

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MEDIT CORPORATION,

Petitioner,

v.

3SHAPE A/S,

Patent Owner.

Case No.: IPR2023- 01316
U.S. Patent No. 11,076,146

DECLARATION OF RONGGUANG LIANG, PHD

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I, Dr. Rongguang Liang, declare as follows:

I. INTRODUCTION

1. I have been retained by Medit Corporation (“Petitioner”) as an independent expert in this *inter partes* review before the United States Patent and Trademark Office (“PTO”) regarding U.S. Patent No. 11,076,146 (“the ’146 patent”), Ex-1001. Specifically, I have been asked to consider whether certain references disclose or suggest the features recited in claims 1, 3-6, 8-13, 15, 16, 21-27, and 29 of the ’146 patent (“challenged claims”). As explained below, it is my opinion that the challenged claims are invalid as anticipated and/or obvious in view of the prior art references discussed in this Declaration and the accompanying Petition.

2. I am being compensated at my ordinary consulting rate of \$350.00 per hour. No part of my compensation is dependent on the outcome of this proceeding or any other proceeding involving the ’146 patent or any of its related patents. I have no other interests in this proceeding.

II. QUALIFICATIONS

3. My qualifications are generally set forth in my Curriculum Vitae, which is attached as Ex-1009. My Curriculum Vitae also includes a list of the publications I have authored and a list of the other cases in which I have testified during the last four years.

4. I possess a comprehensive background in 3D imaging technologies, encompassing techniques such as triangular technology, fringe projection, confocal technology, depth from defocus, and optical coherence tomography. Leveraging this expertise, I have developed commercial 3D imaging devices tailored for dental and other medical applications, along with various general industrial applications.

5. I have engaged in research related to dentistry and optics since 2006. Several of my current and past research projects have also been related to or had particular applications in dentistry. Examples of such projects include: *Bimodal Intraoral Imaging Device for Detection of Oral Epithelial Neoplasia*; *Low-Cost and Compact Multimodal Intraoral Confocal Probe for Oral Cancer Detection and Diagnosis*; and *Low Cost Tri-modal Intra-oral camera for Early Detection of Caries and Cracks*.

6. I am a named inventor on over 50 patents or patent applications, including 7 patents in 3D imaging and shade measurement of teeth:

- U.S. Patent No. 11,605,172 Digital fringe projection and multi-spectral polarization imaging for rapid 3D reconstruction
- U.S. Patent No. 9,314,150 System and method for detecting tooth cracks via surface contour imaging
- U.S. Patent No. 8,570,530 B2: Apparatus for dental surface shape and

shade imaging

- U.S. Patent No. 8,134,719 B2: 3-D imaging using telecentric defocus
- U.S. Patent No. 7,929,151 B2: Intra-oral camera for diagnostic and cosmetic imaging
- U.S. Patent No. 8,075,308 B2: Intra-oral camera for diagnostic and cosmetic imaging
- U.S. Patent No. 8,416,984 B2: Automatic tooth charting using digital images

A. Industry Experience

7. From 1989 to 1996, I worked at Micro-Optic Industrial Group Co. in Xiamen, People's Republic of China as an Optical Engineer in the Research & Development Department. From 2001 to 2007, I worked at Eastman Kodak Co. in Rochester, New York in various roles, including as the Principal Research Scientist in the Medical Science and Technology Center, Research & Development Lab. From 2007 to 2011, I worked at Carestream Health, Inc. as a Senior Principal Research Scientist.

B. Academic Experience

8. Since 2011, I have served as an Associate Professor and Professor in the College of Optical Sciences at The University of Arizona.

C. Other Relevant Experience

9. I have authored or contributed to over 150 publications in the field of optics. I was the editor of *Biomedical Optical Imaging Technologies: Design and Applications*, SPRINGER PRESS (2012), the author of *Optical Design for Biomedical Imaging*, SPIE PRESS (2011), and a co-author in the book chapter Shaun Pacheco, Zhenyue Chen, and Rongguang Liang, *Optics of Biomedical Instrumentation in Handbook of Optical Engineering* (2nd ed), MARCEL DEKKER (2016).

10. I have also served on the editorial boards of several publications. For example, I have served as an Associate Editor for *Optica* from 2015 to 2021. I served on the Editorial Board of *Scientific Reports* from 2018 to 2019. I served as a Topical Editor for *Applied Optics* from 2008 to 2014.

11. I have also chaired numerous conferences, including: Design and Quality Biomedical Technologies (SPIE) (2008-2019); Frontier in Optics, FiO.1 (OSA) (2014-2015); Bio-Optics: Design and Application (OSA) (2011, 2013); The Nature of Light: Light in Nature (SPIE) (2012, 2014, 2016).

III. MATERIALS CONSIDERED

12. My opinions, as set forth in this Declaration, are based on the documents I have reviewed, my experience and background, and my knowledge and professional judgment. In forming these opinions, I have reviewed the '146 patent

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Inter Partes Review of U.S. Patent No. 11,076,146

(Ex-1001), the prosecution history for the '146 patent (Ex-1002), the prior art discussed below, and any other material and information identified in this Declaration. I have also relied on my experience and knowledge in the field of optical measuring and testing and 3D imaging.

13. In particular, my opinions regarding the invalidity of the challenged claims are based on the following prior art references, as informed by my knowledge in the field of optical measuring and testing and 3D imaging.

Exhibit	Description
1001	U.S. Patent No. 11,076,146
1002	Excerpts from File History of U.S. Patent No. 11,076,146
1003	U.S. Patent No. 6,008,905 (“Breton”)
1004	U.S. Patent No. 7,336,375 (“Faul”)
1005	WIPO Publication No. 01/84479 A1 (“Orametrix”)
1006	Claim Construction Order, <i>3Shape A/S v. Medit Corporation</i> , Case No. 6:22-cv-00443, Dkt. No. 76 (W.D. Tex. May 2, 2023)
1007	R.J. Valkenburg, A.M. McIvor, “Accurate 3D measurement using a structured light system”, <i>Image and Vision Computing</i> (1998) (“Valkenburg”)
1008	U.S. Patent No. 7,494,338 (“Durbin”)

Exhibit	Description
1009	Curriculum Vitae of Rongguang Liang, PhD
1010	U.S. Patent Application Publication No. 2008/0118143 (“Gordon”)
1011	Nathan S. Birnbaum, et al. “3D Digital Scanners: A High Tech Approach to More Accurate Dental Impressions”, Inside Dentistry (April 2009) (“Birnbaum”)

IV. TECHNOLOGY BACKGROUND

14. I understand that the ’146 patent issued on July 27, 2021, and claims priority to a provisional application that was filed on June 17, 2009. The ’146 patent purportedly relates to optical scanning for three-dimensional modeling of surfaces, such as teeth and soft tissue. *See, e.g.*, Ex-1001 at 1:24-40. In particular, the ’146 patent discusses using a projected pattern, which is either static or time-varying, to scan a surface and thereby measure the three-dimensional shape of the surface. *See, e.g., id.* at 3:7-22.

15. Projecting time-varying structured light patterns to optically scan and model three-dimensional surfaces is well known and predates the June 2009 priority date of the ’146 patent by many years. For example, Valkenburg, which was published in 1998, describes a 3D measurement system using structured light. *See,*

e.g., Ex-1007 at Abstract; Fig. 1. Structured light is generated by aiming a light source at a pattern, such as a grid or grating, thereby projecting a pattern of light that is composed of brighter and darker features, which can be coded. In Valkenburg, the structured light is referred to as coded stripe patterns, and the pattern can be as simple as a single stripe. *See, e.g., id.* at 99; Figs. 1, 2. As illustrated in Figure 1, Valkenburg describes projecting a sequence of coded stripe patterns onto a scene and capturing a reflected image with a camera:

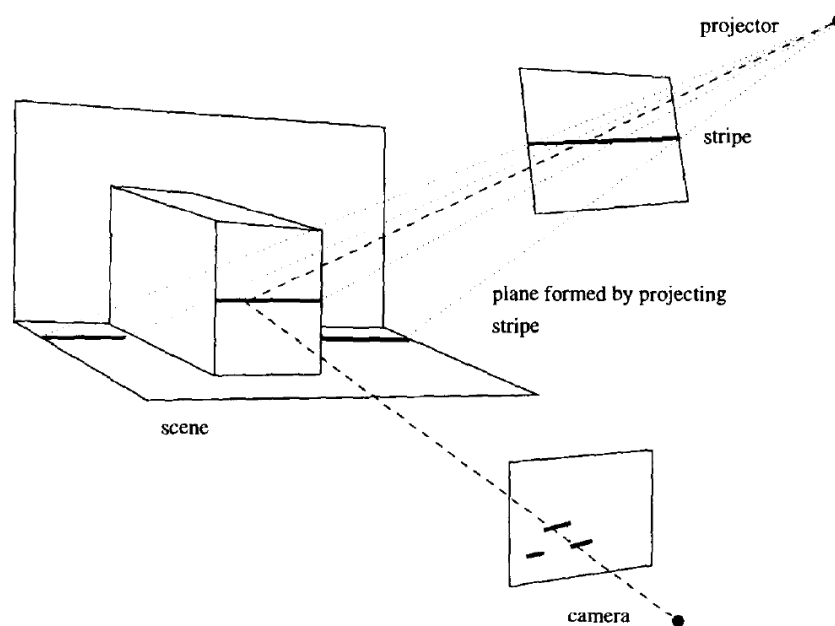


Fig. 1. Idealised structured light system.

16. As Valkenburg explains, the coded stripe patterns provide stripe value and image locations with pixel coordinates. *Id.* at 99. From the stripe values and the pixel coordinates, rays and planes can be used to define unique three-dimensional data. *Id.* The projected stripe patterns are temporally encoded, so that the stripe

pattern projected on the measured surface changes over time. *See id.*; Fig. 2:

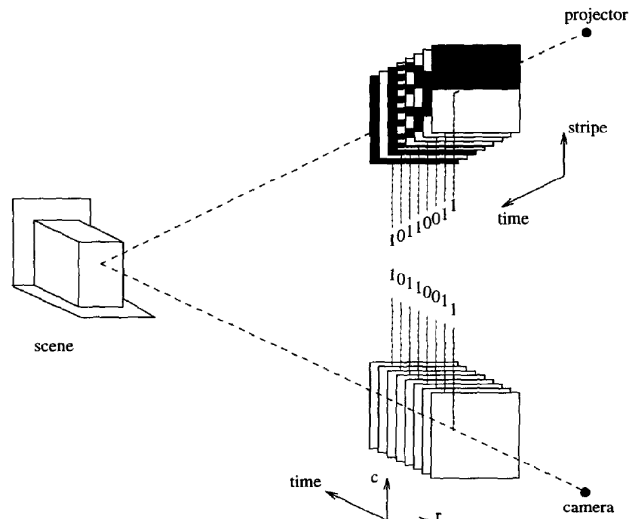


Fig. 2. Temporal encoding scheme.

17. As illustrated by Valkenburg above, only a single projector and camera are required to obtain measurements for three-dimensional modeling. *Id.* at Figs. 1, 2. The light source used for projecting the structured pattern can be a laser or an LED light source. *See, e.g.*, Ex-1010 at [0337] (describing a LED source for pattern projection). *See also, e.g.*, Ex-1011 at 2 (describing the advantages of blue LEDs in pattern projection).

