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ALIGN TECHNOLOGY, INC.
Petitioner

v.

3SHAPE A/S
Patent Owner

Case No. PGR2018-00103
Patent No. 9,962,244

**SECOND CORRECTED DECLARATION OF DR. CHANDRAJIT L.
BAJAJ, PH.D. IN SUPPORT OF POST-GRANT REVIEW OF U.S. PATENT
NO. 9,962,244**

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1. Claim 2: “The focus scanner according to claim 1, wherein the data processing system is configured for generating a sub-scan of a part of the object surface based on surface geometry information and surface color information derived from a plurality of bocks of image sensor pixels.”	285
2. Claim 3: “The focus scanner according to claim 1, where the scanner system comprises a pattern generating element configured for incorporating a spatial pattern in said probe light.”	286
3. Claim 4: “The focus scanner according to claim 1, where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern.”	286
4. Claim 5: “The focus scanner according to claim 4, wherein deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value.”	287
5. Claim 7: “The focus scanner according to claim 6, where the maximum correlation measure value is the highest calculated correlation measure value for the block of image sensor pixels and/or the highest maximum value of the correlation measure function for the block of image sensor pixels.”	288

6.	Claim 8: “The focus scanner according to claim 5, wherein the data processing system is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels.”	289
7.	Claim 9: “The focus scanner according to claim 8, wherein the data processing system is configured for deriving the sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D images in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels and on at least one additional 2D image.”	290
8.	Claim 10: “The focus scanner according to claim 9, where the data processing system is configured for interpolating surface color information of at least two 2D images in a series when determining the sub-scan color.”	291
9.	Claim 15: “The focus scanner according to claim 1, where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter.”	291
10.	Claim 16: “The focus scanner according to claim 15, where the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source.”	292
11.	Claim 18: “The focus scanner according to claim 16, wherein the selected wavelength range matches the W2 wavelength range.”	293
12.	Claim 21: “The focus scanner according to claim 3, where the information of the saturated pixel in the computing of the pattern generating element is configured to provide that the spatial pattern comprises alternating dark and bright regions arranged in a checkerboard pattern.”	293

13.	Claim 26: “The focus scanner according to claim 9, wherein said at least one additional 2D image comprises a neighboring 2D image from the series of captured 2D images.”	294
14.	Claim 28: “The focus scanner according to claim 10, where the interpolation is of surface color information of neighboring 2D images in a series.”	295
XIX.	Conclusion.....	1

I. Introduction

I, Dr. Chandrajit L. Bajaj, Ph.D., declare as follows:

1. I have been retained as an expert witness by Sterne, Kessler, Goldstein & Fox PLLC to provide testimony on behalf of Align Technology, Inc. (“Align” or “Petitioner”) for the above-captioned post-grant review proceeding and a related proceeding that is concurrently filed, PGR2018-00104. This Declaration concerns technical subject matter relevant to the post-grant review petition (“Petition”) concerning U.S. Patent No. 9,962,244 (“the ’244 Patent”) titled “Focus Scanning Apparatus Recording Color” by Bo Esbech, et al. It is my understanding that ’244 Patent is currently assigned to 3Shape A/S (“3Shape” or “Patent Owner”).

2. I am over 18 years of age. I have personal knowledge of the facts stated in this Declaration and would testify competently to them if asked to do so.

3. I have reviewed and am familiar with the specification, claims, and prosecution history of the ’244 Patent.

4. I have reviewed and am familiar with the following documents and materials:

Exhibit	Description
1001	U.S. Patent No. 9,962,244 to Esbech et al. (“the ’244 patent”)
1002	Prosecution File History for the ’244 patent (“’244 patent file history”)

Exhibit	Description
1004	Curriculum vitae of Dr. Chandrajit Bajaj, Ph.D.
1005	U.S. Patent Application Publication No. 2012/0092461 to Fisker et al. (filed June 17, 2009; published: April 19, 2012).
1006	U.S. Patent No. 6,097,854 to Szeliski et al. (filed August 1, 1997; issued August 1, 2000).
1007	U.S. Patent No. 7,106,348 B2 to Matsumoto et al. (filed November 28, 2001; issued: September 12, 2006).
1008	U.S. Patent Application Publication No. 2007/0035641 to Yamada et al. (filed April 25, 2005; published: February 15, 2007).
1009	U.S. Patent Application Publication No. 2013/0070128 to Suzuki et al. (filed September 10, 2012; published March 21, 2013).
1010	U.S. Patent Application Publication No. 2015/0029367 to Tanaka (earliest priority date July 29, 2011; published January 29, 2015).
1011	U.S. Patent Application Publication No. US 2010/0067789 to Cai (filed September 18, 2011; published March 18, 2010).
1012	U.S. Patent Application Publication No. 2012/0075425 to Thiel (“Thiel425”) (filed August 19, 2011; published: March 29, 2012).
1013	U.S. Patent Application Publication No. 2011/0080576 to Thiel et al. (“Thiel576”) (filed October 1, 2010; published: April 7, 2011).
1014	Agini, Andreas, et al. <i>Digital Dental Revolution: The Learning Curve</i> . Quintessence Publishing, First edition, 2015.
1015	U.S. Patent No. 6,750,873 to Bernardini et al. (“Bernardini”) (filed June 27, 2000; issued June 15, 2004).
1016	U.S. Patent Application Publication No. 2013/0101176 to Park et al. (“Park”) (filed August 24, 2012; published April 25, 2013).

Exhibit	Description
1017	U.S. Patent Application Publication No. 2012/0140243 to Colonna de Lega (“Colonna de Lega”) (filed December 1, 2011, published June 7, 2012).
1018	Karatas et al., “Three-dimensional imaging techniques: A literature review,” <i>European Journal of Dentistry</i> , Vol. 8, Issue 1, 2014; pp. 132-140.
1019	Broadbent, B.H., “A New X-Ray Technique and Its Application to Orthodontia,” <i>The Angle Orthodontist</i> , Vol. 1, No. 2, 1931; pp. 45-66.
1020	Hajeer <i>et al.</i> , Current Products and Practices Applications of 3D imaging in orthodontics: Part II, <i>Journal of Orthodontics</i> , vol. 31 (2004).
1021	Yamany et al., “Free-Form Surface Registration Using Surface Signatures,” <i>The Proceedings of the Seventh IEEE International Conference on Computer Vision</i> , September 20-27, 1999; 7 pages.
1022	Ireland et al., “3D surface imaging in dentistry – what we are looking at,” <i>British Dental Journal</i> , Vol. 205, No. 7, October 11, 2008; pp. 387-392.
1023	Remondino et al., “Image-Based 3D Modelling: A Review,” <i>The Photogrammetric Record</i> , Vol. 21, No. 115, September 2006; pp. 269-291.
1024	Ting-Shu et al., “Intraoral Digital Impression Technique: A Review,” <i>J. Prosthodontics</i> , Vol. 24, No. 4, pp. 313-321.
1025	Zimmerman et al., “Intraoral scanning systems – a current overview,” <i>Int. J. Comput. Dent.</i> , Vol. 18, No. 2, 2015, pp. 101-129.
1026	Imburgia et al., “Accuracy of four intraoral scanners in oral implantology: a comparative in vitro study,” <i>BMC Oral Health</i> , Vol. 17, No. 1, 2017, p. 92.
1027	Park et al., “Changes in views on digital intraoral scanners among dental hygienists after training in digital impression taking,” <i>BMC Oral Health</i> , Vol. 15, No. 1, 2015, p.151 (“Park Article”).

Exhibit	Description
1028	Logozzo et al., “Recent advances in dental optics – Part I: 3D intraoral scanners for restorative dentistry,” Optics and Lasers in Engineering, Vol. 54, 2014, pp. 203-221.
1029	U.S. Patent Prov. App. No. 61/764,178 to Esbech et al. (“the Provisional Application”)

5. To the best of my knowledge, Exhibits 1001, 1002, and 1004-1029 are true and accurate copies of what they purport to be. An expert in the field would reasonably rely on them to formulate opinions such as those set forth in this declaration.

6. The '244 Patent describes a scanner system and a method for recording surface geometry and surface color of an object. (Ex.1001, Abstract.) I am familiar with the technology described in the '244 Patent as of its filing date of February 13, 2014, and its alleged February 13, 2013 priority date, which is disputed for at least some claims.

7. I have been asked to provide my technical review, analysis, insights, and opinions regarding the '244 Patent and the references that form the basis for the following Grounds set forth in the two Petitions for Post Grant Review of the '244 Patent.

Claim(s)	Section	Combinations of References
1-5, 7-10, 15, 16, 18, 21, 22, 24, 26, and	Section VII	Fisker and Szeliski or Matsumoto

28		
29	Section VIII	Fisker and Yamada or Suzuki;
	Section XV	Thiel425, Thiel576, and Yamada or Suzuki.
12	Section IX	Fisker, Szeliski or Matsumoto, and Yamada or Suzuki
31-32	Section X	Fisker and Tanaka
	Section XVI	Thiel425, Thiel576, and Tanaka
17 and 19	Section XI	Fisker, Szeliski or Matsumoto, and Tanaka
34	Section XII	Fisker and Suzuki or Cai
	Section XVII	Thiel425, Thiel576, Fisker, and Suzuki or Cai
11	Section XIII	Fisker, Szeliski or Matsumoto, and Suzuki or Cai
1, 22, and 24	Section XVI	Thiel425, Thiel576, and Szeliski or Matsumoto
2-5, 7-10, 15, 16, 18, 21, 26, and 28	Section XVIII	Thiel425, Thiel576, Szeliski or Matsumoto, and Fisker

II. Qualifications and Expertise

8. My *curriculum vitae* (“CV”) is attached hereto as Exhibit 1004 and provides accurate identification of my background and experience. It includes a list of all publications I have authored in the previous 11 years. It also includes a list of all other cases in which, during the previous 5 years, I testified as an expert at trial or by deposition.

9. I am currently employed as a Professor of Computer Science at the University of Texas at Austin (“UT Austin”). I hold the Computational Applied Mathematics endowed Chair in Visualization. I am also the Director of the Computational Visualization Center at UT Austin, which has been funded by the National Institutes of Health, the National Science Foundation, the Department of Energy, and the Department of Defense. The center personnel includes twelve researchers, scientists, post-graduate students, and staff.

10. I have a Bachelor of Technology degree in Electrical Engineering, which I obtained from the Indian Institute of Technology in Delhi (IITD) in 1980. I also have a Master of Science degree and a Doctorate in Computer Science from Cornell University in 1983 and 1984, respectively.

11. Prior to my employment at the University of Texas, I was an assistant professor, associate professor, and finally professor of Computer Sciences at Purdue University (Purdue) from 1984 until I resigned in 1997 and transferred to UT. During this time, I was also the Director of Image Analysis and Visualization Center at Purdue University. I was a visiting associate professor of Computer Science at Cornell University from 1990–1991. I have also been invited for collaborative visits by several academic institutions, and have presented numerous keynote presentations worldwide. I have been an editorial member of the SIAM Journal on Imaging Sciences, and the ACM Transactions on Graphics, and

continue my editorial role for ACM Computing Surveys and the International Journal of Computational Geometry and Applications.

12. I have spent the better part of my career, both at Purdue and UT, researching, designing, teaching and using computer systems to model, simulate and visualize natural and synthetic objects combining computational image and geometry processing. I am knowledgeable about and have much experience in both the hardware and software, including algorithms, used for capturing, analyzing, and displaying interactive imagery.

13. In the 1970s, while majoring in Electrical Engineering at Indian Institute of Technology with a minor in Computer Sciences, I was intimately involved in the design and fabrication of microprocessor-controlled circuits including the development of microprocessor controller software. In the 1980s, while at Cornell University, these past experiences led to research in computational geometry, processing, and optimization. In the early 1990s, I created 3D collaborative multimedia software environments which were fully navigable for multi-person computer gaming and simulation. In 1994, I co-authored a technical paper entitled “Shastra: Multimedia Collaborative Design Environment.” Vinod Anupam and Chandrajit L. Bajaj, *IEEE Multimedia* 1.2 (1994) 39, 39–49. The need for increasing computer graphics to display realism without sacrificing interactivity also led me to explore image processing and geometric modeling

techniques such as surface reconstruction from CT scans, point clouds, and texture mapping with data compression, such as described in my publications: “Multi-Component Heart Reconstruction from Volumetric Imaging,” (Chandrajit Bajaj and Samrat Goswami, *Proceedings of the 2008 ACM Solid and Physical Modeling*, Stony Brook, NY (2008) 193-202), “3D RGB Image Compression for Interactive Applications,” (Chandrajit Bajaj, Insung Ihm, and Sanghun Park, *ACM TRANSACTIONS ON GRAPHICS (TOG)*, (2001)10–38), and “Automatic Reconstruction of Surfaces and Scalar Fields from 3D Scans,” (Chandrajit Bajaj, Fausto Bernardini, and Guoliang Xu, *Proceedings of the 22nd annual conference on Computer Graphics and Interactive Techniques*, (SIGGRAPH 1995) 109-118).

14. In the mid-2000s, I began to create spatially-realistic 3D graphical environments of nature’s molecules and cells with a combination of different types of acquired and reconstructed imagery within which a user may explore, query, and learn. My publication titled “From Voxel Maps to Models” that appeared in an Oxford University Press book called IMAGING LIFE: BIOLOGICAL SYSTEMS FROM ATOMS TO TISSUES, c. 15 (Gary C. Howard, William E. Brown & Manfred Auer eds.) is an example of my research in computational imaging. Over the course of my career, I have participated in the design and use of several computer systems spanning handhelds, laptops, graphics workstations to PC/Linux clusters as well as very large memory supercomputers for capturing, modeling and

displaying virtual and scientific phenomena. My experience with computer modeling and displaying computer graphics imagery encompasses many fields, such as interactive games, molecular, biomedical and industrial diagnostics, oil and gas exploration, geology, cosmology, and military industries.

15. During this time at UT Austin, I also designed and implemented scalable solutions for inverse problems in microscopy, spectroscopy, biomedical imaging, constructing spatially realistic and hierarchical 3D models, development of search/scoring engines for predicting energetically favorable multi-molecular and cellular complexes, and statistical analysis and interrogative visualization of neuronal form-function. Additionally, I have courtesy appointments with and supervise M.S and Ph.D. students from several UT departments, including biomedical and electrical engineering, neurobiology, and mathematics. I currently serve on the editorial boards for the International Journal of Computational Geometry and Applications and the ACM Computing Surveys. Much of my work involves issues relating to interactive image processing, 3D modeling, bio-informatics, computer graphics, and computational visualization. Examples of my publications, including peer-reviewed publications, are listed in my CV.

16. As set forth in my CV, I have authored approximately 161 peer-reviewed journal articles, 34 peer-reviewed book chapters, and 148 peer-reviewed conference publications.

17. I have written and edited four books, on topics ranging from image processing, geometric modeling, and visualization techniques, to algebraic geometry and its applications. I have given 187 invited speaker keynote presentations. I am a Fellow of the American Association for the Advancement of Science, a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), a Fellow of the Society of Industrial and Applied Mathematics (SIAM), and a Fellow of the Association of Computing Machinery (also known as ACM), which is the world's largest education and scientific computing society. ACM Fellow is ACM's most prestigious member grade and recognizes the top 1% of ACM members for their outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community.

III. Legal Understanding

A. My Understanding of Claim Construction

18. I understand that during a post-grant review proceeding, claims are to be construed in light of the specification as would be read by a person of ordinary skill in the relevant art at the time the application was filed. I understand that claim terms are given their ordinary and customary meaning as would be understood by a person of ordinary skill in the relevant art in the context of the entire disclosure. A claim term, however, will not receive its ordinary meaning if the patentee acted as his own lexicographer and clearly set forth a definition of the claim term in the

specification. In this case, the claim term will receive the definition set forth in the patent.

B. A Person of Ordinary Skill in the Art

19. I understand that a person of ordinary skill in the relevant art (herein “POSITA”) is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity—not an automaton.

20. I have been asked to consider the level of ordinary skill in the field that someone would have had at the time the claimed invention was made. In deciding the level of ordinary skill, I considered the following:

- the levels of education and experience of persons working in the field;
- the types of problems encountered in the field; and
- the sophistication of the technology.

21. My opinion below explains how a person of ordinary skill in the art would have understood the technology described in the references I have identified herein around the February 2013 timeframe. I have been advised that the alleged earliest possible effective filing date for some claims of the ’244 Patent is February 13, 2013.

22. Based on the disclosure of the ’244 Patent, a POSITA would have had a bachelor’s degree in computer engineering, computer science, electrical

engineering, physics, computer vision, or an equivalent field as well as at least one or two years of industry experience, or at least five years of comparable industry experience. In particular, a POSITA would have had experience with, and knowledge of, three-dimensional imaging systems and three-dimensional modeling techniques.

23. Regardless if I use “I” or a “POSITA” during my technical analysis below, all of my statements and opinions are always to be understood to be based on how a POSITA would have understood or read a document at the time of the invention.

C. My Understanding of Obviousness

24. I understand that a patent claim is invalid if the claimed invention would have been obvious to a person of ordinary skill in the art at the time the application was filed. I understand that this means that even if all of the requirements of the claim cannot be found in a single prior art reference that would anticipate the claim, the claim can still be invalid.

25. To obtain a patent, a claimed invention must have been, as of its priority date, non-obvious in view of the prior art in the field. I understand that a patent claim is obvious when the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have

been obvious at the time the invention was made to a person of ordinary skill in the art.

26. I understand that in order to prove that the prior art, or a combination of prior art, render a claim obvious, it is necessary to (1) identify the particular references that, singly or in combination, make the claim obvious; (2) specifically identify which elements of the claim appear in each of the asserted references; and (3) explain how the prior art references could have been combined to teach or suggest the limitations in the claim.

27. I also understand that prior art references can be combined under several different circumstances. For example, it is my understanding that one such circumstance is when a proposed combination of prior art references results in a system that represents a predictable variation, which is achieved using prior art elements according to their established functions.

28. I understand that certain objective indicia (secondary indicia) can be important evidence in determining whether a claim is obvious or non-obvious. Such indicia include: commercial success of products covered by the patent claims; a long-felt need for the invention; failed attempts by others to make the invention; copying of the invention by others in the field; unexpected results achieved by the invention as compared to the closest prior art; praise of the invention by the infringer or others in the field; the taking of licenses under the patent by others;

expressions of surprise by experts and those skilled in the art at the making of the invention; and the patentee proceeded contrary to the accepted wisdom of the prior art. At this point, I am not aware of any secondary indicia of non-obviousness.

29. My analysis below is always from the perspective of a POSITA unless otherwise noted, even if that is not explicitly stated. My analysis of the prior art is always made as of the time the alleged invention was made from the perspective of a POSITA.

D. My Understanding of Written Description

30. It is my understanding that in order to provide an adequate written description of an invention, a patent specification must disclose the invention in sufficient detail so a POSITA can clearly conclude that the inventor had possession of the claimed invention. I understand that the disclosure must be within the four corners of the specification, including any originally-filed claims. The disclosure cannot merely provide enough detail to make the invention obvious, but instead must provide enough detail so that a POSITA reading the disclosure understands that the invention is explicitly or inherently disclosed.

31. It is also my understanding that a patent application may claim priority benefit to the filing date of one or more of the applicant's previously filed U.S. patent applications for claims that are supported in those previously-filed applications by an adequate written description. It is my understanding that the

date to which a particular claim is entitled to claim this benefit depends upon when the matter necessary to provide a written description of the claim was first disclosed in an application in the chain of priority. If an application in the chain of priority does not provide a written description of a claim, then that claim is not entitled to claim the benefit of the filing date of that priority application.

IV. Background of the Technologies Disclosed in the '244 Patent

A. Technical Overview of Intraoral Scanners

32. The '244 Patent applies a known image processing method. For example, the '244 Patent acknowledges that 3D scanning, geometry detection, and image processing, including color imaging, existed at the time the '244 Patent was filed. (*See* Ex.1001, 1:13-60.) As I will explain below, the '244 Patent is merely an obvious combination of known and practiced technologies.

1. Early Medical Imaging

33. “In 1895, discovery of X-rays by W.C. Roentgen opened a new era in medicine and dentistry.” (Ex.1018, 133.) Thirty-six years later, standardized methods for the production of cephalometric radiographs were introduced to the dental specialists by Broadbent and Hofrath simultaneously and independently. (*See* Ex.1019, 45–66.) Cephalograms have been widely used in clinical implementations and as an investigation technique to evaluate growth and treatment responses. (*Id.*)

34. The first Computed Tomography (“CT”) scanning device was developed around 40 years ago. (Ex.1018, 133.) After a short time, a stack of CT sectional images was used to obtain 3D information. (*Id.*) “CT imaging, also called computerized axial tomography (CAT) imaging, uses special X-ray equipment to generate cross-sectional images of the body.” (*Id.*)

35. Since its inception in the 1980’s, CT scanning and imaging have presented issues when used in orthodontics. For example, some disadvantages of CT scanning and imaging include: capturing foreign objects such as metal brackets, prosthetics, and restorations; capturing unwanted patient movement that may cause image disorder and/or inconsistency; and exposing the patient to increased levels of radiation.

36. In the late 1990’s, structured light scanning techniques were first implemented to provide surface-level scanning without the use of ionizing radiation. By 1998, OraScanner™, a 3D hand-held intra-oral scanner developed by OraMetrix Company, used the structured light technique to capture and process 3D surface images of teeth. (Ex.1020, 154.) For example, the OraScanner™ used a video camera to record the structured light distortions on dental crowns as it passed over the dentition in about one minute. (*Id.*) A computer processed the captured images and merged them together to create a complete 3D computer model of a dental arch. (*Id.*)

2. Image Stitching and Blending

37. Using the CT and intra-oral scanning methods described above, images of objects taken at different scan times can be co-registered on (pre-defined) overlapping scan points, composited, and 3D models of these objects reconstructed all using existing 3D software. (Ex.1018, 136.) Measurements performed on these imported 3D computer models are used to track object growth changes and evaluate treatment progress. (*Id.*) Thus, stability and post-treatment assessment can be made with the help of 3D superposition. Image stitching and blending are universal for all multi-scan procedures (ultrasound, intra-oral light, etc.) and particularly hand-held procedures. (*Id.*)

38. Since the late 1990s, intra-oral scanning software has been implementing surface stitching and registration. (Ex.1021, 0001.) In order for any surface registration algorithm to perform accurately and efficiently, appropriate representation scheme for the surface is needed. (*Id.*) Most of the surface representation schemes found in literature have adopted some form of shape parameterization, especially for the purpose of object recognition. (*Id.*)

39. A key step in the stitching/registration process is to “match corresponding signature images of two surfaces/objects or between a 3-D scene and objects in a library.” (*Id.*, 0004.) “The ultimate goal of the matching process is to find at least three points correspondence to be able to calculate the

transformation parameters.” (*Id.*) The end result of the matching process is a list of groups of likely three-point correspondences that satisfy the geometric consistency constraint. (*Id.*) The list is sorted such that correspondences that are far apart are at the top of the list. (*Id.*) In some methods, a rigid transformation is calculated for each group of correspondences, and the verification is performed using a modified Iterative Closest Point (ICP) technique. (*Id.*) Groups are ranked according to their verification scores, and the best group is refined using the modified ICP technique. (*Id.*)

3. Image Processing

40. 3D surface scanners, as the name suggests, are devices that create a digital map of the surface of an object and collect data on its three-dimensional shape and size. (Ex.1022, 387.) The raw data are usually obtained in the form of a point cloud, which represents the 3D coordinates in the x, y and z planes of the digitized surface. (*Id.*, 389.) “As the name suggests, this is a representation of each of the data points obtained from the image surface.” (*Id.*) “The density of the point cloud and therefore how accurately it represents the imaged surface depends on numerous factors.” (*Id.*) “These will include the capability of the particular scanner, both in terms of its hardware and software, how it is used by the operator and the time spent scanning.” (*Id.*)

41. “Polygons are usually the most flexible way to accurately represent the results of 3D measurements, providing an optimal surface description.” (Ex.1023, 278.) “For some modeling applications, like building reconstruction, where the object is mainly described with planar or cylindrical patches, a small number of points are required and the structuring and surface generation is often achieved with few triangular patches or fitting particular surfaces to the data.” (*Id.*) “For other applications, such as statues, human body parts or complex objects, and in the case of denser point clouds, surface generation from the measured points is much more difficult and requires ‘smart algorithms’ to triangulate all the measured points, in particular in the case of uneven and sparse point clouds.” (*Id.*)

4. 3D Modeling

42. “Three-dimensional (3D) modeling of an object can be seen as the complete process that starts from data acquisition and ends with a 3D virtual model visually interactive on a computer.” (Ex.1023, 269.) “Often 3D modeling is meant only as the process of converting a measured point cloud into a triangulated network (‘mesh’) or textured surface, while it should describe a more complete and general process of object reconstruction.” (*Id.*) “Three-dimensional modeling of objects and scenes is an intensive and long-lasting research problem in the graphic, vision and photogrammetric communities.” (*Id.*)

43. “Within orthodontics, electronic 3D imaging has several potential and current applications.” (Ex.1022, 390.) “The most obvious is as a substitute for conventional plaster study models.” (*Id.*) “These models are used not only for initial diagnosis, but also as a means of monitoring treatment progress, as a reference against which archwires can be fabricated, [and] as a demonstration of quality of outcome.” (*Id.*)

44. “The overall image-based 3D modeling process consists of several well-known steps: design (sensor and network geometry); 3D measurements (point clouds, lines, etc.); structuring and modeling (segmentation, network/mesh generation, etc.); texturing and visualization.” (Ex.1023, 272.)

45. During pre-processing “erroneous data is eliminated and noise is smoothed out, and points are added to fill gaps. The data may also be resampled to generate a model of efficient size (in case of dense depth maps from correspondence or range data).” (*Id.*, 278.)

46. “Although this seems straightforward, there are many factors affecting the photo-realism of a textured 3D model,” including radiometric image distortion, geometric scene distortion, dynamic rate of the image, and object occlusions.” (*Id.*, 281-82.)

5. Color 3D Modeling using Intraoral Scanners

47. Intraoral scanners are devices for capturing direct optical impressions of a patient's dentition. (*See* Ex.1024, 313; *see also* Ex.1025, 101; Ex.1026, 1-2.) Similar to other three-dimensional (3D) scanners, they project light (e.g., an array of laser light or incoherent structured light) onto the object to be scanned, in this case the dentition, which may include prepared teeth and implant scan bodies (i.e., cylinders screwed on the implants, used for transferring the 3D implant position). The images of the dentogingival tissue (as well as the scan bodies) captured by imaging sensors are processed by the scanning software, which generates point clouds, which represent measured points on the surface of the scanned object. Point clouds from individual scans are aligned (through a process called registration). Points are then triangulated, creating a 3D surface model (mesh) The 3D surface models of the dentogingival tissues are the result of the optical scans and are a digital impression or 'virtual' alternative to traditional models using physical impressions. Intraoral scanners can also make digital color scans (Ex.1014, 102-103.) Generally, color is added to the 3D models derived from the scan, e.g., as photographic overlays. The information on color is meaningful especially in communication with the patient and is therefore of less clinical importance.

