segmentation, on the treatment path, changing the path followed by one or more teeth in the treatment path, or both." Ex-1004, 8:54-61. And "[a]fter the treatment path has been redefined, the outer loop of the overall process is executed again (step 632)." Ex-1004, 8:61-63. "[T]he overall process can be repeated until an acceptable set of aligners is found or an iteration limit is exceeded (step 650)." Ex-1004, 8:66-9:2.

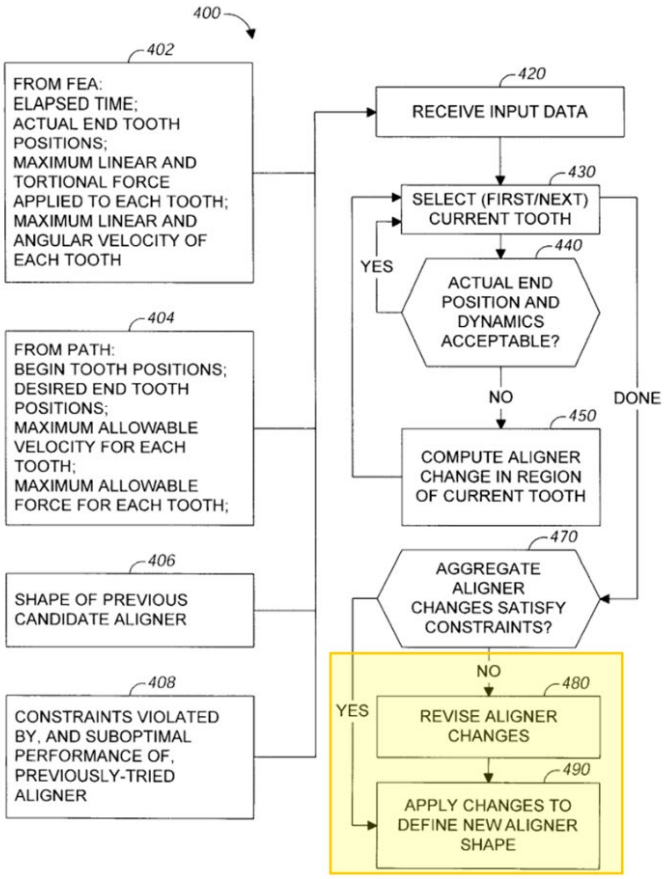


FIG. 4

Ex-1004, Fig. 4 (annotated).

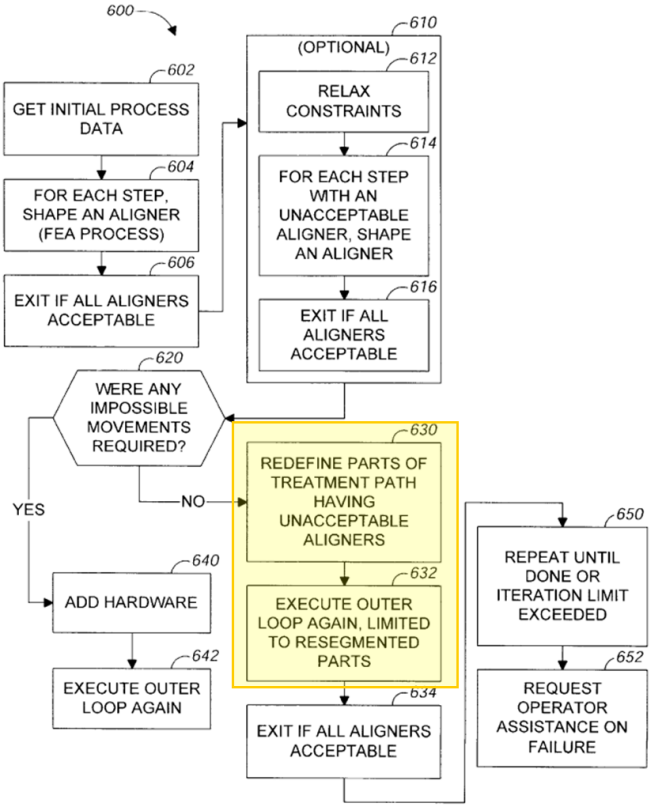


FIG. 6

Ex-1004, Fig. 6 (annotated).

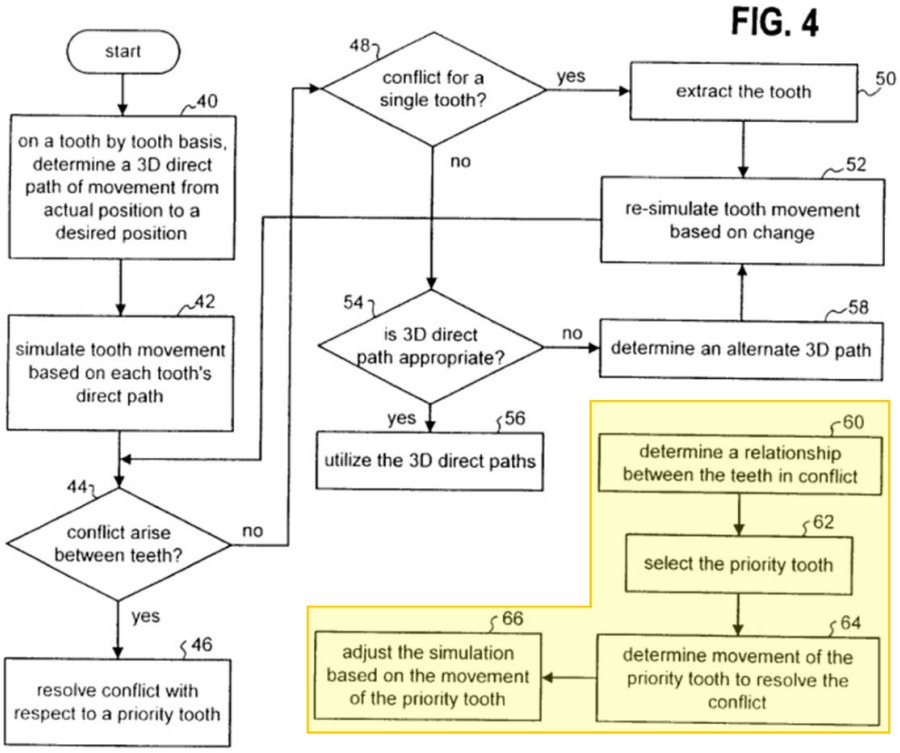
106. In my opinion, a POSITA implementing Chishti-511 would have understood that a schedule of movement resulting in a collision would be orthodontically unacceptable and require an alternative schedule. Indeed, Chishti-511's solution seeks a "clinically viable sequence of tooth positions," moving from an initial position to a final position in stages that "do[] not result in a collision of teeth." Ex-1004, 4:7-22. To ensure unacceptable aligners are not used in the treatment plan, Chishti-511 explains that its method includes a "path definition

process" to redefine portions of the treatment path that are unacceptable. Ex-1004, 8:54-9:14; *see also id.*, 8:42-9:14 (disclosing "[a]ligners may be unacceptable for a variety of reasons"). This redefinition can include "changing the increments of tooth motion, i.e., changing the segmentation, on the treatment path, changing the path followed by one or more teeth, [or both]." Ex-1004, 8:54-9:14. The schedule will continue to be modified and recalculated iteratively until all paths are deemed acceptable. *Id.* Thus, during Chishti-511's path redefinition process, aligners resulting in a collision (unacceptable aligners), are identified and the schedule of movement is modified "in response to the identifying" of a collision.

107. To the extent it is argued Chishti-511 does not expressly disclose modifying the schedule of movement in response to "identifying a collision," in my opinion, Sachdeva does. As discussed for limitation 1(c), Sachdeva describes automatically identifyingh a collision. *See* Section X.A.1.d. And for the reasons discussed in Section VIII, a POSITA would have been motivated to modify Chishti-511 to include Sachdeva's automated collision identification and avoidance teachings. Indeed, Sachdeva discloses a system for simulating tooth movement for an orthodontic patient, implemented by a computer processor, analogous to each of Chishti-511 and the challenged claims. Ex-1007, 4:39-49.

108. During Sachdeva's process, the computer determines the three-dimensional path of movement for each tooth between its actual position and its

desired position. Ex-1007, 4:39-54. It then simulates each of these treatment paths to automatically determine if "[a] conflict in movement arose between at least two teeth," and will attempt to resolve it. Ex-1007, 5:3-36, Fig. 4. In my opinion, a POSITA would have understood that a conflict arises when there is a collision between two dental objects. Indeed, Sachdeva explains that "[a]conflict may arise [between at least two teeth]" if "the movement of one tooth interferes with the direct path movement of another tooth[,] causing a particular tooth to not be able to obtain its desired position." Ex-1007, 5:3-8. As discussed for limitation 1[c], Sachdeva identifies a collision. *See* Section X.A.1.d. The system determines the changes to the movement of the teeth to resolve the conflict (modifying, by one or more computer processors, the schedule of movement) and then adjusts the overall simulation accordingly. Ex-1007, 5:27-32. Indeed, Sachdeva explains that, "[i]f a conflict arose" (i.e., in response to the identifying), the system will automatically change the "movement of the priority tooth to resolve the conflict" (performing a first modification of the schedule of movement). Ex-1007, Fig. 4; *see also id.*, 5:9-36 (discussing delaying a tooth in response to identifying a collision); *see also* Section X.A.10.b (claim 10(b), discussing Sachdeva's delaying modification).