V. OVERVIEW OF THE '146 PATENT

A. Specification of the '146 Patent

18. The '146 patent describes a scanner configured to measure the shape and color of an object, such as teeth. *See, e.g.*, Ex-1001 at Abstract; 1:24-30, claim 1. The scanner obtains the 3D geometry and color of at least part of the surface of the

scanned object. *Id.* at 2:43-45; 33:45-34:18. Figure 8 illustrates an example embodiment of a scanner configured for simultaneous measurement of color and shape:

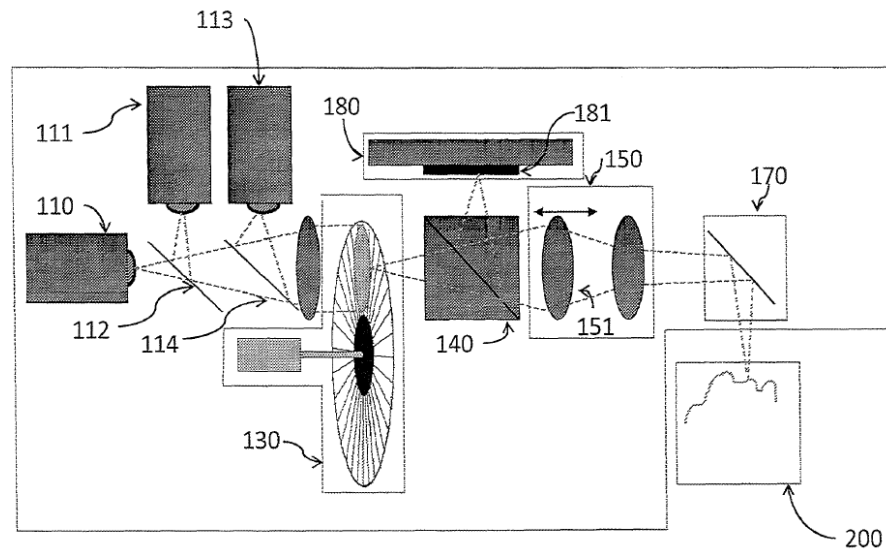


Fig. 8

19. The scanner includes pattern generation 130, which is used to generate a time-varying pattern that is projected onto the surface of scanned object 200. *Id.* at 28:4-13; 29:47-61. The pattern is changed over time by rotating the pattern generator, but may also be varied by translating the pattern over the object to be scanned. *See, e.g., id.* at 3:9-14; 8:38-58; 10:57-59; 28:5-13. The scanner also varies the position of the focal plane for the scanner via the focusing element 151 in optical system 150 and obtains images of the projected time varying pattern on the scanned object at different positions. *See id.* at 3:34-46; 6:62-7:50; 12:1-5; 27:28-37. These

images are then used to determine the 3D surface information for each pixel. *See, e.g., id.* at 3:59-4:8.

20. In order to determine the color of the scanned object, the scanner describes using three lights sources (110, 111, 113) emitting red, blue, and green light. *See e.g., id.* at 33:45-67. In one example embodiment, the lights sources are activated sequentially, providing a single color image of the time-varying pattern on the object. *Id.* The color of the scanned object surface is determined by weighting the detected amplitude signals for each color. *Id.* at 33:64-67.

21. The '146 patent briefly discusses that the scanner may be wireless, but that wireless operation increases the need for local data processing because the transmission of raw 3D data is to be avoided. *Id.* at 9:16-24.

22. The '146 patent also mentions that the camera (e.g., 180/181) may be a standard camera element or a high-speed camera that incorporates multiple A/D converters per line of pixels. *Id.* at 8:1-8.

B. Prosecution History

23. It is my understanding that the claims that issued for the '146 patent were added by preliminary amendment before examination, and that the issued claims were allowed by the examiner on the first office action. Ex-1002.

VI. LEGAL PRINCIPLES USED IN ANALYSIS

24. I am not an attorney and I offer no opinions on the law. I have been advised by Petitioner's counsel of certain legal principles relevant to an invalidity analysis, as summarized below. I have conducted my analysis in accordance with these principles.

A. Prior Art

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

26. I understand that a U.S. or foreign patent qualifies as prior art to a challenged claim if the patent was issued prior to the invention date of the challenged claim. I also understand that a U.S. or foreign patent or published patent application qualifies as prior art to a challenged claim if it was published before the invention date of the challenged claim.

B. Anticipation

27. I understand that a prior art reference "anticipates" an asserted claim, thereby rendering the claim invalid, if all elements of the claim are disclosed in the reference, either expressly or inherently. I understand that an element is disclosed inherently in a prior art reference if it is necessarily present in the prior art reference or is the natural result flowing from the disclosure of the prior art reference. I have been informed that a prior art reference does not need to use the same words as the

challenged claim in order to anticipate the claim.

C. Obviousness

28. I also understand that a patent is invalid 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 to a person of ordinary skill in the pertinent art (“POSITA”) at the time the invention was made. I understand that a POSITA provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents one from using his or her own personal insight or hindsight in deciding whether a claim is obvious.

29. I understand that an obviousness determination includes the consideration of various factors, such as (1) the scope and content of the prior art, (2) the differences between the prior art and the asserted claims, (3) the level of ordinary skill in the pertinent art, and (4) the existence of secondary considerations such as commercial success, long-felt but unresolved needs, failure of others, etc.

30. I understand that an obviousness evaluation can be based on a combination of multiple prior art references. I understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, which does not need to be explicit. I further understand that any need or problem known in the field and addressed by the patent can provide a reason for combining

the elements in the manner claimed. To determine whether there was an apparent reason to combine the known elements in the way a patent claims, I have been informed that I may look to interrelated teachings of multiple patents, to the effects of demands known to the relevant community or present in the marketplace, and to the background knowledge possessed by a POSITA. I also understand that practical and common-sense considerations should guide a proper obviousness analysis because familiar items may have obvious uses beyond their primary purposes. I further understand that a POSITA looking to overcome a problem will often be able to fit together the teachings of multiple publications. I understand that an obviousness analysis therefore accounts for the inferences and creative steps that a POSITA would employ under the circumstances.

31. I understand that the nexus linking two or more prior art references can also be simple common sense. I further understand that the obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace.

32. I understand that if a technique has been used to improve one device, and a POSITA would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her

skill.

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

34. I understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. When a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different field. If a POSITA can implement a predictable variation, the patent claim is likely obvious.

35. As noted above, I understand that a proper obviousness analysis focuses on what was known or obvious to a POSITA, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

36. I understand that a claim can be obvious in light of a single reference,

without the need to combine references, if the elements of the claim that are not found explicitly or inherently in the reference can be supplied by the common sense or knowledge of one of skill in the art.

37. I also understand that secondary indicia of non-obviousness may include: (1) a long-felt but unmet need in the prior art that was satisfied by the invention of the patent; (2) commercial success of processes covered by the patent; (3) unexpected results achieved by the invention; (4) praise of the invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the invention; (7) failure of others to find a solution to the long-felt need; and (8) skepticism by experts.

38. I also understand that there must be a relationship between any such secondary considerations and the invention. I further understand that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.

39. I further understand that an obviousness determination does not require an actual, physical substitution of elements from multiple references. Instead, the criteria is whether the claimed inventions are rendered obvious by the teaching of the prior art of the whole, not whether the references could be physically combined.

40. In sum, it is my understanding that prior art teachings are properly

combined where a POSITA—having the understanding and knowledge reflected in the prior art and being motivated by the general problem facing the inventor—would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

D. Claim Construction

41. I understand that, before an invalidity analysis can be performed, the scope and meaning of the challenged claims must be determined. It is my understanding that this is accomplished through the process of claim construction.

42. I have been informed and understand that claims are generally construed from the perspective of a POSITA at the time of the invention, which I have been asked to assume is the '146 patent's priority date of June 17, 2009. More specifically, I understand that the claims should be afforded a meaning in accordance with the ordinary and customary meaning of the claim, as understood by a POSITA at the time of the invention.

43. I have been advised that, in construing a claim term, one must first look to the “intrinsic” patent evidence, which includes the claims themselves, the patent specification, and the prosecution history of the patent. I have also been informed

that “extrinsic” evidence, which is outside the patent and prosecution history, may be useful in construing patent claims. It is my understanding that such extrinsic evidence may include dictionaries, textbooks, treatises, and similar sources of information.

44. I have been advised that a claim may recite a function to be performed rather than a structure for performing the function. I have been informed that such claim terms are known as “means-plus-function” claim terms. I understand that a term introduced by the phrase “means for” is presumed to be a means-plus-function claim term. I have also been informed that a claim term may be construed as a means-plus-function term where it fails to recite sufficiently definite structure, or else recites function without reciting sufficient structure for performing that function.

45. I have been advised that the construction of a means-plus-function claim term is a two-step process. I understand that the first step requires an identification of the function recited in the claim. I understand that the second step requires determining what structure is disclosed in the specification for performing the recited function. I have been advised that a structure disclosed in the patent specification qualifies as corresponding structure if the intrinsic evidence clearly links or associates that structure to the function recited in the claim. I have been advised that the proper construction for a means-plus-function term is restricted to

the corresponding structure identified in the specification and equivalents thereof.

46. I understand that claims must be construed in an *inter partes* review using the same claim construction standard that would be used to construe the claim in a civil action before a District Court.

VII. LEVEL OF ORDINARY SKILL IN THE ART

47. My opinions have been guided by my appreciation of how a POSITA (described below) would have understood the claims of the '146 patent as of the invention date, which I have been asked to assume is the patent's priority date, June 17, 2009.

48. It is my understanding that a POSITA is one who is presumed to be aware of all pertinent art and is a person of ordinary creativity. I further understand that the following factors may be considered in establishing the level of ordinary skill in the art in the relevant field: the type of problems encountered in the art; the prior art solutions to those problems; the rapidity with which innovations are made; sophistication of the technology; and the educational level of active workers in the field.

49. In June of 2009, it is my opinion that a POSITA would have had a bachelor's degree in computer engineering, computer science, electrical engineering, physics, or an equivalent field, as well as at least one or two years of design

experience, or alternatively, at least five years of comparable industry experience. Furthermore it is my opinion that a POSITA would have had experience with, and knowledge of, 3D imaging systems and 3D modeling techniques.

VIII. CLAIM CONSTRUCTION

50. I have set forth my understanding of relevant claim construction principles above, which I have followed in my analysis. Below, I discuss two claim terms that were construed by the District Court in the related litigation. In my view, the remaining claim terms should be given their plain and ordinary meaning.

A. The Preamble to Independent Claim 1 Is Not Limiting

51. Counsel has informed me that the District Court has determined that the preamble of claim 1 is not limiting and should be afforded its plain and ordinary meaning. Ex-1006 at 4. For the purposes of this declaration, I have adopted this construction in my analysis.

B. “data for the 3D geometry” (Claims 12, 23, 24)

52. Claims 12, 23, and 24 recite “data for the 3D geometry.” Counsel informs me that the District Court has construed “data for the 3D geometry” to mean “the data for the 3D geometry.” Ex-1006 at 4. For the purposes of this declaration, I have adopted the District Court’s construction of this term.

IX. OVERVIEW OF THE PRIOR ART

A. Orametrix

53. Orametrix describes systems and methods for scanning an object surface and generating a three-dimensional model of the scanned surface utilizing triangulation. *See, e.g.*, Ex-1005 at 1:16-21; 46:3-14; 82, claim 32. The scanning in Orametrix is accomplished through projecting patterns that cast structured light onto a surface to be scanned. *Id.* at 25:11-26:5; 27:8-21; 29:8-19; Figs. 16, 19, 23. As depicted below in Figure 23, the projected patterns include both measuring features, *e.g.*, (elements 1011-1013 at T1), and encoding features, *e.g.*, (elements 1021-1023 at T2).

SHAPE NUMBER	BAR CODE	COLOR	PATTERN
0		RED	
1		ORANGE	
2		YELLOW	
3		GREEN	
4		BLUE	
5		INDIGO	
6		VIOLATE	
7		BROWN	

FIGURE 16

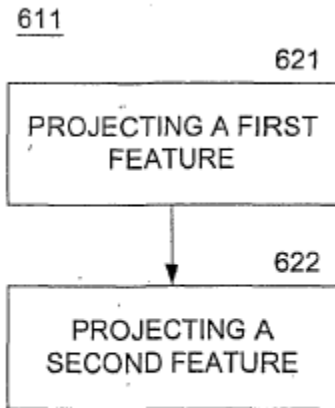


FIGURE 19

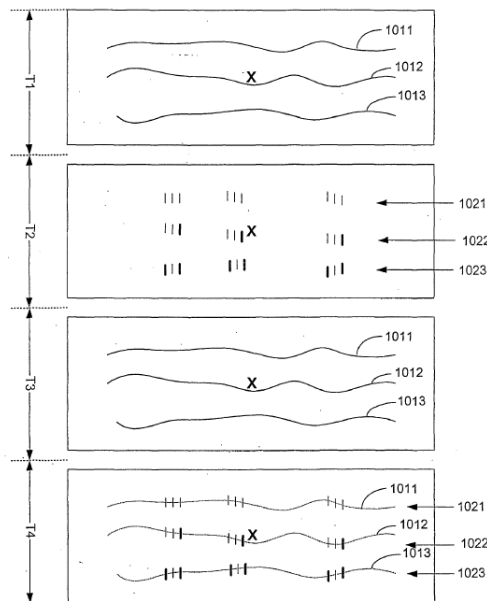
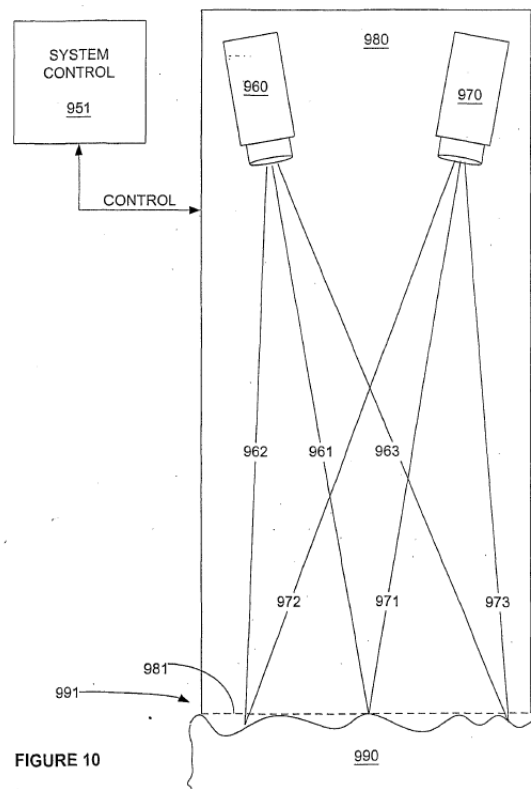


Figure 23

54. As shown between T1 and T4 in Figure 23, the projected patterns can vary in shape. Reflections from the surface of multiple two-dimensional images of the patterns are imaged by a high speed camera. *Id.* at 4:3-10; 16:6-13; 34:1-21.