48. Some earlier devices were either suitable only for 3D measurement or only for color measurement—but not both. Information obtained from 3D measurement and from color measurement is helpful, particularly in dentistry, for designing a dental prosthetic item. Because of the scanning principles used in some early devices, 3D geometry measurement and color measurement was carried out independently.

49. More recently, however, handheld, color optical 3D scanning systems such as TRIOS by 3Shape, iTero by Align, CEREC by Sirona Dental System, etc., have been developed. (Ex.1028, 205.) Additional systems have been described in patents or patent publications, including Fisker (Ex.1005) and Thiel576 (Ex.1013). These systems and methods were developed capable of combining both the color of the individual surface elements of the object being scanned together with the 3D surface topology of the object being scanned. These systems were particularly adapted for intraoral color 3D scanning, i.e., direct scanning of teeth and surrounding soft tissue in the oral cavity. Another known application was the color 3D scanning of the interior and exterior part of a human ear or ear channel impression.

50. Color optical 3D scanning may integrate fast focus scanning and color sensing technologies, all in a handheld intraoral probe. For example, as described in Logozzo, IOS's FastScan system (a handheld wand) was introduced in 2010.

The FastScan system combines laser light “coming from two different perspectives onto a single camera.” (Ex.1028, 213.) FastScan 3D scanner probe “sweeps a sheet of light across one or more surfaces of teeth, while the light projector and imaging aperture rapidly moves back and forth along all or part of the full scan path; a live 3D preview of the digital model of the scanned dentition is displayed approximately in real-time.” (*Id.*) The IOS FastScan system further “includes a scanner to capture colour and translucency information along with the three dimensional shape of dentition.” (*Id.*)

51. Other similar systems typically include at least one image sensor (camera) accommodating an array of sensor elements, an illumination unit generating a spatially patterned light, a method for varying the position of the focus plane of the pattern on the object, hardware and/or software for obtaining at least one image from said array of sensor elements, and an image processor for transforming 2D images into 3D data having real-world coordinates.

52. The method and apparatus technologies are thus for providing a 3D surface registration of objects using light as a non-contact probing agent. The light is provided in the form of an illumination pattern to provide a light oscillation on the object. The variation/oscillation in the pattern may be spatial, e.g., a static checkerboard pattern, and/or it may be time-varying, for example by moving a pattern across the object being scanned. The optical scanner needs to provide for a

variation of the focus plane of the pattern over a range of focus plane positions while maintaining a fixed spatial relation of the scanner and the object. It does not mean that the scan must be provided with a fixed spatial relation of the scanner and the object, but merely that the focus plane can be varied (scanned) with a fixed spatial relation of the scanner and the object.

53. In 3D measurement, the surface information of an object to be measured can be detected using different measuring methods such as a color (chromatic) confocal measuring method or a triangulation measuring method. A broad-band illuminating beam is directed toward the object to be measured, and the reflected light in the form of a monitoring beam is then analyzed.

54. In the chromatic confocal measuring method, a polychromatic illuminating beam is focused onto the surface of an object to be measured. In optical refraction, the angle of refraction is dependent on the wavelength of the refracted light so that light of shorter wavelengths is focused to a focal point located closer to the objective and light of longer wavelengths is focused to a focal point located at a greater distance from the objective. A narrow spectral range of the illuminating beam is focused exactly onto the first plane of the surface of the object to be measured, and the remaining spectral ranges only form out-of-focus images in the form of fuzzy circles on the object to be measured. The reflected illuminating beam forms a monitoring beam that is deflected by a beam splitter

toward the color sensor. Due to the presence of a diaphragm (filter) disposed confocally between the beam splitter and the color sensor, the spectral range of the monitoring beam reflected by the object to be measured passes through the filter, and the remaining spectral ranges forming out-of-focus images on the Surface of the object to be measured are filtered out. The wavelength of the focused spectral range can be determined by means of spectral analysis, and the absolute position of the object to be measured in the direction of the illuminating beam is derived from that.

55. In the triangulation measuring method, the illuminating beam is projected onto the object to be measured. The reflected monitoring beam is then detected by means of an Image sensor such as a CCD camera. The distance from the object to be measured can be determined from the position and direction of the illuminating beam and the monitoring beam by the use of trigonometric methods of calculation. In this measuring method, the monitoring beam is detected in an unfiltered form by the color sensor so that there is no need for a confocally disposed diaphragm/filter. The white-light interferometry measuring method utilizes the interference of a broad-band light such as that of white light. This measuring method compares the delay time of the monitoring beam reflected by the object to be measured by means of an interferometer such as a Michelson interferometer, with the delay time of the illuminating beam having a known

optical path length as a reference. The interference of the two light beams results in a pattern from which the relative optical path length can be derived.

56. In the deflectometry measuring method, the image of the light pattern, such as that of a grid, is observed in the reflection across the surface of the object to be measured. The local gradients of the surface can be determined from the deformation of the grid image, and the 3D information of the object to be measured can be produced from the local gradients. A broadband polychromatic light beam can also be used for this purpose.

57. In the aforementioned methods for color optical 3D measurement, the broadband monitoring beam scans the object to be measured within a measuring area in order to produce the surface information concerning this measuring area. The broad-band illuminating beam has a spectrum that advantageously includes the visible spectral range from 400nm to 800nm. The illuminating beam can represent one or more point light beams, one or more stripes of light, or any other light pattern. For example, a plurality of colored LEDs can be activated such that either a spectrum that is similar to daylight or a broad-band white spectrum is produced by superimposing the spectra of the colored LEDs. The intensity curve of the broad-band spectrum plotted against wavelength is non-essential for the effectiveness of the chromatic confocal measuring method so that the broadband spectrum can have a plurality of maxima and minima at various wavelengths.

58. In methods employed for color measurement, a polychromatic illuminating beam is often deflected toward the object to be measured, the spectrum of which is similar to the daylight spectrum and which has a color temperature ranging from 5000K to 6000K. The reflected monitoring beam is then analyzed spectrally by means of a color sensor such as a CCD camera or a spectrometer. The color impression for the human eye can be inferred from the spectrum detected, and color can be assigned to the object being measured.

59. An advantage is that both 3D measurement and color measurement can be carried out by means of the same device. The same light source emitting a broad-band illuminating beam and the same color sensor is used for both these measurements. In dentistry, in particular, the 3D measurement and color measurement of teeth for the purpose of designing dental prosthetic items is made possible by the use of a single device. A further advantage is that the cost burden and the space required are reduced by combining a device used for color measurement and a device used for 3D measurement.

B. Overview of the '244 Patent

60. The '244 Patent relates to “three dimensional (3D) scanning of the surface geometry and surface color of objects,” particularly within dentistry and for intraocular scanning. (Ex.1001, 1:6-9.) The '244 Patent provides a scanner system and a method for recording surface geometry and surface color of an object

in order to generate a digital 3D representation of the object expressing both color and geometry of the object. (Ex.1001, 2:5-13.)

61. The '244 Patent provides a scanner system 100 comprising a multichromatic light source 101 that emits light through an optical system 150, which provides 2D images having a pattern onto an object 200 and comprises an adjustable focusing element 151 for shifting the focal imaging plane of the pattern on the object 200. (Ex.1001, 15:63-16:18.) The scanner system 100 also comprises a data processing system for deriving geometry information and color information from a block of pixels recorded by a color image sensor 180. (Ex.1001, 16:52-60.)

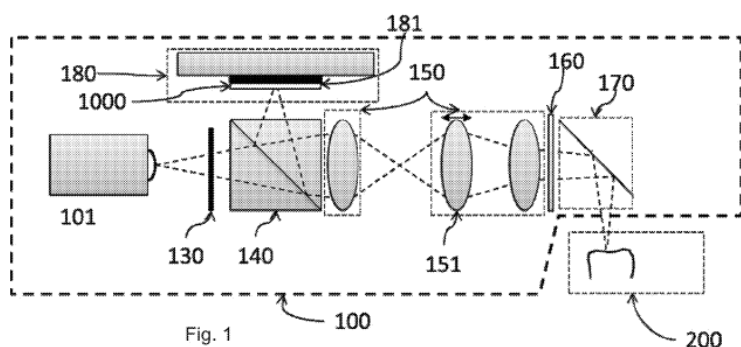


Fig. 1

0	-1	0	1	0	1
-1	0	-1	0	1	0
0	-1	0	1	0	1
1	0	1	0	-1	0
0	1	0	-1	0	-1
1	0	1	0	-1	0

Fig. 3B

G	G	G	G	G	G
G	R	G	G	R	G
G	G	G	G	G	G
G	G	G	G	G	G
G	B	G	G	B	G
G	G	G	G	G	G

Fig. 4

(Ex.1001, Figs. 1, 3B, 4.)

62. The '244 Patent uses a color filter array comprising a plurality of 6x6 color image filters comprised of red, blue, and green filters, which are each assigned a weight value (i.e., -1, 0, or 1) in an attempt to obtain natural-color data. (Ex.1001, 17:18-58, Fig. 3B, 4.) The green filters are provided a non-zero value, and the red and blue filters are provided a zero value. (*Id.*, 17: 25-26.) Blue color filters in positions (2,2) and (5,5) of each cell, red color filters in positions (2,5) and (5,2), and green color filters in all remaining positions of the cell. (*Id.*, 17:48-52.) The green filters are only used to obtain the surface geometry information of the object. (*Id.*) As such, the color filter array can be arranged such that its proportion of pixels with color filters that match the selected wavelength range of the spectrum is larger than 50%. (*Id.*, 10:4-7.)

63. The '244 Patent provides a method for recording surface geometry and color of an object. (*Id.*, 17:61-62, Fig. 5.) First, a scanner system records a series of 2D images of an object from at least two different focus plane positions and derives geometry and color information for a block of image sensor pixels from a plurality of 2D images. (*Id.*, 18:4-15, 65-67.) The scanner system thereafter derives geometry and color information at least partly from one of the 2D images. (*Id.*, 18:8-10.) This can comprise (i) calculating for several 2D images a correlation measure between a portion of a 2D image and a weight function based on information of a spatial function and (ii) identifying the position along the optical

axis at which the corresponding correlation measure has a maximum value. (*Id.*, 6:29-32.)

64. The scanner system can then detect saturated pixels in the 2D images and mitigate or remove error in the color information of the 2D images caused by the pixel saturation. (*Id.*, 8:63-67.) Subsequently, the scanner system combines the geometry and color information to generate a sub-scan expressing both geometry and color of a portion of the object. (*Id.*, 18:4-15, 65-67.)

65. The scanner system can thus derive several sub-scans of different portions of an object and combine them to form a 3D representation expressing both geometry and color of an object. (*Id.*, 10:45-53.) Combining the sub-scans can comprise computing a weighted average of color values derived for corresponding points in overlapping sub-scans. (*Id.*, 11:15-19.) The scanner system can also determine a color of a point on the sub-scan by computing an average of sub-scan colors of surrounding points on the sub-scan. (*Id.*, 7:8-13.)

V. Claims 19, 25, and 32 lack support in the Provisional Application requiring PGR eligibility for the '244 Patent.

A. Claims 19 and 32

66. Claims 19 and 32, recite in-part, “where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and (5,2) are of the W3 type.” These claim elements are not supported by the Provisional Application. (Ex.1029.)

67. The Provisional Application describes two color filter arrays that may be used—a Bayer pattern and “an alternative color filter array”. (Provisional, p.20.) Specifically, the Provisional Application illustrates, in Figure 4, “an alternative color filter array with a higher fraction of green pixels than in the Bayer pattern” that will “potentially provide a better quality of the obtained 3D surface geometry than a Bayer pattern filter.” (*Id.*, pp.20-21.) The Provisional Application notably fails to recite the specific positions of the color filter array pattern. A POSITA is merely left with the illustration of Figure 4 to determine the “alternative color filter array” pattern.

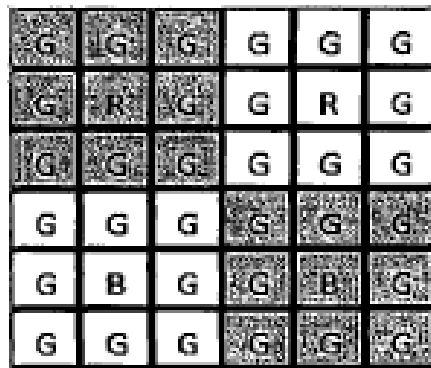


Fig. 4

(Ex.1029, Fig. 4.)

68. As illustrated, the Provisional Application’s illustrated alternative color filter array pattern does not disclose where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and

(5,2) are of the W3 type. No matter which corner of the array is used as the origin, the x,y locations of (2,2) and (5,5) always comprises filters displaying different wavelengths--one is “R” for red, the other is “B” for blue. Similarly, the x,y locations of (2,5) and (5,2) always display different wavelengths.

69. Furthermore, the Provisional Application fails to provide a color filter array where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type and the color filters in positions (2,5) and (5,2) are of the W3 type.

70. Based on the lack of a written description for this claim element in the Provisional Application, a POSITA would not have understood that the inventors were in possession of the subject matter of claims 19 and 32.

B. Claim 25

71. Claim 25 recites, “where the color filter array is such that the proportion of the image sensor pixels of the color image sensor with color filters that match the selected wavelength range of the spectrum has a proportion that equals 32/36, 60/64 or 96/100.” This claim element is not supported by the Provisional Application.

72. As I explained above, the Provisional Application fails to recite the specific positions of the color filter array pattern and, notably, the Provisional Application fails to recite any specific proportions of the image sensor pixel color filters. That is, the Provisional Application merely states that “the color filter array

is such that its proportion of pixels with color filters that match the first part of the spectrum is larger than 50%.” (Ex.1029, p.16.) A POSITA, again, is merely left with the illustration of Figure 4 to determine the specific proportions of the image sensor pixel color filters.

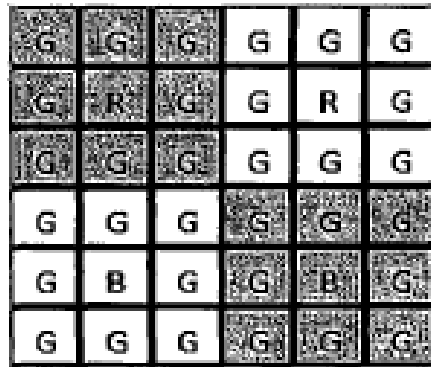


Fig. 4

(Ex.1029, Fig. 4.)

73. As illustrated, the proportion of “G” color filters against the number of R and B filters is 32/36. However, the Provisional Application is entirely silent with respect to an array having 64 or 100 pixels (or factors thereof), much less the proportion/number of green, red, and blue pixels.

74. Based on the lack of a written description for this claim element in the Provisional Application, a POSITA would *not* have understood that the inventors were in possession of the subject matter of claim 25.

VI. Claim Construction

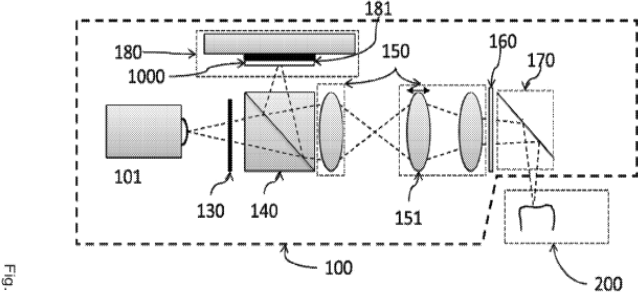
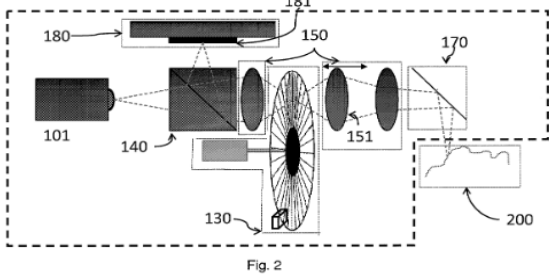
75. I have applied the plain and ordinary meaning of the claim terms as understood to a person of ordinary skill in the art at the time of invention.

VII. The combinations of (a) Fisker and Szeliski and (b) Fisker and Matsumoto render claims 1-5, 7-10, 15, 16, 18, 21, 22, 24, 26, and 28 obvious.

A. Overview of Fisker

76. Like the '244 Patent, Fisker is directed toward a handheld, color optical 3D scanning apparatus and methods, and capable of registering both the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned. (Ex.1005, Abstract, [0151].) Specifically, Fisker teaches “a handheld scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object using confocal pattern projection techniques.” (Ex.1005, Abstract.)

77. The '244 Patent and Fisker share other similarities. For example, Fisker also teaches a multichromatic light source (*Id.*, [0151] (“the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum”); a color image sensor (*Id.*, [0152] (“color image sensor”); and a data processing system (*Id.*, [0192] (“data processing system”).

<p>'244 Patent: "FIG. 1 shows a handheld embodiment of a scanner system." (Ex.1001, 15:53-55.)</p>	<p>Fisker: "FIG. 2: A schematic presentation of a second example embodiment of the device according to the invention (optical correlation)." (Ex.1005, [0221].)</p>
 <p>(Ex.1001, Fig. 1.)</p>	 <p>(Ex.1005, Fig. 2.)</p>

78. Fisker's focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner (Ex.1005, [0064] ("a translation stage, for adjusting and controlling the position of the focus element")) and to capture a series of the 2D images (*Id.*, [0260] ("images are taken at different positions of the focusing element, in effect covering the entire travel range of said focus element")). Fisker's data processing system is configured to derive surface geometry information (*Id.*, [0151] ("obtain the color of the surface being scanned...together with the surface topology of the object being scanned")), derive surface color information (*Id.*), and generate digital 3D representation (*Id.*, [0173] ("merging and/or combining 3D data...thereby providing a full 3D model").)

79. Fisker teaches a "fused image" that is generated by "combining all the in-focus regions of the series" of images. (*Id.*, [0263].) Fisker further teaches that

the fused image can be interpreted as the reference signal and the reference vector/set of weight values for the pixels in the pixel group. (*See id.*, [0263]-[0264].) Fisker's color is further "expressed as, e.g., an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude." (*Id.*, [0157], [0279].)

B. Overview of Szeliski

80. Szeliski is directed to a system of constructing and rendering panoramic mosaic images from a sequence of still images, video images or scanned photographic images. The system is capable of aligning overlapping images by performing patch-based alignment of the overlapping images to produce warped images, perform block adjustment of the warped images to produce block-adjusted images, and then performing pair-wise motion-based local warping of the adjusted images. The invention is applicable in all active areas of research in the field of photogrammetry, computer vision, image processing, and computer graphics.

81. Szeliski discloses a method for aligning a set of plural overlapping images that are useful in constructing a mosaic by performing patch-based alignment of the set of overlapping images. (Ex.1006, Szeliski, Abstract.) Szeliski further teaches a method for mapping multiple images, using focal length and 3D rotation, to build an image mosaic by "registering a sequence of images by

recovering their transformation matrices M_k .” (*Id.*, 7:4-18, 14:24-29.) Each of Szeliski’s transformations correspond to “one image and represents the mapping between the image pixels of I_k and a viewing direction in the world (i.e., a 3D world coordinate system).” (*Id.*)

82. As illustrated at Szeliski Step 3250 in Figure 32, Szeliski teaches a method for using a weighted average calculation to blend color data from corresponding pixels (i.e., points) in overlapping images. (Ex.1006, Fig. 32; 30:20-49.)

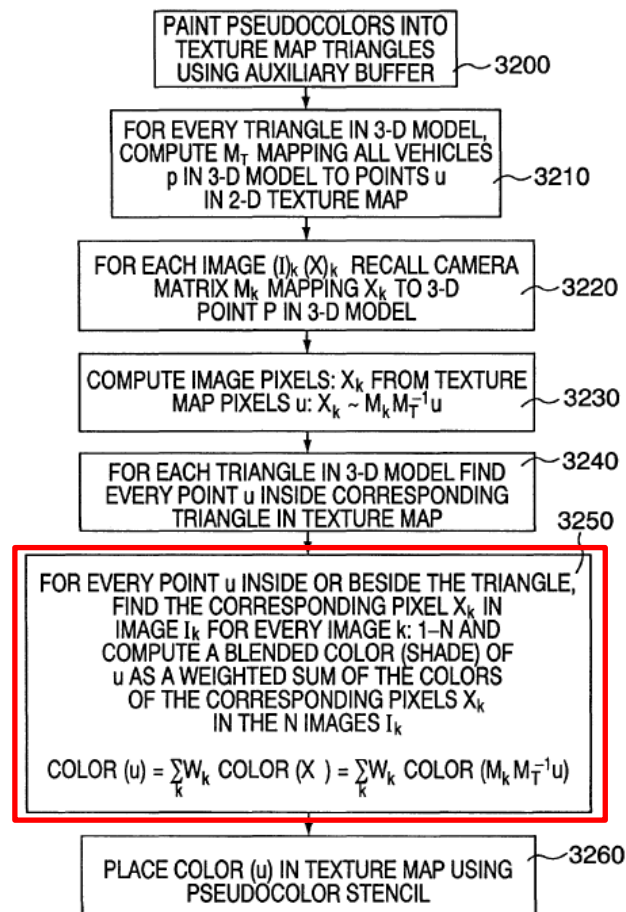


FIG. 32

(Ex.1006, Fig. 32 (annotated).)

83. More specifically, for every point, “a mapping to the corresponding pixel in every overlapping image is found, and those corresponding pixel values (colors or intensities) are blended to form a composited pixel value.” (*Id.*, 30:20-24.) Szeliski thus teaches blending the “color (shade) of u as a weighted sum of the colors of the corresponding pixels X_k in the images I_k .” (*Id.*)

C. Overview of Matsumoto

84. Matsumoto is directed to a texture information assignment method of assigning texture information to a shape model of a real object of interest according to a shape model image obtained by shooting that real object of interest. (Ex.1007, 1:13-22.) This invention is applicable in all computer graphics processing and the like.

85. Matsumoto further teaches “capturing a plurality of object images information by shooting an object of interest from different viewpoints” and “assigning texture information [color, density, or luminance] obtained by carrying out *a weighted mean process* for all the object image information” for each pixel in an area corresponding to a three-dimensional shape constituent element. (Ex.1007, 8:25-37.)

86. Matsumoto’s weighted mean process teaches that the “ I_{cnt} -th reference image information subjected to a weight of variable w_{ght} is stored in

color information storage unit 240 as the texture information of the Ecnt-th three-dimensional shape constituent element (step S2506).” (Ex.1007, 27:36-39.) The values of “variable wght” are then “accumulated for variable wacc (step S2508).” (Ex.1007, 27:41-43.)

D. Claim 1

87. The combination of Fisker and Szeliski renders claim 1 obvious. Claim 1 is reproduced below. The claim limitations have been labeled, e.g. claim 1’s preamble is [1.P], for ease of discussion.

1. [1.P]: “A focus scanner for recording surface geometry and surface color of an object”

88. Fisker discloses a focus scanning apparatus. (Ex.1005, Title.) For example, Fisker teaches “a handheld scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object using confocal pattern projection techniques.” (Ex.1005, Abstract.)¹ Fisker additionally teaches that its scanner is “adapted to obtain the color of the surface being scanned.” (*Id.*, [0151].)

89. Thus, Fisker teaches a “focus scanner for recording surface geometry and surface color of an object” as recited in claim 1.

¹ Unless otherwise noted, any emphasis in a citation has been added.

2. [1.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object.”

90. Fisker teaches a scanner head that comprises “a light source 110.” The light “from the light source 110 travels back and forth through the optical system 150.” (Ex.1005, [0244].) As the light travels back and forth, the scanner sees the variation in the light signal corresponding to the variation of the light illuminating the object. (*See id.*, [0086], [0110].) Fisker further discloses that to “obtain color information the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.” (*Id.*, [0151].) A white light or a light comprising at least three monochromatic light sources, as disclosed in Fisker, teaches a multichromatic probe light. As the ’244 Patent provides, a white light source is an example of a multichromatic light. (*See id.*, 5:23-25.)

91. Thus, Fisker teaches “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object,” as recited in claim 1.

3. [1.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

92. To provide color information as described above [IV.A.5.], Fisker teaches a color image sensor comprising an “array of sensor elements” or “sensor

elements (pixels).” (Ex.1005, [0070], [0152].) One or more 2D images are captured at the color image sensor when light is transmitted through a pattern towards the object and by imaging “light reflected from the object to the camera.” (*Id.*, [0028], [0061].)

93. In Fisker’s description of its digital camera, Fisker describes the camera’s “[i]maging sensor comprising a plurality of sensors that respond to light input onto the imaging sensor. The sensors are preferably ordered in a 2D array in rows and columns.” (Ex.1005, [0046].) Fisker additionally states that the “camera may be a standard digital camera accommodating a standard CCD or CMOS chip with one A/D converter per line of sensor elements (pixels)” (Ex.1005, [0070].) Thus, Fisker refers to imaging sensor elements as pixels. Therefore Fisker’s array of sensor elements (pixels) teaches the recited array of image sensor pixels.

94. Thus, Fisker teaches “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object” as recited in claim 1.

4. [1.3.a]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner”

95. Fisker describes an optical axis as a “straight line” defined by the “configuration of a plurality of optical components, e.g., the configuration of lenses in the optical system.” (Ex.1005, [0041].) Fisker’s optical system includes a

“focus element” that may include a “translation stage for adjusting and controlling the position of the focus element.” (*Id.*, [0064].) That is, Fisker’s focus plane “may be varied, for example by translating the focus element back and forth along the optical axis.” (*Id.*) This is further detailed with FIG. 1 of Fisker, namely, the “optical axis in FIG.1 is the axis defined by a straight line through the light source 110, optics 120 and the lenses in the optical system 150.” (Ex.1005, [0245]). Fisker further elaborates that the “focus element is adjusted in such a way that the image of the pattern on the scanned object is shifted along the optical axis, preferably in equal steps from one end of the scanning region to the other.” (Ex.1005, [0246])

96. Thus, Fisker teaches a focus scanner that is “configured to operate by translating a focus plane along an optical axis of the focus scanner” as recited in claim 1.

5. [1.3.b]: “wherein the focus scanner is configured to operate by...capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”

97. Fisker teaches a process for “recording a series of images” of an illumination checkerboard pattern being projected onto a surface, preferably oriented orthogonally to the optical axis of the scanner. “The images are taken at different positions of the focusing element, in effect covering the entire travel range of said focus element, Preferably, the images are taken at equidistant locations.” (Ex.1005, [0260].) Fisker further teaches that the illumination pattern

can be a “time-varying pattern” and thus “a number of 2D images at different positions of the focus plane and at different instances of the pattern” can be collected. (*Id.*, [0028].) Fisker’s different positions of the focus plane teach the recited “different focus plane positions,” as recited by the claim. Therefore, Fisker’s series of 2D images captured over the full range of the focus element teaches a “series of captured 2D images that forms a stack of 2D images.”