Ex-1007, Fig. 4 (annotated). Moreover, Sachdeva explains that the steps of the method may be performed on a computer by a computer processor. Ex-1007, 3:34-50, 4:39-49 (explaining that the process can be implemented as operational instructions, stored in memory, and executed by a processing module).

109. Thus, Sachdeva discloses performing a first modification of the schedule of movement in response to identifying a collision. And, to the extent that it is argued that this feature is not disclosed by Chishti-511 alone, it would have been obvious based on Chishti-511 in view of Sachdeva.

f. [1(e)] round-tripping the first dental object.

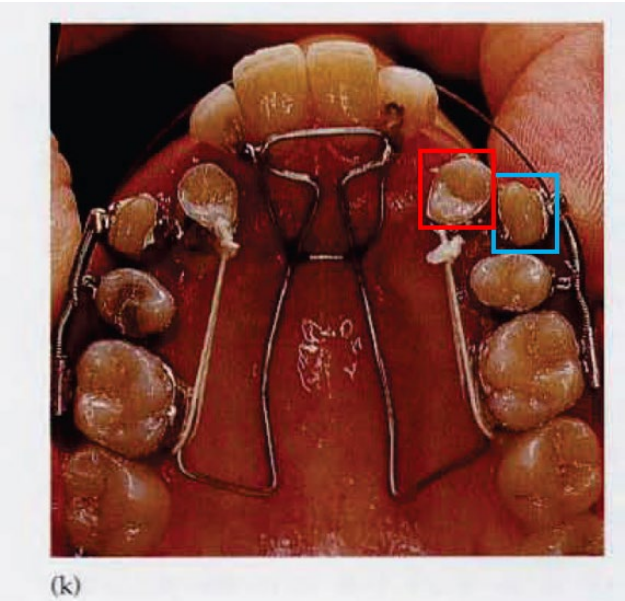
110. In my opinion, Chishti-511 in view of Becker renders this limitation obvious. I understand that the claim term "round-tripping" has been construed to mean "moving a first tooth out of the path of a second tooth, and once the second tooth has moved sufficiently, moving the first tooth back to its previous position before proceeding to a desired final position of that first tooth." Ex-1013, 8. For the same reasons discussed in Section VIII, a POSITA would have been motivated to modify the combined system to implement Becker's round-tripping collision avoidance.

111. Chishti-511 refers to "round-tripping" as a general type of indirect movement, explaining that "[r]ound-tripping is any motion of a tooth in any direction other than directly toward the desired final position." Ex-1004, 4:7-22. While Chishti-511 seeks to move teeth "in the quickest fashion with the least amount of round tripping," it recognizes that "[r]ound-tripping is sometimes necessary to allow teeth to move past each other." *Id.*

112. In my opinion, a POSITA would have understood that round-tripping is a category of movement type that may include different implementations depending on the treatment needs of a patient. A POSITA would recognize that the need for and specifics of a particular type of round-tripping motion would depend on a variety of factors, including the specific malocclusion and treatment goals, and

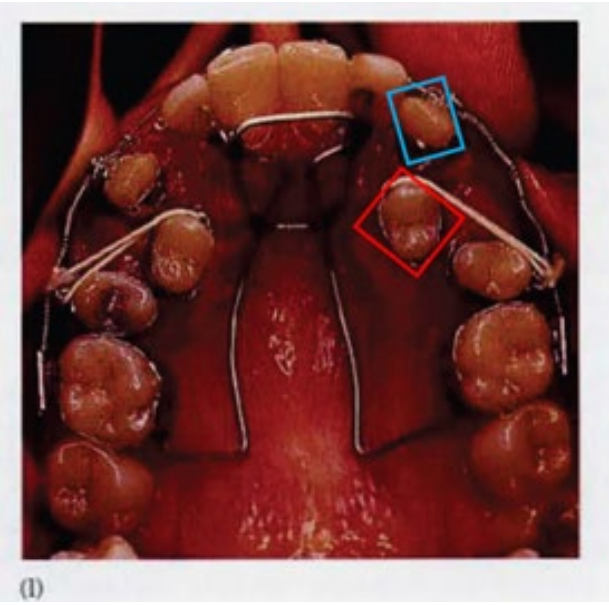
that it was a well-known orthodontic practice that in some instances may be the best treatment method for avoiding a collision among teeth. For example, in my opinion, a POSITA would have understood that round-tripping may be necessary where teeth have erupted in an abnormal position in the dental arch. In my opinion, a POSITA would have understood that in such cases, a collision would result between the teeth if the ectopic tooth is not resolved. In such instances, a POSITA would have understood that resolving such a malocclusion—particularly without extraction—may include round-tripping a tooth.

113. In my opinion, a POSITA would have understood that Becker discloses the claimed round-tripping modification to avoid a collision. Ex-1006, 5. Indeed, Becker presents a malocclusion in which a more lingual tooth ("first tooth," red) is transposed with a more buccal tooth ("second tooth," blue)—such that the more buccal tooth needs to be moved toward the incisors and the midline of the mouth. *Id.*



Ex-1006, 7 (Fig. 8.6(k) (annotated)).

114. As can be seen from Figure 8.6(k) above, moving the more buccal tooth to its proper position would cause a collision between the two teeth. To resolve the transposition, Becker discloses "slid[ing] the more buccal of the transposed teeth" (i.e., the tooth closer to the cheek) "in the medio-distal plane" (i.e., toward the midline or center of the dental arch). Ex-1006, 5. To allow this movement, Becker discloses that "the more lingual of the transposed teeth" "must be moved further lingually to allow its partner to pass by" (*id.*) ("moving a first tooth out of the path of a second tooth"). Figure 8.6(l) below depicts the more lingual tooth after it has moved lingually and allowed the more buccal tooth to pass by. Ex-1006, 5.



Ex-1006, 7 (Fig. 8.6(l) (annotated)).

115. After the more lingual tooth is moved lingually "to allow its partner [the more buccal tooth] to pass by," the more lingual tooth moves back to its previous position before proceeding to a desired final position of that first tooth. Ex-1006, 5. In particular, once the more buccal tooth has "moved sufficiently," Becker explains that the more lingual tooth "must be moved in the opposite mesio-distal direction and back in the line of the arch." *Id.* A POSITA would understand that moving the more lingual tooth in the "opposite" direction that it previously moved and "back" to where it was before ("in line of the arch") (*id.*) would move the more lingual tooth "back to its previous position."

116. A POSITA would have understood, however, that the more lingual tooth's previous position is not its final position, and that further movement is

necessary. Thus, Becker shows that the more lingual tooth continued to move (e.g., along the arch) to proceed to its desired final position. Indeed, Figure 8.6(m) below shows the more lingual tooth after it proceeds to its desired final position.

Ex-1006, 8 (Fig. 8.6(m) (annotated)).

117. Such a subsequent movement to a final position also would have been obvious to a POSITA, who would have understood that multiple small adjustments are often necessary to achieve a final satisfactory arrangement of teeth (e.g., removing all gaps, precise alignment with other teeth). Becker's subsequent movement to a final position is also consistent with Sachdeva. Sachdeva explains that a "conflict" is where "movement of one tooth interferes with the direct path movement of another tooth[,] causing a particular tooth to not be able to obtain its desired position." Ex-1007, 5:5-8. Thus, a POSITA would have understood that

Sachdeva's disclosure of "mov[ing] [a tooth] sufficiently to resolve the conflict" (Ex-1007, 5:27-30) would result in the previously blocked tooth being able to obtain its desired position. Sachdeva's "process then proceeds to step 66 where the simulation is adjusted based on the movement of the priority tooth." Ex-1007, 5:30-32.

118. A POSITA would recognize that subsequent simulation may cause further movement as the tooth proceeds, and thus, Sachdeva similarly recognizes that a treatment plan may include moving the first tooth more after resolving of the conflict.

2. Dependent Claim 2: The method of claim 1, wherein the movement pattern is selected by a user.

119. In my opinion, Chishti-876 renders this limitation obvious.

120. Chishti-876 explains that its process "allows a user to select one move pattern from a plurality of move patterns" to complete the desired dental repositioning. Ex-1005, 17:17-19; *see also* Ex-1005, 17:65-67 ("In summary, the process 2100 directs the procedure to an appropriate process depending on the move pattern that is ***specified by the user***." (emphasis added)). In my opinion, a POSITA would have been motivated to modify Chishti-511 to include Chishti-876's teachings regarding selection of a movement pattern by a user. *See* Section VIII.

3. Dependent Claim 3: The method of claim 1, wherein the selecting comprises analyzing, by a computer processor, the dental objects in their respective initial and final positions.