From these two dimensional images, the shape of the scanned surface is determined. *Id.* at 1:15-22; 15:19-21; 30: 15-23; Fig. 10. Orametrix also describes an intermediary step of adding photo data containing color information to the scan data underlying the three-dimensional virtual model, so that color can also be determined for the model, which may be pertinent to the intended application of the model (e.g., design and manufacture of an anatomical device). *Id.* at 64:6-15.



55. Orametrix additionally discloses that in the scanning process, different patterns are projected over different periods of time. *Id.* at 29:8-19; Figs. 16, 19, 23.

Orametrix also illustrates the scanning device in a handheld configuration, described, for example in 56:11-22, and depicted, for example, by element 4401 in Figure 44:

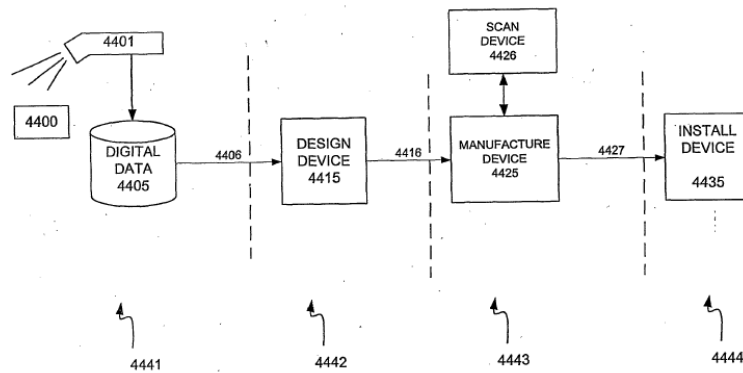
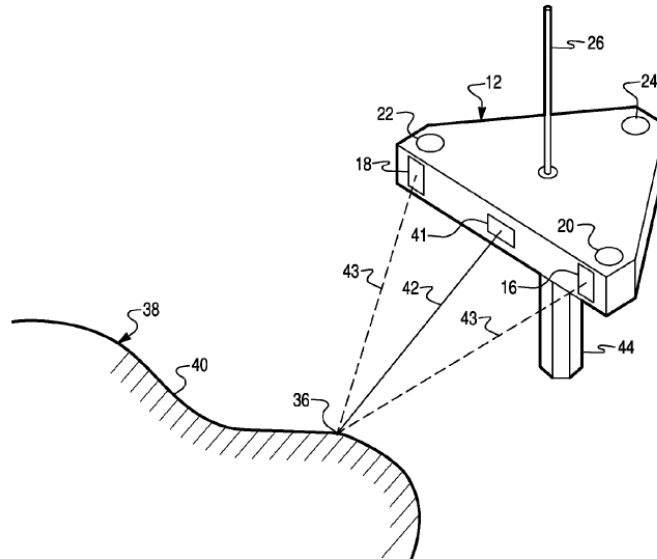


FIGURE 44

B. Faul

56. Faul describes a handheld scanner for three dimensional shape sensing utilizing projected structured light and triangulation. *See, e.g.*, Ex-1004 at Abstract; 1:61-2:15; 5:38-41; 7:29-31; 16:58-59; Figs. 2, 5.

Fig. 2



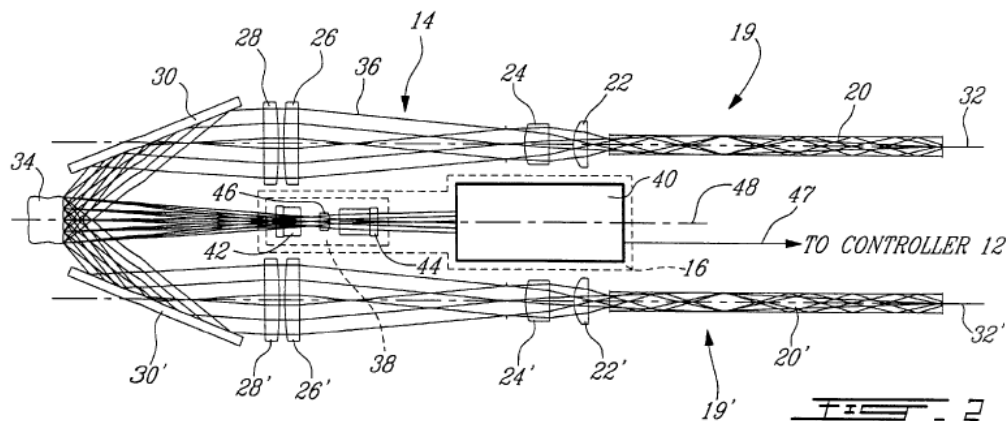
57. This shape determination is made by projecting dynamically-varied, structured light on a surface to be measured by means of a digital video projector. *See id.* at 4:36-53. The structured light is varied over time so that varying patterns are projected on the scanned surface. *Id.* at 4: 25-35. Faul also describes measuring the color of the scanned surface by dynamically altering the color of the projected structured light. *See, e.g., id.* at 6:60-67; 10:64-11:4. Reflections of the structured light projections from the scanned surface are detected by optical imaging sensors to determine the color and shape of the surface. *Id.* at 4:59-5:9; 5:38-51 (describing the process for transforming 2D data to 3D data); 6:60-67 (describing that surface model 80 includes color or texture data in addition to geometrical shape data); Fig. 2. Faul also describes performing processing within the wireless scanner to reduce

the amount of transmitted data to a workstation. *See, e.g., id.* at 12:43-63.

C. Breton

58. Breton describes a method and apparatus for determining the color and shape of a scanned object, such as a tooth. *See, e.g., Ex-1003 at Abstract; 5:35-55;*

Fig. 2.



59. The wavelength of the light emitted by illumination assembly 14 is stepped over a range in order to change the color of the projected light that is used to scan the surface of object 34. *Id.* at 6:62-7:20. Illumination assembly 14 includes multiple light sources (not pictured). *Id.* at 4:16-26. The shape of surface 34 is determined by acquiring spatial resolution data that is used to build a position registry. *Id.* at 7:39-52. This position registry corresponds to a spectral map that is built from a complete spectral decomposition of every scanned point. *Id.* From the position registry and spectral map, the shape and color of the scanned surface is

determined. *Id.* Breton also discloses that the color of the teeth can be accurately measured only using 3 sampling bands in the red, blue, and green portions of the wavelength spectrum, and that limiting the spectral band samples can reduce computation time. *Id.* at 8:24-36.

D. Durbin

60. Durbin describes a three-dimensional dental scanner that uses a fixed coordinate reference frame to generate a three-dimensional representation of a dental structure in an oral cavity. *See* Ex-1008 at Abstract; Fig. 1.

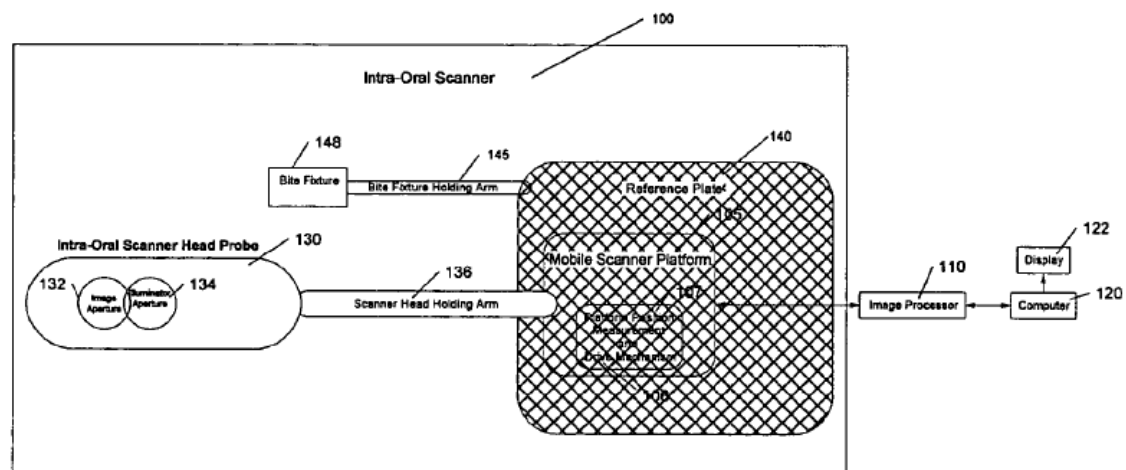


Figure 1

61. Durbin discloses that the dental scanner acquires images along a pre-scan traced path, and that these images are used as the basis of the three-dimensional model of the dental structure. *Id.* at 4:33-44; 10:48-11:17. Durbin describes that the

three-dimensional model may be based on structured light illumination *See, e.g., id.* at 5:37-43; 6:20-26. Durbin also describes using a CMOS-based imager with higher-sensitivity in order to allow image capture at frame rates of greater than 1000 frames per second, as well as to allow for dynamic resizing of an imaging window during the scanning process. *See id.* at 17:4-9.

X. THE PRIOR ART RENDERS ALL OF THE CLAIMED ELEMENTS OF THE '146 PATENT OBVIOUS

A. Claims 1, 3-6, 8-13, 15, 21-27, and 29 Are Rendered Obvious by Orametrix In View of Faul Further In View of Breton

62. As discussed above in Section IX, Orametrix, Faul, and Breton all describe measuring systems for acquiring the color and shape of scanned objects. As such, it is my opinion that these three references belong to the same technical field, provide similar scanning systems, and thus provide elements and features that a POSITA would have looked to in order to arrive at the combination of elements comprising the invention described by the claims. Furthermore, because they each describe similar scanning systems with similar objectives, it is my opinion that a POSITA would have had a reasonable expectation of success in combining Orametrix, Faul, and Breton in order to achieve accurate color and shape measurements in three-dimensional models of scanned objects.

63. Both Orametrix and Faul recognize the need for obtaining accurate

scans of objects for three-dimensional modeling and mapping. For example, Orametrix describes the need for accurate three-dimensional models to develop medical and dental devices and appliances that will reduce the level of subjective criteria required in manufacturing or reproducing them. *See, e.g.*, Ex-1005 at 1:17-22; 2:1-3:20. Similarly, Faul describes the desirability of obtaining three-dimensional models of real world objects that are enhanced through wireless optical scanning, which does not require cables or other mechanical linkage or any physical contact with the object. *See, e.g.*, Ex-1004 at 1:18-34; 2:36-39; 2:42-3:32; 15:16-19.

64. As with Orametrix, Breton describes the need to obtain an objective three-dimensional model of a tooth to create an accurate reproduction for a replacement tooth that minimizes subjectivity. *See, e.g.*, Ex-1003 at 1:14-40. Breton discusses the difficulty in matching the color shade of a reproduction tooth. *Id.* at 1:29-34. Thus, because Orametrix, Faul, and Breton are in the same field, teach analogous scanning solutions to the same issues, and have the same purpose to increase objectivity and accuracy in three-dimensional modeling of real world objects, it is my opinion that a POSITA would have been motivated to combine the various elements of these three references to increase the accuracy of the color and shape measurements underlying the subsequent three dimensional modeling of the real world objects.