98. Thus, Fisker teaches a focus scanner that is “configured to operate by...capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images form a stack of 2D images” as recited in claim 1.

6. [1.4.a]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor”

99. The ’244 Patent does not provide an explicit definition for a “block” of sensor pixels. The ’244 Patent does, however, appear to use the terms “block” of sensor pixels and “group” of sensor pixels, interchangeably. (*See, e.g.*, Ex.1001, 18:24-26 (“The correlation measure is determined for all active image sensor pixel groups on the color image sensor for every focus plane position, i.e., for every 2D image of the stack”); 5:50-54 (“deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure

has a maximum value.”.) Accordingly, a POSITA would have understood that the terms “block” or “group” of sensor pixels may include all sensor pixels in the array of pixels or a subset thereof.

100. As I explained in Section VII.D.5. above, Fisker teaches capturing a series of 2D images that form a stack of 2D images. Fisker further teaches a “data processing system” configured to perform the disclosed methods. (*See* Ex.1005, [0074], [0192].) Fisker’s disclosed methods include an embodiment that is “adapted to obtain the color of the surface being scanned, i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker further discloses “the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions,” and “an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude.” (*Id.*, [0157].) That is, Fisker’s obtaining the surface topology of the object being scanned teaches “deriv[ing] surface geometry information” for at least one 2D image in the stack of 2D images.

101. Like the ’244 Patent, Fisker discloses a group of sensor pixels (i.e., a block of image sensor pixels). (*See* Ex.1005, [0070], [0128].) For example, as I explained above, the ’244 Patent provides that “[t]he maximum value of the

correlation measure for each group of pixels is monitored along the analysis of the 2D images such that when a 2D image has been analyzed the values for the correlation measure for the different pixels.” (Ex.1001, 18:48-52.) Similarly, Fisker teaches that “[t]he focus position corresponding to the pattern being in focus on the object for a single group of sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group.” (Ex.1005, [0128].)

102. Fisker further elaborates that as “the focus plane generally is not a geometrical plane, different regions of the flat surface will be in focus in different images. Examples of three such images are shown in FIGS. 17a-17c, where 1700 is an in-focus region,” (Ex.1005, [0261]) and “[i]n-focus regions within an image are found as those of maximum intensity variances (indicating maximum contrast) over the entire said series of images. The region to compute variance over need not be the same as the pixel group dimension used in spatial correlation, but should be large enough to contain both dark and light regions of the pattern, and it must be the same for all images in the series.” (Ex.1005, [0262].) In view of the foregoing, and because the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for selected full-color focal plane positions, Fisker’s “group” of images sensor pixels teaches the recited “block” of images sensor pixels because Fisker’s “group” of images sensor pixels perform the same

functions and because the '244 Patent uses the terms “block” and “group” interchangeably.

103. Thus, Fisker teaches or suggests “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor,” as recited by claim 1.

7. [1.4.b]: “the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”

104. The '244 Patent discloses a scanner system for recording surface geometry and surface color, in which the surface geometry and color information are “acquired *simultaneously*” using one image sensor. (Ex.1001, 2:1-13.) Similarly, Fisker teaches, and illustrates in Figure 9, a device for “*simultaneous* scanning of a surface shape and color” using one image sensor 181. (Ex.1005, [0228], [0244].)

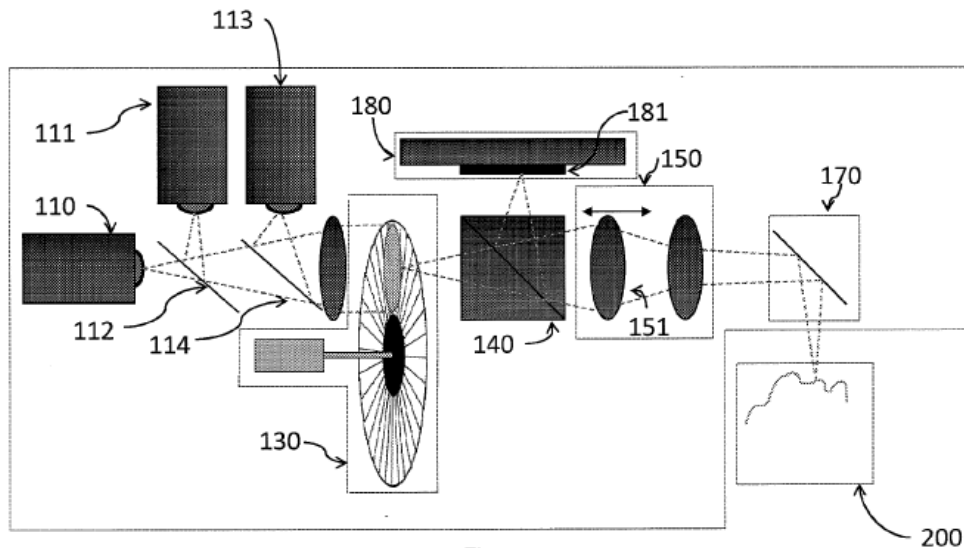


Fig. 9

(Ex.1005, Fig. 9.)

105. As I explained in Section VII.6.D, Fisker’s data processing system is “adapted to obtain the color of the surface being scanned, i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (Ex.1005, [0151].) Fisker’s image sensor “provides color registration at each element,” based on the amplitude of light received at each of the sensor elements. (See Ex.1005, [0151]-[0157].) The amplitude is determined for at least one color at every focal plan position. (*Id.*, [0158].) So, a POSITA would have understood that at every focus position, the amplitude of light received at the sensor elements is used to compute the maximum of the correlation measure function, to determine surface topology and the surface color, e.g., an RGB color coordinate, for each surface element . This surface color is reconstructed by appropriate weighting of the image sensor

amplitude signal for each color corresponding to the maximum correlation function. (Section VI.D.6; Ex.1005 , [0151]-[0158] and [0279].)

106. Because the color of the surface being scanned may then be obtained by combining and/or weighting the color information from a plurality of the sensor elements, and the color expressed as an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude (Ex.1005, [0157],) a POSITA would have understood that Fisker teaches a data processing system configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information.

107. Thus, Fisker teaches “the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information,” as recited by claim 1.

8. [1.5.a]: “wherein the data processing system further is configured to combining [sic] a number of sub-scans to generate a digital 3D representation of the object”

108. The '244 Patent describes a sub-scan as expressing “at least the geometry of the part of the object” that is typically derived from “one stack of captured 2D images.” (Ex.1001, 3:61-63.)

109. Fisker discloses a data processing system that's configured for combining a number of sub-scans to generate a digital 3D representation of an object.

Specific applications of the scanner according to the invention relates to scanning of cavities, in particular body cavities. Scanning in cavities may relate to scanning of objects in the cavity, such as scanning of teeth in a mouth. However, scanning of e.g. the ear related to scanning of the inner surface of the cavity itself. In general scanning of a cavity, especially a small cavity, requires some kind of probe for the scanner. Thus, in one embodiment of the invention the point of emission of probe light and the point of accumulation off the reflected light is located on a probe, said probe being adapted to be entered into a cavity, such as a body cavity.

(*See* Ex.1005, [0161].) Fisker further elaborates “[t]hus, one embodiment of the invention comprises a housing accommodating the camera, pattern generation means, focus varying means and data processing means” (*See Id.*, [0163], [0164] and [0074].) Fisker explains how its integrated invention of a 3D scanner with its data processing means enables acquiring several 3D sub-scans of a scanned to generate a larger 3D digital representation of the object. “In a further embodiment of the invention the probe is detachable from the housing. Thus, a scan may be obtained with the probe attached to the housing. However, a scan may also be

obtained with the probe detached from the housing.” (*See Id.*, [0168] and [0173].)

Fisker continues, “[i]n other words: the housing with probe attached may be adapted to scan the interior part of a human ear and the housing with the probe detached may be adapted to scan the exterior part of said human ear. Preferably, means for merging and/or combining 3D data for the interior and exterior part of the ear provided, thereby providing a full 3D model of a human ear” (*See Id.*, [0168] and [0173].)

110. Fisker further describes this as a stitching and/or registering process where “partial scans” (i.e., sub-scans) are combined. (*Id.*, [0177].) Fisker further anticipates the need for and hence teaches partial or sub-scanning followed by a software-based stitching/registration of the sub-scans. “This advantage is relevant when the field of view off the scanner is smaller than the object to be scanned. In this situation, the scanner is applied for small regions of the object (one at a time) and then are combined to obtain the full scan.” (*See Id.*, [0177].) Fisker further explains the use of a software-based stitching/registration of partial scans based on, e.g., the Iterative Closet Point class of algorithms. (*See Id.*, [0177].)

111. For example, Fisker’s claim 136 recites the scanner equipped with hardware and software for “combining at least two partial scans to a 3D model of the surface of an object.” (*Id.*, claim 136.). Moreover, Fisker elaborates on this invention, “[i]n some embodiments of this invention, the scanner provides

feedback to a user when the registrations of subsequent scans to a larger model of the 3D surface fails” (*Id.*, [0171]).

112. Thus, Fisker teaches a data processing system “configured to combining [sic] a number of sub-scans to generate a digital 3D representation of the object” as recited in claim 1.

9. [1.5.b]: “determining [sic] object color of a least one point of the generated digital 3D representation of the object from sub-scan color of the sub-scans combined to generate the digital 3D representation”

113. As described above, Fisker teaches a “data processing system” configured perform the disclosed methods. (Section VII.D.6; Ex.1005, [0074], [0192].) Fisker is “adapted to *obtain the color* of the surface being scanned, i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (Ex.1005, [0151].) Fisker’s obtaining the color of the surface being scanned and registering the color of the individual surface elements teaches determining the object color of at least one point of the object. Fisker teaches that different regions of the scanned surface will be in focus in different images. (*See* Ex.1005, [0261].) “In focus regions within an image are found as those of maximum intensity variance (indicating maximum contrast) over the entire said series of images.” (*Id.*, [0262].) Fisker further describes a “fused image” that is generated by “combining all the in-focus regions of the series” of images, (*Id.*, [0263].)

114. Fisker also teaches converting the 2D color image data into a 3D surface data in each sub-scan and then “merging and/or combining 3D data for the interior and exterior part of the ear provided, thereby providing a full 3D model of a human ear.” (Ex.1005, [0032], [0173].) Furthermore, Fisker expounds on its method for determining object color and generating a full 3D model:

An embodiment of a color 3D scanner is shown in FIG 9. Three light sources 110, 111, and 113 emit red, green, and blue light. The light sources are maybe LEDs or lasers. The light is merged together to overlap or essentially overlap. This may be achieved by means of two appropriately coated plates 112 and 114. Plate 112 transmits the light from 110 and reflects the light from 111. Plate 114 transmits the light from 110 and 111 and reflects the light from 113. The color measurement is performed as follows: For a given focus position the amplitude of the time-varying pattern projected onto the probed object is determined for each sensor element in the sensor 181 by one of the above mentioned methods for each of the light sources individually. In the preferred embodiment only one light source is switched on at the time, and the light sources are switched on after turn. In this embodiment the optical system 150 maybe achromatic. After determining the amplitude for each light source the focus position is shifted to the next position and the process is repeated. The color expressed

as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude.

(*Id.*, [0279].)

115. Because Fisker collects the surface geometry and the surface color of the scanned surface, using color values obtained at individual surface elements, it would have been obvious to a POSITA that the full digital 3D representation, and model thereof, would include the object color of a least one point of the generated digital 3D representation of the object from sub-scan color of the sub-scans combined to generate the digital 3D representation.

116. Thus, Fisker teaches “determining [sic] object color of a least one point of the generated digital 3D representation of the object from sub-scan color of the sub-scans combined to generate the digital 3D representation” as recited in claim 1.

10. [1.5.c]: “such that the digital 3D representation expresses both geometry and color profile of the object”

117. As described above, Fisker further discloses “merging and/or combining 3D data for the interior and exterior part of the ear provided, thereby providing a full 3D model of a human ear.” (Ex.1005, [0173].) Also as described above, Fisker teaches “One embodiment of the invention is only registering the

surface topology (geometry) of the object being scanned. However, another embodiment is being adapted to *obtain the color* of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.”

(*Id.*, [0151].) Because Fisker collects the surface geometry and the surface color of the scanned surface, it would have been obvious that the full digital 3D representation, and model thereof, would express both the geometry and color profile of the scanned object.

118. Thus, Fisker teaches a digital 3D representation that “expresses both geometry and color profile of the object,” as recited in claim 1.

11. [1.6]: “wherein determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface.”

a) Fisker

119. Fisker teaches a “fused image” that is generated by “combining all the in-focus regions of the series” of images. (Ex.1005, [0263].) Fisker further teaches that the fused image can be interpreted as the reference signal and the reference vector/set of weight values for the pixels in the pixel group. (*See id.*, [0263]-[0264].) Fisker’s color is further “expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the

amplitude signal for each color corresponding the maximum amplitude.” (*Id.*, [0157], [0279].)

120. Fisker also describes that “a correlation image is generated based on the “fused image” and the set of images recorded with the camera during a scan. For each image recorded by the scanner during a sweep of the focusing element, there will thus be an array of $(H/N) \times (W/N)$ values of A. This array can be visualized as an image” (Ex.1005, [0268].) Fig 18 (top section) shows one visualization example of the correlation measure image, of part of a human tooth and its edge. Fisker then describes that “a fused correlation image” is generated based on the “fused image” and the set of images recorded with the camera by a weighted average of color values and for the entire set of scans. “The array of values of A can be computed for every image recorded in a sweep of the focus element. Combining the global extrema (overall images) of A in all pixel groups, in the same manner, the fused image was combined, one can obtain a pseudo-image of dimension $(H/N) \times (W/N)$. This we call the fused correlation image”. (*See id.*, [0270]). A visual example of a fused correlation image of several teeth and gingiva is also shown in FIG. 19.

121. Fisker also describes the use of these fused correlation images for partially overlapped color sub-scans, used for extracting color and 3D geometry. Fisker teaches “Another embodiment of the invention is shown in FIG.4. The light

from two sources 110 and 111 emitting light of different colors/wavelengths is merged together using a suitably coated plate (e.g. a dichroic filter) 112 that transmits the light from 110 and reflects the light from 111. During scanning the focus position is moved such that the light from 110 is used to project an image of the pattern to a position below 171 while 111 is switched off. The 3D surface of the object in the region below 171 is recorded. Then 110 is switched off and 111 is switched on and the focus position is moved such that the light from 111 is used to project an image of the pattern to a position below 172. The 3D surface of the object in the region below 172 is recorded. The region covered with the light from 110 and 111 respectively may partially overlap.” (Ex.1005, [0272].)

122. Because Fisker discloses a method for combining a number of sub-scans to generate a digital 3D representation and also to obtain the color of the surface being scanned (i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned), a POSITA would have understood that Fisker teaches “computing a weighted average of sub-scan colors derived from corresponding points in overlapping sub-scans at that point of the object surface” as recited in claim 1.

123. While Fisker describes a weighting scheme for expressing color values for the scanned pixels, to the extent Patent Owner argues that Fisker does

not teach or suggest computing a weighted average of overlapping sub-scan colors, it was known in the prior art, e.g., as taught or suggested by Szeliski and Matsumoto.

b) Szeliski

124. As I stated in Section VII.B, Szeliski provides a method for “computing texture map color values for any geometry and choice of texture map coordinates.” (Ex.1006, 28:44-46.) Szeliski further teaches a method for mapping multiple images, using focal length and 3D rotation, to build an image mosaic by “registering a sequence of images by recovering their transformation matrices M_k .” (*Id.*, 7:4-18, 14:24-29.) Each of Szeliski’s transformations correspond to “one image and represents the mapping between the image pixels of I_k and a viewing direction in the world (i.e., a 3D world coordinate system).” (*Id.*)

125. As illustrated at Szeliski Step 3250 in Figure 32, Szeliski teaches a method for using a weighted average calculation to blend color data from corresponding pixels (i.e., points) in overlapping images. (Ex.1006, Fig. 32, 30:20-49.)

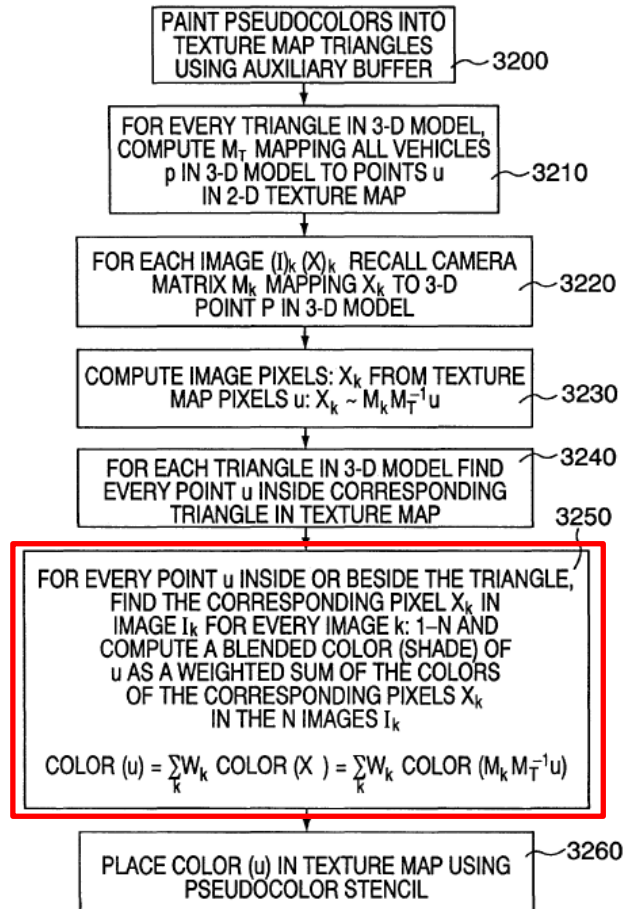


FIG. 32

(Ex.1006, Fig. 32 (annotated).)

126. More specifically, for every point, “a mapping to the corresponding pixel in every overlapping image is found, and those corresponding pixel values (colors or intensities) are blended to form a composited pixel value.” (*Id.*, 30:20-24.) The composite pixel value is calculated from corresponding pixels in overlapping images using a weighted average according to the following equation:

$$\text{COLOR}(u) = \sum_k W_k \text{COLOR}(X_k) = \sum_k W_k \text{COLOR}(M_k M_T^{-1} u)$$

Szeliski thus teaches blending the “color (shade) of u as a weighted sum of the colors of the corresponding pixels X_k in the images I_k .” (*Id.*)

127. As I will explain in greater detail below, a POSITA would have been motivated to combine Fisker with Szeliski.

128. Therefore, the combination of Fisker and Szeliski teaches that “determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface,” as recited in claim 1.

c) Matsumoto

129. Matsumoto discloses a weighted mean process that is applied to image information (color, density, or luminance) and results in improved texture information and a 3D model of higher accuracy. (Ex.1007, 5:30-34, 7:48-50.)

130. Matsumoto further teaches “capturing a plurality of object images information by shooting an object of interest from different viewpoints” and “assigning texture information [color, density, or luminance] obtained by carrying out *a weighted mean process* for all the object image information” for each pixel in an area corresponding to a three-dimensional shape constituent element. (Ex.1007, 8:32-37.)

131. As illustrated at step S2509 in Figure 19 below, Matsumoto’s weighted mean process teaches that the “ I_{cnt} -th reference image information

subjected to a weight of variable wght is stored in color information storage unit 240 as the texture information of the Ecnt-th three-dimensional shape constituent element (step S2506).” (Ex.1007, 27:36-39.) The values of “variable wght” are then “accumulated for variable wacc (step S2508).” (*Id.*, 27:41-43.)

132. According to Matsumoto, “Icnt” is an auxiliary variable that “counts the corresponding label number with respect to the shot image is initialized to the value of 0” (*Id.*, 20:42-44) and “Ecnt” is another auxiliary variable that counts the corresponding polygons of the three-dimensional shape (*Id.*, 20:54-55).

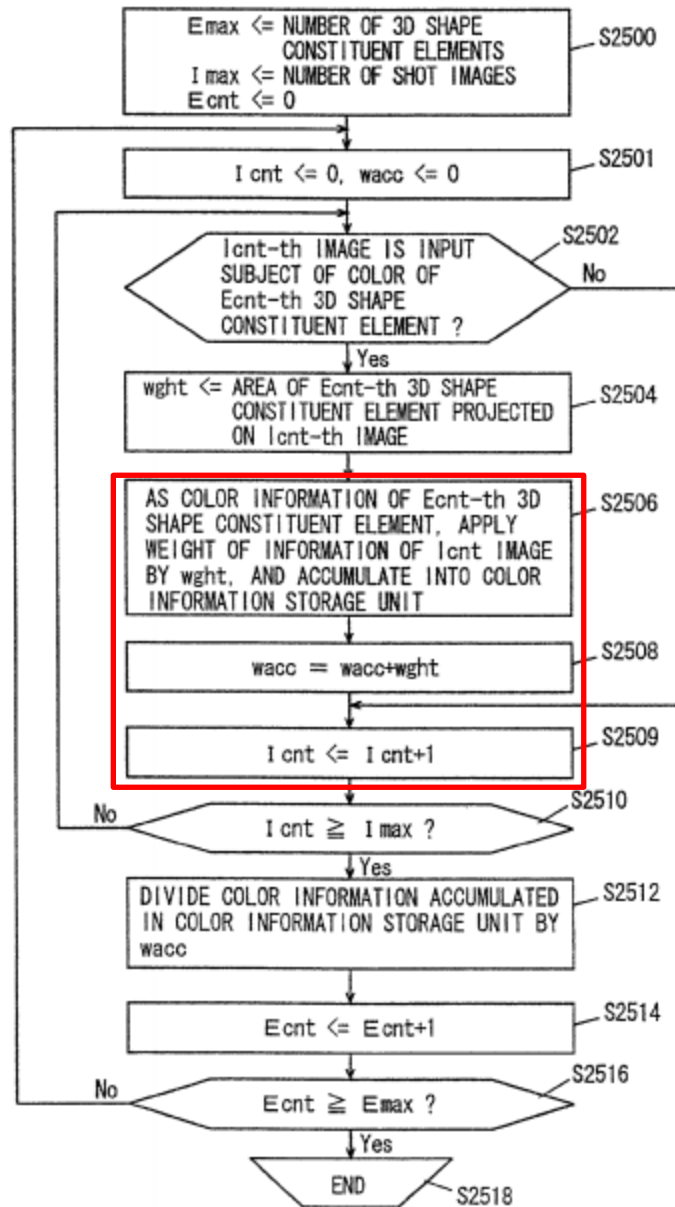
Accordingly, Matsumoto’s method assigns a weighting variable to corresponding points on corresponding images. For example, Matsumoto further teaches:

The object of interest is represented as a shape model (wire frame model) 300 using a polygon (triangular patch). When texture information is to be assigned to shape model 300, color information (texture information) of the image information of a corresponding label number is assigned for each triangular patch according to the direction of the camera shooting the object of interest.

(*Id.*, 2:20-26.)

133. Matsumoto’s Figure 19 is a flowchart of the weighted mean process carried out after the assignment of a reference image information number with respect to each polygon i.

FIG. 19



(Ex.1007, Fig. 19 (annotated).)

134. In view of the foregoing, Matsumoto teaches determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface.

135. As I will explain in greater detail below, a POSITA would have been motivated to combine Fisker with Matsumoto.

136. Thus, the combination of Fisker and Matsumoto teaches that “determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface,” as recited in claim 1.

d) Motivation to Combine

137. At the outset, Fisker, Szeliski, and Matsumoto each use a data processing means (or computing system) to analyze and process captured images, as does the challenged '244 Patent. Each is directed to a computer system for constructing and rendering 3D images. (Ex.1005, [0001]; Ex.1006, 1:9-12; Ex.1007, Abstract.) And each is similarly concerned with image quality and alignment.

138. Szeliski teaches a mosaic or “stitching” method for aligning and compositing overlapping images into a model. For example, “for every point in a given triangle of the 3D model, thus defining the pixels in the corresponding triangle in texture space.” (Ex.1006, 30:18-20.) In Szeliski’s step 3250, “for every point in a bounding box surrounding a given triangle in texture space, a mapping to the corresponding pixel in every overlapping image is found, and those corresponding pixel values (colors or intensities) are blended to form a composited

pixel value” based on a weighted average. (*Id.*, 30:18-30.) Image mosaic methods, like the methods taught by Szeliski, were commonly used in the dental industry to create 3D models. For example, in “Digital Dental Revolution,” a textbook that provides an overview of intraoral scanners and image processing methods where overlapping scans are stitched together to produce a 3D virtual model. (Ex.1014, 102-103, Figs. 32-33.)

139. Similarly, Matsumoto teaches a weighted mean process that is applied to image information (color, density, or luminance) and results in improved texture/color information and a 3D model of higher accuracy. (Ex.1007, 5:30-34, 7:48-50.) More specifically, as described above, Matsumoto teaches a weighted mean process for images captured from differing viewpoints and using the collected image data to create a 3D model. (*Id.*, 8:32-37.)

140. A POSITA would have been motivated to make the minor modification required to Fisker’s image processing method to include Szeliski’s and Matsumoto’s similar processing method. The resulting combination is little more than the use of a known image processor and known image processing technique to improve image quality—e.g., produce a more accurate color image using data captured by multiple images. A POSITA thus would have improved image processing systems and methods, like Fisker’s, in the same way that Szeliski suggests—namely, improving image quality by blending color from multiple

images to account for movements in the image (Ex.1006, Figs. 1, 32, 4:1-9) and in the same way that Matsumoto suggests—applying a weighted mean process by assigning a weight variable to the stored color information and then accumulating the information. (Ex.1007, 8:1-9, 28:54-59.) And after the combination, each feature would continue to function as intended.

141. A POSITA would have modified and enhanced Fisker's image processor and known image processing techniques with that of Szeliski and Matsumoto for at least two reasons.

142. *First*, a POSITA would have recognized the advantages of Szeliski and Matsumoto's teachings with respect to combining images from multiple focal depths and/or viewpoints to determine the correct pixel texture and color. Fisker teaches that its system comprises a "means for varying the position of the focus plane" while images are captured. (Ex.1005, [1015].) Fisker further teaches obtaining "the color of the surface being scanned." (*Id.*, [0151]-[0158].) Fisker teaches: "evaluating a correlation measure at each focus plane position between at least one image pixel and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern." (*Id.*, [0017].) While Fisker does not explicitly teach using a weight function to derive surface color information, it does recognize the advantages of using a weight function to improve surface color quality. (*Id.*, [0157].) Thus, Szeliski's and

Matsumoto's methods for computing a blended color as a weighted sum of the colors of corresponding pixels and assigning texture information obtained by carrying out a weighted mean process, respectively, in corresponding would have been an obvious modification to improve Fisker.