121. In my opinion, Chishti-511 alone or in view of Chishti-876 renders this limitation obvious.

122. Chishti-511 discloses that its computer processor analyzes the dental objects in their respective initial and final positions. As explained above for limitation 1(a), Chishti-511 gathers an initial digital data set representative of the patient's initial arrangement of dental objects (i.e., their respective initial positions) and sets "[t]he desired final position of the teeth." Ex-1004, 3:40-4:6; *supra* Section X.A.1.b. Chishti-511 explains that after "[h]aving both a beginning position and a final position for each tooth, the process [implemented by a computer processor] defines a tooth path for the motion of each tooth." Ex-1004, 4:7-22. These initial and final tooth positions are used to "optimize[]" the tooth paths "so that the teeth are moved in the quickest fashion with the least amount of round-tripping to bring the teeth from their initial positions to their desired final positions." *Id.* A POSITA would recognize that, in optimizing these movements and while creating the acceptable tooth paths, the teeth would be analyzed in their respective initial positions and respective final positions, such that each tooth's movement stays within orthodontically approved limits. *Id.* As Chishti-511 explains, these steps "are

advantageously implemented as [a] computer program" and thus executed by a computer processor. Ex-1004, 2:34-39, 3:31-39, 10:19-51.

123. To the extent it is argued that Chishti-511 does not alone disclose this limitation, in my opinion, a POSITA would have understood that such a step would have been an obvious implementation of Chishti-511 in view of Chishti-876. Specifically, Chishti-876 similarly explains that its computer-implemented process repositions a patient's teeth "from their initial tooth arrangement to a final tooth arrangement by placing a series of incremental position adjustment appliances over the patient's teeth." Ex-1005, 7:13-19; *see also* Ex-1005, 9:13-19 (explaining that the process will "define or map the movement of selected individual teeth from the initial position to the final position over a series of successive steps"), Fig. 3.

124. Chishti-876 teaches that it analyzes the dental objects in their initial and final positions when selecting a movement pattern because its system, *inter alia*, "takes into consideration the following: 1. ***Initial Position***: a detailed description of the initial maloclussion [sic]," and "2. ***Final Position***: a detailed description of treatment goals for the patient." Ex-1005, 9:34-67 (emphases added). Indeed, Chishti-876 explains that the "computer-implemented process" will use "the initial and final positions of the patient's teeth" to select the intermediate positions for each tooth and thereby generate and select "non-linear treatment paths along which a patient's teeth will travel during treatment." Ex-1005, 13:23-48.

125. Moreover, Chishti-876 explains, its system plans the "tooth path in accordance with a library of movements," based on the "given initial position of [a] patient['s] teeth and a final corrected position." Ex-1005, 16:48-55. By analyzing the initial and final position, Chishti-876's "system generates in-between stages by finding the stage positions of each tooth in accordance with a selected movement." *Id.*

126. In my opinion, a POSITA would have understood that when creating acceptable tooth path frames, the computer processor would analyze the dental objects in their initial and final positions. Thus, Chishti-876's selecting includes analyzing the dental objects in their respective initial positions and respective final positions. Chishti-876 also discloses one or more computer processors for executing instructions to perform its relevant steps. [5] *See* Ex-1005, 13:23-48, 23:7-32. In my opinion, a POSITA would have been motivated to analyze the dental objects in their initial and final positions, as a POSITA would recognize that this data would assist in analyzing whether the dental objects started and ended in their correct locations and to identify whether the generated paths had been "optimized" as taught by Chishti-511. I understand that a POSITA also would have had a reasonable

[5] This applies equally to all remaining claim limitations that recite steps performed "by a computer processor."

expectation of success in the combination of Chishti-511 and Chishti-876. Ex-1017, ¶¶ 77-78.

4. Dependent Claim 4: The method of claim 3, wherein the analyzing comprises determining, by a computer processor, a respective distance needed to move each of the dental objects from its respective initial position to its respective final position.

127. In my opinion, Chishti-876 discloses this feature. The ’217 patent admits that “the computer program can suitably calculate distances between a first tooth and a second tooth and then apply geometrical techniques, such as those disclosed in [Chishti-876].” Ex-1001, 6:45-52. As explained above for claim 3, Chishti-876 discloses that the computer processor will determine a respective distance needed to move each of the dental objects from its initial position to its desired final position. *Supra* Section X.A.3. Chishti-876 discloses using this distance: “determining [that] a tooth path comprises finding a collision-free shortest path between an initial position and a final position for one or more teeth.” Ex-1005, claim 3. In my opinion, a POSITA would have understood that determining a “shortest” path would include determining a distance between an initial position and final position to be able to determine which collision-free path is shortest. Chishti-876 also discloses with its X-type or “all equal” movement pattern, the system determines the schedule of movement by first analyzing, for each tooth, a beginning frame and ending frame, and determining if the movement from the beginning frame

to the mid frame is too large (i.e., the first half of the distance) and determining whether the movement from the mid frame to the end frame is too large (i.e., the second half of the distance). Ex-1005, 16:57-67, 18:1-42, Fig. 15-16. A POSITA would recognize that, together these values constitute the "respective distance needed to move each of the dental objects from its respective initial position to its respective final position" which is determined and analyzed by Chishti-876. Thus, the system determines the respective distance needed to move each dental object from its respective initial position to its respective final position.

128. In my opinion, a POSITA would have further understood that these distance measurements aid in achieving a safe and effective treatment. First, a POSITA would have recognized that, when possible, it is often advantageous to move the teeth as little as possible to improve chances for good treatment outcomes. Chishti-511 similarly discloses that by "[h]aving both a beginning position and a final position for each tooth, … tooth paths are optimized in the aggregate so that the teeth are moved in the quickest fashion." Ex-1004, 4:7-12. A POSITA would recognize that determining a respective distance between initial and final positions, as disclosed in Chishti-876, would allow the system to choose the shortest or quickest path available that provides proper treatment.

129. Second, as Chishti-876 explains, the path needs to comply with certain orthodontic constraints, such as "the maximum distance over which a tooth should

move between treatment steps." Ex-1005, 13:56-14:12. These constraints are patient dependent and may be different depending on "the patient's age and jaw bone density," for example. *Id.* In my opinion, because these safety limits dictate how far a given tooth may move during a treatment step, a POSITA would have understood that the Chishti-876 system analyzes the respective distance needed to move each of the dental objects from its respective initial position to its respective final position such that it can provide a treatment plan with the appropriate number of stages without violating the safety limits. *See* Ex-1005, 10:23-25 (explaining that each aligner may be designed to move a tooth approximately 0.25-0.33 mm every two weeks).

130. To the extent it is argued that the claimed distance is not determined, it would have been obvious to calculate a respective distance needed to move each of the dental objects from its respective initial position to its respective final position to ensure that the shortest path is achieved. Ex-1005, claim 3; *see also* Fig. 7, 14:25-40. In my opinion, a POSITA would have been motivated to implement, in Chishti-511's system, determining a respective distance needed to move each of the dental objects from their respective initial positions to their respective final positions to improve patient results by allowing it to determine which paths have shorter distances and to avoid the use of paths that may violate safe movement limits, especially since Chishti-511 expresses a desire to move teeth "in the quickest

fashion." Moreover, I understand that a POSITA would have had a reasonable expectation of success in such a combination. Ex-1017, ¶¶ 66-69.

5. Dependent Claim 5

a. [5(a)] The method of claim 1, further comprising: determining, by a computer processor, that the first modification does not avoid a collision between the first and second dental objects; and

131. In my opinion, Chishti-511 discloses this feature and renders it obvious both alone and in view of Sachdeva. Chishti-511 teaches determining whether the proposed path segmentations are orthodontically acceptable and, if not, iteratively modifying the segmentations until the system reaches an acceptable treatment. As explained above for limitations 1(c)-1(d), the combination will identify a collision between dental objects and perform a modification to avoid the collision. *Supra* Sections X.A.1.d-e.

132. During Chishti-511's "path definition process," it will redefine the segments of the treatment path that are unacceptable, such as those portions causing two dental objects to collide. Ex-1004, 8:54-9:14. Indeed, in my opinion, a POSITA would have understood that a treatment path causing two dental objects to collide during the treatment would result in unacceptable aligners since Chishti-511's overall goal is to incrementally reposition teeth in a clinically viable sequence of movements that "does not result in a collision of teeth." Ex-1004, 4:18-22.

133. Chishti-511 explains that "[a]fter the treatment path has been redefined" to account for the unacceptable aligners, the process is re-executed to ensure that all aligners are now acceptable (e.g., the collision has been resolved and there are no further collisions). Ex-1004, 8:54-9:14. In particular it states that "the outer loop of the overall process is executed again (step 632)" for the redefined aligners and that "the overall process can be repeated until an acceptable set of aligners is found or an iteration limit is exceeded." Ex-1004, 8:61-9:2. Thus, Chishti-511 discloses an iterative process that continues to evaluate its planned treatment until it attains an acceptable treatment path without collisions.