65. A POSITA also would have had an expectation of success in combining the features and teachings of Orametrix, Faul, and Breton because these optical systems all rely on similar scanning arrangements, and the substitution and combinations of features would be simple and yield the expected results of more accurate and objective optical measurements to make three-dimensional models of real world objects.

66. As a result, it is my opinion that the combined teachings of these references, the knowledge, creativity, and common sense of a POSITA and the nature of the problem to be solved would have led a POSITA to the claimed combination and would have indicated a reasonable likelihood of success in making the above referenced combination.

1. Claim 1 Is Rendered Obvious by Orametrix In View of Faul Further in View of Breton

67. As explained below, it is my opinion that Orametrix in view of Faul further in view of Breton teaches, and therefore renders obvious every element of claim 1.

- a. **[Claim 1 pre]: “An intraoral scanner for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, the intraoral scanner comprising:”**

68. As discussed above in Section VIII.A, I have been informed that the

District Court determined that the preamble of claim 1 is not limiting. Nevertheless, it is my opinion that Orametrix teaches this limitation. Orametrix teaches a scanning system for determining the shape and color of tooth in an oral cavity. *See, e.g.*, Ex-1005 at 1:15-22; 15:19-21; 30:15-23; 31:11-33:7; 64:6-15, Figs. 10, 27, 28, 29.

b. [Claim 1a]: “at least one camera accommodating an array of sensor elements;”

69. It is my opinion that Orametrix teaches this limitation and therefore renders it obvious. Orametrix teaches a camera or viewer for capturing the reflected projected structured light pattern from an object to be scanned, including a CCD (charge coupled device). *See id.* at 4:3-10; 16:6-13; 34:4-6. It is my opinion that a POSITA would understand the camera/viewer of Orametrix would necessarily include an array of sensor elements. Therefore, it is my opinion that Orametrix renders obvious “at least one camera accommodating an array of sensor elements,” as recited by this claim element.

c. [Claim 1b]: “a pattern generator configured to generate, using a light source, a probe light with a plurality of configurations in the form of a time-varying illumination pattern;”

70. It is my opinion that both Orametrix and Faul each teach this claim limitation and therefore render it obvious. Orametrix describes system controller 951 which includes data processor 952, projection image representation 953,

projector controller 954, and viewer controller 955. Ex-1005 at 16:19-22; Figs. 10, 11. System controller 951 provides specific information to scanner 980 specifying a specific image to be projected onto surface 991 of object 990. *Id.* at 15:19-21. Orametrix describes that the image to be projected can be a digital image that is stored in memory by data processor 952. *Id.* at 17:11-19. Orametrix further describes that in the scanning process, different patterns can be projected over different periods of time. *Id.* at 29:8-19; Figs. 16, 19, 23. Orametrix teaches that changing the projected patterns with different encoding and measuring features over time allows for more information to be obtained about the surface. *Id.*

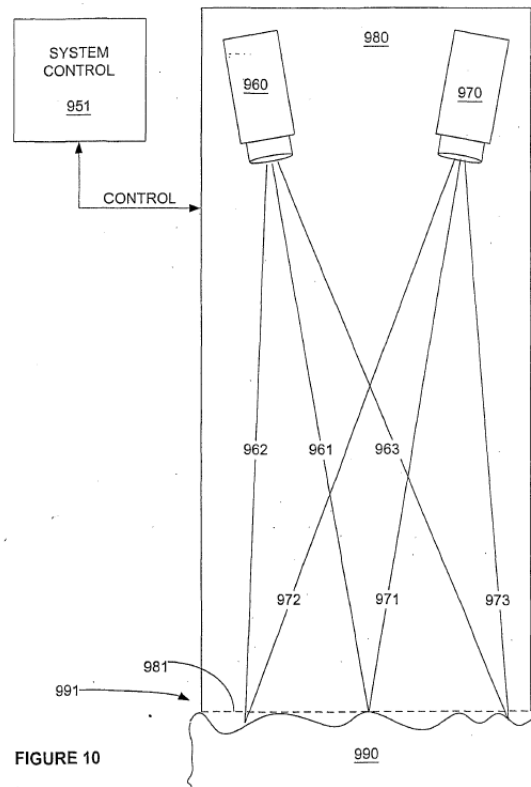
71. Faul also describes projecting a time-varying pattern of structured light to determine the shape of an object. *See* Ex-1004 at 4:36-53. Faul describes generating a time-varying pattern with a digital video projector. *Id.* at 4:25-53; 5:52-57. Faul discloses that the scanner includes a microprocessor and memory, *id.* at 7:64-8:8, and it is my opinion that a POSITA would understand that this microprocessor would be utilized to implement the measurement process, including light source and camera control, as well as image processing.

72. It is my opinion that a POSITA would have considered the digital image projection of Orametrix or Faul's projected pattern of structured light to be "a probe light with a plurality of configurations in the form of a time-varying illumination

pattern,” as claimed. Thus, it is my opinion that Orametrix and Faul each teaches, and/or renders obvious “a pattern generator configured to generate, using a light source, a probe light with a plurality of configurations in the form of a time varying illumination pattern,” as recited in claim 1.

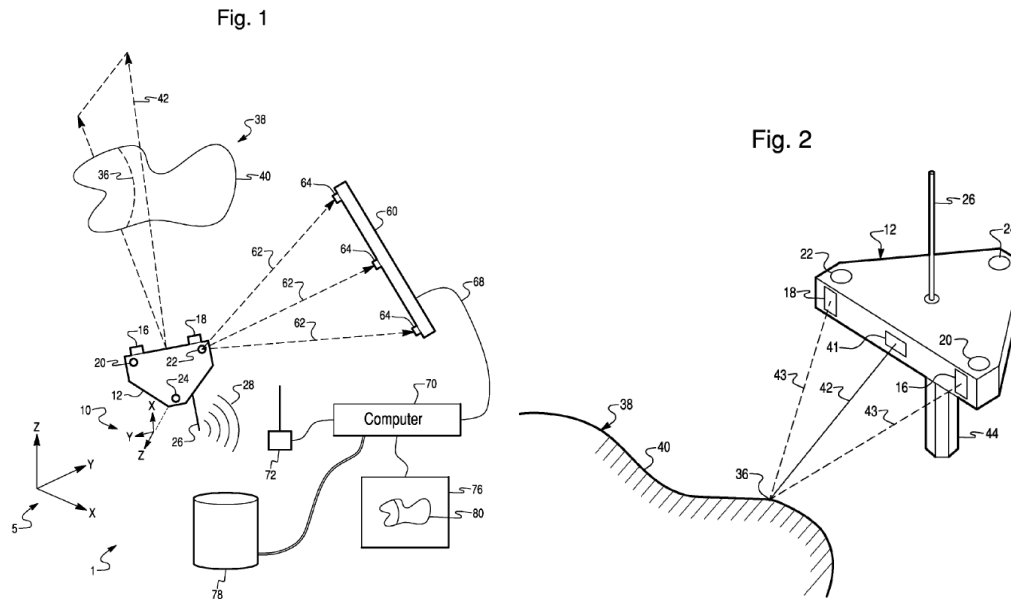
- d. **[Claim 1c]: “an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object with the time-varying illumination pattern . . .;”**

73. It is my opinion that Orametrix and Faul each teaches and/or renders obvious this limitation. Figure 10 of Orametrix illustrates an optical system according to this claim element:



74. As illustrated above, Orametrix shows projector 960 that transmits the patterned probe light beam along an optical path to the surface of object 990 thereby illuminating at least a part of the object with the time-varying illumination pattern. Ex-1005 at 16:6-13. The reflected light from the object is detected by viewing device 970. *Id.* Orametrix further describes that the scanner receives a projected frame pattern that is digitized into a 2D image frame. *Id.* at 30:7-8. The 2D image frames are then converted into three dimensions using conventional 3D imaging techniques. *Id.* at 30:8-12; *see also id.* at 75 (claim 4).

75. It is my opinion that Faul also describes the elements of this claim limitation. Figures 1 and 2 of Faul illustrate the claimed optical system:



76. As illustrated above, Faul describes a light source 41 projected on an optical path to a surface 36 from which reflected light is detected by at least one imaging sensor 16 or 18. Ex-1004 at 4:59-5:3; 8:45-9:25; 10:37-60. Faul describes the two-dimensional video data based on the reflected time-varying pattern that are detected by 16 or 18 are used as the basis for a three-dimensional model of the scanned surface. *Id.* at 4:59-9:25; 7:11-29.

77. It is my opinion that a POSITA would recognize that Orametrix's projector 960 and Faul's light source 41 are both "an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least

a part of the object with the time-varying illumination pattern,” as recited by this claim element. Therefore, it is my opinion that both Orametrix and Faul each teaches and/or renders this claim element obvious.

- e. **[Claim 1d]: “an optical system . . . for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images . . .”**

78. It is my opinion that both Orametrix and Faul each teaches and/or renders this claim limitation obvious.

79. As discussed above in Section X.A.1.d, Orametrix describes that light projected by projector 960 reflected from the surface of object 990 is detected by viewing device 970. Ex-1005 at 16:6-13; Fig. 10.

80. Faul describes that projected light from light source 41 is projected onto surface 36, the reflection of which is then detected by imaging sensor 16 or 18. Ex-1004 at 2:63-3:10; 4:59-5:3; 8:45-9:25; 10:37-50.

81. It is my opinion that a POSITA would recognize that Orametrix’s viewing device and Faul’s imaging sensors, in combination with the optical path of reflected light from surface, comprise “an optical system . . . for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images . . .,” as recited in this claim element. Therefore, it is my opinion that Faul and Orametrix each teaches and/or renders this claim element

obvious.

f. [Claim 1e]: “wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;”

82. It is my opinion that both Orametrix and Faul each teaches and/or renders this claim limitation obvious.

83. As discussed above in Section X.A.1.d, Orametrix describes that the scanner receives a projected frame pattern that is digitized into a 2D image frame. Ex-1005 at 30:7-8. The 2D image frames are then converted into three dimensions using conventional 3D imaging techniques. *Id.* at 30:8-12; *see also id.* at 75 (claim 4).

84. Faul describes the two-dimensional video data based on the reflected time-varying pattern that are detected by 16 or 18 are used as the basis for a three-dimensional model of the scanned surface. Ex-1004 at 4:59-5:9; 5:38-41; 6:24-42; 7:11-29.

85. It is my opinion that a POSITA would recognize that Orametrix’s 2D image frame conversion and Faul’s two-dimensional video data analysis teach that “the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern,” as recited in this claim element. Therefore, it is my opinion that Orametrix and Faul each teaches and/or renders this claim element

obvious.

g. [Claim 1f]: “a tip configured to be inserted into the oral cavity; and”

86. Orametrix teaches this claim element. Orametrix describes a scanning device 4401 that shows a tip, as illustrated in Figure 44:

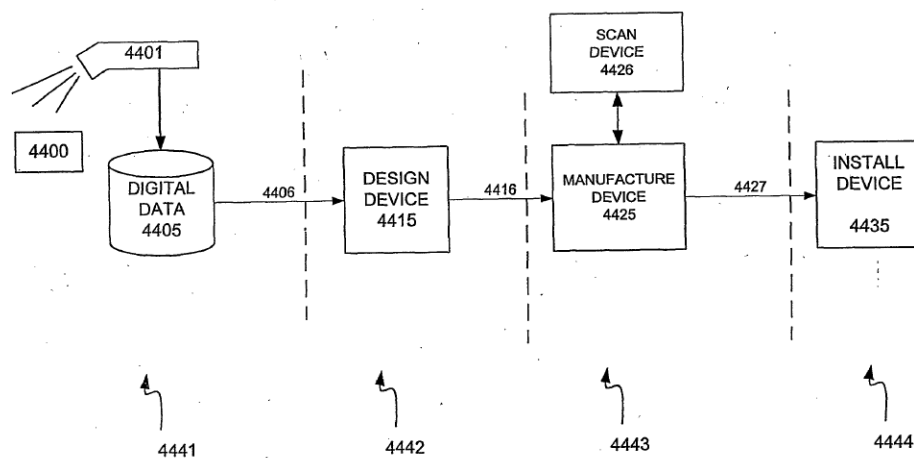


FIGURE 44

87. Orametrix further discloses that the anatomical structure, such as a tooth, can be scanned directly by scanner 4401. Ex-1005 at 56:11-20; *see also id.* at 31:11-19; Fig. 27 (describing scanning a tooth surface). It is my opinion that the scanner illustrated in Figure 44, in combination with the description of direct scanning of anatomical structures teaches the claimed “tip” limitation. Furthermore, it is my opinion that a POSITA would understand that in order to facilitate direct scanning of an anatomical structure, such as a tooth in a mouth, a housing that

includes a tip would be needed to protect the scanning optics from damage or debris.