143. *Second*, a POSITA would have recognized the advantages of Szeliski's method for accounting for scanner movement. Fisker provides that its method is related to "[s]pecific embodiments...for intraoral scanning and scanning of the interior part of a human ear." (Ex.1005, Abstract.) However, a POSITA would have understood that Fisker's method requires "varying the position of the focus plane of the pattern on the object while maintaining a fixed spatial relation of the scanner and the object." (*Id.*, [0185].) A POSITA would have understood that performing an intraoral and/or an interior ear scan, while maintaining a fixed spatial relationship between the scanner and the object being scanned, is extremely difficult. Szeliski specifically solves the problem of a moving scanner (or moving object). That is, Szeliski teaches that its system "solves the problem of loss of detail or image ghosting by computing local motion estimates (block-based optical flow) between pairs of overlapping images, and using these estimates to warp each input image so as to reduce the mis-registration." (Ex.1006, 4:1-9.) Thus, a POSITA would have recognized the advantages of applying the method of accounting for motion of either the scanner or the object being scanned.

144. A POSITA would have modified and enhanced Fisker's image processor and known image processing technique with that of Matsumoto to improve the color and texture continuity of the image data by carrying out Matsumoto's weighted mean process. (Ex.1007, 27:36-43.) Specifically, Matsumoto's techniques provide "a method and apparatus of three-dimensional model generation that can generate a three-dimensional model in high accuracy" even when several images, in a plurality of images, are inaccurate. (*Id.*, 5:30-34.)

145. The '244 Patent, Fisker, Szeliski, and Matsumoto are concerned with providing clear and accurate images, including surface topography and surface color of the image being scanned. The foregoing methods for providing clear and accurate images were known in the art, as exemplified by Ex.1015 ("Bernardini"), Ex.1016 ("Park"), Ex.1010 ("Tanaka"), and Ex.1009 ("Suzuki").

146. For example, Bernardini teaches improving image data using weighted averaging techniques (Ex.1015, 5:33-38 ("combining the best data available at each point using weights that reflect the level of confidence in the data. The weighted averaging lowers noise present in the images, while the fine registration avoids blurring, ghosting, and loss of fine texture details.")) Tanaka's background Section introduces a technique for determining pixel data using a weighted average. (Ex.1010, [0009] ("a technique of using surrounding pixels of a target pixel of a mosaic image in a Bayer array to calculate correlations in

horizontal, vertical, and oblique (NE, NW) directions (four directions), and *weights are applied according to ratios of the calculated correlations to interpolate the pixels.*”) Suzuki employs a weighted average technique to correct erroneous pixel data in an image. (Ex.1009, [0070], (“for the pixel value of an attention pixel, performs correction based on *a weighted average of pixel values* of the pixels selected from the plurality of pixels located at the periphery of the correction target region.”) Park teaches using a weighted average of multiple sub-images to determine depth information for an image. (Ex.1016, [0044] (“A first average image may be generated by averaging the N sub-images multiplied by first weighting factors, a second average image may be generated by averaging the N sub-images multiplied by second weighting factors, and the depth information may be calculated from the first average image and the second average image.”).)

147. Thus, using a weighted average to improve color image quality were known in the art, as described in, at least, Fisker, Szeliski, Matsumoto, Bernardini, Tanaka, and Suzuki. Further, a weighted average is known to improve depth (3D surface) information as well, as taught in Park.

148. As described, a POSITA would have understood the advantages of enhancing Fisker’s image processor and known image processing techniques of Szeliski and Matsumoto. Thus, the benefits of employing a Szeliski-like method

and a Matsumoto-like method for processing images in an image processor, such as that of Fisker, would have thus been predictable to a POSITA.

149. As provided above, Fisker's image processor and method for processing images would have benefited from Szeliski's and Matsumoto's method for combining the data of multiple images into a 3D representation of that data. Fisker teaches "a computer program product comprising program code means for causing a data processing system to perform the method, when said program code means are executed on the data processing system." (Ex.1005, [0192].) Similarly, Szeliski explains that its methods are performed by computer systems using "program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks." (Ex.1006, 7:52-60.) Yet further, Matsumoto explains that "the object extraction apparatus includes a computer 130" and that "[c]omputer 130 detects and extracts an object portion in the object image according to a program 301." (Ex.1007, 30:33-34.)

150. Based on the foregoing, and a POSITA's experience, a POSITA would have understood that the method for processing images, as described in each of the '244 Patent, Fisker, Szeliski, Matsumoto, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Szeliski's and Matsumoto's image processing modules, it would have been obvious to enhance Fisker's software (and algorithms) using routine coding and

engineering practices. Therefore, a POSITA would have been motivated to enhance Fisker's method for processing images to include a Szeliski-style method for combining image data from multiple sub-scans, accounting for scanner movement, and determining a scanned object's color using data from multiple images and a Matsumoto-style method for improving the color and texture continuity of the image data, resulting in more accurate 3D model.

151. Finally, a POSITA would have had a reasonable expectation of success when enhancing Fisker's image processing method with that of Szeliski and Matsumoto (or Bernardini). Such a modification would have been a routine matter for a POSITA because the methods of Szeliski and Matsumoto would not require any additional hardware and could be implemented within Fisker's data processor by adding, or altering, the computer code that controls the image processing algorithms.

152. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Fisker's image processing methods and systems with the methods of Szeliski or Matsumoto. Therefore, the combination of (a) Fisker and Szeliski and (b) Fisker and Matsumoto each teach or suggest this claim element.

E. Claim 2: “The focus scanner according to claim 1, wherein the data processing system is configured for generating a sub-scan of a part of the object surface based on surface geometry information and surface color information derived from a plurality of blocks of image sensor pixels.”

153. In addition to the explanations in Sections VII.D.8-9, Fisker discloses “a method and a scanner for obtaining and/or measuring the 3D geometry of at least *a part of the surface of an object*.” (Ex.1005, [0010].) Fisker’s scanner is further adapted to obtain the color of the surface being scanned together with the surface topology of the object being scanned. (*See id.*, [0151].) Fisker’s processing system is also capable of recording and integrating a plurality of the sensor elements over a range of focus plane positions, and then combining the collected information. (*See id.*, [0114], [0157].) Fisker anticipates the need for and hence teaches partial or sub-scans. For example, Fisker teaches that “[t]his advantage is relevant when the field of view off the scanner is smaller than the object to be scanned. In this situation, the scanner is applied for small regions of the object (one at a time) and then are combined to obtain the full scan.” (Ex.1005, [0177].) Fisker further explains the use of a software-based stitching/registration of partial scans based on, e.g., the Iterative Closet Point class of algorithms. (*See Id.*, [0177].)

154. Thus, Fisker teaches a data processing system that is “configured for generating a sub-scan of a part of the object surface based on surface geometry

information and surface color information derived from a plurality of blocks of image sensor pixels,” as recited in claim 2.

F. Claim 3: “The focus scanner according to claim 1, where the scanner system comprises a pattern generating element configured for incorporating a spatial pattern in said probe light.”

155. Fisker teaches a scanner head comprising a “pattern generation means 130” that when light passes through the optical system, the light “images the pattern 130 onto the object being scanned 200 and further images the object being scanned onto the image sensor 181.” (Ex.1005, Fig. 1, [0244].) Fisker further discloses that its “pattern is varied in time in a periodic fashion for a fixed focus position then the in-focus regions on the object will display an *spatially varying pattern*.” (*Id.*, [0246].) Furthermore, the spatial pattern is incorporated in the probe light (*Id.*, [0012].)

156. Thus, Fisker teaches a scanner system comprising “a pattern generating element configured for incorporating a spatial pattern in said probe light,” as recited in claim 3.

- G. Claim 4: “The focus scanner according to claim 1, where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern.”**

157. As I explained in Sections VII.D.6-7 above, Fisker teaches deriving the surface object geometry information and surface color information from determining in-focus image sensor pixels, and discriminating out-of-focus information, using a correlation measure. Those same teachings and explanations are applicable here as well.

158. Fisker teaches that “The pattern is applied to provide illumination with an embedded spatial structure on the object being scanned. Determining in-focus information relates to calculating a correlation measure of this spatially structured light signal (which we term input signal) with the variation off the pattern itself (which we term reference signal). In general the magnitude off the correlation measure is high if the input signal coincides with the reference signal”. (Ex.1005, [0074].)

159. Like the '244 Patent, Fisker's correlation measure is defined “mathematically with a discrete set of measurements as a dot product computed from a signal vector, $I=(I_1,\dots,I_n)$, with $n>1$ elements representing sensor signals and a reference signal vector, $f=(f_1,\dots,f_n)$, of same length as said signal

vector of reference **weights**. (Ex. 1005 [0076]). Furthermore, as I restate below, the actual correlation measure function A is identical to the function used in the '244 Patent.

160. Moreover, as in the '244 patent, Fisker teaches that the correlation measure is computed on signal vectors that represent sensor signals, available as 2D digital color images captured at each focus element position, i.e., images with a finite number of discrete pixels. (*See id.*, [0077], [0080]). For the case of sensors grouped in square regions with N sensors as square length then $n=N^2$. Fisker additionally evaluates the above correlation measure at “all focus element positions,” and thus Fisker teaches calculating a correlation measure for several 2D images. (*Id.*, [0078].)

161. Like the '244 Patent, Fisker's correlation measure is a “measure between the weight function and the recorded light signal” that “translates to a pixel values of an image” and the correlation measure is computed using several image sensor pixels. (Ex.1005, [0052].) That is, Fisker teaches calculating a correlation measure for several 2D images, between the portion of the 2D image signal captured by said block of image sensor pixels and a reference weight function.

162. The similarities between the correlation measures disclosed in the '244 Patent and that of Fisker are further exemplified by the following table:

'244 Patent	Fisker
<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>('244 Patent, 6:1-12.)</p>	<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>(Ex.1005, [0076].)</p>

163. Thus, Fisker teaches “where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern” as recited in claim 4.

H. Claim 5: “The focus scanner according to claim 4, wherein deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value.”

164. As I explained in Sections VII.D.6-7 and VII.G above, Fisker teaches deriving the surface geometry information and surface color information for a block of image sensor pixels. Those same teachings and explanations are applicable here as well. Fisker further teaches identifying the position along the optical axis at which the corresponding correlation measure has a maximum value. (Ex.1005, [0288].) For example, Fisker teaches that its focus plan is controlled by focusing optics and that for each pixel, it is possible to “*identify* individual settings of the focusing optics for which each pixel will be in-focus.” (*Id.*)

165. Fisker further teaches that the “focus position corresponding to the pattern being in focus on the object being scanned for a single sensor element in the camera will then be given by the maximum value of the correlation measure recorded with that sensor element when the focus position is varied over a range of values.” (*Id.*, [0114].) Because Fisker’s focus position is varied by translating its focus plane along an optical axis, as I explained in Section VII.D.4-5, Fisker’s obtaining a maximum correlation measure value when the pattern is in focus teaches this claim.

166. Thus, Fisker teaches “wherein deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value” as recited in claim 5.

I. Claim 7: “The focus scanner according to claim 6, where the maximum correlation measure value is the highest calculated correlation measure value for the block of image sensor pixels and/or the highest maximum value of the correlation measure function for the block of image sensor pixels.”

167. As I explained in Sections VII.G above, Fisker teaches calculating, for several 2D images, a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, and identifying the position along the optical axis at which the correlation measure functions have their maximum value for the block.

168. Fisker also discloses the “global maximum” correlation measure value which gives the “focus position corresponding to the pattern being in focus on the object being scanned.” (Ex.1005, [0114].) In other words, Fisker further discloses that its “[i]n-focus regions within an image are found as those of maximum intensity variance (indicating maximum contrast) over the entire said series of images.” (*Id.*, [0262].)

169. Thus, Fisker teaches “where the maximum correlation measure value is the highest calculated correlation measure value for the block of image sensor

pixels and/or the highest maximum value of the correlation measure function for the block of image sensor pixels,” as recited in claim 7.

J. Claim 8: “The focus scanner according to claim 5, wherein the data processing system is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels.”

170. As I explained in Sections VII.D.6-7 and VII.H above, Fisker teaches deriving the surface geometry information and surface color information based on the maximum of correlation measure between multiple 2D images and a reference weight function based on the input spatial light pattern. Those same teachings and explanations are applicable here as well.

171. Fisker teaches that the correlation measure is high an input signal coincides with the reference signal:

The pattern is applied to provide illumination with an embedded spatial structure on the object being scanned. Determining in-focus information relates to calculating a correlation measure of this spatially structured light signal (which we term input signal) with the variation of the pattern itself (which we term reference signal). In general the magnitude of the correlation measure is high if the input signal coincides with the reference signal.

(Ex.1005, [0074].)

172. Like the '244 Patent, Fisker's correlation measure is defined "mathematically with a discrete set of measurements as a dot product computed from a signal vector, $I=(I_1,\dots,I_n)$, with $n>1$ elements representing sensor signals and a reference signal vector, $f=(f_1,\dots,f_n)$, of same length as said signal vector of reference **weights**. (Ex.1005, [0076]; Section VII.G.) Furthermore, as I restate below, the actual correlation measure function A is identical to the function used in the '244 Patent.

173. Moreover, as in the '244 patent, Fisker teaches that the correlation measure is computed on signal vectors that represent sensor signals, available as 2D digital color images captured at each focus element position, i.e., images with a finite number of discrete pixels. (*See id.*, [0077], [0080]). Fisker additionally evaluates the above correlation measure at "all focus element positions" and thus Fisker teaches calculating a correlation measure for several 2D images. (*Id.*, [0078].)

174. Like the '244 Patent, Fisker's correlation measure is a "measure between the weight function and the recorded light signal" that "translates to a pixel values of an image" and the correlation measure is computed using several image sensor pixels. (Ex.1005, [0052].) That is, Fisker teaches calculating a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function.

175. The similarities between the correlation measures disclosed in the '244 Patent and that of Fisker are further exemplified by the following table (Section VII.G):

'244 Patent	Fisker
<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>('244 Patent, 6:1-12.)</p>	<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>(Ex.1005, [0076].)</p>

176. Fisker's method includes reconstructing the surface color using an appropriate weighting corresponding to the maximum amplitude/correlation measure. (Ex.1005, [0157]-[0158], [0279]-[0280].) Fisker's data processing system is "adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned." (Section VII.C.6; Ex.1005, [0151].) Fisker's image sensor "provides color registration at each element," based on the amplitude of light received at each of the sensor elements.

(See Ex.1005, [0151]-[0157].) The amplitude is determined for at least one color at every focal plane position. (*Id.*, [0158].) So, at every focus position, the amplitude of light received at the sensor elements is used to compute the maximum of the correlation measure function, to determine surface topology and the surface color, e.g., an RGB color coordinate, for each surface element . This surface color is reconstructed by appropriate weighting of the image sensor amplitude signal for each color corresponding to the maximum correlation function. (Section VI.D.6; Ex.1005 , [0151]-[0158] and [0279].)

177. Thus, Fisker teaches “wherein the data processing system further is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels” as recited by claim 8.

K. Claim 9: “The focus scanner according to claim 8, wherein the data processing system is configured for deriving the sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D images in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels and on at least one additional 2D image.”

178. As I explained in Sections VII.D.7 and VII.H-J above, Fisker teaches a data processing system configured for deriving the sub-scan color for a point on a

generated sub-scan using a correlation measure. Those same teachings and explanations are applicable here as well.

179. Fisker's scanner is "adapted to *obtain the color* of the surface being scanned, i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned." (Ex.1005, [0151].)

180. Fisker's scanner is further configured to determine the "amplitude of the light signal of each of a plurality of the sensor elements...for each color *for each focal plane positions*." (*Id.*, [0157]; *see also id.*, [0280].) In accordance with Fisker's method, the color of the surface being scanned is "obtained by combining and/or weighing the color information from a plurality of the sensor elements" and the "RGB color coordinate of each surface element can be reconstructed *by appropriate weighting of the amplitude signal for each color corresponding to the maximum amplitude*." (*Id.*) Then, the color of the surface being scanned may be obtained by interpolating the color information from full-color focal plane positions. (*See id.*, [0158], [0279]-[0280].)

181. Because Fisker's method includes reconstructing the surface color using an appropriate weighting corresponding to the maximum amplitude and because the color is determined by interpolating the color information from

multiple focal plane positions, Fisker's method teaches this claim. (*See id.*, [0157]-[0158], [0279]-[0280].)

182. Thus, Fisker teaches "wherein the data processing system is configured for deriving the sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D images in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels and on at least one additional 2D image" as recited in claim 8.

L. Claim 10: "The focus scanner according to claim 9, where the data processing system is configured for interpolating surface color information of at least two 2D images in a series when determining the sub-scan color."

183. In addition to the teachings that I described in Section VII.K above, which are applicable here as well, Fisker further teaches that "[o]ne specific embodiment of the invention only registers the amplitude for all colors at an interval of P focus positions." (Ex.1005, [0280].) Using the information at each focal position, the "[c]olor of each surface element of the probed object is determined by interpolation between the focus positions where full color information is obtained." (*Id.*)

184. Thus, Fisker's disclosure of interpolating the surface color information between the focus positions teaches "where the data processing system is configured for interpolating surface color information of at least two 2D images in a series when determining the sub-scan color," as recited in claim 10.

M. Claim 15: “The focus scanner according to claim 1, where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter.”

185. Like the '244 Patent, Fisker teaches a color image sensor. (Section VII.D.3.) Fisker also teaches a color filter array comprising at least three types of color filters. For example, Fisker teaches that to provide color information, “the array of sensor elements may be a color image sensor. The image sensor may accommodate a Bayer color filter scheme.” (Ex.1005, [0152].) It is known in the art that a Bayer color filter scheme includes three types of color filters—red, green, and blue. (*Id.*, [0279]-[0280].)

186. Fisker further teaches that when a white light source is used, then some kind of filtering must be provided at the color image sensor to detect color, the filters “[p]referably comprising *a plurality of color filters, such as red, green and blue color filters.*” (*Id.*, [0153].) Thus, Fisker teaches at least three types of colors filters, each allowing light in a known wavelength range.

187. The '244 Patent provides up to six different color filters (red, green, blue, cyan, magenta, and yellow) but is silent with respect to which wavelengths W1, W2, and W3 represent. (Ex.1001, 7:30-32.) Fisker’s Bayer color filter scheme of red, green, and blue filters teach or suggest three different wavelengths (W1, W2, and W3). (Ex.1005, [0158], [0279].)

188. Thus, Fisker teaches “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter” as recited in claim 15.

N. Claim 16: “The focus scanner according to claim 15, where the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source.”

189. Fisker teaches that “the focus position is calculated by determining the light oscillation amplitude for each of a plurality of sensor elements for a range of focus planes.” (Ex.1005, [0029].) Thus, the light amplitude is measured to determine surface geometry. Fisker further teaches that one color of light may be selected to determine the amplitude at all focus positions. (*See id.*, [0155], [0157], [0280], (“[o]ne specific embodiment of the invention only registers the amplitude for all colors at an interval of P focus positions; while one color is selected for determination of the amplitude at all focus positions.”).) The maximum amplitude measurements collected using the selected color of light is used to determine the surface geometry of the scanned object.

190. Thus, Fisker teaches “where the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source” as recited in claim 16.

O. Claim 18: “The focus scanner according to claim 16, wherein the selected wavelength range matches the W2 wavelength range.”

191. Like the '244 Patent, Fisker does not specify any specific wavelength for the W2 wavelength range. However, Fisker does teach that the surface geometry information is derived from light in a selected wavelength range. (Section VII.N.) Fisker teaches that one color wavelength may be selected to determine the amplitude at all focus positions. (Ex.1005, [0280] (“one color is selected for determination of the amplitude at all focus positions.”).)

192. Thus, Fisker’s one selected wavelength teaches “wherein the selected wavelength range matches the W2 wavelength range” as recited in claim 18.

P. Claim 21: “The focus scanner according to claim 3, where the information of the saturated pixel in the computing of the pattern generating element is configured to provide that the spatial pattern comprises alternating dark and bright regions arranged in a checkerboard pattern.”

193. As I explained in Section VII.F, Fisker teaches a pattern generating element configured for incorporating a spatial pattern in said probe light. Fisker further teaches that the illuminated pattern may be “a static checkerboard pattern” having dark and light (i.e., bright) regions. (Ex.1005, [0023].)

194. For example, Fisker’s Figure 3c illustrates “a static pattern as applied in a spatial correlation embodiment of this invention.” (Ex.1005, [0249].) Fisker

continues, “the checkerboard pattern shown is preferred because calculations for this regular pattern are easiest.” (*Id.*)

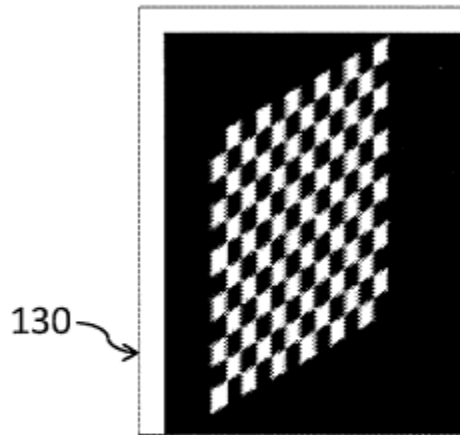


Fig. 3c

(Ex.1005, Fig. 3c.)

195. Fisker’s dark and light checkerboard pattern teaches alternating dark and bright regions arranged in a checkerboard pattern. Thus, Fisker teaches “where the information of the saturated pixel in the computing of the pattern generating element is configured to provide that the spatial pattern comprises alternating dark and bright regions arranged in a checkerboard pattern,” as recited in claim 21.

Q. Claim 22

196. Claim elements [22.2]-[22.4] are substantially similar to elements [1.1]-[1.4.b] above. The difference being that claim elements [22.2]-[22.4] are written as method steps (in gerund form) whereas claim 1 recites apparatus

features and corresponding functionalities. Fisker teaches these elements for at least the reasons that I provided above in Sections VII.D.2-7.

1. [22.P]: “A method of recording surface geometry and surface color of an object”

197. Fisker discloses a “method for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object.” (Ex.1005, [0182], [0207], and claim 138.) Fisker further teaches a method for “registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].)

198. Thus, Fisker teaches “[a] method of recording surface geometry and surface color of an object” as recited in claim 22.

2. [22.1]: “obtaining a focus scanner according to claim 1.”

199. The ’244 Patent is unclear how or who obtains the focus scanner. A POSITA would have understood that the plain and ordinary meaning of “obtaining a focus scanner” would be to gain possession of a scanner somehow.

200. Both the ’244 Patent and Fisker disclose a handheld device that can be held, manipulated, or obtained by a user. For example, the ’244 Patent discloses a “handheld part of a scanner system with components inside a housing 100.” (Ex.1001, 15:63-64.) Likewise, Fisker teaches “a scanner which may be integrated in a manageable housing, such as a handheld housing” that “rests comfortably inside the hand of the operator.” (Ex.1005, [0009], [0174].)

201. Thus, a POSITA would have understood that Fisker teaches “obtaining a focus scanner” as recited in claim 22.

3. [22.2]: “illuminating the surface of said object with multichromatic probe light from said multichromatic light source”

202. Claim element [22.2] is substantially similar to claim element [1.2] above. The difference being that claim element [22.2] is written as a method step (in gerund form). As I explained in Section VII.D.3, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

203. Fisker teaches a scanner head that comprises “a light source 110.” The light “from the light source 110 travels back and forth through the optical system 150.” (Ex.1005, [0244].) As the light travels back and forth, the scanner sees the variation in the light signal corresponding to the variation of the light illuminating the object. (*See id.*, [0086], [0110].) Fisker further discloses that to “obtain color information the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.” (*Id.*, [0151].) A white light or a light comprising at least three monochromatic light sources, as disclosed in Fisker, teaches a multichromatic probe light. As the ’244 Patent provides, a white light source is an example of a multichromatic light. (*See* Ex.1001, 5:23-25.)

204. Thus, Fisker teaches “illuminating the surface of said object with multichromatic probe light from said multichromatic light source,” as recited in claim 22.

4. [22.3]: “capturing a series of 2D images of said object using said color image sensor.”

205. Claim element [22.3] draws from concepts of claim elements [1.2] and [1.3.b] above. More specifically, claim element [1.3.b] recites “capturing a series of the 2D images” while claim element [1.2] recites “a color image sensor...for capturing one or more 2D images.” As I explained in Sections VII.D.3 and VII.C.5, Fisker teaches both of those elements. The explanations that I provided in those sections are also applicable here.

206. As I explained in Section VII.D.3, to provide color information as described above, Fisker teaches a color image sensor comprising an “array of sensor elements” or “sensor elements (pixels).” (Ex.1005, [0070], [0152].) One or more 2D images are captured at the color image sensor when light is transmitted through a pattern towards the object and by imaging “light reflected from the object to the camera.” (*Id.*, [0028], [0061].)

207. Fisker teaches a process for “recording a series of images” of an illumination pattern being projected onto a surface. (*Id.*, [0260].) Each of the images is “taken at different positions of the focusing element, in effect covering the entire travel range of said focus element.” (*Id.*) Fisker further teaches that the

illumination pattern can be a “time varying pattern” and thus “a number of 2D images at different positions of the focus plane and at different instances of the pattern” can be collected (*Id.*, [0028].) Fisker’s different positions of the focus plane teach the recited “different focus plane positions,” as recited by the claim. Therefore, Fisker’s series of 2D images captured over the full range of the focus element teaches a “series of captured 2D images that form a stack of 2D images.”

208. Thus, Fisker teaches a focus scanner that is “capturing a series of 2D images of said object using said color image sensor” as recited in claim 22.

5. [22.4]: “deriving both surface geometry information and surface color information for a block of image sensor pixels at least partly from one captured 2D image.”

209. Claim element [22.4] is substantially similar to claim elements [1.4.a]-[1.4.b] above. The difference being that claim element [22.4] is written as a method step (in gerund form). As I explained in Sections VII.D.6-7, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

210. Fisker teaches capturing a series of 2D images that form a stack of 2D images. Fisker further teaches a “data processing system” configured to perform the disclosed methods. (*See id.*, [0074], [0192].) Fisker’s disclosed methods include an embodiment that is “adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of

the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker further discloses “the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions.” and “an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude.” (*Id.*, [0157].) That is, Fisker’s obtainment of the surface topology of the object being scanned teaches deriv[ing] surface geometry information for at least one 2D image in the stack of 2D images.

211. Like the ’244 Patent, Fisker discloses a group of sensor pixels (i.e., a block of image sensor pixels). (*See id.*, [0070], [0128].) For example, the ’244 Patent provides that “[t]he maximum value of the correlation measure for each group of pixels is monitored along the analysis of the 2D images such that when a 2D image has been analyzed the values for the correlation measure for the different pixels.” (Ex.1001, 18:49-52.) Similarly, Fisker teaches that “[t]he focus position corresponding to the pattern being in focus on the object for a single group of sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group.” (Ex.1005, [0128].)

212. In view of the foregoing, and because the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for the selected full-color focal plane positions, Fisker’s group of pixels teaches the

recited “block” of images sensor pixels because the sensor pixels perform the same functions.