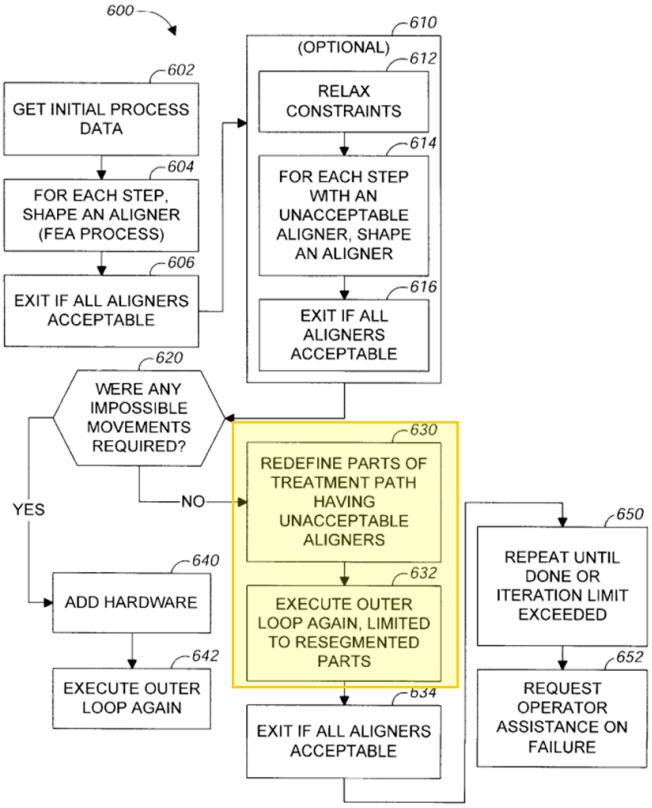


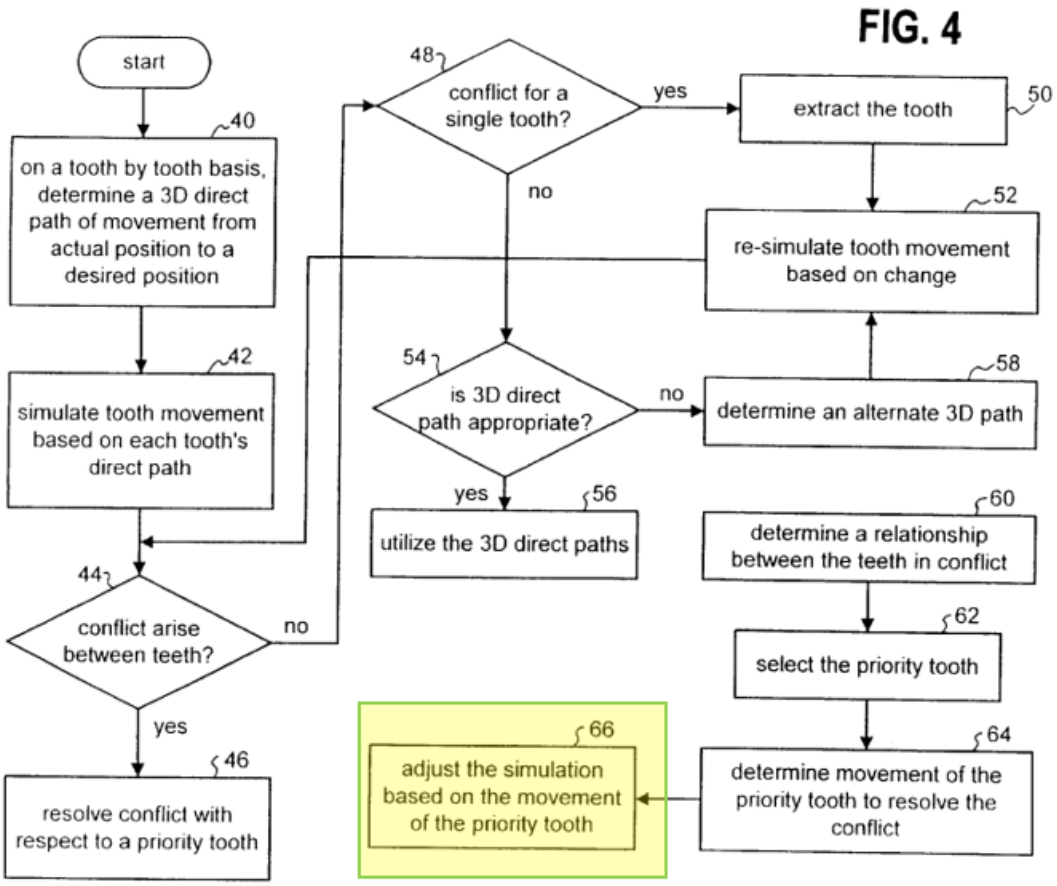
FIG. 6

Ex-1004, Fig. 6 (annotated).

134. Thus, the same steps of the combined system discussed in limitations 1(c)-1(d) will be performed again in an iterative process to determine whether the aligners are acceptable. *Supra* Sections X.A.1.d-e. If the system determines that unacceptable aligners still remain, the process repeats, identifying that a collision was not avoided and performing additional modifications or redefinitions "until an acceptable set of aligners is found." *Id.* Thus, because Chishti-511 (in view of Sachdeva) continues to check if the aligners are acceptable as the process iterates, in

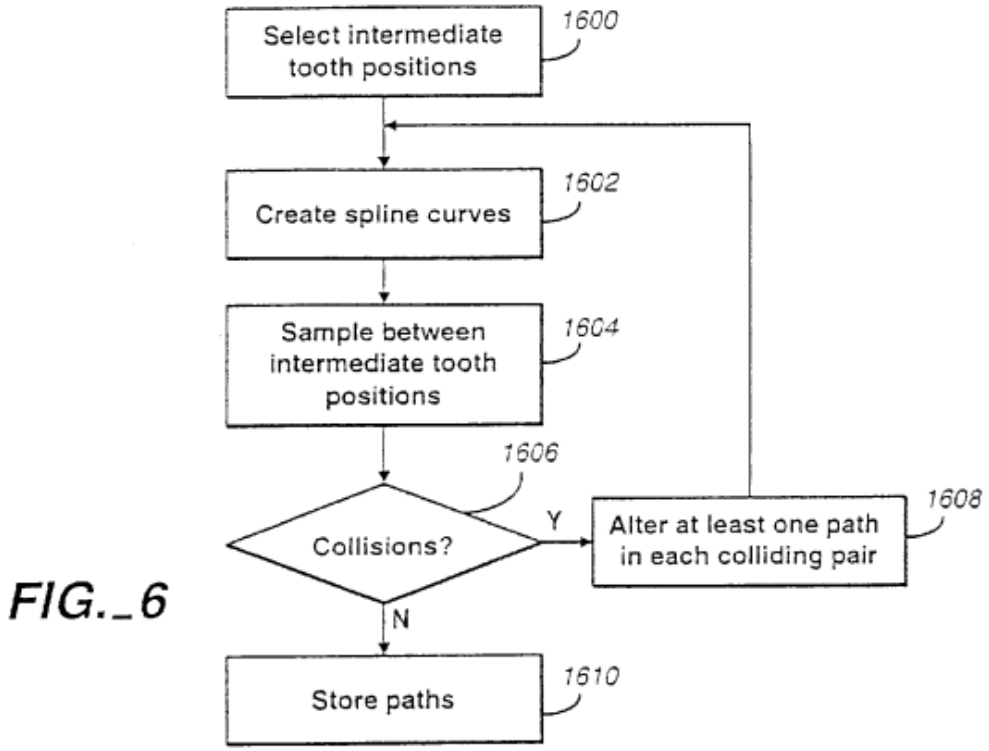
my opinion, a POSITA would have understood that its system makes a determination regarding whether the first modification (i.e., round-tripping) successfully avoided the collision between the first and second dental objects, including determining if the modification did not avoid a collision. Ex-1004, 4:18-22, 4:51-56, 5:25-43, 8:29-35; Figs. 1, 2, 4, 6.

135. This understanding of the combined system is also consistent with Sachdeva. Sachdeva discloses that "the simulation is adjusted based on the movement" previously performed to avoid a collision. Ex-1007, 5:29-32. *see also* Ex-1007, Fig. 4 (annotated):



Thus, like Chishti-511, Sachdeva will continue to simulate results to detect additional potential collisions.

136. This is further consistent with Chishti-876's disclosure of a collision detection algorithm that will create a new path to avoid a collision, and "then samples the new path (1604) and again applies the collision detection algorithm (1606)," and that "[t]he program continues in this manner until no collisions are detected." Ex-1005, 13:38-48.



Id., Fig. 6. Thus, in my opinion, this feature was well known and Chishti-511 in view of Sachdeva suggests and renders obvious additional determinations that collisions are not avoided after a first modification ("that the first modification does not avoid a collision between the first and second dental objects").

b. [5(b)] performing, by a computer processor after the determining, a second modification of the schedule of movement, the second modification comprising slowing or stopping movement of the first dental object during one or more of the treatment stages

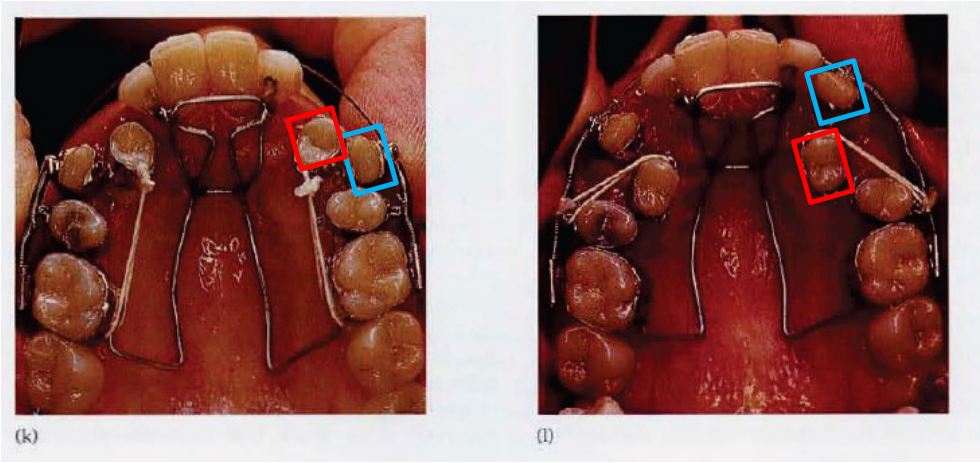
following a previous one of the treatment stages in which the first dental object moved.