88. Therefore, it is my opinion that Orametrix renders obvious “a tip configured to be inserted into the oral cavity,” as recited by this element of claim 1.

h. [Claim 1g]: “a hardware processor configured to: selectively switch a color of the probe light, thereby illuminating the object with different colors at different times;”

89. It is my opinion that Orametrix or Faul further in view of Breton teaches this claim element. As described above in Section X.A.1.c, Orametrix describes scanning the object surface with a time-varying pattern to determine shape information. Furthermore, Orametrix describes changing the color of projected encoded features used for registration in multiframe scanning. Ex-1005 at 14:13-17; 25:11-26:5; Fig. 16. Orametrix also describes that photo data containing color information can be added to the digital data of the 3D virtual model of the anatomical structure. *Id.* at 64:6-15. Orametrix teaches that the measurement techniques may be implemented and executed by a hardware processor as part of the system. *See, e.g., id.* at 16:19-22; 64:6-15; 69:15-70:10; Fig. 46.

90. Faul also describes projecting a time-varying pattern to determine the shape of an object. *See* Ex-1004 at 4:36-53. Faul describes a digital video projector for generating a time-varying pattern. *Id.* at 4:25-53; 4:36-52. Faul also describes measuring the color of the scanned surface. *See, e.g., id.* at 6:60-67. Faul also

describes dynamically altering the color of the projected structured light. *See id.* at 10:64-11:4. Faul discloses that the scanner includes a microprocessor, *id.* at 7:49-8:8, and it is my opinion that a POSITA would understand that this microprocessor would be utilized to implement the measurement process, including light source and camera control, as well as image processing.

91. Breton describes changing the wavelength of projected light from a controlled monochromatic light source over time to illuminate the scanned object with different colors at different times to measure the color of the surface of the scanned object. *See, e.g.,* Ex-1003 at 6:62-7:20; Fig. 2. Breton describes that the wavelength of the light source needs to be stepped through a number of discrete spectral bands at a maximum bandwidth in order to achieve adequate spectral resolution for the spectral map that corresponds to the color of the tooth surface. *Id.* Breton further discloses that the color of the teeth can be accurately measured using only three sampling bands in the red, blue, and green portions of the wavelength spectrum, and that limiting the spectral bands can reduce computation time. *Id.* at 8:24-36.

92. In my opinion, it would have been obvious to a POSITA to combine the wavelength scanning of the monochromatic light source of Breton with time-varying pattern projection of Orametrix or Faul in order to measure the color of the

scanned surface at an adequate spectral resolution, and therefore achieve an accurate color measurement. As discussed above the processor of Orametrix is already configured to change the color of projected encoding features, and is configured to introduce color information from photo data into the three-dimensional model. And as discussed above, Faul itself teaches color measurement and suggests dynamically changing the color of the projected time-varying structured light. It is my opinion that a POSITA would understand that the processors described by Orametrix and Faul would be configured to implement the color changing scheme as taught by Breton in the structured light projection in order to obtain sufficient spectral resolution to achieve an accurate color measurement of the scanned object surface. Thus, it is my opinion that Orametrix and Faul, further in view of Breton, teaches “a hardware processor configured to: selectively switch a color of the probe light, thereby illuminating the object with different colors at different times,” as recited by this claim element.

- i. **[Claim 1h]: “a hardware processor configured to: ... record different images by the at least one camera at the different times, thereby recording images of the object with the different colors; and”**

93. It is my opinion that Orametrix or Faul further in view of Breton teaches this claim element. As discussed above in Section X.A.1.c, both Orametrix and Faul teach recording images of the scanned surface at different times with different

projected patterns. For example Orametrix describes that the data may be a composite of scans taken at different times. Ex-1005 at 57:7-16. Likewise, Faul describes assigning timestamps to each scanned image. Ex-1004 at 14:7-39. Faul also describes recording images of the object with different colors. *Id.* at 12:20-30; Fig. 4 (describing data format 403 that includes RGB color intensities for each point in the image). As discussed above in Section X.A.1.h, it is my opinion that a POSITA would be motivated to combine Breton's color determination through wavelength scanning with either Orametrix or Faul in order to obtain sufficient spectral resolution in order to accurately measure the color of the scanned surface. A POSITA would understand that the wavelength scanning of this combination would necessarily require recording different images at different times reflecting the stepped wavelength changes.

94. Thus, it is my opinion that the combination of Orametrix or Faul in view of Breton teaches "a hardware processor configured to: ... record different images at different times, thereby recording images of the object with different colors," as recited by this claim element.

- j. **[Claim 1i]: "a hardware processor configured to: ... combine the different colors from the different images, thereby obtaining the color of the surface of the object,"**

95. It is my opinion that Orametrix or Faul in view of Breton teaches this

claim element. As discussed above in Section X.A.1.h, both Faul and Breton disclose dynamically varying the color of the projected light on the scanned object. Faul further teaches that the color data from a pattern with a variety of wavelengths is used to determine the color of the scanned surface. *See* Ex-1004 at 6:60-67. Faul also teaches measuring red-green-blue (RGB) color intensities for each location in the scanned image of the surface. *Id.* at 12:20-30. A POSITA would understand that these RGB intensities would be combined to obtain the color of the scanned surface. Similarly, Breton teaches building a color shade image map of the scanned surface out of several spectral images. *See* Ex-1003 at 6:47-54; 6:62-7:5. Breton also teaches that the color of a scanned surface can be measured by a linear combination of spectral sampling bands. *See id.* at 9:43-47. As discussed above in Sections X.A.1.e and X.A.1.f, it is my opinion that a POSITA would be motivated to combine either Orametrix or Faul with Breton in order to achieve an accurate color measurement of the scanned surface. Thus, it is my opinion that Orametrix or Faul further in view of Breton teaches “a hardware processor configured to: ... combine the different colors from the different images, thereby obtaining the color of the surface of the object,” as recited by this claim element.

k. [Claim 1j]: “wherein the intraoral scanner is wireless, and”

96. It is my opinion that Orametrix in view of Faul teaches this claim

element. Orametrix describes the direct measurement of anatomical structures, including teeth. Ex-1005 at 56:11-20. Orametrix describes wirelessly communicating scanning data from the system to a client. *Id.* at 58:21-59:13; Fig. 44. This client may be, for example, design device 4415 at facility 4442, which is a workstation located remotely from scanner 4401. *Id.* The scan data may be a dental structure, and Orametrix describes an example where the scanner may be performed at home by a user for monitoring the progress of a treatment plan. *Id.* at 58:1-14. It is my opinion that a POSITA would understand that this scanner would be wireless and communicating data wirelessly for remote processing.

97. Faul teaches the advantages of a wireless handheld scanner for obtaining scanning data of three dimensional shapes in that it is unencumbered by a cable or mechanical linkage. *See, e.g.*, Ex-1004 at 2:36-39. In my opinion it would have been obvious to a POSITA to configure the scanner of Orametrix with the wireless configurations taught by Faul because Orametrix already contemplates the wireless transmission of data, and Faul teaches that making the handheld scanning unit wireless allows the user to scan objects without mechanical linkage or cables, which would facilitate easier direct measurements of teeth in a mouth.

98. Therefore, it is my opinion that Orametrix in view of Faul teaches “wherein the intraoral scanner is wireless,” as recited by this claim element.

I. [Claim 1k]: “wherein the at least one camera is a high-speed camera.”

99. It is my opinion that Orametrix teaches this claim element. For example, Orametrix teaches that the scan rates can be chosen to allow for real-time viewing of a three-dimensional image. Ex-1005 at 34:12-21. Based on this disclosure, it is my opinion that a POSITA would understand the camera disclosed by Orametrix to be a high-speed camera.

100. Thus, it is my opinion that Orametrix teaches “wherein the at least one camera is a high-speed camera,” as recited by this claim element.

2. Claim 3 Is Rendered Obvious by Orametrix, Faul, and Breton

101. It is my opinion that Orametrix in view of Faul further in view of Breton renders this claim obvious.

a. [Claim 3]: “The intraoral scanner according to claim 1, wherein the pattern generator is based on a projector such as a liquid crystal display (LCD) projector or a digital light processing (DLP) projector.”

102. As discussed above in Section X.A.1.c, Orametrix describes using a digital projection image that is stored in memory. Ex-1005 at 17:11-19. It is my opinion that a POSITA would understand this to be a digital light processing projector. Additionally, Faul teaches dynamically changing the projected pattern of the structured light using a digital video projector. Ex-1004 at 4:40-45.

103. Thus, it is my opinion that Orametrix and Faul both teach, and therefore render obvious “wherein the pattern generator is based on a projector such as ... a digital light processing (DLP) projector,” as recited by claim 3.

3. Claim 4 Is Rendered Obvious by Orametrix in View of Faul and Breton

104. It is my opinion that Orametrix in view of Faul further in view of Breton renders this claim obvious.

- a. [Claim 4]: “The intraoral scanner according to claim 1, wherein the different colors are provided by at least three monochromatic light sources of the light source.”**

105. As discussed above in Section X.A.1.j, Orametrix in view of Faul in view of Breton teaches changing colors of the projected structured light pattern. Breton further describes that illumination assembly 14 contains a number of light sources that are not pictured. Ex-1003 at 3:53-56; 4:20-26. Breton also teaches the advantages of limiting the color band analysis to the red, blue, and green color bands to conserve processing resources. *Id.* at 11:20-27. It is my opinion that a POSITA would have understood that the multiple light sources of Breton to include three monochromatic light sources to provide the red, blue, and green wavelength bands for scanning the object surface.

106. Thus, it is my opinion that Orametrix in view of Faul further in view of

Breton renders obvious “wherein the different colors are provided by at least three monochromatic light sources of the light source,” as recited by claim 4.

4. Claim 5 Is Rendered Obvious by Orametrix in View of Faul and Breton

107. It is my opinion that Orametrix in view of Faul further in view of Breton renders this claim obvious.

- a. [Claim 5]: “The intraoral scanner according to claim 4, wherein the at least three monochromatic light sources are light-emitting diodes (LEDs) or a segmented LED.”**

108. As discussed in Section IX.C, Breton describes illumination assembly 14 as containing multiple light sources. It is my opinion that a POSITA would know to use LED light sources in a structured light projection system for many reasons, including that LEDs are cheap and require low drive current, and are also well known to be used as light sources in digital video projection. Indeed, as I discuss in Section IV, it is well known to use LED lights sources in structured light projection. *See, e.g.,* Ex-1010 at [0337]; Ex-1011 at 2. As such, it is my opinion that a POSITA would have been motivated to use LED sources in the combination of Orametrix, Faul, and Breton to achieve those advantages. Furthermore, as discussed above in Section X.A.3.a, it is my opinion that a POSITA would understand that illumination assembly of Breton could contain three monochromatic light source with the red,

green, and blue wavelength bands. It is my opinion that it would have been obvious to a POSITA to use LED sources in the illumination assembly to implement the wavelength scanning taught by Breton for the advantages discussed above. Therefore, it is my opinion that Orametrix in view of Faul further in view of Breton renders obvious, “wherein the at least three monochromatic light sources are light-emitting diodes (LEDs) or a segmented LED,” as recited in claim 5.

5. Claim 6 Is Rendered Obvious by Orametrix in View of Faul and Breton

109. It is my opinion that Orametrix in view of Faul further in view of Breton renders this claim obvious.

- a. [Claim 6]: “The intraoral scanner according to claim 4, wherein the hardware processor is configured to selectively switch the color of the probe light by switching on and off the at least three monochromatic light sources.”**

110. As discussed above in Sections IX.C, X.A.3.a, X.A.4.a, Breton describes an illuminator assembly comprised of multiple light sources. Breton also teaches changing the wavelength of the light used to scan the tooth surface. Ex-1003 at 6:62-7:11. It is my opinion that a POSITA would selectively switch the three monochromatic light sources in the combination of Orametrix, Faul, and Breton to obtain separate measurements of the red, blue, and green spectral bandwidths, and therefore obtain an accurate color measurement of the tooth surface while

conserving computational resources.