213. Fisker’s data processing system is “adapted to obtain the color of the surface being scanned, i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker’s image sensor “provides color registration at each element,” based on the amplitude of light received at each of the sensor elements. (*See id.*, [0151]-[0157].) The amplitude is determined for at least one color at every focal plan position. (*Id.*, [0158].) So, at every focus position, the amplitude of light received at the sensor elements is used to determine surface topology and the surface color. (*Id.*, [0151]-[0158].)

214. Moreover, Fisker ‘s Figure 9 depicts “a schematic presentation of an example embodiment of a device for simultaneous scanning of a surface shape and color.” (*Id.*, [0228].)

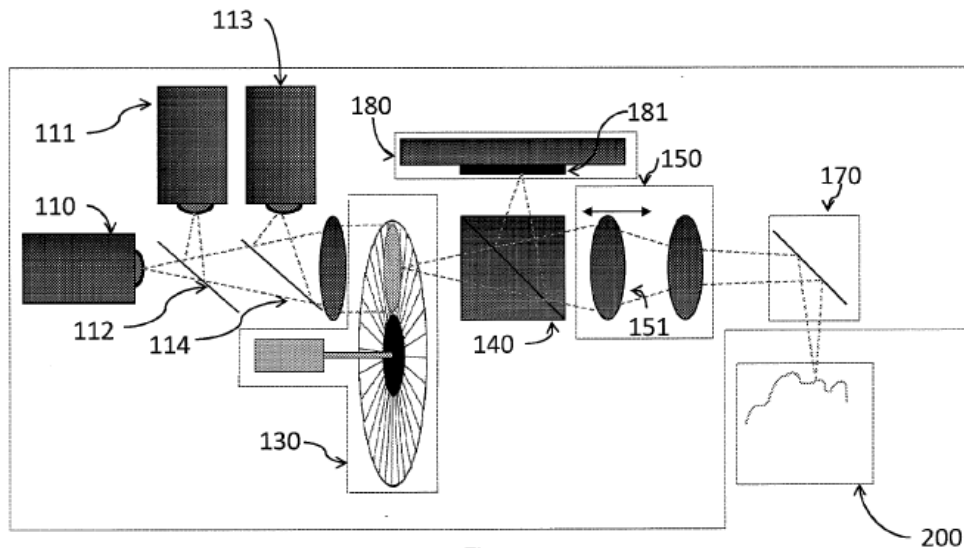


Fig. 9

(Ex.1005, Fig. 9.)

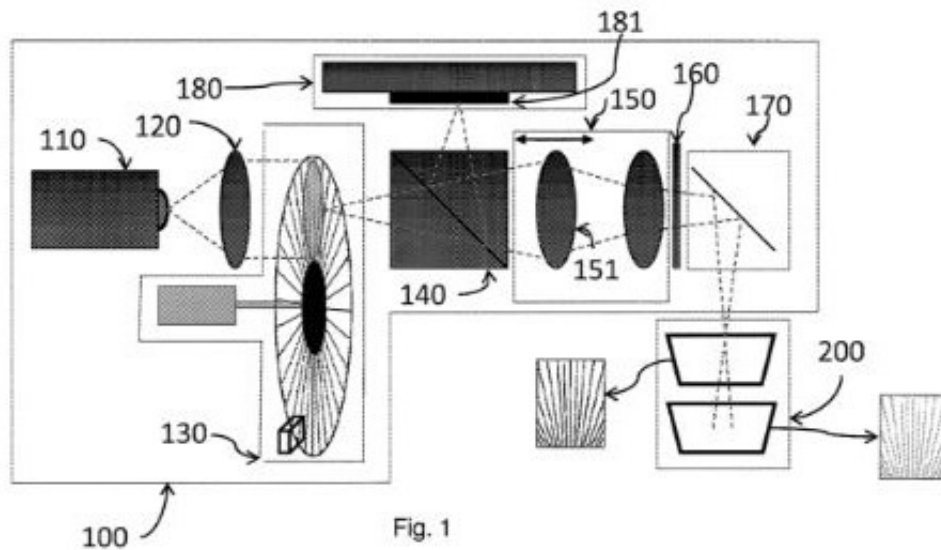
215. Because the color of the surface being scanned may then be obtained by combining and/or weighing the color information from a plurality of the sensor elements, and the color of each surface element expressed as an RGB color coordinate can be reconstructed by appropriately weighing of the amplitude signal for each color corresponding to the maximum amplitude (*Id.*, [0157]), a POSITA would have understood that Fisker teaches a data processing system configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information.

216. Thus, Fisker teaches “deriving both surface geometry information and surface color information for a block of image sensor pixels at least partly from one captured 2D image” as recited by claim 22.

R. Claim 24: “The focus scanner according to claim 1, wherein the multichromatic light source, the color image sensor, and at

least a portion of the data processing system are included in a hand held unit.”

217. Fisker teaches a “hand-held scanner with all components inside the housing (head) 100.” As illustrated in Figure 1, Fisker’s scanner includes, “a light source 110” and “an image sensor and electronics 180.” (Ex.1005, [0244].)



(Ex.1005, Fig. 1.) Fisker later describes the scanner electronics as “processing electronics” (*Id.*, [0170]), and describes a real-time image processing, using the “camera electronics” to “discriminate out-of-focus information.” (*Id.*, [0074].)

218. Thus, Fisker’s hand-held scanner teaches “wherein the multichromatic light source, the color image sensor, and at least a portion of the data processing system are included in a hand held unit” as recited in claim 24.

S. Claim 26: “The focus scanner according to claim 9, wherein said at least one additional 2D image comprises a neighboring 2D image from the series of captured 2D images.”

219. In addition to the teachings that I described in Sections VII.D.4-5 and VII.G-K above, which are applicable here as well, Fisker further discloses registering surface color data by switching between at least two colors (preferably three, such as red, green and blue) for each focal plane position. When the amplitude has been determined for all colors, the focus position is changed, and the process is repeated. The color of the surface being scanned is then obtained by combining and/or weighting the color information from a plurality of the 2D imaging sensor elements, where the color (RGB) expressed by the surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude, as determined by the correlation measure function from different focal plane images . (*See* Ex.1005, [0158] and [0280].) Fisker’s surface color information is then provided by data interpolation from the 2D images corresponding to the maximum focal plane position for each of the colors. (*Id.*) A POSITA would readily understand that since the surface geometry and surface color of the object being scanned may not be flat, the maximum color focal plane positions would occur at different focal plane positions. The data interpolation technique would thus include a neighboring 2D image from the series of captured 2D images because a neighboring 2D image, of

the images captured from multiple focal plane positions, would provide more accurate surface color information for each surface element of the reconstructed 3D object surface geometry.

220. Thus, Fisker teaches “wherein said at least one additional 2D image comprises a neighboring 2D image from the series of captured 2D images” as recited in claim 26.

T. Claim 28: “The focus scanner according to claim 10, where the interpolation is of surface color information of neighboring 2D images in a series.”

221. In addition to the teachings that I described in Sections VII.D.4-5, VII.G-K, and VII.S, which are applicable here as well, Fisker further discloses registering color data for at least one color at all focus positions. (*See id.*, [0158], [0280].) Fisker’s surface color information is then provided by data interpolation from 2D images corresponding to maximum color focus plane positions. (*Id.*) Thus, the color of the surface being scanned may be obtained by interpolating the color information from multiple 2D images captured at different focal plane positions. (*Id.*) A POSITA would readily understand that the data interpolation technique would include a neighboring 2D image from the series of captured 2D images because a neighboring 2D image of the images captured from multiple focal plane positions, would provide more accurate surface color information.

222. Thus, Fisker teaches or suggests “where the interpolation is of surface color information of neighboring 2D images in a series” as recited in claim 28.

VIII. The combinations of (a) Fisker and Yamada and (b) Fisker and Suzuki render claim 29 obvious.

A. Overview of Yamada

223. Yamada discloses a method for “efficiently executing correction of false color, such as purple fringe, caused by chromatic aberration and for generating and outputting high-quality image data are provided.” (Ex.1008, Abstract.) Yamada’s method includes detecting a “white-saturated pixel” from image data and setting a false-color-pixel detection area around the detected white-saturated pixel, and detecting pixels having color corresponding to false color such as purple fringe from the set area. (*Id.*) Yamada’s detected pixels are determined as “false-color pixels and correction processing based on the values of the surrounding pixels is performed on the determined false-color pixels.” (*Id.*) Yamada then corrects the pixel values for each of the detected pixels. (*Id.*)

B. Overview of Suzuki

224. Suzuki discloses a camera having an imaging unit that includes an imaging element with pixels, and generates a pixel value as image data. (Ex.1009, Abstract.) Suzuki’s camera further includes a specification unit that specifies a position of a defective pixel in the image data generated by the camera’s imaging unit. (*Id.*) Suzuki further discloses a region specification unit “that specifies a

region in the image data in which image noise occurs due to the defective pixel.” (*Id.*) Suzuki also teaches a correction unit that “corrects a pixel value of each of a plurality of pixels included in the region in the image data specified by the region specification unit.” (*Id.*) The correction is made using “a weighted average of pixels values of a plurality of pixels located at a periphery of the region.” (*Id.*) As disclosed, Suzuki’s defective pixel may include a “white defect,” which is “displayed as whitening,” teaches or suggests pixel saturation. (*See id.*, [0058].)

C. Claim 29

225. Claim 29 is reproduced below with labeled limitations for ease of discussion.

1. [29.P]: “A focus scanner for recording surface geometry and surface color of an object”

226. Claim element [29.P] is identical to claim element [1.P] above. As I explained in Section VII.D.1, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

227. Fisker discloses a focus scanning apparatus. (Ex.1005, Title.) For example, Fisker teaches “a handheld scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object using confocal pattern projection techniques.” (*Id.*, Abstract.) Fisker additionally teaches that its scanner is “adapted to obtain the color of the surface being scanned.” (*Id.*, [0151].)

228. Thus, Fisker teaches a “focus scanner for recording surface geometry and surface color of an object” as recited in claim 29.

2. [29.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object”

229. Claim element [29.1] is identical to claim element [1.1] above. As I explained in Section VII.D.2, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

230. Fisker teaches a scanner head that comprises “a light source 110.” The light “from the light source 110 travels back and forth through the optical system 150.” (*Id.*, [0244].) As the light travels back and forth, the scanner sees the variation in the light signal corresponding to the variation of the light illuminating the object. (*See id.*, [0086], [0110].) Fisker further discloses that to “obtain color information the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.” (*Id.*, [0151].) A white light or a light comprising at least three monochromatic light sources, as disclosed in Fisker, teaches a multichromatic probe light. As the ’244 Patent provides, a white light source is an example of a multichromatic light. (*See* Ex.1001, 5:23-25.)

231. Thus, Fisker teaches “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 29.

3. [29.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

232. Claim element [29.2] is identical to claim element [1.2] above. As I explained in Section VII.D.3, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

233. To provide color information as described above, Fisker teaches a color image sensor comprising an “array of sensor elements” or “sensor elements (pixels).” (Ex.1005, [0152], [0070].) One or more 2D images are captured at the color image sensor when the light is transmitted through a pattern towards the object and by imaging “light reflected from the object to the camera.” (*Id.*, [0028], [0061].)

234. In Fisker’s description of its digital camera, Fisker describes the camera’s “Imaging sensor comprising a plurality of sensors that respond to light input onto the imaging sensor. The sensors are preferably ordered in a 2D array in rows and columns.” (Ex.1005, [0046].) Fisker additionally states that “The camera may be a standard digital camera accommodating a standard CCD or CMOS chip with one A/D converter per line of sensor elements (pixels)” (Ex.1005, [0070].)

Therefore Fisker's array of sensor elements (pixels), teaches the recited array of image sensor pixels.

235. Thus, Fisker teaches "a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object" as recited in claim 29.

4. **[29.3.a-b]: "wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images"**

236. Claim elements [29.3.a]-[29.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections VII.D.4-5, Fisker teaches these claim elements. The explanations that I provided in these sections are also applicable here.

237. Fisker describes an optical axis as a "straight line" defined by the "configuration of a plurality of optical components, e.g. the configuration of lenses in the optical system." (Ex.1005, [0041].) Fisker's optical system includes a "focus element" that may include a "translation stage for, adjusting and controlling the position of the focus element." (*Id.*, [0064].) That is, Fisker's focus plane "may be varied, for example by translating the focus element back and forth along the optical axis." (*Id.*)

238. Fisker further teaches a process for “recording a series of images” of an illumination pattern being projected onto a surface. (*Id.*, [0260].) Each of the images is “taken at different positions of the focusing element, in effect covering the entire travel range of said focus element.” (*Id.*) Fisker further teaches that the illumination pattern can be a “time varying pattern” and thus “a number of 2D images at different positions of the focus plane and at different instances of the pattern” can be collected. (*Id.*, [0228].) Fisker’s different positions of the focus plane teach the recited “different focus plane positions,” as recited by the claim. Therefore, Fisker’s series of 2D images captured over the full range of the focus element teaches a “series of captured 2D images that form a stack of 2D images.”

239. Thus, Fisker teaches “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 29.

5. **[29.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

240. Claim elements [29.4.a]-[29.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections VII.D.6-7, Fisker teaches these claim elements. The explanations that I provided in these sections are also applicable here.

241. Fisker teaches capturing a series of 2D images that form a stack of 2D images. Fisker further teaches a “data processing system” configured perform the disclosed methods. (*See* Ex.1005, [0074], [0192].) Fisker’s disclosed methods include an embodiment that is “adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker further discloses “ the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions.” and “an RGB color coordinate of each surface element can be reconstructed by appropriate[ly] weighting of the amplitude signal for each color corresponding to the maximum amplitude.” (*Id.*, [0157].) That is, Fisker’s

obtaining the surface topology of the object being scanned teaches deriv[ing] surface geometry information for at least one 2D image in the stack of 2D images.

242. Like the '244 Patent, Fisker discloses a group of sensor pixels (i.e., a block of image sensor pixels). (*See id.*, [0070], [0128].) For example, the '244 Patent provides that “[t]he maximum value of the correlation measure for each group of pixels is monitored along the analysis of the 2D images such that when a 2D image has been analyzed the values for the correlation measure for the different pixels.” (Ex.1001, 18:49-52.) Similarly, Fisker teaches that “[t]he focus position corresponding to the pattern being in focus on the object for a single group of sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group.” (Ex.1005, [0128].)

243. In view of the foregoing, and because the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for the selected full-color focal plane positions, Fisker’s group of pixels teaches the recited “block” of image sensor pixels because the sensor pixels perform the same functions.

244. Fisker’s image sensor “provides color registration at each element,” based on the amplitude of light received at each of the sensor elements. (*See id.*, [0151]-[0157].) The amplitude is determined for at least one color at every focal plan position. (*Id.*, [0158].) So, at every focus position, the amplitude of light

received at the sensor elements is used to determine surface topology and the surface color. (Section VII.D.6; Ex.1005, [0151]-[0158].)

245. Moreover, Fisker 's Figure 9 depicts “a schematic presentation of an example embodiment of a device for simultaneous scanning of a surface shape and color.” (Ex.1005, [0228].)

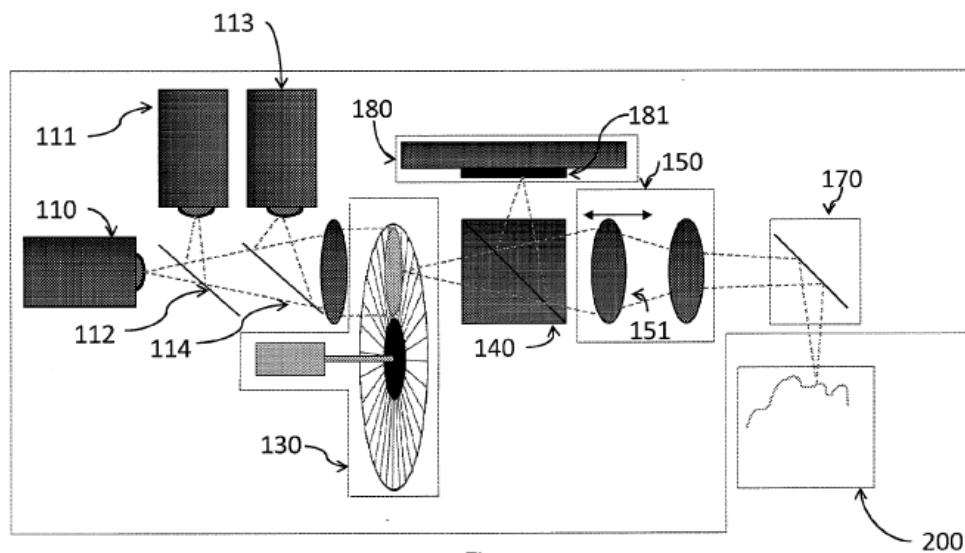


Fig. 9

(Ex.1005, Fig. 9.)

246. Because the color of the surface being scanned may then be obtained by combining and/or weighting the color information from a plurality of the sensor elements, and the color expressed as “an RGB color coordinate of each surface element can be reconstructed by appropriate[ly] weighting of the amplitude signal for each color corresponding to the maximum amplitude” (*Id.*, [0157].) A POSITA would have understood that Fisker teaches a data processing system configured to

derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information.

247. Thus, Fisker teaches “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information,” as recited in claim 29.

6. **[29.5]: “where the data processing system further is configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation.”**

a) Fisker

248. Fisker explains that objects having multiple scattering or a shiny or metallic-looking surface or a polished (e.g., teeth) or very smooth surface (e.g., human ear canal) are difficult to scan and often create saturated images. (*See* Ex. 1005, [0277].) While Fisker provides a passive method for mitigating image saturation by preferential imaging of the diffuse surface reflection from the object on the camera using a polarizing beam splitter (*see* Ex. 1005, [0275]- [0277]), Fisker does not disclose a method for detecting a saturated pixel.

249. Detecting and mitigating errors in surface color information caused by saturated pixels in captured 2D images were known in the art, as evidenced by Yamada and Suzuki.

b) Yamada

250. Yamada discloses a method for correcting false color caused by chromatic aberration, such as a false-color pixels cause by pixel saturation, and for generating and outputting high-quality image data. (Ex.1008, Abstract.)

Specifically, Yamada's image processing apparatus includes "a white-saturation detection unit for detecting a white saturated pixel from image data." (*Id.*, [0011].)

Yamada's teaches a saturation detecting step, which is "a step of executing processing for selecting a white-saturated pixel having a luminance higher than or equal to a predetermined threshold." (*Id.*, [0036].)

251. After a saturated pixel has been detected, Yamada mitigates the error caused by the saturation using pixel-value correction. (*See* Ex.1008, [0030]-[0032].) Yamada's pixel-value correcting step is a step of selecting pixels, other than the false-color pixels or the white-saturated pixels, from pixels that exist the neighborhood of white-saturated pixels and executing compensation interpolation processing based on the selected pixels. (*Id.*, [0030]-[0032], [0085].) Thus, Yamada teaches mitigating the error in the sub-scan color caused by the pixel saturation.

252. Thus, the combination of Fisker and Yamada teaches “where the data processing system further is configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation” as recited in claim 29.

c) Suzuki

253. Suzuki discloses a digital camera imaging unit that specifies (i.e., detects) a position of a defective pixel, such as a white defect, (i.e., saturated pixel) among a plurality of pixels. (*See* Ex.1009, Abstract, [0058].) Suzuki’s camera further includes a region specification unit that specifies a region in the image data in which image noise occurs due to the defective (i.e., saturated) pixel. (*See id.*, Abstract, [0063]-[0065].) Suzuki’s camera also includes a correction unit that corrects a pixel value of each of the pixels in the region based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region. (*See id.*, Abstract, [0066]-[0070].)

254. As disclosed, Suzuki’s defective pixel may include a “white defect,” which when “displayed as whitening,” teaches or suggests pixel saturation. (*See id.*, [0058].) Thus, Suzuki teaches a data processing system configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the sub-scan color caused by the pixel saturation.

255. Thus, the combination of Fisker and Suzuki teaches “where the data processing system further is configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation” as recited in claim 29.

d) Motivation to Combine

256. Fisker, Yamada, and Suzuki each use a processing means (or computing system) to analyze and process captured images, as does the challenged ’244 Patent. Each is directed to a computer system for constructing and rendering 3D images and/or high-quality color image data. (*See* Ex.1005, [0001]; *see also* Ex.1008, [0001]; Ex.1009, Abstract.) And each is similarly concerned with image quality.

257. A POSITA would have been motivated to make the minor modification required to Fisker’s image processing method to include Yamada’s and Suzuki’s similar pixel correction method. The resulting combination is little more than the use of a known image processor and known image processing technique to improve image quality—e.g., produce a more accurate and clear image in the presence of one or more defective/saturated pixels. A POSITA thus would have improved image processing systems and methods, like Fisker’s, in the same way that Yamada suggests—namely, detecting saturated pixels, false-color

pixels, and then correcting the pixel values using an interpolation process based on surrounding pixels, (Ex.1008, [0030]-[0032]), and in the same way that Suzuki suggests—specifying a defective pixel and correct the pixel value of each defective pixel in the region, based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region. (See Ex.1009, Abstract, [0063]-[0070].) And after any of these obvious combinations, each enhanced feature would continue to function as intended.

258. Fisker recognized the need the difficulty in scanning shiny or metallic-looking surfaces. (See Ex.1005, [0277].) While Fisker provides a passive method for mitigating image saturation, that a shiny or metallic-looking surface may potentially cause, using a polarizing beam splitter, Fisker does not have a method for detecting and/or correcting errors that occur as a result of the increased intensity of reflected light. Saturated pixels not only have a whitening effect on an image, but the surrounding pixels also display a false color. (See Ex.1008, [0003]; Ex.1009, [0058].) To produce a high-quality image, a POSITA would have been motivated to find additional methods for reducing and/or overcoming pixel saturation.

259. To be more specific, a POSITA would have modified and enhanced Fisker's image processor and known image processing technique with that of Yamada to detect a white-saturation pixel, a false-color pixel, and to correct the

image data to generate and output a high-quality image without affecting the entire image. (*See* Ex.1008, Abstract.)

260. Similarly, a POSITA would have modified and enhanced Fisker's image processor and known image processing technique with that of Suzuki to improve image processing efficiency and produce a more accurate image. (*See* Ex.1009, [0011]-[0013].)

261. The '244 Patent, Fisker, Yamada, and Suzuki are concerned with providing clear and accurate images. As described, a POSITA would have understood the advantages of enhancing Fisker's image processor and known image processing techniques of Yamada and Suzuki. Thus, the benefits of employing a Yamada-like method and a Suzuki-like method for processing images in an image processor, such as that of Fisker, would have thus been predictable to a POSITA.

262. As provided above, Fisker's image processor and method for processing images would have benefited from Yamada's and Suzuki's methods for detecting defective pixels and correcting the pixel errors. Fisker teaches "a computer program product comprising program code means for causing a data processing system to perform the method, when said program code means are executed on the data processing system." (Ex.1005, [0192].) Similarly, Yamada explains that its methods may be controlled or implemented using a computer

program that is executed by a general-purpose computer system that can execute various program codes via storage media. (*See* Ex.1008, [0048].) Suzuki similarly explains that its methods may be carried out on “a computer capable of executing various functions by installing various programs, for example, a general-purpose personal computer.” (Ex.1009, [0136].)

263. Based on the foregoing, and a POSITA’s experience, a POSITA would have understood that the method for processing images, as described in each of the ’244 Patent, Fisker, Yamada, Suzuki, and methods, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Yamada’s and Suzuki’s image processing modules, it would have been obvious to enhance Fisker’s software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance Fisker’s method for processing images to include the methods of Yamada and Suzuki.

264. Finally, a POSITA would have had a reasonable expectation of success when enhancing Fisker’s image processing method with that of Yamada and Suzuki. Such a modification would have been a routine matter for a POSITA because implementing Yamada’s method would not require any additional hardware and could be implemented within Fisker’s data processor by adding, or altering, the computer code that controls the image processing algorithms.

265. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Fisker's image processing methods and systems with the methods of Yamada or Suzuki. Thus, the combinations of (a) Fisker and Yamada and (b) Fisker and Suzuki each teach or suggest this limitation.

IX. The combinations of (a) Fisker, Szeliski, and Yamada, (b) Fisker, Szeliski, and Suzuki, (c) Fisker, Matsumoto, and Yamada, and (d) Fisker, Matsumoto, and Yamada render claim 12 obvious.

A. Claim 12: "The focus scanner according to claim 1, wherein the data processing system is configured for detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation."

266. Claim 12 is substantially similar to claim element [29.5] above; the differences include the use of "wherein" and "configured for" in claim 12 whereas element [29.5] recites "where" and "configured to," respectively. Thus, the same prior art teachings that I explained in Sections VIII.C.6.a-c also apply here.

Because claim 12 depends from claim 1, however, the prior art references that I provided for claim 1 are also included here.

267. As I explained in Sections VIII.C.6.a-c above, the combinations of (a) Fisker, Szeliski, Yamada, and Suzuki and (b) Fisker, Matsumoto, Yamada, and Suzuki teaches or suggests this claim element. The explanations that I provided in Sections VII.D.1-11 and VIII.C.6 are also applicable here.

a) Fisker

268. Fisker explains that objects having a shiny or metallic-looking surface are difficult to scan and often create saturated image. (*See* Ex.1005, [0277].)

While Fisker provides a method for mitigating image saturation by preferential imaging of the diffuse surface reflection from the object on the camera using a polarizing beam splitter (*see id.*, [0277]), Fisker does not disclose a method for detecting a saturated pixel.

269. Detecting and mitigating errors in surface color information caused by saturated pixels in captured 2D images were known in the art, as evidenced by Yamada and Suzuki.

b) Yamada

270. Yamada discloses a method for correcting false color caused by chromatic aberration, such as a false-color pixels caused by pixel saturation, and for generating and outputting high-quality image data. (Ex.1008, Abstract.)

Specifically, Yamada's image processing apparatus includes "a white-saturation detection unit for detecting a white saturated pixel from image data." (*Id.*, [0011].)

Yamada's teaches a saturation detecting step, which is "a step of executing processing for selecting a white-saturated pixel having a luminance higher than or equal to a predetermined threshold." (*Id.*, [0036].)

271. After a saturated pixel has been detected, Yamada mitigates the error caused by the saturation using pixel-value correction. (*See id.*, [0030]-[0032].) Yamada's pixel-value correcting step is a step of selecting pixels, other than the false-color pixels or the white-saturated pixels, from pixels that exist the neighborhood of white-saturated pixels and executing compensation interpolation processing based on the selected pixels. (*Id.*, [0030]-[0032], [0085].) Thus, Yamada teaches mitigating the error in the sub-scan color caused by the pixel saturation.