137. In my opinion, Chishti-511 in view of Becker and Chishti-876 renders this limitation obvious. As explained above with reference to limitation 5(a), Chishti-511 details an iterative process. Therefore, for the same reasons discussed with respect to limitation 1(d), the combination likewise renders obvious performing a second modification of the schedule of movement. Ex-1004, 8:54-9:14 (Chishti will iteratively "redefine those parts of the treatment path [still] having unacceptable aligners."); *supra* Sections X.A.1.e, X.A.5.a. Indeed, as discussed, the system "repeat[s] until an acceptable set of aligners is found or an iteration limit is exceeded." Ex-1004, 8:54-9:14. Thus, Chishti-511's path definition process will be repeated and those unacceptable portions of the treatment path will be redefined, such as by changing the segmentation, changing the path, or both, if the first modification did not avoid a collision. Ex-1004, 8:54-9:14, Fig. 6.

138. While Chishti-511 seeks to avoid collisions, in my opinion, it leaves open to a POSITA the methods for how to alter tooth movement to avoid collisions that are detected. Chishti-876 discloses one such movement alteration method of slowing a tooth's movement during treatment stages. Ex-1005, 12:25-31 ("One component may accelerate along a curve between one pair of stages (e.g., stages 3 and 8 in a treatment plan having that many stages), while another moves linearly

between another pair of stages (e.g., stages 1 to 5), and then changes direction suddenly and slows down along a linear path to a later stage (e.g., stage 10)"). Thus, in Chishti-876 one is scheduled to move at a rate less than the rate of other teeth (Ex-1001, 13:3-7) as the other described tooth accelerates (whereas the slower tooth moves linearly) and thereafter the slower tooth "slows down" even further relative to the other described tooth so that a collision does not occur, consistent with the agreed-upon construction for slowing. Ex-1005, 12:25-31. Further, the tooth slows "during one or more of the treatment stages following a previous one of the treatment stages in which the first dental object moved," consistent with the claim.

139. As described above, Becker's technique involves moving a tooth (the more lingual tooth, below) to allow another tooth (the more buccal tooth, below) "to pass by." Ex-1006, 5.



See also Ex-1006, 7 (Figs. 8.6(k), (l) (annotated)).

140. In my opinion, a POSITA would recognize that after the more lingual tooth was moved lingually ("following a previous one of the treatment stages in which the first dental object moved"), it would be stationary or stopped for some time to allow the more buccal tooth to "pass by." A first iterative modification using Chishti-511's system may find that the more lingual tooth was not stopped long enough for the more buccal tooth to "pass by," and a collision may still result. A POSITA would have found it obvious for the same reasons discussed above and with respect to claim 1 to further modify the parameters associated with using Becker's treatment ("a second modification of the schedule of movement"), such as lengthening the number of treatment stages that the more lingual tooth is stopped, to ensure that the more buccal tooth can "pass by" as directed by Becker ("stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages in which the first dental object moved"). A second modification as described would help ensure that a collision is avoided, and that Becker's technique is properly applied. In my opinion, it is also consistent with the iterative system of Chishti-511, which recognizes that multiple changes to aligners may need to take place to identify acceptable aligners. Ex-1004, 4:43-50, 5:7-30, 6:57-7:8, 8:29-35.

141. Chishti-876 likewise provides a solution to this problem. Like Chishti-511, Chishti-876's program will detect collision and iteratively alter the movement

of at least one of the colliding teeth until no collisions are detected. Ex-1005, 13:23-48. Indeed, Chishti-876 explains that once its process generates treatment paths, its program "applies [a] collision detection algorithm" to determine if the generated paths will cause a collision among any dental objects. *Id.* If a collision is detected, Chishti-876 discloses a program to "alter[] the path of at least one tooth in each colliding pair." *Id.* The program will rerun the collision detection program and continue to alter the treatment paths until no collisions are detected. *Id.*

142. To avoid an impending collision, Chishti-876 explains that incrementally moving a dental object an equal distance each increment towards its final position may not always be satisfactory. Ex-1005, 12:6-21, 13:23-48. Instead, alterations of the movements may be necessary. *Id.* For instance, in some situations, the dental objects may need to move towards an intermediate position (using key frames) before moving in a different direction towards either another key frame or its final desired position (Ex-1005, 12:6-21), while in other situations (such as those causing collisions), Chishti-876 teaches ***slowing*** or stopping the dental objects along the movement pattern (Ex-1005, 12:22-32).

143. Specifically, Chishti-876 explains that, advantageously, each dental object may move independently (e.g., one moving at one rate as another moves at a slower rate). Ex-1005, 3:24-33, 12:22-25. Therefore, one dental object may be accelerated along the path between stages while another may have moved linearly

between preceding stages, then suddenly change direction "and ***slow[] down*** along a linear path to a later stage" ("slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages in which the first dental object moved"). Ex-1005, 12:25-31 (emphasis added). This satisfies the agreed construction of "slowing" as it describes "having one or more teeth scheduled to move at a rate less than the rate of other teeth." Ex-1013, 8. Thus, Chishti-876 details a flexible system "allow[ing] a great deal of freedom in planning a patient's treatment" with several options to avoid collisions or other patient-specific circumstances, including slowing dental objects during one or more of the treatment stages following a previous one of the treatment stages in which the first dental object moved. Ex-1005, 12:22-32.

144. In my opinion, and as discussed above, a POSITA would understand that applying Becker's technique may still result in a collision if the more buccal tooth is not given sufficient time to "pass by" before the more lingual tooth is moved to its previous and final positions. As an alternative to the more lingual tooth remaining stationary for longer, a POSITA would have recognized that Chishti-876 provides a suitable alternative solution. In particular, a POSITA would have been motivated to implement Chishti-876's teaching of slowing a dental object, as they would have understood that slowing the more lingual tooth ("first dental object") after it is moved out of the path of the more buccal tooth ("second dental object") so

that it is scheduled to move at a rate less than the rate of the more buccal tooth would provide more time for the more buccal tooth to "pass by" before the more lingual tooth would move to its previous location. Thus, it would be obvious to have "one or more teeth scheduled to move at a rate less than the rate of other teeth, … so that collisions and/or obstructions do not occur," as recited in the agreed-upon construction of slowing.

145. In my opinion, a POSITA would have found this to be beneficial because, if the rate of movement of the premolar was slowed, it may move toward its previous and final positions sooner while still avoiding a collision, potentially leading to faster overall treatment. In my opinion, a POSITA would have been motivated to find the manner in which treatment could be completed soonest, as Chishti-511 expressly discloses that it is interested in the teeth being "moved in the quickest fashion with the least amount of round-tripping to bring the teeth from their initial positions to their desired final positions." Ex-1004, 4:7-12. By starting the more lingual tooth toward its previous and final positions sooner, and leveraging a slower rate of movement to avoid collisions, a POSITA would understand that this could bring the teeth from their initial positions to their desired final positions in a quicker manner than keeping the more lingual tooth stationary for a longer period of time. In this manner, the round-tripped tooth would also potentially be out of position for less time, which would increase the chances of successful treatment.

Thus, in my opinion, it would have been obvious for the computer process to use Chishti-876's slowing feature after the determining as a "second modification" to the schedule of movement.

146. Moreover, in my opinion, a POSITA would have understood that modifying a schedule to include slowing or stopping were two of a finite number of identified, predictable solutions. I understand that a POSITA would have had a reasonable expectation of success in modifying Chishti-511 to include Becker's stopping or Chishti-876's slowing technique within Chishti-511's software system. Ex-1017, ¶¶70-71.

6. Dependent Claim 6

a. [6(a)] The method of claim 5, further comprising: determining, by a computer processor, that the second modification does not avoid a collision between the first and second dental objects; and

147. In my opinion, Chishti-511 discloses this feature and renders it obvious both alone and in view of Sachdeva for the same reasons discussed with respect to limitation 5(a) above. *Supra* Section X.A.5.a. Indeed, because it is an iterative process, the combination will determine after each modification if any orthodontically unacceptable movements, such as collisions, will occur (including whether the modification does not avoid a collision), especially in view of Chishti-

511's goal of incrementally repositioning teeth in a clinically viable sequence of movements that "does not result in a collision of teeth." Ex-1004, 4:18-22.

b. [6(b)] performing, by a computer processor after determining that the second modification does not avoid a collision, a third modification of the schedule of movement, the third modification comprising round-tripping the first dental object.