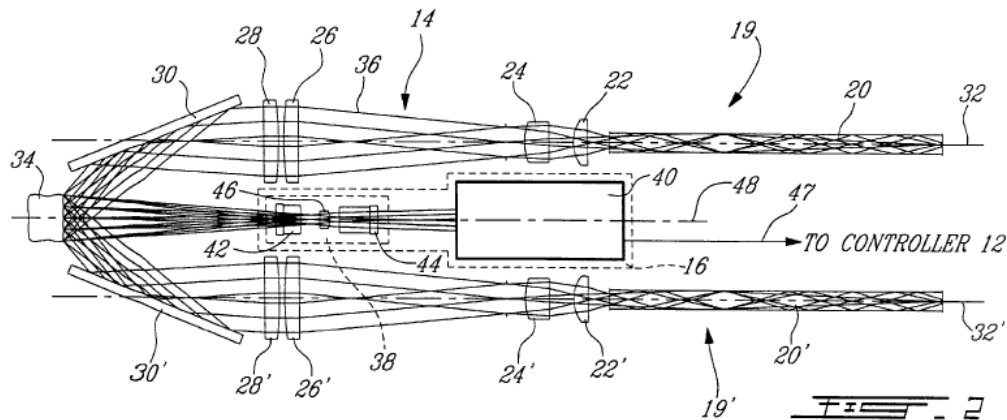
111. Thus, it is my opinion that Orametrix in view of Faul further in view of Breton renders “wherein the hardware processor is configured to selectively switch the color of the probe light by switching on and off the at least three monochromatic light sources,” as recited by claim 6.

6. Claim 8 Is Rendered Obvious by Orametrix in View of Faul and Breton

112. It is my opinion that Orametrix in view of Faul further in view of Breton renders this claim obvious.

- a. **[Claim 8]: “The intraoral scanner according to claim 1, wherein the probe light is directed towards the object in a direction substantially parallel with the longitudinal axis of the tip, and wherein the probe light is further reflected towards the object by a single reflective mirror located in the tip.”**

113. As illustrated in Figure 2 of Breton, the measurement illumination is directed towards the tooth being measured in a direction parallel with the longitudinal axis of the device:



114. Breton also describes directing the measurement illumination from integrator rod 20 towards tooth surface 34 using mirror 30. Ex-1003 at 4:1-26. Breton teaches that this configuration minimizes specular reflection. *Id.* at 4:19-26. Breton also teaches that other illumination and mirror configurations could be utilized. *Id.* It is my opinion that a POSITA would be motivated to include a single mirror, as taught by Breton, in the tip of the scanner of the combination of Orametrix and Faul in order to accurately scan the surface to be measured and avoid specular reflections.

115. Therefore, it is my opinion that Orametrix in view of Faul further in view of Breton renders obvious, “wherein the probe light is directed towards the object in a direction substantially parallel with the longitudinal axis of the tip, and wherein the probe light is further reflected towards the object by a single reflective mirror located in the tip,” as recited by claim 8.

7. Claim 9 Is Rendered Obvious by Orametrix in View of Faul

116. It is my opinion that Orametrix in view of Faul renders this claim obvious.

- a. **[Claim 9]: “The intraoral scanner according to claim 1, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.”**

117. As discussed above in Section X.A.1.f, Orametrix and Faul describe determining the 3D geometry based on the plurality of 2D images.

118. Faul describes processing two-dimensional image data locally in the scanning device to reduce the amount of data that is required to be transmitted from the scanning device to a workstation. Ex-1004 at 4:59-5:51; 12:43-50. Faul describes that subpixel coordinates of given points on the scanned 2D image are transformed into three-dimensional coordinates that are then transmitted. *Id.* at 12:27-32. It is my opinion that a POSITA would implement the local processing taught by Faul in the combined scanning system of Orametrix, Faul, and Breton to reduce the amount of data required to be transmitted wirelessly and increase overall processing speed for rendering the three-dimensional model of the scanned surface.

119. Therefore, it is my opinion that Orametrix in view of Faul further in

view of Breton renders “wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images,” as recited by claim 9.

8. Claim 10 Is Rendered Obvious by Orametrix in View of Faul

120. It is my opinion that Orametrix in view of Faul renders claim 10 obvious.

- a. **[Claim 10]: “The intraoral scanner according to claim 1, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.”**

121. As discussed above with respect to claim 9 in Section X.A.7.a, Faul describes local processing of the imaging data before wirelessly transmitting the data for further processing at a workstation. In addition to local processing data to reduce the burden of wireless transmission Faul specifically describes locally processing 2D data into 3D data. Ex-1004 at 4:59-5:51; 12:43-50. Faul describes this local processing as significantly reducing the amount of transmitted geometric and color data, as compared to conventional transmission. *Id.* at 12:43-50.

122. Therefore, it is my opinion that Orametrix in view of Faul renders obvious “wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images,” as recited by claim 10.

9. Claim 11 Is Rendered Obvious by Orametrix in View of Faul

123. It is my opinion that Orametrix in view of Faul renders this claim obvious.

a. [Claim 11]: “The intraoral scanner according to claim 9, wherein the data for the 3D geometry is wirelessly transmitted to a workstation.”

124. As discussed above with respect to claims 1, 9, and 10, in Sections X.A.1, X.A.7, and X.A.8, Faul describes wireless transmission of the data for the 3D geometry to a workstation. Ex-1004 at 4:59-5:51; 12:43-50. And as discussed above in Section X.A.1.k, a POSITA would incorporate the wireless teachings of Faul into Orametrix to achieve an untethered scanning instrument.

125. Therefore, it is my opinion that Orametrix in combination with Faul renders obvious “wherein the data for the 3D geometry is wirelessly transmitted to a workstation,” as recited by claim 11.

10. Claim 12 Is Rendered Obvious by Orametrix and Faul

126. It is my opinion that Orametrix and Faul render this claim obvious.

- a. **[Claim 12]: “The intraoral scanner according to claim 9, wherein the hardware processor processes the raw 3D data into data for the 3D geometry in real time.”**

127. Orametrix describes allowing for real-time viewing of a three-dimensional image of the scanned object. Ex-1005 at 34:12-15. Faul also describes rendering the geometry of a three-dimensional object in real-time. Ex-1004 at 8:56-60.

128. Therefore, it is my opinion that Orametrix and Faul render obvious “wherein the hardware processor processes the raw 3D data into data for the 3D geometry in real time,” as recited by claim 12.

11. Claim 13 Is Rendered Obvious by Orametrix in View of Faul

129. It is my opinion that Orametrix in view of Faul renders this claim obvious.

- a. **[Claim 13]: “The intraoral scanner according to claim 1, wherein a temporal correlation measure is computed with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed.”**

130. Faul describes temporal correlation of the pattern of light and the

scanner position that allows for accurate three dimensional coordinate transformation. Ex-1004 at 2:49-62; 3:11-24; 9:27-42. It is my opinion that a POSITA would be motivated to combine the correlation described by Faul in the system of Orametrix in order to obtain accurate coordinate data based on the changing projected pattern and the location of the scanning device.

131. Therefore, it is my opinion that Orametrix in view of Faul renders obvious “wherein a temporal correlation measure is computed with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed,” as recited by claim 13.

12. Claim 15 Is Rendered Obvious by Orametrix in View of Faul

132. It is my opinion that Orametrix in view of Faul renders this claim obvious.

- a. **[Claim 15]: “The intraoral scanner according to claim 13, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.”**

133. Faul describes calibrating the handheld scanner including details about the pattern of structured light. Ex-1004 at 7:64-8:8. In my opinion a POSITA would be motivated to incorporate the calibration of Faul into the system and methods of

Orametrix in order to accurately determine the three-dimensional shape of the scanned object.

134. Therefore, it is my opinion that Orametrix in view of Faul renders obvious “wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern,” as recited by claim 15.

13. Claim 21 Is Rendered Obvious by Orametrix in View of Faul, Further in View of Breton

135. It is my opinion that Orametrix in view of Faul further in view of Breton renders all the elements of claim 21 obvious.

- a. **[Claim 21 pre]: “A method for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, said method comprising the steps of:”**

136. It is my understanding that this preamble is not considered to be limiting. Nonetheless, to the extent that it is considered limiting, it is my opinion that Orametrix teaches this limitation. Orametrix teaches a method for determining the shape and color of tooth in an oral cavity. *See, e.g.*, Ex-1005 at 1:15-22; 15:19-21; 30:15-23; 31:11-33:7; 64:6-15 Figs. 10, 27, 28, 29.

b. [Claim 21a]: “using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern;”

137. It is my opinion that Orametrix and Faul each teaches and/or renders obvious this claim limitation and therefore render it obvious. Orametrix describes system controller 951 which includes data processor 952, projection image representation 953, projector controller 954, and viewer controller 955. Ex-1005 at 16:19-22; Figs. 10, 11. System controller 951 provides specific information to scanner 980 specifying a specific image to be projected onto surface 991 of object 990. *Id.* at 15:19-21. Orametrix describes that the image to be projected can be a digital image that is stored in memory by data processor 952. *Id.* at 17:11-19. Orametrix further describes that in the scanning process, different patterns can be projected over different periods of time. *Id.* at 29:8-19; Figs. 16, 19, 23. Orametrix teaches that changing the projected patterns with different encoding and measuring features over time allows for more information to be obtained about the surface. *Id.* Orametrix teaches that the measurement techniques may be implemented and executed by a hardware processor as part of the system. *See, e.g., id.* at 16:19-22; 64:6-15; 69:15-70:10; Fig. 46. It is my opinion that a POSITA would understand that the hardware processor of Orametrix would be utilized to implement the claimed method element.

138. Faul also describes projecting a time-varying pattern of structured light to determine the shape of an object. *See* Ex-1004 at 4:36-53. Faul describes generating a time-varying pattern with a digital video projector. *Id.* at 4:25-53; 5:52-7. Faul discloses that the scanner includes a microprocessor and memory, *id.* at 7:64-8:8, and it is my opinion that a POSITA would understand that this microprocessor would be utilized to implement the measurement process, including light source and camera control, as well as image processing. It is my opinion that a POSITA would understand that this microprocessor would be utilized to implement the claimed method element.

139. Thus, it is my opinion that Orametrix and Faul each teaches and/or renders obvious “using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern,” as recited by this claim element.

- c. **[Claim 21b]: “transmitting the probe light, through a tip of intraoral scanner inserted into the oral cavity, towards the object along an optical path, thereby illuminating at least a part of the object with the time-varying illumination pattern;”**

140. It is my opinion that Orametrix in view of Faul teaches this claim element. Orametrix describes a scanning device 4401 that appears to show a tip, as illustrated in Figure 44:

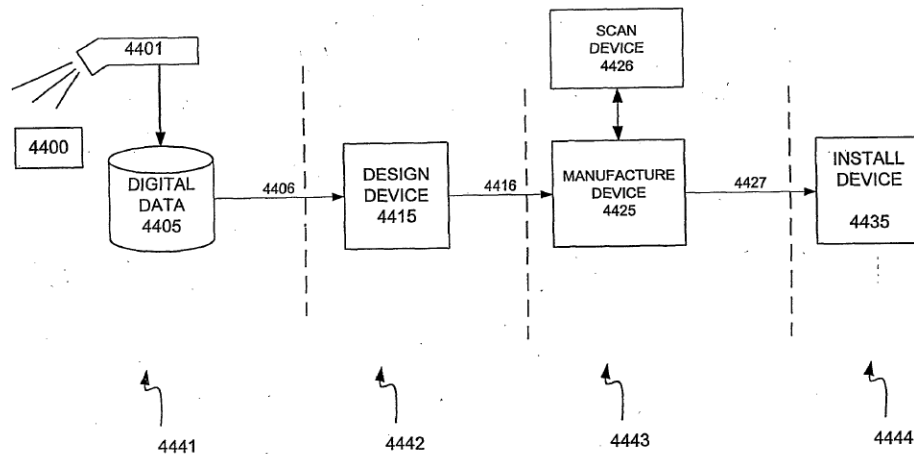
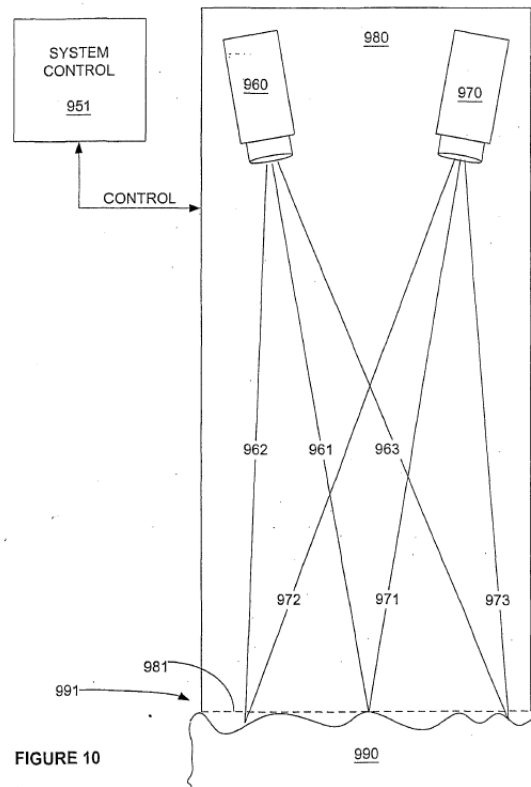