272. Thus, the combination of Fisker and Yamada teaches "where the data processing system further is configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation" as recited in claim 12.

c) Suzuki

273. Suzuki discloses a digital camera imaging unit that specifies (i.e., detects) a position of a defective pixel, such as a white defect, (i.e., saturated pixel) among a plurality of pixels. (*See Ex.1009, Abstract*, [0058].) Suzuki's camera further includes a region specification unit that specifies a region in the image data in which image noise occurs due to the defective (i.e., saturated) pixel. (*See id.*, *Abstract*, [0063]-[0065].) Suzuki's camera also includes a correction unit that

corrects a pixel value of each of the pixels in the region based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region. (*See id.*, Abstract, [0066]-[0069].)

274. As disclosed, Suzuki's defective pixel may include a "white defect," which is "displayed as whitening," teaches or suggests pixel saturation. (*See id.*, [0058].) Thus, Suzuki teaches a data processing system configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the sub-scan color caused by the pixel saturation.

275. Thus, the combination of Fisker and Suzuki teaches "where the data processing system further is configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation" as recited in claim 29.

d) Motivation to Combine

276. A POSITA would have been motivated to combine (a) Fisker, Szeliski, and Yamada; (b) Fisker, Szeliski, and Suzuki; (c) Fisker, Matsumoto, and Yamada; or (d) Fisker, Matsumoto, and Suzuki for at least the reasons that I described in Sections VIII.C.6.d above. That is, the image processors and methods for processing image of the (a) Fisker and Szeliski combination and (b) the Fisker and Matsumoto combination would have benefited from Yamada's or Suzuki's

methods for detecting defective pixels and correcting the pixel errors. To achieve the benefits of Yamada's or Suzuki's image processing modules, it would have been obvious to enhance the combinations' software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance the combinations to include the methods of Yamada and Suzuki. Finally, a POSITA would have had a reasonable expectation of success when enhancing the combinations with the methods of Yamada and/or Suzuki.

277. Thus, the combinations of (a) Fisker, Szeliski, and Yamada; (b) Fisker, Szeliski, and Suzuki; (c) Fisker, Matsumoto, and Yamada; and (d) Fisker, Matsumoto, and Suzuki, each teach this claim.

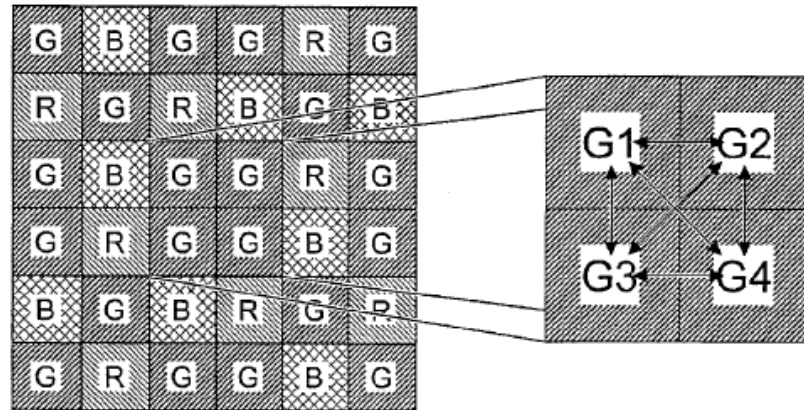
X. The combination of Fisker and Tanaka renders claims 31 and 32 obvious.

A. Overview of Tanaka

278. Tanaka discloses a “color imaging apparatus comprising: a color imaging element comprising a plurality of pixels and color filters of a color filter array arranged on the plurality of pixels, the color filter array including first filters corresponding to a first color that most contributes to obtaining luminance signals and second filters corresponding to two or more second colors.” (Ex.1010, Abstract.) Tanaka's color filter array includes filters corresponding to “a first color that most contributes to obtaining luminance signals and second filters corresponding to two or more second colors.” (*Id.*, [0024].) As illustrated in Figure

5, Tanaka's "basic array pattern of 6x6 pixels included in the color filter array of the color imaging element of the first embodiment are divided into A arrays and the B arrays of 3x3 pixels." (*Id.*, [0050].)

FIG.5



(Ex.1010, Fig. 5.)

B. Claim 31

279. Claim 31 is reproduced below with labeled limitations for ease of discussion.

1. [31.P]: "A focus scanner for recording surface geometry and surface color of an object"

280. Claim element [31.P] is identical to claim element [1.P] above. As I explained in Section VII.D.1, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

281. Fisker discloses a focus scanning apparatus. (Ex.1005, Title.) For example, Fisker teaches "a handheld scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object using confocal pattern

projection techniques.” (*Id.*, Abstract.) Fisker additionally teaches that its scanner is “adapted to obtain the color of the surface being scanned.” (*Id.*, [0151].)

282. Thus, Fisker teaches a “focus scanner for recording surface geometry and surface color of an object” as recited in claim 31.

2. [31.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object”

283. Claim element [31.1] is identical to claim element [1.1] above. As I explained in Section VII.D.2, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

284. Fisker teaches a scanner head that comprises “a light source 110.” The light “from the light source 110 travels back and forth through the optical system 150.” (Ex.1005, [0244].) As the light travels back and forth, the scanner sees the variation in the light signal corresponding to the variation of the light illuminating the object. (*See id.*, [0086], [0110].) Fisker further discloses that to “obtain color information the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.” (*Id.*, [0151].) A white light or a light comprising at least three monochromatic light sources, as disclosed in Fisker, teaches a multichromatic probe light. As the ’244 Patent provides, a white light source is an example of a multichromatic light. (*See* Ex.1001, 5:23-25.)

285. Thus, Fisker teaches “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 31.

3. [31.2.a]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

286. Element [31.2.a] is identical to claim element [1.2] above. As I explained in Section VII.D.3, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

287. To provide color information as described above, Fisker teaches a color image sensor comprising an “array of sensor elements” or “sensor elements (pixels).” (Ex.1005, [0152], [0070].) One or more 2D images are captured at the color image sensor when the light is transmitted through a pattern towards the object and by imaging “light reflected from the object to the camera.” (*Id.*, [0028], [0061].)

288. In Fisker’s description of its digital camera, Fisker describes the camera’s “[i]maging sensor comprising a plurality of sensors that respond to light input onto the imaging sensor. The sensors are preferably ordered in a 2D array in rows and columns.” (Ex.1005, [0046].) Fisker additionally states that “[t]he camera may be a standard digital camera accommodating a standard CCD or CMOS chip with one A/D converter per line of sensor elements (pixels)” (Ex.1005, [0070].)

Thus, Fisker refers to imaging sensor elements as pixels. Therefore, Fisker's array of sensor elements (pixels) teaches the recited array of image sensor pixels.

289. Thus, Fisker teaches "a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object" as recited in claim 31.

4. **[31.2.b]: "where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter"**

290. Like the '244 Patent, Fisker teaches a color image sensor. (Section VII.D.3.) Fisker also teaches a color filter array comprising at least three types of color filters. For example, Fisker teaches that to provide color information, "the array of sensor elements may be a color image sensor. The image sensor may accommodate a Bayer color filter scheme." (Ex.1005, [0152].) It is known in the art that a Bayer color filter scheme includes three types of color filters—red, green, and blue.

291. Fisker further teaches that when a white light source is used, then some kind of filtering must be provided at the color image sensor to detect color, the filters "[p]referably comprising *a plurality of color filters, such as red, green and blue color filters.*" (*Id.*, [0153].) Thus, Fisker teaches at least three types of colors filters, each allowing light in a known wavelength range.

292. The '244 Patent provides up to six different color filters (red, green, blue, cyan, magenta, and yellow), but is silent with respect to which wavelengths W1, W2, and W3 represent. (Ex.1001, 7:30-32.) Fisker's Bayer color filter scheme of red, green, and blue filters teach or suggest three different wavelengths (W1, W2, and W3). (Ex.1005, [0158], [0279].)

293. Thus, Fisker teaches "where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter" as recited in claim 31.

5. [31.3.a-b] "wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images"

294. Claim elements [31.3.a]-[31.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections VII.D.4-5, Fisker teaches these claim elements. The explanations that I provided in those sections are also applicable here.

295. Fisker describes an optical axis as a "straight line" defined by the "configuration of a plurality of optical components, e.g. the configuration of lenses in the optical system." (Ex.1005, [0041].) Fisker's optical system includes a "focus element" that may include a "translation stage for adjusting and controlling the

position of the focus element.” (*Id.*, [0064].) That is, Fisker’s focus plane “may be varied, for example by translating the focus element back and forth along the optical axis.” (*Id.*)

296. Fisker further teaches a process for “recording a series of images” of an illumination pattern being projected onto a surface. (*Id.*, [0260].) Each of the images is “taken at different positions of the focusing element, in effect covering the entire travel range of said focus element.” (*Id.*) Fisker further teaches that the illumination pattern can be a “time varying pattern” and thus “a number of 2D images at different positions of the focus plane and at different instances of the pattern” can be collected (*Id.*, [0028].) Fisker’s different positions of the focus plane teach the recited “different focus plane positions,” as recited by the claim. Therefore, Fisker’s series of 2D images captured over the full range of the focus element teaches a “series of captured 2D images that form a stack of 2D images.”

297. Thus, Fisker teaches “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 31.

6. **[31.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing**

system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”

298. Claim elements [31.4.a]-[31.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections VII.D.6-7, Fisker teaches these claim elements. The explanations that I provided in those sections are also applicable here.

299. The '244 Patent does not provide an explicit definition for a “block” of sensor pixels. The '244 Patent does, however, appear to use the terms “block” of sensor pixels and “group” of sensor pixels, interchangeably. (*See, e.g.*, Ex.1001, 18:24-26 (“The correlation measure is determined for all active image sensor pixel groups on the color image sensor for every focus plane position, i.e., for every 2D image of the stack”); 5:50-54 (“deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value.”).) Accordingly, a POSITA would have understood that the terms “block” or “group” of sensor pixels may include all sensor pixels in the array of pixels or a subset thereof.

300. Fisker teaches capturing a series of 2D images that form a stack of 2D images. Fisker further teaches a “data processing system” configured perform the disclosed methods. (*See* Ex.1005, [0074], [0192].) Fisker’s disclosed methods

include an embodiment that is “adapted to obtain the color of the surface being scanned, i.e., capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker further discloses “ the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions.” and “an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude.” (*Id.*, [0157].) That is, Fisker’s obtaining the surface topology of the object being scanned teaches deriv[ing] surface geometry information for at least one 2D image in the stack of 2D images.

301. Like the ’244 Patent, Fisker discloses a group of sensor pixels (i.e., a block of image sensor pixels). (See *id.*, [0070], [0128].) For example, the ’244 Patent provides that “[t]he maximum value of the correlation measure for each group of pixels is monitored along the analysis of the 2D images such that when a 2D image has been analyzed the values for the correlation measure for the different pixels.” (Ex.1001, 18:49-52.) Similarly, Fisker teaches that “[t]he focus position corresponding to the pattern being in focus on the object for a single group of sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group.” (Ex.1005, [0128].)

302. In view of the foregoing, and because the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for selected full-color focal plane positions, Fisker's group of pixels teaches the recited "block" of images sensor pixels because the sensor pixels perform the same functions.

303. Fisker's image sensor "provides color registration at each element," based on the amplitude of light received at each of the sensor elements. (*See id.*, [0151]-[0157].) The amplitude is determined for at least one color at every focal plan position. (*Id.*, [0158].) So, at every focus position, the amplitude of light received at the sensor elements is used to determine surface topology and the surface color. (Section VII.D.6; Ex.1005, [0151]-[0158].)

304. Moreover, Fisker 's Figure 9 depicts "a schematic presentation of an example embodiment of a device for simultaneous scanning of a surface shape and color." (Ex.1005, [0228].)

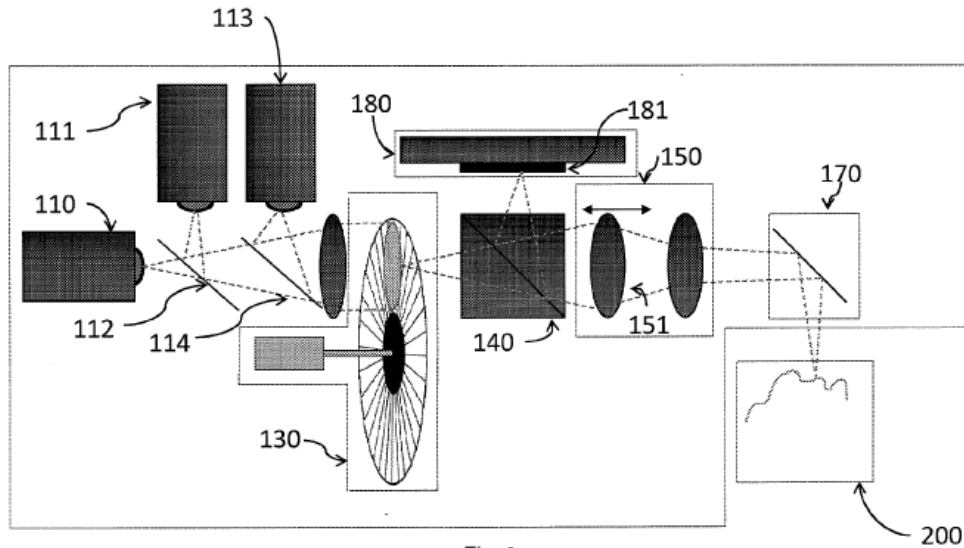


Fig. 9
(Ex.1005, Fig. 9.)

305. Because the color of the surface being scanned may then be obtained by combining and/or weighting the color information from a plurality of the sensor elements, and the color expressed as an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude (Ex.1005, [0157]), a POSITA would have understood that Fisker teaches a data processing system configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information.

306. Thus, Fisker teaches “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data

processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information,” as recited in claim 31.

7. [31.5.a]: “where the data processing system further is configured to derive the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source”

307. Fisker teaches that “the focus position is calculated by determining the light oscillation amplitude for each of a plurality of sensor elements for a range of focus planes.” (*Id.*, [0029].) Thus, the light amplitude is measured to determine surface geometry. Fisker further teaches that one color of light may be selected to determine the amplitude at all focus positions. (*See* Ex.1005, [0155], [0157], [0280], (“[o]ne specific embodiment of the invention only registers the amplitude for all colors at an interval of P focus positions; while one color is selected for determination of the amplitude at all focus positions.”).) The maximum amplitude measurements collected using the selected color of light is used to determine the surface geometry of the scanned object.

308. Thus, Fisker teaches “where the data processing system further is configured to derive the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source” as recited in claim 31.

8. **[31.5.b]: “where the color filter array is such that its proportion of pixels with color filters that match the selected wavelength range of the spectrum is larger than 50%.”**

a) Fisker

309. As I explained in Sections VII.M above, Fisker teaches a color image sensor comprising a color filter array comprising at least three types of colors filters. Furthermore, like the '244 Patent, Fisker also teaches a color filter array comprising at least three types of color filters. For example, Fisker teaches that to provide color information, “the array of sensor elements may be a color image sensor. The image sensor may accommodate a Bayer color filter scheme.” (Ex.1005, [0152].) It is known in the art that a Bayer color filter scheme includes three types of color filters—red, green, and blue. (*Id.*, [0279] and [0280].)

310. Fisker does not teach how many color filters within an array of filters match a selected wavelength. However, the claim element of “a proportion of the image sensor pixels of the color image sensor with color filters that match the selected wavelength range of the spectrum is larger than 50%,” was known in the art, as evidenced by Tanaka.

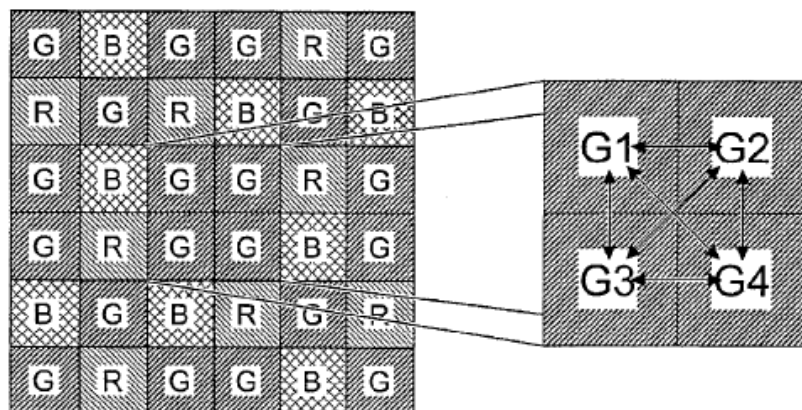
b) Tanaka

311. Tanaka teaches a color imaging apparatus having “a plurality of pixels” and “a color filter array arranged on the plurality of pixels.” (Ex.1010, [0024].) Tanaka’s color filter array includes filters corresponding to “a first color

that most contributes to obtaining luminance signals and second filters corresponding to two or more second colors.” (*Id.*)

312. As illustrated in Figure 5, Tanaka’s “basic array pattern of 6x6 pixels included in the color filter array of the color imaging element of the first embodiment are divided into A arrays and the B arrays of 3x3 pixels.” (*Id.*, [0050].)

FIG.5



(Ex.1010, Fig. 5.)

Of the 36 color filters illustrated in Tanaka’s Figure 5, twenty (20) of the filters are green (G) filters, which is more than 50% of the filters. Thus, Tanaka teaches this claim element, and the combination of Fisker and Tanaka teaches this claim.

c) Motivation to Combine

313. Fisker and Tanaka are analogous art because they each disclose a color scanning apparatus having a processing means (or computing system) to analyze and process captured color images, as does the challenged ’244 Patent.

314. Because Fisker is aimed at improving the color spatial resolution (and color image quality) of a scanned object, a POSITA would have been motivated to make the minor modification required to Fisker's sensor pixel array to include Tanaka's color filter array and pattern. The resulting combination is little more than the use of a known imaging apparatus and known light filtering technique to improve image resolution and quality—e.g., produce a more accurate and clear image by improving resolution and suppressing the generation of false color. (Ex. 1010, [0077].) The foregoing methods for providing clear and accurate color images using color filters were well known in the art, as also exemplified by Cai, Suzuki, and Colonna de Lega.

315. For example, Cai teaches a method that employs a Bayer pattern color filter array to capture color data. (Ex. 1011, [0001] (“cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values.”), [0020], (“[m]any imagers (e.g., CMOS and CCD image/video sensors) use a Bayer pattern as the color filter array.”).) Suzuki teaches also teaches the use of a Bayer filter array. (Ex. 1009, [0045], (“imaging elements are configured from photoelectric transducers of CMOS (Complementary Metal Oxide Semiconductor) sensor-type. A color filter

such as a Bayer array is installed on the imaging elements.”) Colonna de Lega teaches using one or more color filters at the image-recording device. (Ex.1017, [0061], (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”).)

316. A POSITA thus would have improved image processing systems and methods, like Fisker’s, in the same way that Tanaka suggests—namely, arranging the filters of all colors of R, G, and B in the lines in the horizontal and vertical directions of the basic array pattern P, thereby suppressing the generation of color Moire (false color) and improving color resolution. (Ex.1010, [0074]-[0077].)

317. As provided above, Fisker recognizes the need for a color filter array when scanning an object using multichromatic or white light. That is, Fisker teaches that when a white light source is used, some kind of filtering must be provided at the color image sensor to detect color. (Ex.1005, [0153].) Fisker, further discloses that its image sensor may be configured to accommodate a Bayer color filter scheme involving a plurality of color filters, such as red, green and blue color filters. (*Id.*, [0152]-[0153] and [0279]-[0280].) Tanaka teaches a color filter scheme that offers an improvement on the Bayer color filter scheme. For example, the Bayer color filter does not correctly reproduce an oblique high-frequency

image. (Ex.1010, [0005].) Tanaka provides a color filter scheme that offers advantages over the Bayer filter by suppressing false color generation and improving image resolution. (*Id.*, [0024]-[0026].)

318. To achieve the benefits of Tanaka's color filter scheme, it would have been obvious to enhance Fisker's color filters using routine engineering practices and to enhance Fisker's software to accommodate and account for the new filter scheme. Therefore, a POSITA would have had a reasonable expectation of success when enhancing Fisker's color filter array with that of Tanaka's color filter scheme.

319. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Fisker's color filter array with that of Tanaka's color filter scheme.

C. Claim 32

320. Claim 32 is reproduced below with labeled limitations for ease of discussion.

1. [32.P]: "A focus scanner for recording surface geometry and surface color of an object"

321. Claim element [32.P] is identical to claim element [1.P] above. As I explained in Section VII.D.1, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

322. Fisker discloses a focus scanning apparatus. (Ex.1005, Title.) For example, Fisker teaches “a handheld scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object using confocal pattern projection techniques.” (*Id.*, Abstract.) Fisker additionally teaches that its scanner is “adapted to obtain the color of the surface being scanned.” (*Id.*, [0151].)

323. Thus, Fisker teaches a “focus scanner for recording surface geometry and surface color of an object” as recited in claim 32.

2. [32.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object.”

324. Claim element [32.1] is identical to claim element [1.1] above. As I explained in Section VII.D.2, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

325. Fisker teaches a scanner head that comprises “a light source 110.” The light “from the light source 110 travels back and forth through the optical system 150.” (Ex.1005, [0244].) As the light travels back and forth, the scanner sees the variation in the light signal corresponding to the variation of the light illuminating the object. (*See id.*, [0086], [0110].) Fisker further discloses that to “obtain color information the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.” (*Id.*, [0151].) A white light or a light comprising at

least three monochromatic light sources, as disclosed in Fisker, teaches a multichromatic probe light. As the '244 Patent provides, a white light source is an example of a multichromatic light. (*See* Ex.1001, 5:23-25.)

326. Thus, Fisker teaches “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 32.

3. [32.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

327. Claim element [32.2] is identical to claim element [1.2] above. As I explained in Section VII.D.3, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

328. To provide color information as described above, Fisker teaches a color image sensor comprising an “array of sensor elements” or “sensor elements (pixels).” (Ex.1005, [0070],[0152].) One or more 2D images are captured at the color image sensor when the light is transmitted through a pattern towards the object and by imaging “light reflected from the object to the camera.” (*Id.*, [0028], [0061].)

329. In Fisker’s description of its digital camera, Fisker describes the camera’s “Imaging sensor comprising a plurality of sensors that respond to light input onto the imaging sensor. The sensors are preferably ordered in a 2D array in

rows and columns.” (Ex.1005, [0046].) Fisker additionally states that “The camera may be a standard digital camera accommodating a standard CCD or CMOS chip with one A/D converter per line of sensor elements (pixels)” (Ex.1005, [0070].) Thus, Fisker refers to imaging sensor elements as pixels. Therefore Fisker’s array of sensor elements (pixels) teaches the recited array of image sensor pixels.

330. Thus, Fisker teaches “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object,” as recited in claim 32.

4. **[32.3.a-b]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”**

331. Claim elements [32.3.a]-[32.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections VII.D.4-5, Fisker teaches these claim elements. The explanations that I provided in those sections are also applicable here.

332. Fisker describes an optical axis as a “straight line” defined by the “configuration of a plurality of optical components, e.g. the configuration of lenses in the optical system.” (*Id.*, [0041].) Fisker’s optical system includes a “focus element” that may include a “translation stage, for adjusting and controlling the position of the focus element.” (*Id.*, [0064].) That is, Fisker’s focus plane “may be

varied, for example by translating the focus element back and forth along the optical axis.” (*Id.*)

333. Fisker further teaches a process for “recording a series of images” of an illumination pattern being projected onto a surface. (*Id.*, [0260].) Each of the images is “taken at different positions of the focusing element, in effect covering the entire travel range of said focus element.” (*Id.*) Fisker further teaches that the illumination pattern can be a “time varying pattern” and thus “a number of 2D images at different positions of the focus plane and at different instances of the pattern” can be collected (*Id.*, [0028].) Fisker’s different positions of the focus plane teach the recited “different focus plane positions,” as recited by the claim. Therefore, Fisker’s series of 2D images captured over the full range of the focus element teaches a “series of captured 2D images that form a stack of 2D images.”

334. Thus, Fisker teaches “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 32.

5. **[32.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

335. Claim elements [32.4.a]-[32.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections VII.D.6-7, Fisker teaches these claim elements. The explanations that I provided in those sections are also applicable here.

336. The '244 Patent does not provide an explicit definition for a “block” of sensor pixels. The '244 Patent does, however, appear to use the terms “block” of sensor pixels and “group” of sensor pixels, interchangeably. (*See, e.g.*, Ex.1001, 18:24-26 (“The correlation measure is determined for all active image sensor pixel groups on the color image sensor for every focus plane position, i.e. for every 2D image of the stack”), 5:50-54 (“deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value.”).) Accordingly, a POSITA would have understood that the terms “block” or “group” of sensor pixels may include all sensor pixels in the array of pixels or a subset thereof.

337. Fisker teaches capturing a series of 2D images that form a stack of 2D images. Fisker further teaches a “data processing system” configured perform the disclosed methods. (*See* Ex.1005, [0074], [0192].) Fisker’s disclosed methods include an embodiment that is “adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker further discloses “ the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions.” and “an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude.” (*Id.*, [0157].) That is, Fisker’s obtainment of the surface topology of the object being scanned teaches “deriv[ing] surface geometry information” for at least one 2D image in the stack of 2D images.

338. Like the ’244 Patent, Fisker discloses a group of sensor pixels (i.e., a block of image sensor pixels). (*See id.*, [0070], [0128].) For example, the ’244 Patent provides that “[t]he maximum value of the correlation measure for each group of pixels is monitored along the analysis of the 2D images such that when a 2D image has been analyzed the values for the correlation measure for the different pixels.” (Ex.1001, 18:48-52.) Similarly, Fisker teaches that “[t]he focus position corresponding to the pattern being in focus on the object for a single group of

sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group.” (Ex.1005, [0128].)

339. In view of the foregoing, and because the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for selected full-color focal plane positions, Fisker’s group of pixels teaches the recited “block” of images sensor pixels because the sensor pixels perform the same functions.

340. Fisker’s image sensor “provides color registration at each element,” based on the amplitude of light received at each of the sensor elements. (*See id.*, [0151]-[0157].) The amplitude is determined for at least one color at every focal plan position. (*Id.*, [0158].) So, at every focus position, the amplitude of light received at the sensor elements is used to determine surface topology and the surface color. (Section VII.D.6; Ex.1005, [0151]-[0158].)

341. Moreover, Fisker ‘s Figure 9 depicts “a schematic presentation of an example embodiment of a device for simultaneous scanning of a surface shape and color.” (*Id.*, [0228].)