148. In my opinion, Chishti-511 in view of Sachdeva and Becker renders this limitation obvious. As discussed for limitation 5(a), Chishti-511 includes an iterative process that performs modifications, redefining the schedule of movement until an acceptable set of aligners is found. Ex-1004, 8:54-9:14; *see* Section X.A.5.a. Thus, in my opinion, a POSITA would have understood Chishti-511 to disclose an iterative process for altering the segmentation until one is found that is acceptable. Chishti-511 expressly provides that a segmentation resulting in a collision would be unacceptable. *See* Ex-1004, 4:7-22. Accordingly, in my opinion, a POSITA would have understood from Chishti-511 in view of Sachdeva that if a second modification of the schedule of movement does not resolve the collision between teeth, a third modification or redefinition would be performed. Using round-tripping as a modification would have been obvious for the same reasons discuss above in limitation 1(e). *Supra* Section X.A.1.f.

149. A POSITA would understand that a collision may still be present after the second modification (slowing or stopping) is performed if the second tooth

begins moving too quickly before the first tooth has had time to "pass by." An unacceptable aligner may still be present after stopping or slowing the first tooth if, for example, the first tooth did not move far enough away or did not move away quickly enough. Additional issues may arise if a second tooth were to begin to move too soon or too quickly before the first tooth has sufficiently moved out of the path of the second tooth. In my opinion, a POSITA would understand that various parameters may be modified to achieve acceptable treatment.

150. In my opinion, while Chishti-511 explains that the schedule of movement would be modified in light of an unresolved collision, it leaves open to a POSITA the methods for how to avoid the collision. One such avoidance method, disclosed in Becker, is a method of round-tripping the first dental object. Thus, this limitation is rendered obvious by the combination for the same reasons as above in limitation 1(e). *Supra* X.A.1.f.

151. Moreover, the subsequent (third) modification of the schedule of movement may include round-tripping differently from the first modification in any one of a variety of ways. In the context of Becker's disclosure, for example, the third modification may change (1) how far away the more lingual tooth moves to ensure avoidance of the more buccal tooth, (2) the rate that the more lingual tooth moves out of the path of the more buccal tooth to ensure it avoids the more buccal tooth's path of movement, (3) the treatment stage at which the more buccal tooth begins to

move to ensure the more lingual tooth has had time to move out of the way (such as delaying when the more buccal tooth begins to move),[6] (4) the rate of movement of the more buccal tooth to ensure that the more lingual tooth has had time to move out of the way, or (5) the direction of movement for the more lingual tooth to ensure a collision is avoided. In my opinion, a POSITA also would have understood that modifying a schedule to include round-tripping is one of a finite number of identified, predictable solutions.

7. Dependent Claim 7

a. [7(a)] The method of claim 1, further comprising: determining, by a computer processor, that the first modification does not avoid a collision between the first and second dental objects; and

152. In my opinion, Chishti-511 in view of Sachdeva discloses this feature for the same reasons discussed with respect to limitation 5(a). *Supra* Section X.A.5.a.

b. [7(b)] performing, by a computer processor after the determining, a second modification of the schedule of movement, the second modification comprising round-tripping the first dental object.

153. In my opinion, Chishti-511 in view of Sachdeva and Becker renders this limitation obvious for the same reasons discussed with respect to limitations 1(e)

[6] As discussed below with respect to limitation 10(b) (*infra* Section X.A.10.b), delaying initial movement of a tooth was well known and would have been obvious in this context for the same reasons discussed there.

and 6(b). *Supra* Section X.A.1.f and X.A.6.b. Although claim 6(b) recites performing round-tripping as a third modification, as discussed, round-tripping would have been an obvious option for a first modification (claim 1(e)) or a second modification, as recited in claim 7(b). In my opinion, due to Chishti-511 iteratively performing modifications and redefining the schedule of movement until an acceptable set of aligners is found, a POSITA would have understood that if a first modification (round-tripping the first dental object) does not resolve the collision between teeth, a second modification or redefinition would need to be performed. Ex-1004, 8:54-9:14. Indeed, as explained above, this subsequent modification of the schedule of movement may include modifying aspects of the round-tripping to resolve the collision. *Supra* Section X.A.5-.6. In my opinion, this type of iterative processing would have been obvious in view of Chishti-511's and Sachdeva's teachings, and a POSITA would have been motivated to look to Becker for the same reasons as stated above for at least limitation 1(e). *Supra* Sections VIII, X.A.1.f.

8. Dependent Claim 8: The method of claim 1, further comprising producing a series of orthodontic appliances based at least on the modified schedule of movement, wherein each of the orthodontic appliances corresponds to a respective one of the treatment stages.

154. In my opinion, Chishti-511 discloses this feature. As Chishti-511 explains, each appliance has a specific geometry selected to reposition a tooth from its initial arrangement to a first intermediate arrangement. Ex-1004, 1:47-58. Once

that intermediate arrangement is approached or achieved, then one or more additional intermediate appliances are produced and successively placed on the teeth, moving the teeth in stages, until a final appliance is placed on the teeth resulting in the desired final tooth arrangement. Ex.1004, 1:33-58; *see also* Ex-1004, 4:51-67 (explaining that "each appliance configuration represents a step along the treatment path" and segmented tooth paths are then "used to calculate clinically acceptable appliance configurations"); *supra* Section X.A.1.b (1(a)) (discussing the segmented tooth paths). Thus, in my opinion, each of the orthodontic appliances (a series of orthodontic appliances) in Chishti-511 correspond to a respective one of the treatment stages. Chishti-511 further explains that process 100 may be "implemented as computer program modules for execution on one or more conventional digital computers" and includes a "manufacturing step (step 180) in which appliances defined by the process are manufactured." Ex-1004, 3:32-39, 5:1-6; *see also* Ex-1004, 10:19-51.

155. Chishti-511 discloses a process and system to define tooth paths and segmentations to ultimately reposition teeth into a final desired position. Ex-1004, 4:7-22. It does so iteratively, modifying the segmentations until the system achieves an acceptable movement pattern. Ex-1004, 8:54-9:14 (explaining that the movement pattern will continue to be modified and recalculated iteratively until all paths are deemed acceptable); *supra* Sections X.A.1.d.-.f (1(c)-1(e)), X.A.5-.7 (claims 5-7).

156. Chishti-511 further discloses that the appliances are manufactured (produced) after the schedule of movement is redefined and acceptable. Indeed, as shown in Chishti-511's Figure 1 below, the repositioning appliances are manufactured, producing an appliance for each step of the treatment path defined by the segmentation:

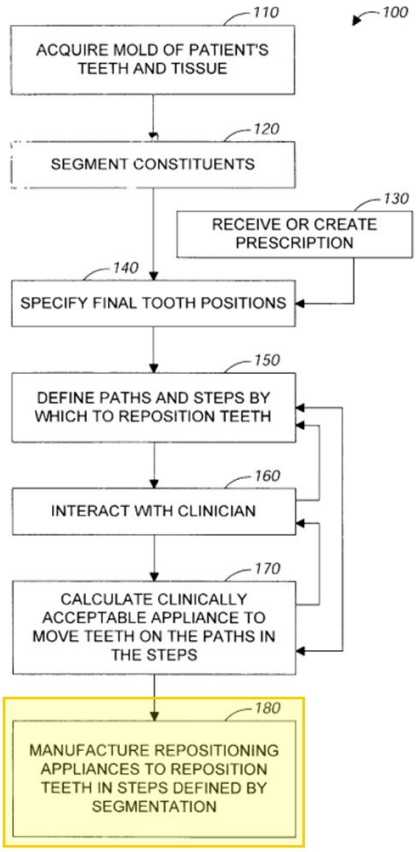


FIG. 1

Ex-1004, Fig. 1 (annotated); *see also* Ex-1004, 5:1-6. Thus, the series of orthodontic appliances is based at least on the modified schedule of movement.

9. Dependent Claim 9

a. [9(a)] The method of claim 8, wherein the producing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and

157. In my opinion, Chishti-511 discloses this feature, explaining that its manufacturing process relies on the "generation of positive models to produce the repositioning appliance[s]," and that "adding a wax patch to the digital model will generate a positive mold that has the same added wax patch geometry." Ex-1004, 9:43-56. As explained above, each appliance configuration represents one stage along the treatment path. Ex-1004, 4:51-67. Therefore, for each aligner, a respective positive physical model of the patient is created from the digital scan. Ex-1004, 9:43-56. Then, the "aligner is manufactured by pressure fitting polymeric material over a positive physical model of the digital teeth," respective to that stage of the treatment path. *Id.*

158. In my opinion, a POSITA would have understood that because this manufacturing process is required to produce the aligners for each stage of the movement pattern, this fabrication would be required for at least two of the treatment stages, as claimed.

b. [9(b)] thermoforming a respective one of the orthodontic appliances over each of the respective positive molds.