FIGURE 44

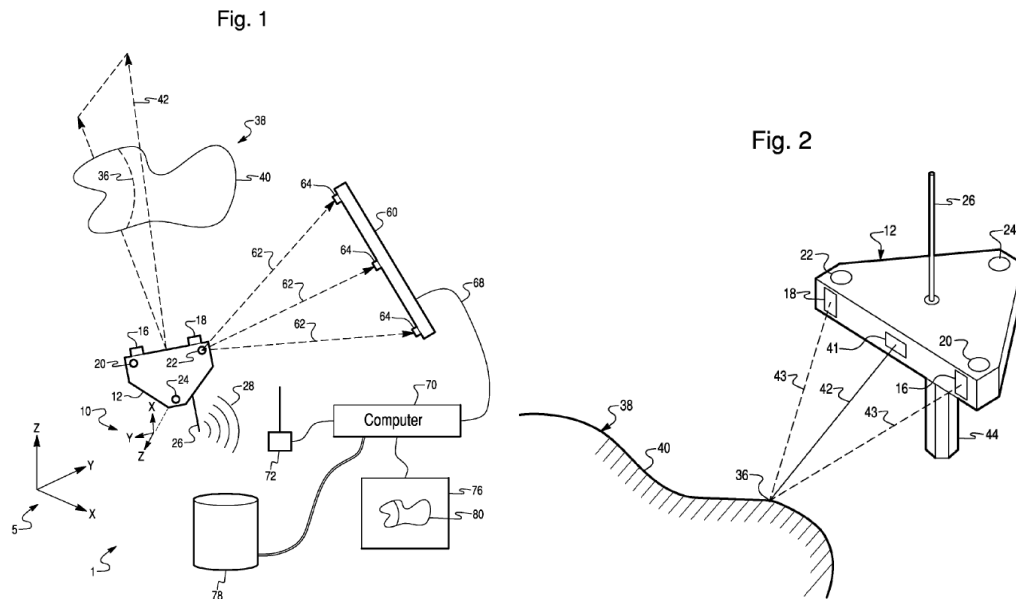
141. Orametrix further discloses that the anatomical structure, such as a tooth, can be scanned directly by scanner 4401. Ex-1005 at 56:11-20; *see also id.* at 31:11-19; Fig. 27 (describing scanning a tooth surface). It is my opinion that the scanner illustrated in Figure 44, in combination with the description of direct scanning of anatomical structures teaches the claimed “tip” limitation. Furthermore, it is my opinion that a POSITA would understand that in order to facilitate direct scanning of an anatomical structure, such as a tooth in a mouth, a housing that includes a tip would be needed to protect the scanning optics from damage or debris.

142. Figure 10 of Orametrix further illustrates additional limitations of this claim element:



143. As illustrated above, Orametrix shows projector 960 that transmits the patterned probe light beam along an optical path to the surface of object 990 thereby illuminating at least a part of the object with the time-varying illumination pattern. *Id.* at 16:6-13.

144. It is my opinion that Faul also describes the elements of this claim limitation. Figures 1 and 2 of Faul illustrate the claimed optical system:



145. As illustrated above, Faul describes a light source 41 projected on an optical path to a surface 36 from which reflected light is detected by at least one imaging sensor 16 or 18. Ex-1004 at 4:59-5:3; 8:45-9:25; 10:37-60. Faul describes the two-dimensional video data based on the reflected time-varying pattern that are detected by 16 or 18 are used as the basis for a three-dimensional model of the scanned surface. *Id.* at 4:59-9:25; 7:11-29. It is my opinion that Faul shows “transmitting the probe light, ... towards the object along an optical path, thereby illuminating at least a part of the object with the time-varying illumination pattern.” Thus, it is my opinion that Orametrix in view of Faul teaches “transmitting the probe light, through a tip of intraoral scanner inserted into the oral cavity, towards the object along an optical path, thereby illuminating at least a part of the object with

the time-varying illumination pattern,” as recited by this claim element.

- d. [Claim 21c]: “transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a plurality of 2D images,”**

146. It is my opinion that Orametrix and Faul each teaches this limitation.

147. As discussed above in Section X.A.1.d, Orametrix describes that light projected by projector 960 reflected from the surface of object 990 is detected by viewing device 970. Ex-1005 at 16:6-13; Fig. 10.

148. Faul describes that projected light from light source 41 is projected onto surface 36, the reflection of which is then detected by imaging sensor 16 or 18. Ex-1004 at 2:63-3:10; 4:59-5:3; 8:45-9:25; 10:37-50.

149. It is my opinion that a POSITA would recognize that Orametrix’s viewing device and Faul’s imaging sensors, in combination with the optical path of reflected light from surface, comprise “an optical system . . . for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images . . .,” as recited in this claim element. Therefore, it is my opinion that both Faul and Orametrix render this claim element obvious.

150. Thus, it is my opinion that Orametrix and Faul each teaches, and therefore renders obvious, “transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a

plurality of 2D images,” as recited by this claim element.

- e. **[Claim 21d]: “wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;”**

151. It is my opinion that Orametrix and Faul each teaches this claim element and therefore renders this claim limitation obvious.

152. As discussed above in Section X.A.1.d, Orametrix describes that the scanner receives a projected frame pattern that is digitized into a 2D image frame. Ex-1005 at 30:7-8. The 2D image frames are then converted into three dimensions using conventional 3D imaging techniques. *Id.* at 30:8-12; *see also id.* at 75 (claim 4).

153. Faul describes the two-dimensional video data based on the reflected time-varying pattern that are detected by 16 or 18 are used as the basis for a three-dimensional model of the scanned surface. Ex-1004 at 4:59-5:9; 5:38-41; 6:41-42; 7:11-29.

154. It is my opinion that a POSITA would recognize that Orametrix’s 2D image frame conversion and Faul’s two-dimensional video data analysis teach that “the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern,” as recited in this claim element. Therefore, it is my opinion that Orametrix and Faul each renders this claim element obvious.

f. [Claim 21e]: “selectively switching a color of the probe light, thereby illuminating the object with different colors at different times;”

155. It is my opinion that Orametrix or Faul further in view of Breton teaches this claim element. As described above in Section X.A.1.c, Orametrix describes scanning the object surface with a time-varying pattern in order to determine shape information. Furthermore, Orametrix describes changing the color of projected encoded features used for registration in multiframe scanning. Ex-1005 at 14:13-17; 25:11-26:5; Fig. 16. Orametrix also describes that photo data containing color information can be added to the digital data of the 3D virtual model of the anatomical structure. *Id.* at 64:6-15. Orametrix teaches that the measurement techniques may be implemented and executed by a hardware processor as part of the system. *See, e.g., id.* at 16:19-22; 64:6-15; 69:15-70:10; Fig. 46.

156. Faul describes projecting a time-varying pattern in order to determine the shape of an object. *See* Ex-1004 at 4:36-53. Faul describes using digital video projection to generate a time-varying pattern. *Id.* at 4:25-53; 5:53-54. Faul also describes measuring the color of the scanned surface. *See, e.g., id.* at 6:60-67. Faul also describes dynamically altering the color of the projected structured light. *See id.* at 10:64-11:4. Faul discloses that the scanner includes a microprocessor, *id.* at 7:49-8:8, and it is my opinion that a POSITA would understand that this

microprocessor would be utilized to implement the measurement process, including light source and camera control, as well as image processing.

157. Breton describes changing the wavelength of projected light from a controlled monochromatic source over time to illuminate the scanned object with different colors at different times in order to measure the color of the surface of the scanned object. *See, e.g.*, Ex-1003 at 6:62-7:20; Fig. 2. Breton describes that the wavelength of the light source needs to be stepped through a number of discrete spectral bands at a maximum bandwidth in order to achieve adequate spectral resolution for the spectral map that corresponds to the color of the tooth surface. *Id.* Breton further discloses that the color of teeth can be accurately measured using only three sampling bands in the red, blue, and green portions of the wavelength spectrum, and that limiting the spectral bands can reduce computation time. *Id.* at 78:24-36.

158. In my opinion, it would have been obvious to a POSITA to combine the wavelength scanning of the monochromatic light source of Breton with time-varying pattern projection Orametrix or Faul in order to measure the color of the scanned surface at an adequate spectral resolution, and therefore achieve an accurate color measurement. As discussed above, the processor of Orametrix is already configured to change the color of projected encoding features, and is configured to introduce color information from photo data into the three-dimensional model. And

as discussed above, Faul itself teaches color measurement and suggests dynamically changing the color of the projected time-varying structured light. It is my opinion that a POSITA would understand that the processors described by Orametrix and Faul would be configured to implement the color changing scheme as taught by Breton in the structured light projection in order to obtain sufficient spectral resolution to achieve an accurate color measurement of the scanned object surface.

159. Thus, it is my opinion that Orametrix or Faul, further in view of Breton, teaches “selectively switching a color of the probe light, thereby illuminating the object with different colors at different times,” as recited by this claim element.

g. [Claim 21f]: “recording different images by the at least one camera at the different times, thereby recording images of the object with the different colors;”

160. It is my opinion that Orametrix or Faul further in view of Breton teaches this claim element. As discussed above in Section X.A.1.c, both Orametrix and Faul teach recording images of the scanned surface at different times with different projected patterns. For example Orametrix describes that the data may be a composite of scans taken at different times. Ex-1005 at 57:7-16. Likewise, Faul describes assigning timestamps to each scanned image. Ex-1004 at 14:7-39. Faul also describes recording images of the object with different colors. *Id.* at 12:20-30; Fig. 4 (describing data format 403 that includes RGB color intensities for each point

in the image). As discussed above in Section X.A.1.h, it is my opinion that a POSITA would be motivated to combine Breton's color determination through wavelength scanning with either Orametrix or Faul in order to obtain sufficient spectral resolution in order to accurately measure the color of the scanned surface. A POSITA would understand that the wavelength scanning of this combination would necessarily require recording different images at different times reflecting the stepped wavelength changes.

161. Thus, it is my opinion that the combination of Orametrix or Faul further in view of Breton teaches "recording different images by the at least one camera at the different times, thereby recording images of the object with the different colors," as recited by this claim element.

h. [Claim 21g]: "combining the different colors from the different images to obtain the color of the surface of the object; and"

162. It is my opinion that Orametrix or Faul in view of Breton teaches this claim element. As discussed above in Section X.A.1.h, both Faul and Breton disclose dynamically varying the color of the projected light on the scanned object. Faul further teaches that the color data from a pattern with a variety of wavelengths is used to determine the color of the scanned surface. *See* Ex-1004 at 6:60-67. Faul also teaches measuring red-green-blue color intensities for each location in the

scanned image of the surface. *Id.* at 12:20-30. A POSITA would understand that these RGB intensities would be combined to obtain the color of the scanned surface. I Similarly Breton teaches building a color shade image map of the scanned surface out of several spectral images. *See* Ex-1003 at 6:47-54; 6:62-7:5. Breton also teaches that the color of a scanned surface can be measured by a linear combination of spectral sampling bands. *See id.* at 9:43-47. As discussed above in Sections X.A.1.e and X.A.1.f, it is my opinion that a POSITA would be motivated to combine either Orametrix or Faul with Breton in order to achieve an accurate color measurement of the scanned surface.

163. Thus, it is my opinion that Orametrix or Faul further in view of Breton teaches “combining the different colors from the different images to obtain the color of the surface of the object,” as recited by this claim element.

i. [Claim 21h]: “wirelessly transmitting the data for the 3D geometry.”