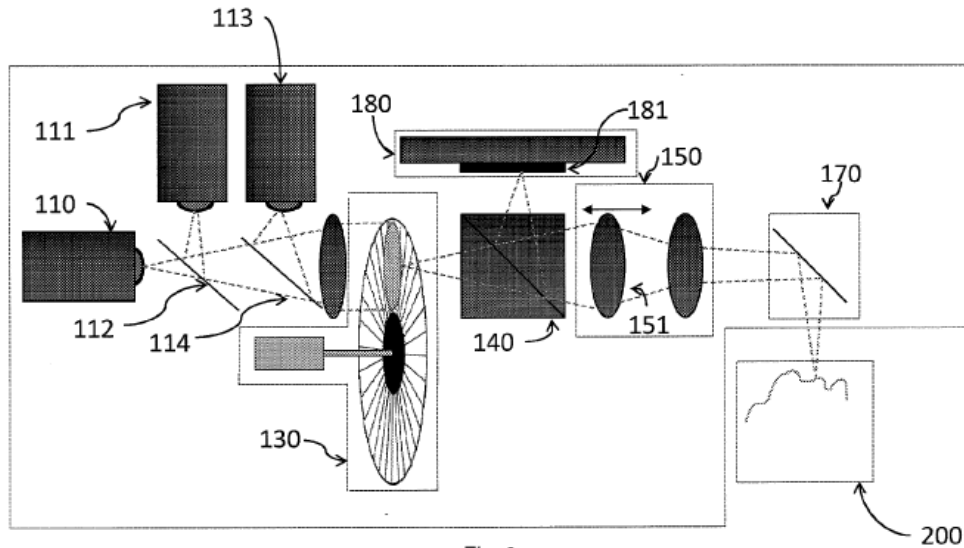


Fig. 9

(Ex.1005, Fig. 9.)

342. Because “[t]he color of the surface being scanned may then be obtained by combining and/or weighting the color information from a plurality of the sensor elements,” and the color expressed as “an RGB color coordinate of each surface element can be reconstructed by appropriate[ly] weighting of the amplitude signal for each color corresponding to the maximum amplitude, (*id.*, [0157]), a POSITA would have understood that Fisker teaches a data processing system configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information.

343. Thus, Fisker teaches “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data

processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information,” as recited in claim 32.

6. [32.5.a]: “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter”

344. Like the '244 Patent, as I explained above in Section VII.D.3, Fisker teaches a color image sensor. Fisker also teaches a color filter array comprising at least three types of color filters. For example, Fisker teaches that to provide color information, “the array of sensor elements may be a color image sensor. The image sensor may accommodate a Bayer color filter scheme.” (*Id.*, [0152].) It is known in the art that a Bayer color filter scheme includes three types of color filters—red, green, and blue. (*Id.*, [0279]-[0280].)

345. Fisker further teaches that when a white light source is used, then some kind of filtering must be provided at the color image sensor to detect color, the filters “[p]referably comprising a *plurality of color filters, such as red, green and blue color filters.*” (*Id.*, [0153].) Thus, Fisker teaches at least three types of colors filters, each allowing light in a known wavelength range.

346. The '244 Patent provides up to six different color filters (red, green, blue, cyan, magenta, and yellow) but is silent with respect to which wavelengths W1, W2, and W3 represent. (Ex.1001, 7:30-32.) Fisker’s Bayer color filter scheme

of red, green, and blue filters teaches three different wavelengths (W1, W2, and W3). (Ex.1005, [0158], [0279].)

347. Thus, Fisker teaches “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter” as recited in claim 32.

7. [32.5.b]: “the filters are arranged in a plurality of cells of 6×6 color filters, where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and (5,2) are of the W3 type.”

a) Fisker

348. Like the '244 Patent, and as I explained above in Section VII.D.3, Fisker teaches a color image sensor. Also like the '244 Patent, Fisker's color image sensor is configured to accommodate a Bayer color filter scheme. More specifically, Fisker teaches that to provide color information, “the array of sensor elements may be a color image sensor. The image sensor may accommodate a Bayer color filter scheme.” (*Id.*, [0152].) To the extent Patent Owner that Fisker does not teach or suggest this limitation, it was known in the prior art, e.g., as taught by Tanaka.

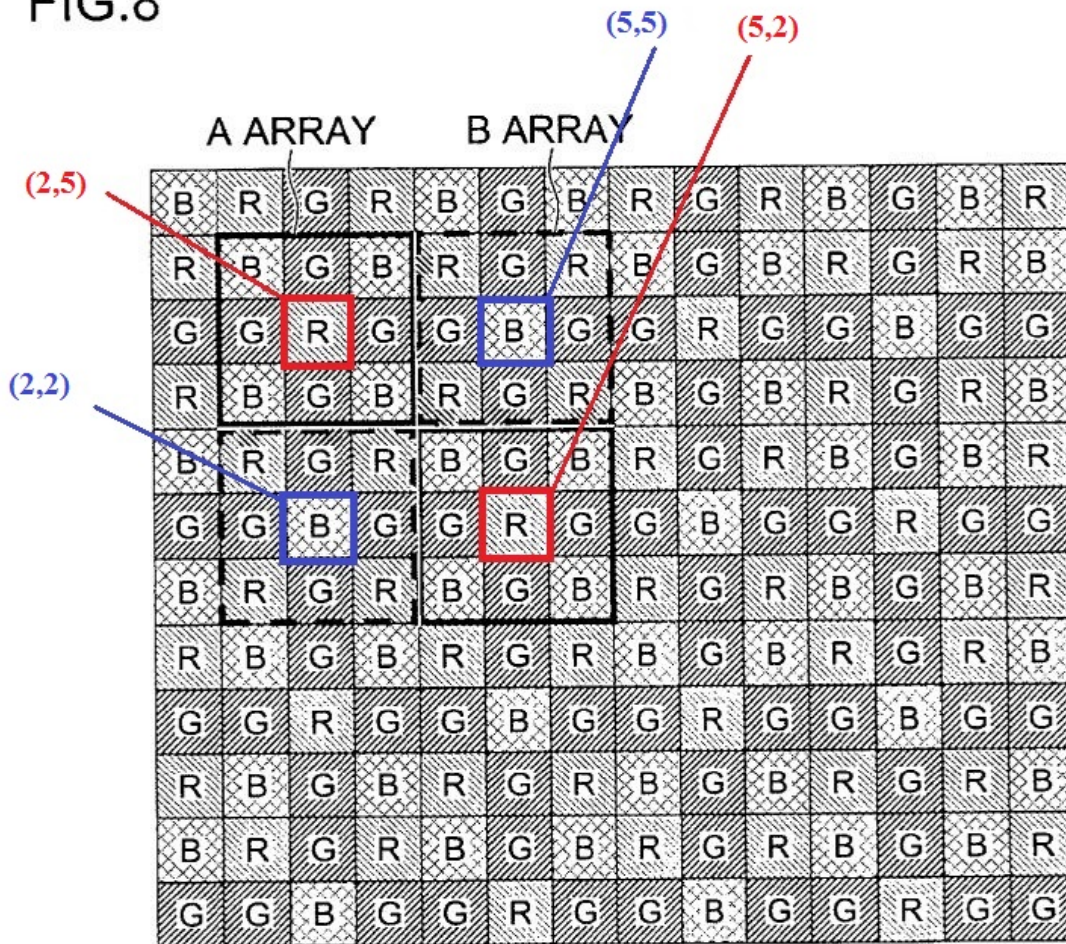
b) Tanaka

349. Tanaka teaches a color imaging apparatus having “a plurality of pixels” and “a color filter array arranged on the plurality of pixels.” (Ex.1010,

Abstract and [0024].) Tanaka's color filter array includes filters corresponding to "a first color that most contributes to obtaining luminance signals and second filters corresponding to two or more second colors." (*Id.*)

350. Tanaka, elaborates in this second embodiment of its color filters invention, "[a]s shown in FIG. 8 [illustrated below], the color filter array of the color imaging element includes basic array patterns formed by square array patterns corresponding to 6×6 pixels, and the basic array pattern is repeatedly arranged in the horizontal and vertical directions." (*Id.*, [0126].) Accordingly, Tanaka's filter array includes filters arranged in a predetermined cycle. (*Id.*)

FIG.8



(Ex.1010, Fig. 8, annotated.) In the 6x6 highlighted portion, designated as side-by-side A array and B array, the color filters in positions (2,2) and (5,5) are of the B type (i.e., a possible W1 wavelength) and the color filters in positions (2,5) and (5,2) are of the R type (i.e., a possible W3 wavelength).

351. Thus, the combination of Fisker and Tanaka teaches “the filters are arranged in a plurality of cells of 6×6 color filters, where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and (5,2) are of the W3 type,” as recited in claim 32.

c) Motivation to Combine

352. A POSITA would have been motivated to enhance Fisker with Tanaka at least for the reasons described in Section X.B.8.c. above.

353. Fisker and Tanaka are analogous art because they each disclose a color scanning apparatus having a processing means (or computing system) to analyze and process captured images, as does the challenged '244 Patent.

354. Because Fisker is aimed at improving the spatial color resolution (and quality) of a scanned object, a POSITA would have been motivated to make the minor modification required to Fisker's sensor pixel array to include Tanaka's color filter array and pattern. The resulting combination is little more than the use of a known imaging apparatus and known light filtering technique to improve image resolution and quality—e.g., produce a more accurate and clear image by improving resolution and suppressing the generation of false color. (Ex. 1010, [0077].) The foregoing methods for providing clear and accurate images using color filters were well known in the art, as also exemplified by Cai, Suzuki, and Colonna de Lega.

355. For example, Cai teaches a method that employs a Bayer pattern color filter array to capture color data. (Ex.1011, [0001] (“cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array,

the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values.”), [0020], (“[m]any imagers (e.g., CMOS and CCD image/video sensors) use a Bayer pattern as the color filter array.”).) Suzuki teaches also teaches the use of a Bayer filter array. (Ex.1009, [0045] (“imaging elements are configured from photoelectric transducers of CMOS (Complementary Metal Oxide Semiconductor) sensor-type. A color filter such as a Bayer array is installed on the imaging elements.”) Colonna de Lega teaches using one or more color filters at the image-recording device. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”).)

356. A POSITA thus would have improved image processing systems and methods, like Fisker’s, in the same way that Tanaka suggests—namely, arranging the filters of all colors of R, G, and B in the lines in the horizontal and vertical directions of the basic array pattern P, thereby suppressing the generation of color moire (false color) and improving resolution. (Ex.1010, [0074]-[0077].)

357. As provided above, Fisker recognizes the need for a color filter array when scanning an object using multichromatic or white light. That is, Fisker teaches that when a white light source is used, “some kind of filtering must be

provided at the color image sensor to detect color.” (Ex.1005, [0153].) Fisker, further discloses that its image sensor may be configured to accommodate a Bayer color filter scheme involving a plurality of color filters, such as red, green and blue color filters. (*Id.*, [0152]-[0153].) Tanaka teaches a color filter scheme that offers an improvement on a standard Bayer color filter scheme. For example, the Bayer color filter does not correctly reproduce an oblique high-frequency image. (Ex.1010, [0005].) Tanaka provides a color filter scheme that offers advantages over the Bayer filter by suppressing false color generation and improving image resolution. (*Id.*, [0024]-[0026].)

358. To achieve the benefits of Tanaka’s color filter scheme, it would have been obvious to enhance Fisker’s color filters using routine engineering practices and to enhance Fisker’s software to accommodate and account for the new filter scheme. Therefore, a POSITA would have had a reasonable expectation of success when enhancing Fisker’s color filter array with that of Tanaka’s color filter scheme.

359. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Fisker’s color filter array with that of Tanaka’s color filter scheme. Thus, the combination of Fisker and Tanaka teach this claim element.

XI. The combinations of (a) Fisker, Szeliski, and Tanaka and (b) Fisker, Matsumoto, and Tanaka render claims 17 and 19 obvious.

A. Claim 17: “The focus scanner according to claim 16, where the color filter array is such that the proportion of the image sensor pixels of the color image sensor with color filters that match the selected wavelength range of the spectrum is larger than 50%.”

360. Claim 17 is substantially similar to claim element 31.5.b above. The combination of Fisker, Szeliski, and Tanaka teaches claim 17 for at least the reasons that I provided in Sections VII.D.6.a-c and X.B.8, above.

361. A POSITA would have been motivated to combine Fisker, Szeliski, and Tanaka and/or Fisker, Matsumoto, and Tanaka for at least the reasons that I described Sections Section X.B.8.c and X.C.7.c, above.

B. Claim 19: “The focus scanner according to claim 15, wherein the color filter array comprises a plurality of cells of 6×6 color filters, where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and (5,2) are of the W3 type.”

362. Claim 19 is substantially similar to claim element 32.5.b above. The combination of Fisker, Szeliski, and Tanaka teaches claim 19 for at least the reasons that I provided in Section X.C.7, above

363. A POSITA would have been motivated to combine Fisker, Szeliski, and Tanaka and/or Fisker, Matsumoto, and Tanaka for at least the reasons that I described Sections X.B.8.c and X.C.7.c, above.

XII. The combinations of (a) Fisker and Suzuki and (b) Fisker and Cai render claim 34 obvious.

A. Overview of Cai

364. Cai teaches an “[a]rchitecture for decoding (demosaicing) a source image and performing reconstruction directly from the Bayer pattern to reduce memory size and improve communication bandwidth.” (Ex.1011, Abstract.) Cai further teaches a method for obtaining an interpolated color value from adjacent real pixel values of the same color. (*Id.*, [0021].) That is, Cai teaches “where a red pixel R8 in the target image maps to a center position of four surrounding real red pixels, the target red pixel R8 is interpolated by the simple average of the color values of the surrounding real pixels in the source image such that interpolated pixel $R8 = (R2 + R4 + R12 + R14) / 4$.” (*Id.*)

B. Claim 34

365. Claim 1 is reproduced below with labeled limitations for ease of discussion.

1. [34.P]: “A focus scanner for recording surface geometry and surface color of an object”

366. Claim element [34.P] is identical to claim element [1.P] above. As I explained in Section VII.D.1, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

367. Fisker discloses a focus scanning apparatus. (Ex.1005, Title.) For example, Fisker teaches “a handheld scanner for obtaining and/or measuring the

3D geometry of at least a part of the surface of an object using confocal pattern projection techniques.” (*Id.*, Abstract.) Fisker additionally teaches that its scanner is “adapted to obtain the color of the surface being scanned.” (*Id.*, [0151].)

368. Thus, Fisker teaches a “focus scanner for recording surface geometry and surface color of an object” as recited in claim 34.

2. [34.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object”

369. Claim element [34.1] is identical to claim element [1.1] above. As I explained in Section VII.D.2, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

370. Fisker teaches a scanner head that comprises “a light source 110.” The light “from the light source 110 travels back and forth through the optical system 150.” (Ex.1005, [0244].) As the light travels back and forth, the scanner sees the variation in the light signal corresponding to the variation of the light illuminating the object. (*See id.*, [0086], [0110].) Fisker further discloses that to “obtain color information the light source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.” (*Id.*, [0151].) A white light or a light comprising at least three monochromatic light sources, as disclosed in Fisker, teaches a

multichromatic probe light. As the '244 Patent provides, a white light source is an example of a multichromatic light. (*See* Ex.1001, 5:23-25.)

371. Thus, Fisker teaches “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 34.

3. [34.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

372. Claim element [34.2] is identical to claim element [1.2] above. As I explained in Section VII.D.3, Fisker teaches this claim element. The explanations that I provided in that section are also applicable here.

373. To provide color information as described above, Fisker teaches a color image sensor comprising an “array of sensor elements” or “sensor elements (pixels).” (Ex.1005, [0070], [0152].) One or more 2D images are captured at the color image sensor when light is transmitted through a pattern towards the object and by imaging “light reflected from the object to the camera.” (*Id.*, [0028], [0061].)

374. In Fisker’s description of its digital camera, Fisker describes the camera’s “Imaging sensor comprising a plurality of sensors that respond to light input onto the imaging sensor. The sensors are preferably ordered in a 2D array in rows and columns.” (Ex.1005, [0046].) Fisker additionally states that “The camera

may be a standard digital camera accommodating a standard CCD or CMOS chip with one A/D converter per line of sensor elements (pixels)” (Ex.1005, [0070].) Thus, Fisker refers to imaging sensor elements as pixels. Therefore, Fisker’s array of sensor elements (pixels) teaches the recited array of image sensor pixels.

375. Thus, Fisker teaches “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object” as recited in claim 34.

4. **[34.3.a-b]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”**

376. Claim elements [34.3.a]-[34.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections VII.D.4-5, Fisker teaches these claim elements. The explanations that I provided in those sections are also applicable here.

377. Fisker describes an optical axis as a “straight line” defined by the “configuration of a plurality of optical components, e.g. the configuration of lenses in the optical system.” (Ex.1005, [0041].) Fisker’s optical system includes a “focus element” that may include a “translation stage for adjusting and controlling the position of the focus element.” (*Id.*, [0064].) That is, Fisker’s focus plane “may be

varied, for example by translating the focus element back and forth along the optical axis.” (*Id.*)

378. Fisker further teaches a process for “recording a series of images” of an illumination pattern being projected onto a surface. (*Id.*, [0260].) Each of the images is “taken at different positions of the focusing element, in effect covering the entire travel range of said focus element.” (*Id.*) Fisker further teaches that the illumination pattern can be a “time varying pattern” and thus “a number of 2D images at different positions of the focus plane and at different instances of the pattern” can be collected. (*Id.*, [0028].) Fisker’s different positions of the focus plane teach the recited “different focus plane positions,” as recited by the claim. Therefore, Fisker’s series of 2D images captured over the full range of the focus element teaches a “series of captured 2D images that form a stack of 2D images.”

379. Thus, Fisker teaches “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images” as recited in claim 34.

5. **[34.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

380. Claim elements [34.4.a]-[34.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections VII.D.6-7, Fisker teaches these claim elements. The explanations that I provided in those sections are also applicable here.

381. The '244 Patent does not provide an explicit definition for a “block” of sensor pixels. The '244 Patent does, however, appear to use the terms “block” of sensor pixels and “group” of sensor pixels, interchangeably. (E.g., Ex.1001, 18:24-26 (“The correlation measure is determined for all active image sensor pixel groups on the color image sensor for every focus plane position, i.e. for every 2D image of the stack”); 5:50-54 (“deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value.”).) Accordingly, a POSITA would have understood that the terms “block” or “group” of sensor pixels may include all sensor pixels in the array of pixels or a subset thereof.

382. Fisker teaches capturing a series of 2D images that form a stack of 2D images. Fisker further teaches a “data processing system” configured perform the disclosed methods. (*See* Ex.1005, [0074], [0192].) Fisker’s disclosed methods include an embodiment that is “adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (*Id.*, [0151].) Fisker further discloses “the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions” and “an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding to the maximum amplitude.” (*Id.*, [0157].) That is, Fisker’s obtaining the surface topology of the object being scanned teaches “deriv[ing] surface geometry information” for at least one 2D image in the stack of 2D images.

383. Like the ’244 Patent, Fisker discloses a group of sensor pixels (i.e., a block of image sensor pixels). (*See* Ex.1005, [0070], [0128].) For example, the ’244 Patent provides that “[t]he maximum value of the correlation measure for each group of pixels is monitored along the analysis of the 2D images such that when a 2D image has been analyzed the values for the correlation measure for the different pixels.” (Ex.1001, 18:48-54.) Similarly, Fisker teaches that “[t]he focus position corresponding to the pattern being in focus on the object for a single group

of sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group.” (Ex.1005, [0128].)

384. In view of the foregoing, and because the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for selected full-color focal plane positions, Fisker’s group of pixels teaches the recited “block” of images sensor pixels because the sensor pixels perform the same functions.

385. Fisker’s image sensor “provides color registration at each element,” based on the amplitude of light received at each of the sensor elements. (*See* Ex.1005, [0151]-[0157].) The amplitude is determined for at least one color at every focal plane position. (*Id.*, [0158].) So, at every focus position, the amplitude of light received at the sensor elements is used to determine surface topology and the surface color. (Section VII.D.6; Ex.1005, [0151]-[0158].)

386. Moreover, Fisker’s Figure 9 depicts “a schematic presentation of an example embodiment of a device for simultaneous scanning of a surface shape and color.” (Ex.1005, [0228].)

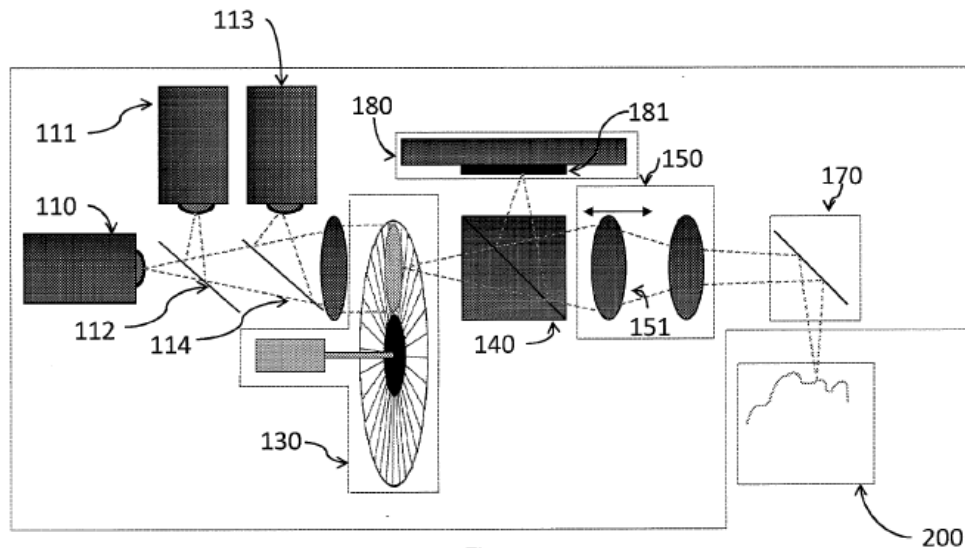


Fig. 9

(Ex.1005, Fig. 9.)

387. Because the color of the surface being scanned may then be obtained by combining and/or weighting the color information from a plurality of the sensor elements, and the color expressed as an RGB color coordinate of each surface element can be reconstructed by appropriately weighting of the amplitude signal for each color corresponding to the maximum amplitude (*id.*, [157]), a POSITA would have understood that Fisker teaches a data processing system configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information.

388. Thus, Fisker teaches “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block

of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information” as recited in claim 34.

6. **[34.4.c]: “where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern”**

389. Claim element [34.4.c] is identical to claim 4 above. As I explained in Sections VII.D.6-7 and VII.G above, Fisker teaches deriving the surface geometry information and surface color information. Those same teachings and explanations are applicable here as well.

390. Fisker further teaches a “means for evaluating a correlation measure at each focus plane position between at least one image pixel and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern.” (Ex.1005, [0017].) Because Fisker evaluates a correlation measure at “each focus plane,” Fisker teaches calculating a correlation measure for several 2D images.

391. Like the '244 Patent, Fisker's correlation measure is a “measure between the weight function and the recorded light signal” that “translates to a pixel value within an image” and is computed using several camera sensors. (Ex.1005, [0053]-[0054].) That is, Fisker teaches calculating a correlation measure

between the portion of the 2D image captured by said block of image sensor pixels and a weight function.

392. Thus, in view of the foregoing, Fisker teaches “where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern,” as recited in claim 34.

7. [34.4.d]: “identifying the position along the optical axis at which the corresponding correlation measure has a maximum value”

393. Fisker teaches that different regions (i.e., a block of image sensor pixels) of the scanned surface will be in focus in different images. (*See* Ex.1005, [0261].) Fisker further describes a “fused image” that is generated by “combining all the in-focus regions of the series” of images using stitching and/or registering process where “partial scans” are combined. (*Id.*, [0175], [0263].) Fisker’s in-focus regions are “found as those of maximum intensity variance (indicating maximum contrast) over the entire said series of images.” (*Id.*, [0262].)

394. Thus, Fisker teaches “wherein generating a sub-scan comprises...identifying the position along the optical axis at which the correlation measure functions have their maximum value” as recited by claim 34.

8. **[34.4.e]: “where the data processing system further is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels.”**

395. As I explained in Sections VII.D.7 and VII.G-K, Fisker teaches a data processing system configured for deriving the sub-scan color for a point on a generated sub-scan using a correlation measure and for generating a sub-scan based on the surface color information of the 2D images in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels. The explanations that I provided in those sections are also applicable here.

396. Fisker teaches that “[t]he pattern is applied to provide illumination with an embedded spatial structure on the object being scanned. Determining in-focus information relates to calculating a correlation measure of this spatially structured light signal (which we term input signal) with the variation of the pattern itself (which we term reference signal). In general the magnitude of the correlation measure is high if the input signal coincides with the reference signal”. (Ex.1005, [0074].)

397. Like the '244 Patent, Fisker's correlation measure is defined “mathematically with a discrete set of measurements as a dot product computed from a signal vector, $I=(I_1, \dots, I_n)$, with $n>1$ elements representing sensor

signals and a reference signal vector, $f = (f_1, \dots, f_n)$, of same length as said signal vector of reference **weights**. Fisker's correlation measure function A is identical to the one used in the '244 Patent, and as I explained above in Section VII.G.

398. Moreover, as in the '244 patent, Fisker teaches that the correlation measure is computed on signal vectors that represent sensor signals, available as 2D digital color images captured at each focus element position, i.e., images with a finite number of discrete pixels. (*See id.*, [0077], [0080]). Fisker additionally evaluates the above correlation measure at "all focus element positions" and thus Fisker teaches calculating a correlation measure for several 2D images. (*Id.*, [0078].)

399. Like the '244 Patent, Fisker's correlation measure is a "measure between the weight function and the recorded light signal" that "translates to a pixel values of an image" and the correlation measure is computed using several image sensor pixels. (Ex.1005, [0052].) That is, Fisker teaches calculating a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function.

400. The similarities between the correlation measures disclosed in the '244 Patent and that of Fisker are further exemplified by the following table (Section VII.G):

'244 Patent	Fisker
<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>('244 Patent, 6:1-12.)</p>	<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>(Ex.1005, [0076].)</p>

401. Fisker's method includes reconstructing the surface color using an appropriate weighting corresponding to the maximum amplitude/correlation measure. (Ex.1005, [0157]-[0158], [0279]-[0280].) Fisker's data processing system is "adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned." (Section VII.C.6; Ex.1005, [0151].) Fisker's image sensor "provides color registration at each element," based on the amplitude of light received at each of the sensor elements. (See Ex.1005, [0151]-[0157].) The amplitude is determined for at least one color at every focal plane position. (*Id.*, [0158].) So, at every focus position, the amplitude of light received at the sensor elements is used to compute the maximum of the

correlation measure function, to determine surface topology and the surface color, e.g., an RGB color coordinate, for each surface element. This surface color is reconstructed by appropriate weighting of the image sensor amplitude signal for each color corresponding to the maximum correlation function. (Section VI.D.6; Ex.1005 , [0151]-[0158] and [0279]-[0280].)

402. Thus, Fisker teaches “where the data processing system further is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels” as recited in claim 34.

9. **[34.4.f]: “where the data processing system further is configured for...computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of surrounding points on the sub-scan.”**

a) Fisker

403. Fisker teaches that different regions of the scanned surface will be in focus in different images. (*See* Ex.1005, [0261].) “In focus regions within an image are found as those of maximum intensity variance (indicating maximum contrast) over the entire said series of images.” (*Id.*, [0262].) Fisker further describes a “fused image” that is generated by “combining all the in-focus regions of the series” of images, (*Id.*, [0263].)