159. In my opinion, Chishti-511 alone or in view of Chishti-876 renders this feature obvious. As explained above, Chishti-511 discloses that the aligners may be manufactured by pressure fitting polymeric material over a positive physical model of the digital teeth. Ex-1004, 9:43-56. In my opinion, a POSITA would have understood that the ’217 patent’s claimed “thermoforming” fabrication is disclosed by Chishti-511’s pressure fitting manufacturing process. A POSITA would have understood that thermoforming is a well-known manufacturing process whereby a plastic sheet is heated to a pliable temperature, shaped into a specific form using a mold, and then cooled to maintain its new shape. Pressure-fitting a polymeric material over a positive physical model of teeth—as disclosed in Chishti-511—would be understood by a POSITA to be a type of thermoforming, as pressure-fitting uses air pressure in conjunction with the heated plastic sheet to help shape the appliance in the form of the mold. Indeed, the ’217 patent admits that this process was known—the specification’s only mention of a manufacturing technique describes “using a ***conventional pressure molding*** technique to form the appliance around the positive mold.” Ex-1001, 3:38-44 (emphasis added). Thus, the ’217 patent admits that the required fabrication process was merely “conventional,” (*id.*), and a POSITA would have understood that the ’217 patent’s conventional

manufacturing process, which is consistent with Chishti-511's disclosure of pressure fitting, matches the '217 patent's disclosure, making this limitation both disclosed and rendered obvious by Chishti-511.

160. To the extent it is argued that Chishti-511 does not disclose this feature, and that "thermoforming" means something other than "pressure molding," in my opinion, this limitation is rendered obvious by the combination. Indeed, Chishti-876 discloses fabricating the orthodontic aligners by "thermoforming." Ex-1005, 7:54-64.

161. Chishti-876 explains that its dental appliances may be polymeric shells configured to receive a patient's teeth and reposition them into an intermediate or final tooth arrangement. Ex-1005, 7:1-18. To manufacture these dental appliances, Chishti-876 uses known methods, such as forming the appliances "from a thin sheet of a suitable elastomeric polymer, such as Tru-Tain 0.03 in, ***thermal forming*** dental material, available from Tru-Tain Plastics, Rochester, Minn." Ex-1005, 7:54-64. A POSITA would have understood that the disclosed thermal forming dental material would create Chishti-876's polymeric shells through the process of thermoforming the dental material over a respective positive mold (as described in Chishti-511).

162. In my opinion, a POSITA also would have been motivated to consider the teachings of Chishti-876 regarding the manufacture of dental aligners disclosed in Chishti-511. Chishti-511 discloses that the aligners may be manufactured by

pressure fitting polymeric material over a positive physical model of the digital teeth. Ex-1004, 9:43-56. In my opinion, a POSITA would have been motivated to look to ways to manufacture the generated aligners, and Chishti-876 discloses known methods for manufacturing these dental appliances. Ex-1005, 7:54-64.

163. In my opinion, a POSITA would have understood the use of thermoforming for appliance manufacturing would have had a reasonable expectation of success, as thermoforming is just one of a finite number of identified, predictable solutions, and was a well-known and routine technique for aligner manufacturing at the relevant time. The '217 patent's specification and reference texts confirm that thermoforming was a well-known technique for aligner manufacturing at the time of the invention. *See, e.g.*, Ex-1001, 3:38-44 ("One technique for producing an orthodontic appliance involves creating a positive mold of the patient's dentition at one of the treatment stages and using a conventional pressure molding technique to form the appliance around the positive mold."). In my opinion, the state of the art also confirms this technique was known. Ex-1016, 198 ("A thermoforming process is used for aligner fabrication. A thermoplastic sheet is first heated and then a vacuum/pressure thermoforming process is used to form the aligner. The hot sheet is drawn down over a stereolithographic (SLA) model of the patient's dental anatomy. Pressure and vacuum forces cause the material to adapt or conform to the SLA model."); Ex-1016, 18-23 (describing the history of

thermoforming and explaining that a thermoforming technique was first used to fabricate dental appliances in 1959). A POSITA also would have had a reasonable expectation of success in combining these teachings, given that thermoforming was a well-known manufacturing option at the time. Accordingly, in my opinion, it would have been obvious to a POSITA at the relevant time to combine Chishti-876's disclosure of thermoforming with Chishti-511's disclosure of manufacturing the dental aligners.

10. Dependent Claim 10

a. [10(a)] The method of claim 1, further comprising: performing, by a computer processor, a second modification of the schedule of movement in response to the identifying, the second modification comprising one or more of:

164. In my opinion, Chishti-511 discloses this feature and renders it obvious both alone and in view of Sachdeva. In my opinion, a POSITA would have understood that Chishti-511 explains that if a collision is identified, there is an unacceptable movement pattern requiring "changing the increments of tooth motion, i.e., changing the segmentation, on the treatment path, changing the path followed by one or more teeth in the treatment path, ***or both***." Ex-1004, 8:54-9:14 (emphasis added). Thus, in my opinion, a POSITA would have understood that more than one modification may be performed and may be necessary during the redefinition phase in response to the identification of an impending collision. Thus, in response to

identifying a collision, Chishti-511's process will perform a second modification or redefinition to avoid the collision, resulting in an acceptable set of aligners. In my opinion, a POSITA would have understood that the movement of teeth in the crowded mouth of a patient with a malocclusion will often require multiple techniques involving coordinated teeth movements and may include the delaying, slowing, or stopping of teeth movement as teeth proceed to their final positions.

165. For the same reasons as explained for limitations 1(c) and 1(d), to the extent it is argued that Chishti-511 does not disclose modifying the schedule of movement "in response to" identifying a collision, Sachdeva does. *Supra* Section X.A.1.d-e. And in my opinion, a POSITA would have been motivated to modify the combined system to implement Sachdeva's modification in light of a collision identification for the same reasons as stated above for limitations 1(c) and 1(d). *Supra* Sections X.A.1.d-.e.

b. [10(b)] delaying initial movement of the first dental object; and

166. In my opinion, Sachdeva discloses this feature. As explained above for limitation 1(c), Sachdeva describes a process for resolving conflicts among teeth, such as the conflict that arises when "the movement of one tooth interferes with the direct path movement of another tooth," causing a collision. Ex-1007, 5:3-8; *supra* Section X.A.1.d. Sachdeva discloses that in some circumstances, such as those

where "the lower tooth protrudes preventing the upper tooth from moving back, the lower tooth must be moved before the upper tooth can be positioned" (delaying initial movement of the upper tooth). Ex-1007, 5:9-26. "Conversely, if the upper tooth is interfering with the lower tooth from being moved out, the upper tooth must first be moved" (delaying initial movement of the lower tooth). *Id.* In my opinion, a POSITA would have understood that that, normally, teeth will move at the same time if possible. In the examples provided by Sachdeva, however, two teeth are prevented from initially moving together due to interfering with each other. Thus, Sachdeva discloses delaying the initial movement of the blocked tooth until the obstruction has been cleared. In my opinion, a POSITA would have understood that Sachdeva's disclosure details an instance where, in response to the identification of a collision, the initial movement of a dental object must be delayed in order to allow another dental object to first be moved, as claimed.

167. Additionally, delaying may also be used as a second modification in combination with a first, round-tripping modification. As discussed with respect to limitation 6(b), there are many parameters that may be adjusted with respect to the round-tripping technique to avoid collisions. *Supra* Section X.A.6.b. In Becker's exemplary patient, the more lingual tooth is free to move in the mesio-distal plane unobstructed, yet a POSITA would recognize that for other patients, that tooth might not be able to move immediately. For example, movement of the more lingual tooth

may be restricted by an incisor. In that situation, a POSITA would recognize that the incisor may need to be moved first, before the more lingual tooth may be moved out of the way of the more buccal tooth. In such a situation, initial movement of the more lingual tooth (the first dental object) would need to be delayed, as the incisor would take priority and need to be moved first, as disclosed in Sachdeva.

168. Thus, this feature is rendered obvious by the combination of references, and for the reasons explained in Section VIII, in my opinion, a POSITA would have been motivated to modify Chishti-511 to include Sachdeva's delaying technique to avoid collisions.

c. [10(c)] slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages during which the first dental object moved.

169. In my opinion, Chishti-511 in view of Chishti-876 and Sachdeva renders this limitation obvious. Limitations 10(b) and 10(c) recite that the second modification "compris[es] one or more of[] delaying … and slowing or stopping." In my opinion, if an interpretation is applied that requires only one of either (i) delaying ***and/or*** (ii) slowing or stopping, Sachdeva discloses the claimed delaying feature as discussed with respect to limitation 10(b), satisfying this claim.

170. However, if it is argued that this limitation also requires "slowing or stopping movement" in addition to delaying initial movement, in my opinion,

Chishti-511 in view of Sachdeva and Chishti-876 renders this limitation obvious for the same reasons as above for limitation 5(b). *Supra* Section X.A.5.b. As discussed with respect to limitation 5(b), in my opinion, Chishti-876 discloses techniques for slowing a dental object following a previous one of the treatment stages where it moved. Additionally, my earlier analysis also provides additional discussion of how and why slowing a dental object may be used as an option in the context of a modification of round-tripping. A POSITA would have understood that the crowded geometry of a patient's teeth often requires multiple adjustments to a treatment plan to achieve an efficient and collision-free schedule of movement. Moreover, the analysis of limitations 10(b), 6(b), and 5(b) explain why the combination of delaying and slowing/stopping may be used (e.g., delaying the more lingual tooth if initial movement is obstructed and slowing/stopping more lingual tooth as/before it moves to its previous and final positions, to ensure the more buccal tooth has time to pass by). *Supra* Sections X.A.5.b (5(b)), X.A.6.b (6(b)), X.A.10.b (10(b)). Thus, in my opinion, claim 10 is rendered obvious regardless of whether one or both of delaying and slowing/stopping are required.