164. It is my opinion that Orametrix in view of Faul teaches this claim element. Orametrix describes wirelessly communicating data from the system to a client. Ex-1005 at 58:21-59:13. This client may be, for example, design device 4415 at facility 4442, which is a workstation located remotely from scanner 4401. *Id.* The scan data may be a dental structure, and Orametrix describes an example where the scanner may be performed at home by a user for monitoring the progress of a

treatment plan. *Id.* at 58:1-14. It is my opinion that a POSITA would understand that this scanner would be wireless and communicating data wirelessly for remote processing.

165. Faul teaches the advantages of a wireless handheld scanner for obtaining scanning data of three dimensional shapes in that it is unencumbered by a cable or mechanical linkage. *See, e.g.*, Ex-1004 at 2:36-39. Faul describes processing two-dimensional image data locally in the scanning device to reduce the amount of data that is required to be transmitted from the scanning device to a workstation. Ex-1004 at 4:59-5:51; 12:43-50. It is my opinion that a POSITA would implement the local processing taught by Faul in the combined scanning system of Orametrix, Faul, and Breton to reduce the amount of data required to be transmitted wirelessly and increase overall processing speed. Furthermore, in my opinion it would have been obvious to a POSITA to configure the scanner of Orametrix with the wireless configurations taught by Faul because Orametrix already contemplates the wireless transmission of data, and Faul teaches that making the handheld scanning unit wireless allows the user to scan objects without the encumbrance of a mechanical linkage or cables.

166. Therefore, it is my opinion that Orametrix in view of Faul teaches “wirelessly transmitting the data for the 3D geometry,” as recited by this claim

element.

14. Claim 22 Is Rendered Obvious by Orametrix

167. It is my opinion that Orametrix renders this claim obvious.

- a. **[Claim 22]: “The method according to claim 21, wherein the plurality of 2D images is recorded using a high-speed camera.”**

168. It is my opinion that Orametrix teaches that the reflected structured light is imaged by a high-speed camera. For example, Orametrix teaches that the scan rates can be chosen to allow for real-time viewing of a three-dimensional image. Ex-1005 at 34:12-21. Based on this disclosure, it is my opinion that a POSITA would understand the camera disclosed by Orametrix to be a high-speed camera in order to match the high-speed scan rates required for real-time viewing.

169. Thus, it is my opinion that Orametrix teaches “wherein the plurality of 2D images is recorded using a high-speed camera,” as recited by this claim element.

15. Claim 23 Is Rendered Obvious by Orametrix in View of Faul

170. It is my opinion that Orametrix in view of Faul teaches this claim element.

- a. **[Claim 23]: “The method according to claim 21, wherein the method further comprises a step of locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.”**

171. Faul describes processing two-dimensional image data, such as 2D video image data, locally in the scanning device to reduce the amount of data that is required to be transmitted from the scanning device to a workstation. Ex-1004 at 4:59-5:51; 12:43-50. Faul describes that subpixel coordinates of given points on the scanned 2D image are transformed into three-dimensional coordinates that are then transmitted. *Id.* at 12:27-32. It is my opinion that a POSITA would implement the local processing taught by Faul in the combined scanning system of Orametrix, Faul, and Breton to reduce the amount of data required to be transmitted wirelessly and increase overall processing speed.

172. Therefore, it is my opinion that Orametrix in view of Faul teaches, and therefore renders obvious, “locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images,” as recited by claim 23.

16. Claim 24 Is Rendered Obvious by Orametrix in View of Faul

173. It is my opinion that Orametrix in view of Faul teaches this claim element.

- a. **[Claim 24]: “The method according to claim 21, wherein the method further comprises a step of locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.”**

174. As discussed above with respect to claim 9 in Section X.A.7.a and claim 23 in Section X.A.15.a, Faul describes local processing of the imaging data before wirelessly transmitting the data for further processing at a workstation. In addition to locally processing data to reduce the burden of wireless transmission, Faul specifically describes locally processing 2D data into 3D data. Ex-1004 at 4:59-5:51. Faul describes this local processing as significantly reducing the amount of transmitted geometric and color data, as compared to conventional transmission. *Id.* at 12:43-50.

175. It is my opinion that a POSITA would have been motivated to combine the local processing described by Faul into the method of scanning and processing described by Orametrix in order to achieve the advantage of reduced wireless data transmission burden.

176. Therefore, it is my opinion that Orametrix in view of Faul teaches, and therefore renders obvious, “locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images,” as recited by claim 24.

17. Claim 25 Is Rendered Obvious by Orametrix in View of Faul

177. It is my opinion that Orametrix in view of Faul renders this claim obvious.

a. [Claim 25]: “The method according to claim 23, wherein the step of wirelessly transmitting the data for the 3D geometry is to a workstation.”

178. As discussed above with respect to claims 1, 9, and 10, in Sections X.A.1.k, X.A.7, and X.A.8, and claims 21, 23, and 24 above in Sections X.A.13.i, X.A.15, and X.A.16, Orametrix describes wirelessly communicating scanning data from the scanning system to a client. Ex-1005 at 58:21-59:13; Fig. 44. As further discussed above in the same sections, Faul describes wireless transmission of the data for the 3D geometry to a workstation. Ex-1004 at 4:59-5:51; 12:43-50. And as discussed above in Section X.A.1.k, a POSITA would incorporate the wireless teachings of Faul into Orametrix in order to achieve an untethered scanning

instrument.

179. Therefore, it is my opinion that Orametrix in combination with Faul renders obvious “wherein the step of wirelessly transmitting the data for the 3D geometry to a workstation,” as recited by claim 25.

18. Claim 26 Is Rendered Obvious by Orametrix and Faul

180. It is my opinion that Orametrix and Faul teach this claim element.

a. [Claim 26]: “The method according to claim 23, wherein the step of locally processing is in real time.”

181. Orametrix describes allowing for real-time viewing of a three-dimensional image of the scanned object. Ex-1005 at 34:12-15. Faul also describes rendering the geometry of a three-dimensional object in real-time. Ex-1004 at 8:56-60.

182. Therefore, it is my opinion that Orametrix and Faul each render obvious “wherein the hardware processor processes the raw 3D data into data for the 3D geometry in real time,” as recited by claim 26.

19. Claim 27 Is Rendered Obvious by Orametrix in View of Faul

183. It is my opinion that Orametrix in view of Faul renders this claim obvious.

- a. **[Claim 27]: “The method according to claim 21, where the method further comprises a step of computing a temporal correlation measure with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed.”**

184. Faul describes temporal correlation of the pattern of light and the scanner position that allows for accurate three dimensional coordinate transformation. Ex-1004 at 2:49-62; 3:11-24; 9:27-42. It is my opinion that a POSITA would be motivated to combine the temporal correlation described by Faul in the system of Orametrix in order to obtain accurate coordinate data based on the changing projected pattern and the location of the scanning device.

185. Therefore, it is my opinion that Orametrix in view of Faul renders obvious “computing a temporal correlation measure with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed,” as recited by claim 27.

20. Claim 29 Is Rendered Obvious by Orametrix in View of Faul

186. It is my opinion that Orametrix in view of Faul renders this claim element obvious.

- a. **[Claim 29]: “The method according to claim 27, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.”**

187. Faul describes calibrating the handheld scanner including details about the pattern of structured light. Ex-1004 at 7:64-8:8. In my opinion, a POSITA would be motivated to calibrate the scanning system of Orametrix as taught by Faul in order to ensure accurate determination of the three-dimensional shape of the scanned object.

188. Therefore, it is my opinion that Orametrix in view of Faul renders obvious “wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern,” as recited by claim 29.

B. Claim 16 is rendered obvious by Orametrix, Faul, and Breton in View of Durbin

189. As discussed above in Section X.A, it is my opinion that Orametrix in view of Faul and Breton teaches all the claim elements of claim 1. It is my opinion that the combination of Orametrix, Faul, and Breton in view of Durbin renders this claim obvious.

190. As discussed above in Section IX, Orametrix, Faul, and Breton all describe measuring systems for acquiring the color and shape of scanned objects.

As discussed in Section IX.D, Durbin also describes an optical scanning system for acquiring the three-dimensional shape of an object using structure light projection. As such, it is my opinion that these four references belong to the same technical field, provide similar scanning systems, and thus provide elements and features that a POSITA would have looked to in order to arrive at the combination of elements comprising the invention described by the claims. Furthermore, because they each describe similar scanning systems with similar objectives, it is my opinion that a POSITA would have had a reasonable expectation of success in combining Orametrix, Faul, Breton, and Durbin in order to achieve accurate color and shape measurements in three-dimensional models of scanned objects.

191. Both Orametrix and Faul recognize the need for obtaining accurate scans of objects for three-dimensional modeling and mapping. For example, Orametrix describes the need for accurate three-dimensional models to develop medical and dental devices and appliances that will reduce the level of subjective criteria required in manufacturing or reproducing them. *See, e.g.*, Ex-1005 at 1:17-22; 2:1-3:20. Similarly, Faul describes the desirability of obtaining three-dimensional models of real world objects that are enhanced through wireless optical scanning, which does not require cables or other mechanical linkage or any physical contact with the object. *See, e.g.*, Ex-1004 at 1:18-34; 2:36-39; 2:42-3:32; 15:16-19.

192. As with Orametrix and Faul, Durbin describes generating a three-dimensional model of a scanned surface using two-dimensional images from structured light projection. *See, e.g.*, Ex-1008 at 5:37-43; 6:20-26. Durbin describes the need for accurate in vivo three-dimensional imaging of teeth and dental structures. *See, e.g., id.* at 4:12-20.

193. And as with Orametrix and Durbin, Breton describes the need to obtain an objective three-dimensional model of a tooth to create an accurate reproduction for a replacement tooth that minimizes subjectivity. *See, e.g.*, Ex-1003 at 1:14-40. Breton discusses the difficulty in matching the color shade of a reproduction tooth. *Id.* at 1:29-34. Thus, because Orametrix, Faul, Breton, and Durbin are in the same field, teach analogous scanning solutions to the same issues, and have the same purpose to increase objectivity and accuracy in three-dimensional modeling of real world objects, it is my opinion that a POSITA would have been motivated to combine the various elements of these three references to increase the accuracy of the color and shape measurements underlying the subsequent three dimensional modeling of the real world objects.

194. A POSITA also would have had an expectation of success in combining the features and teachings of Orametrix, Faul, Breton, and Durbin because these optical systems all rely on similar scanning arrangements, and the substitution and

combinations of features would be simple and yield the expected results of more accurate and objective optical measurements to make three-dimensional models of real world objects.

195. As a result, it is my opinion that the combined teachings of these references, the knowledge, creativity, and common sense of a POSITA and the nature of the problem to be solved would have led a POSITA to the claimed combination and would have indicated a reasonable likelihood of success in making the above referenced combination.

- a. **[Claim 16]: “The intraoral scanner according to claim 1, wherein the high-speed camera records images at a frame rate of at least 500 frames per second or at a frame rate of at least 2000 frames per second.”**

196. Orametrix describes that scan rates greater than 20 frames per second can be used to allow for real-time viewing of a three-dimensional image. Ex-1005 at 34:12-21. It is my opinion that based on this disclosure, it would be obvious to a POSITA that the camera of Orametrix would necessarily be capable of recording images at a frame rate of at least 500 frames per second in order to correspond to a scanning frame rate that allows for real-time viewing of the three-dimensional image of the scanned object. For example, Durbin teaches a three-dimensional dental scanner that uses a camera to capture images. *See* Ex-1008 at Abstract. Durbin

further discloses that it can be advantageous to use a CMOS-based imager with higher-sensitivity in order to allow for image capturing at frame rates of greater than 1000 frames per second, and allow for dynamic resizing of an imaging window during the scanning process. *See id.* at 17:4-9. Based on Durbin’s disclosure, it is my opinion that it would have been obvious to a POSITA to include a CMOS imager in the combination of Orametrix, Faul, and Breton to achieve the increased sensitivity and facilitate real-time viewing of the three-dimensional model of the scanned object.

197. Therefore, it is my opinion that Orametrix, Faul, and Breton in combination with Durbin renders obvious “wherein the high-speed camera records images at a frame rate of at least 500 frames per second,” as recited by claim 16.

XI. CONCLUSION

198. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and 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: August 16, 2023

By: Rongguang Liang