11. Independent Claim 11

a. [11(pre)] A non-transitory computer-readable medium comprising instructions that, when executed

by one or more computer processors, cause at least one of the one or more processors to:

171. Claim 11 recites features that are substantively identical to features recited in claim 1, with the exception of differing language in the preamble and removal of "by a computer processor." *Compare* Ex-1001, 16:6-25, *with* Ex-1001, 17:17-37. The table below shows the correspondence between the claims.

Claim 1	Claim 11
[1(pre)] A method comprising:	[11(pre)] A non-transitory computer-readable medium comprising instructions that, when executed by one or more computer processors, cause at least one of the one or more processors to:
[1(a)] selecting a movement pattern from a plurality of movement patterns for moving dental objects from an initial arrangement toward a final arrangement, the dental objects being based on output of a scanning device, the movement pattern defining a schedule of movement of the dental objects during treatment stages as each of the dental objects moves from a respective initial position toward a respective final position;	[11(a)] select a movement pattern from a plurality of movement patterns for moving dental objects from an initial arrangement toward a final arrangement, the dental objects being based on output of a scanning device, the movement pattern defining a schedule of movement of the dental objects during treatment stages as each of the dental objects moves from a respective initial position toward a respective final position;
[1(b)] calculating, by a computer processor, a respective treatment path for each of the dental objects between its respective initial and final positions;	[11(b)] calculate a respective treatment path for each of the dental objects between its respective initial and final positions;
[1(c)] identifying, by a computer processor, a collision between a first of the dental objects and a second of the	[11(c)] identify a collision between a first of the dental objects and a second of the dental objects based at least on

dental objects based at least on one of the respective treatment paths; and	one of the respective treatment paths; and
[1(d)] performing, by a computer processor, a first modification of the schedule of movement in response to the identifying, the first modification comprising:	[11(d)] perform a first modification of the schedule of movement in response to the identifying, the first modification comprising:
[1(e)] round-tripping the first dental object.	[11(e)] round-tripping the first dental object.

172. In my opinion, to the extent the preamble is limiting, Chishti-511 discloses it. As discussed previously with respect to limitation 1(b), Chishti-511 discloses that its system may be implemented in "computer programs" that are executed on "at least one programmable processor." Ex-1004, 10:29-43; *supra* Section X.A.1.c. Chishti-511 explains that its system "can be implemented as a computer program product, tangibly stored on a computer-readable medium, having instructions operable to cause a computer to perform the steps of the method of the invention." Ex-1004, 2:34-39. Chishti-511 further explains that the "data processing aspects of the invention can be implemented advantageously in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from and to transmit data and instructions to a data storage system, at least one input device, and

at least one output device." Ex-1004, 10:29-35.[7] Chishti-511 also discloses "[s]torage devices suitable for tangibly embodying computer program instructions" and provides various examples of "non-transitory computer-readable medium[s]." Ex-1004, 10:43-51. This is consistent with Chishti-876's and Sachdeva's disclosures of one or more computer processors for executing instructions to perform its relevant steps. *See* Ex-1005, 13:23-48, 23:7-32; Ex-1007, 4:39-49.

173. Accordingly, claim limitations 11(pre)-11(e) are taught or suggested for the reasons discussed here and in Sections X.A.1.a-.f, which discuss the corresponding portions of claim 1.

12. Dependent Claims 12-20

174. Claims 12 through 20 repeat or recite features that are substantively identical to features recited in claims 2-10, respectively. For example, the features added by claims 12, 19, and 20 are identical to claims 2, 9 and 10, respectively. Claims 13 and 14 are identical to claims 3 and 4, respectively, except for the removal of "by a computer processor" in claims 13 and 14. And claims 15-18 have slightly more extensive changes to their wording relative to earlier claims, but they remain largely identical to claims 5, 6, 7, and 8, respectively. *Compare* Ex-1001, 16:26-

[7] This applies equally to all remaining claim limitations, which recite "instructions [that], when executed by the one or more processors, further cause at least one of the one or more processors" to perform steps.

17:16, *with* Ex-1001, 17:38-18:51. The tables below show the correspondence between the claims.

Claim 2	Claim 12
The method of claim 1, wherein the movement pattern is selected by a user.	The medium of claim 11, wherein the movement pattern is selected by a user.

Claim 3	Claim 13
The method of claim 1, wherein the selecting comprises analyzing, by a computer processor, the dental objects in their respective initial and final positions.	The medium of claim 11, wherein the selecting comprises analyzing the dental objects in their respective initial and final positions.

Claim 4	Claim 14
The method of claim 3, wherein the analyzing comprises determining, by a computer processor, a respective distance needed to move each of the dental objects from its respective initial position to its respective final position.	The medium of claim 13, wherein the analyzing comprises determining a respective distance needed to move each of the dental objects from its respective initial position to its respective final position.

Claim 5	Claim 15
[5(a)] The method of claim 1, further comprising:	[15(a)] The medium of claim 11, wherein the instructions, when executed by the one or more processors, further cause at least one of the one or more processors to:
determining, by a computer processor, that the first modification does not avoid	determine that the first modification does not avoid a collision between the first and second dental objects; and

a collision between the first and second dental objects; and	
[5(b)] performing, by a computer processor after the determining, a second modification of the schedule of movement, the second modification comprising slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages in which the first dental object moved.	[5(b)] perform, after the determining, a second modification of the schedule of movement, the second modification comprising slowing or stopping the movement of the first dental object during at least one of the treatment stages following a previous one of the treatment stages during which the first dental object moved.

Claim 6	Claim 16
[6(a)] The method of claim 5, further comprising:	[16(a)] The medium of claim 15, wherein the instructions, when executed by the one or more processors, further cause at least one of the one or more processors to:
determining, by a computer processor, that the second modification does not avoid a collision between the first and second dental objects; and	determine that the second modification does not avoid a collision between the first and second dental objects; and
[6(b)] performing, by a computer processor after determining that the second modification does not avoid a collision, a third modification of the schedule of movement, the third modification comprising round-tripping the first dental object.	[16(b)] perform, after determining that the second modification does not avoid a collision, a third modification of the schedule of movement, the third modification comprising round-tripping the first dental object moved.

Claim 7	Claim 17
[7(a)] The method of claim 1, further comprising:	[17(a)] The medium of claim 11, wherein the instructions, when executed

determining, by a computer processor, that the first modification does not avoid a collision between the first and second dental objects; and	by the one or more processors, further cause at least one of the one or more processors to: determine that the first modification does not avoid a collision between the first and second dental objects; and
[7(b)] performing, by a computer processor after the determining, a second modification of the schedule of movement, the second modification comprising round-tripping the first dental object.	[17(b)] perform, after the determining, a second modification of the schedule of movement, the second modification comprising round-tripping the first dental object.

Claim 8	Claim 18
The method of claim 1, further comprising producing a series of orthodontic appliances based at least on the modified schedule of movement, wherein each of the orthodontic appliances corresponds to a respective one of the treatment stages.	The medium of claim 11, wherein the instructions, when executed by the one or more processors, further cause at least one of the one or more processors to produce a series of orthodontic appliances based at least on the modified schedule of movement, wherein each of the orthodontic appliances corresponds to a respective one of the treatment stages.

Claim 9	Claim 19
[9(a)] The method of claim 8, wherein the producing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and	[19(a)] The medium of claim 18, wherein the producing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and

[9(b)] thermoforming a respective one of the orthodontic appliances over each of the respective positive molds.	[19(b)] thermoforming a respective one of the orthodontic appliances over each of the respective positive molds.

Claim 10	Claim 20
[10(a)] The method of claim 1, further comprising: performing, by a computer processor, a second modification of the schedule of movement in response to the identifying, the second modification comprising one or more of:	[20(a)] The method of [claim] 11, further comprising: performing, by a computer processor, a second modification of the schedule of movement in response to the identifying, the second modification comprising one or more of:
[10(b)] delaying initial movement of the first dental object; and	[20(b)] delaying initial movement of the first dental object; and
[10(c)] slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages during which the first dental object moved.	[20(c)] slowing or stopping movement of the first dental object during one or more of the treatment stages following a previous one of the treatment stages during which the first dental object moved.

175. Accordingly, claims 12-20 are taught or suggested for the reasons discussed in Sections X.A.2-.10, which discuss the corresponding portions of claims 2-10.

XI. Conclusion

176. For the reasons set forth above, in my opinion, a person of ordinary skill in the art would have considered claims 1-20 of the ’217 patent to be obvious over the prior art discussed above.

177. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with 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.

Dated: April 11, 2025 By: Sumit Yadav

Dr. Sumit Yadav