404. Fisker also teaches converting the 2D color image data into a 3D surface data in each sub-scan and then “merging and/or combining 3D data for the interior and exterior part of the ear provided, thereby providing a full 3D model of a human ear.” (Ex. 1005, [0032] and [0173].) Furthermore, Fisker elaborates, “An embodiment of a color 3D scanner is shown in FIG 9. Three light sources 110, 111, and 113 emit red, green, and blue light. The light sources are maybe LEDs or lasers. The light is merged together to overlap or essentially overlap. This may be achieved by means of two appropriately coated plates 112 and 114. Plate 112 transmits the light from 110 and reflects the light from 111. Plate 114 transmits the light from 110 and 111 and reflects the light from 113. The color measurement is performed as follows: For a given focus position the amplitude of the time-varying pattern projected onto the probed object is determined for each sensor element in the sensor 181 by one of the above mentioned methods for each of the light sources individually. In the preferred embodiment only one light source is switched on at the time, and the light sources are switched on after turn. In this embodiment the optical system 150 maybe achromatic. After determining the amplitude for each light source the focus position is shifted to the next position and the process is repeated. The color expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude. ” (Id., [0279].)

405. While Fisker describes a weighting averaging scheme for expressing sub-scan color values for a number of points of the sub-scan , Patent Owner may argue that Fisker does not teach or suggest this claim limitation. (*Id.*) However, computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface was well known in the prior art, e.g., as taught or suggested by Suzuki and Cai.

b) Suzuki

406. As described above, Suzuki discloses a digital camera imaging unit that specifies (i.e., detects) a position of a defective pixel among a plurality of pixels. (Section VIII.C.6.c; *see also* Ex.1009, Abstract, [0058].) Suzuki's camera includes a correction unit that corrects the pixel values of each of the pixels in the region based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region. (*See* Ex.1009, Abstract, [0066]-[0069].) Suzuki's formula (1), illustrated below, further teaches a formula for determining a pixel value using a weighted average of the surrounding pixels:

$$VA=(VA1\times6+VA2\times12+VA3\times4+VA4\times12+VA5\times6+VA6\times4+VA7\times6+VA8\times3)\div(6+12+4+12+6+4+6+3) \quad (1)$$

(*See* Ex.1009, [0072]-[0073] ("In formula (1), VA indicates the pixel value of the attention pixel at the position A after correction, and VA1 to VA8 respectively indicate the pixel values at position A1 to position A8. In addition, the weighting for each of the pixel values VA1 to VA8 is set based on the inverse of the

additional value of the distance in the horizontal direction and the distance in the vertical direction from the position A of the attention pixel.”)

407. Suzuki’s teachings and formula teach computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of surrounding points on the sub-scan. (*See* Suzuki, [0070]-[0090].)

408. Therefore, the combination of Fisker and Suzuki teaches a data processing system configured for “computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of surrounding points on the sub-scan,” as recited in claim 1.

c) Cai

409. Cai discloses an architecture that employs multiple different algorithms for calculating the target pixel based on real and virtual source pixels based on the location of the source pixel. (*See* Ex.1011, [0006].) The disclosed architecture and algorithms decode a source image and “performs reconstruction directly from the source mosaic pattern (e.g., Bayer) to the target mosaic pattern (e.g., Bayer) to reduce memory size and improve communication bandwidth.” (*Id.*, [0005].)

410. Cai further teaches a method for obtaining an interpolated color value from adjacent real pixel values of the same color. (*See id.*, [0021] (“where a red

pixel R8 in the target image maps to a center position of four surrounding real red pixels, the target red pixel R8 is interpolated by the simple average of the color values of the surrounding real pixels in the source image such that interpolated pixel $R8 = (R2 + R4 + R12 + R14) / 4$.”.) Thus, Cai teaches this claim limitation.

411. Therefore, the combination of Fisker and Cai teaches a data processing system configured for “computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of surrounding points on the sub-scan” as recited in claim 1.

d) Motivation to Combine

412. Fisker, Suzuki, and Cai are analogous art because they each use a processing means (or computing system) to analyze and process captured images of scanned objects, as does the challenged '244 Patent. Fisker and Suzuki are directed to a computer system for constructing and rendering 3D images. (Ex.1005, [0001]; Ex.1009, Abstract.) Fisker and Cai each disclose methods for improving data processing efficiency and improving data transfer capabilities. (Ex.1005, [0001]; Ex.1011, Abstract.) And each of the references is concerned with color image quality.

413. For example, Suzuki discloses a method for detecting a pixel color error within a captured image and then correcting the erroneous pixel color based on a weighted average of pixel values located at the periphery of an error region.

(Ex.1009, Abstract, [0066]-[0069].) A POSITA would have recognized the benefit for enhancing Fisker's image processing to include Suzuki's method for determining pixel color based on a weighted average of surrounding pixels because doing so would improve image quality.

414. Likewise, Cai discloses multiple algorithms for calculating a pixel value by obtaining an interpolated color value from adjacent real pixel values of the same color and thereby improving image quality. (Ex.1011, [0006], [0020].) Cai's image processing methods also save memory and improve the communication bandwidth by performing its methods directly from a Bayer pattern. A POSITA would have recognized the benefit for enhancing Fisker's image processing to include Cai's methods because doing so would improve memory and computing efficiency.

415. A POSITA would have been motivated to make the minor modification required to Fisker's image processing method to include Suzuki's and Cai's similar pixel correction methods. The resulting combination is little more than the use of a known image processor and known image processing technique to improve image quality—e.g., produce a more accurate and clear image having more accurate color data. A POSITA thus would have improved image processing systems and methods, like Fisker's, in the same way that that Suzuki suggests—specifying a defective pixel and correcting the pixel value of each defective pixel

in the region, based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region (Ex.1009, Abstract, [0063]-[0069],) and in the way that Cai suggests-- reconstruction an image by interpolated color value from adjacent real pixel values of the same color. (Ex.1011, [0021].) And after the combination, each feature would continue to function as intended.

416. The '244 Patent, Fisker, Suzuki, and Cai are concerned with providing clear and accurate images of scanned objects. As described, a POSITA would have understood the advantages of enhancing Fisker's image processor and known image processing techniques of Suzuki and Cai. Thus, the benefits of employing a Cai-like method and a Suzuki-like method for processing images in an image processor, such as that of Fisker, would have been predictable to a POSITA. Further, as I explained in Section VII.D.11.d above, the foregoing methods for providing clear and accurate images were known in the art, as are further exemplified in Bernardini (ex. 1015) and Tanaka (Ex.1010).

417. As provided above, Fisker's image processor and method for processing images would have benefited from Suzuki's and Cai's methods for determining a pixel's color value. Fisker teaches "a computer program product comprising program code means for causing a data processing system to perform the method of the preceding claim, when said program code means are executed on the data processing system." (Ex.1005, [0139].)

418. And Suzuki explains that its methods may be carried out on “a computer capable of executing various functions by installing various programs, for example, a general-purpose personal computer.” (Ex.1009, [0136].) Likewise, Cai’s methods are performed based on “computer-executable instructions” that can run on a computer. (Ex.1011, [0061].)

419. Based on the foregoing, and a POSITA’s experience, a POSITA would have understood that the method for processing images, as described in each of the ’244 Patent, Fisker, Suzuki, Cai, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Suzuki’s and Cai’s image processing modules, it would have been obvious to enhance Fisker’s software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance Fisker’s method for processing images to include the methods of Yamada and Suzuki.

420. Finally, a POSITA would have had a reasonable expectation of success when enhancing Fisker’s image processing method with that of Suzuki and Cai, because such a modification would have been a routine matter for a POSITA. Implementing Suzuki’s and Cai’s methods would not require any additional hardware and could be implemented within Fisker’s data processor by adding, or altering, the computer code that controls the image processing algorithms.

421. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Fisker's image processing methods and systems with the methods of Suzuki or Cai and that the combinations of (a) Fisker and Suzuki and (b) Fisker and Cai teach or suggest this limitation

XIII. The combinations of (a) Fisker, Szeliski, Suzuki, and Cai and (b) Fisker, Matsumoto, Suzuki, and Cai render claim 11 obvious

A. Claim 11: "The focus scanner according to claim 9, wherein the data processing system is configured for computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of different points."

422. Claim 11 is substantially similar to limitation [34.4.f] above. Claim element [34.4.f] recites "where computing comprises an averaging of sub-scan colors of *surrounding points on the sub-scan*," whereas, claim 11 does not recite "surrounding points on the sub-scan" rather "different points." The combination of (a) Fisker, Szeliski, Suzuki, and/or Cai and/or (b) Fisker, Matsumoto, Suzuki, and/or Cai teaches claim 11 for at least the reasons that I described in Sections XII.B.9.a-d above.

423. A POSITA would have been motivated to combine (a) Fisker, Szeliski, Suzuki, and/or Cai and/or (b) Fisker, Matsumoto, Suzuki, and/or Cai for at least the reasons that I described in those same Sections.

424.

XIV. The combinations of (a) Thiel425, Thiel576, and Szeliski and (b) Thiel425, Thiel576, and Matsumoto render claims 1, 22, and 24 obvious.

A. Overview of Thiel425

425. Thiel425 discloses a “handheld dental camera” that performs three-dimensional, optical measurements. (Ex.1012, Abstract.) As illustrated in Thiel425’s Figure 1, Thiel425’s camera further includes a “light source that emits an illuminating beam, a scanning unit, a color sensor, and a deflector.” Using a focusing element, Thiel425 focuses “the illuminating beam onto a surface of an object to be measured,” the object “reflects the illuminating beam and forms a monitoring beam,” and the color sensor detects the beam. (*Id.*)

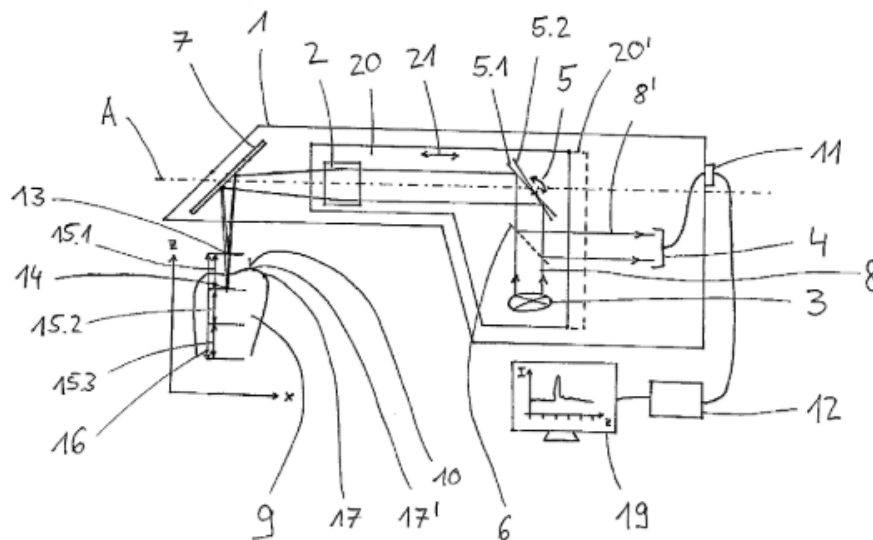


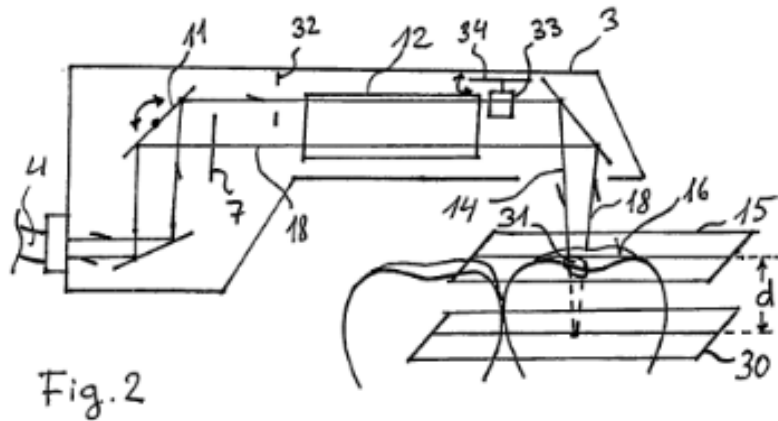
Fig. 1

(Ex.1012, Fig. 1.)

426. Thiel425's Figure 1 further illustrates a handheld dental camera comprising a scanning unit that includes a chromatic objective 2, a polychromatic light source 3, a pivotal mirror 5, and a beam splitter 6, and which is capable of being moved along the longitudinal axis A within the handheld dental camera 1. (*Id.*, [0077].) Thiel425's camera 1 further comprises a color sensor, such as a CCD sensor. (*Id.*, [0078].)

B. Overview of Thiel576

427. Like Thiel435, Thiel576 teaches a device and a method for optical 3D measurement. Thiel 576 also provides a method for adjusting the focal length of the objective. Specifically, as illustrated in Figure 2, "the focal length of the objective 12 is altered such that the illuminating beam 14 is focused onto a second plane 30. The second plane 30 is parallel to the first plane 15 of the surface 16 of the object to be measured and is situated at a distance d therefrom." (Ex.1013, [0106].) A "monitoring beam 18" reflected from the surface "is directed toward the color sensor 8 of the base unit 2." (*Id.*) Based on the "spectrum of the monitoring beam 18, the color of the surface 16 of the object to be measured is determined, which is in this case the surface of a tooth." (*Id.*)



(Ex.1013, Fig. 2.)

C. Claim 1

428. Claim 1 is reproduced below with labeled limitations for ease of discussion.

1. [1.P]: “A focus scanner for recording surface geometry and surface color of an object”

a) Thiel425

429. Thiel425 teaches a handheld dental camera (focus scanner) for performing optical 3D object measurements (surface geometry). (Ex.1012, [0013].) The focus scanner comprises a polychromatic light source emitting an illuminating beam onto an object’s surface, a scanning unit for changing the focal depths of the illuminating beam as required for chromatic confocal measurements, and a color sensor for capturing each of the wavelengths of the reflected light from the object’s surface and configured to determine the optical 3D measurement. (*Id.*, [0085]). Thiel425 further teaches that each chromatic depth range overlaps, such that the

color sensor receives data sets of different chromatic depth ranges that at least partially overlap (a stack of 2D images). (*Id.*, [0013]-[0014], [0023].)

430. Thus, although Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object and determining the surface geometry of the object therefrom, it does not explicitly disclose determining surface color of the 3D object. However, it would have been obvious to a POSITA to determine both the geometry and colorimetric measurements of the 3D object from the stack of 2D color images at two different focus depths, e.g., in view of Thiel576.

b) Thiel576

431. Thiel576 teaches a device (focus scanner) comprising a polychromatic light source for emitting a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. (Ex.1013, [0008], [0016], [0087].) The focus scanner also comprises a color sensor for receiving a beam reflected from the object's surface that is used to determine the surface color measurements (surface color).

432. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to determine the object's surface color as taught in Thiel576, since Thiel425 already considers sensing and processing of multiple colors (wavelengths) at different focal depths.

433. Therefore, the combination of Thiel425 and Thiel 576 teaches or suggests a "focus scanner for recording surface geometry and surface color of an object" as recited in claim 1.

c) Motivation to Combine

434. Enhancing Thiel425's image processing methods with the methods of Thiel576 would have been obvious to a POSITA.

435. *First*, Thiel425 and Thiel576 share the same inventor (i.e., Frank Thiel) and assignee (i.e., Sirona Dental Systems GmbH). Thiel425 and Thiel576 were also filed in Germany less than two months apart. As such, given the same assignee and inventor and the closeness of filings, a POSITA would have naturally been led from Thiel425 to Thiel576 and vice-versa.

436. *Second*, Thiel425 and Thiel576 are each directed to providing clear and accurate images of teeth and complement each other. Thiel425 and Thiel576 are both directed to dental devices and methods for performing optical 3D measurements of teeth. (Ex.1012, [0002], [0015], [0043]; Ex.1013, [0002]-[0005],

[0066], [0106].) Thiel425 specifically teaches its device “is particularly suitable for producing dental intraoral images of teeth.” (Ex.1012, [0015].) Thiel576 specifically teaches that its methods particularly facilitate imaging of teeth in a patient’s oral cavity. (Ex.1013, [0046].)

437. *Third*, Thiel425 and Thiel576 are both directed to using handheld chromatic confocal apparatuses and methods to perform optical 3D measurements. Thiel576 teaches a device having a first mode for optical 3D measurement using a chromatic confocal measuring method. Thiel425 teaches a device that provides optical 3D surface measurement using an improved chromatic confocal measuring method, specifically one that is capable of carrying out rapid optical 3D surface measurements of an object. Thus, it would be obvious to a POSITA that both Thiel25 and Thiel576 have similar if not identical color confocal measuring apparatus and perform the identical function, so their color image processing methods are easily combinable .

438. *Fourth*, Thiel425 and Thiel576 each provide a component that controls the focus of the illumination beam when performing optical 3D measurements. Thiel425 teaches a device that has a scanning unit that focuses an illuminating beam onto an object’s surface and permits different chromatic depth measurement ranges with stepwise displacement so that a first chromatic depth measurement range in a first focus position, and a second chromatic depth

measurement range in a second focus position are precisely adjoined in the direction of a measurement depth, or are partially overlapped. (Ex.1012, Abstract, [0014].) Thiel576 teaches a device that has an objective which focuses an illuminating beam onto a first plane of the surface of an object to be measured and also focused by means of the objective onto a second plane other than the first plane at a distance d from the surface of the object. (Ex.1013, [0008].) As such, it would have been obvious to a POSITA, that both Thiel425 and Thiel576 permit the adjustment of the objective to translate the focus across its optical axis and at different depths from the surface of the 3D object being measured, to obtain a similar stack of color 2D images.

439. *Fifth*, Thiel425 and Thiel576 each use a processing means (or computing system) to analyze and process a captured stack of color 2D images in dentistry. (Ex.1012, [0018]; Ex.1013, [0043]-[0044].) Each is directed to a computer system for constructing and rendering of 3D images of teeth. (*Id.*) And each is similarly concerned with image quality and alignment of images of teeth. (*Id.*) As such, a POSITA would have found it obvious that the method for processing a stack of color 2D images, as described in Thiel425 and Thiel576, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Thiel576's 3D object surface color estimation image processing modules, it would have been obvious to enhance Thiel425's color

image processing software (and algorithms) for the same 3D object surface color estimation using routine coding and engineering practices.

440. *Sixth*, a POSITA would have had a reasonable expectation of success when enhancing Thiel425's image processing method with that of Thiel576. Such a modification would have been a routine matter for a POSITA.

441. For at least these reasons, a POSITA would have understood how and why to enhance Thiel425's color image processor with the color image processing techniques of Thiel576 based on similar multi-chromatic confocal measurements. The benefits of combining a Thiel425-like method for processing images in an image processor, such as that of Thiel576, would have therefore been predictable to a POSITA.

442. For at least the foregoing reasons, a POSITA would have found it obvious to combine Thiel425's image processing methods with the methods of Thiel576. Thus, the combination of Thiel425 and Thiel576 teaches or suggests the preamble of this claim.

2. [1.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object”

443. Thiel425 teaches that the dental camera comprises a polychromatic light source configured to emit “an illuminating beam (8) that can be focused, at least in terms of one wavelength thereof, onto the surface of an object of interest

by means of the chromatic objective.” (Ex.1012, [0013].) Thiel 425 further states that “polychromatic light source 3 has a spectral range of two or more wavelengths.” (*Id.*, [0080].)

444. A polychromatic light source and a multichromatic light source each refer to a light source having two or more colors. A POSITA would understand that poly and multi are synonyms, in this context. Thus, Thiel425’s polychromatic light source teaches “a multichromatic probe light for illumination of the object.”

445. Thus, Thiel425 teaches or suggests “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 1.

3. [1.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

446. Thiel425 teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength.” (Ex.1012, [0078], [0088].) A POSITA would have understood that a CCD camera comprises a plurality of sensor elements (image sensor pixels) arranged in an array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically

employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

447. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

448. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061], (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

449. In view of the foregoing and based on Thiel⁴²⁵, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel⁴²⁵’s CCD camera suggests at least a color image sensor comprising an array

of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

450. Thus, Thiel425 teaches or suggests “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object” as recited in claim 1.

4. [1.3.a]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner”

451. Thiel425 teaches that “[t]he scanning unit 20 is a unit that is moved (i.e., translated) in the direction of the arrow 21 within the handheld dental camera 1 along the longitudinal axis A [(i.e., optical axis)] of the handheld dental camera 1, for example, by means of an electronically controlled electric motor, so that the focal points 13, 14 of the illuminating beam 8 are moved along the z axis.” (Ex.1012, [0084].)

452. Thiel425’s use of a motor to move the scanning unit 20 along the longitudinal axis A of the camera suggests or teaches or suggests “translating a focus plane along an optical axis of the focus scanner.”

453. Thus, Thiel425 teaches or suggests “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner” as recited in claim 1.

5. **[1.3.b]: “wherein the focus scanner is configured to operate by...capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”**

454. Thiel425 teaches that by means of the scanning unit, the handheld dental camera (focus scanner) provides focal points of different wavelengths over various depth measurement ranges of the object that can adjoin or overlap each other (a stack of 2D images) along the z-axis of the object (different focus plane positions) and be measured successively. (Ex.1012, [0013].) Thus, Thiel425 teaches this claim element.

455. Thus, Thiel425 teaches or suggests “wherein the focus scanner is configured to operate by...capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images” as recited in claim 1.

6. **[1.4.a]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor”**

456. In view of the '244 Patent, a POSITA would have understood a “block” or “group” of sensor pixels as including all sensor pixels in the array of sensor pixels or a subset thereof.

457. Thiel425 teaches the chromatic objective keeping the focal points of the illuminating beam apart and thus forming a chromatic depth measurement

range. (Ex.1012, [0083].) Thiel425 further teaches that the scanning unit moves the illuminating beam onto the object's surface within the chromatic depth measurement range and that data sets are received at each chromatic depth measurement range. (*Id.*, [0084].) Thiel425 further teaches that the chromatic depth measurement ranges can be overlapping. (*Id.*)

458. Thiel425 also teaches that a data processing unit (data processing system) in communication with a color sensor (color image sensor) that receives successive data sets (2D images) for different chromatic depth measurement ranges are saved and combined (stack of 2D images) to form a 3D data set of the object of interest. (*Id.*, [0085].) Thiel425 teaches that this can permit determination of a z value (surface geometry information) for a point on an x-y plane of an object of interest. (*Id.*)

459. Thus, Thiel425 teaches or suggests “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor” as recited in claim 1.

7. [1.4.b]: “the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”

a) **Thiel425**

460. As I explained in Sections XIV.C.1.c and XIV.C.6, Thiel425’s data processing system in communication with its color image sensor and derives a stack of 2D images from data received by the color image sensor. As I also explained in Section XIV.C.6, Thiel425 further teaches a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object.

461. Thus, as I stated previously in Section XIV.C.6, although Thiel425 teaches determining surface geometry information of the object of interest from an image in the stack of 2D images, it does not explicitly disclose determining surface color information of the object of interest from at least one of the images in the stack of 2D images. However, it would have been obvious to a POSITA to determine surface color information from at least one image in the stack of 2D images of Thiel425, e.g., in view of Thiel576.

b) **Thiel576**

462. As I explained in Section XIV.C.1.b, Thiel576 teaches a device (focus scanner) that emits a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object’s surface

and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. As I also explained in Section XIV.C.1.b, Thiel576 further teaches that the device receive beam reflected from the object's surface that is used to determine the surface color measurements (surface color information).

463. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to derive surface color measurements a color information simultaneous to its deriving surface geometry information in view of Thiel576, since Thiel425's device already operates on the stack of 2D color images (at least one of the 2D images used to derived the surface geometry information) derived from different focal depths.

c) Motivation to Combine

464. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

8. [1.5.a]: “wherein the data processing system further is configured to combining [sic] a number of sub-scans to generate a digital 3D representation of the object”

465. As I stated in Section XIV.C.6, Thiel425's data processing system in communication with its color image sensor. Thiel425 further teaches that “[t]he color sensor 4 [...] is capable of detecting a wavelength spectrum and of

reproducing the intensity of the individual wavelength. Thus a wavelength-dependent intensity profile of the monitoring beam 8 and thus the wavelength having the maximum intensity is ascertained, from which the elevation value, that is, the z value can be computed.” (Ex.1012, [0085]) Thiel425 further teaches that “the data sets successively acquired for different chromatic depth measurement ranges 15.1-4 in different positions of the scanning unit 20 are saved and combined to form an overall 3D data set of the object of interest over the total depth measurement range 16.” (*Id.*)

466. For at least these reasons, a POSITA would have understood how and why to enhance Thiel425’s image processor with the image processing techniques of Thiel576. The benefits of employing a Thiel425-like method for processing images in an image processor, such as that of Thiel576, would have thus been predictable to a POSITA. Therefore, a POSITA would have understood two different data sets acquired from different pairs of overlapping chromatic depth ranges of Thiel425 as being two sub-scans and thus Thiel425 teaches “combining [sic] a number of sub-scans to generate a digital 3D representation of the object” as claimed in part by this limitation. Thus, Thiel425 teaches this limitation.

9. **[1.5.b]: “wherein the data processing system further is configured to ... determining [sic] object color of a least one point of the generated digital 3D representation of the object from sub-scan color of the sub-scans combined to generate the digital 3D representation, such that the digital**

3D representation expresses both geometry and color profile of the object”

467. As I previously stated in Sections XIV.C.6 and XIV.C.8, Thiel425’s data processing system in communication with its color image sensor and that the color image sensor receives data sets from different, overlapping chromatic depth ranges. As previously stated in section XIV.C.8, a POSITA would have understood that at least two data sets acquired from different, overlapping chromatic depth ranges of Thiel425 is a single “sub-scan” as claimed and thus Thiel425 teaches “combining [sic] a number of sub-scans to generate a digital 3D representation of the object” as claimed in part by limitation 1.4.b.

468. As I stated in sections XIV.C.1 and XIV.C.7, Thiel425/Thiel576 teaches that the data sets of Thiel425 can be utilized to determine geometry and colorimetric measurements of the object. As such, a POSITA would have understood that at least two data sets combined to form the digital 3D representation of the object (generated digital 3D representation of the object from sub-scan color of the sub-scans combined to generate the digital 3D representation) of Thiel425 would have at least one point with geometry and colorimetric measurements. Thus, the combination Thiel425 of Thiel576 teaches this limitation.

- 10. [1.6]: “wherein determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface.”**

a) Thiel425 and Thiel576

469. As I previously stated in XIV.C.8, Thiel425 teaches receiving data sets from different overlapping chromatic depth ranges. A POSITA would have understood that two different data sets acquired from different pairs of overlapping chromatic depth ranges of Thiel425 as being two sub-scans. As such, a POSITA would have understood that the combination of Thiel425 and Thiel576 teaches each data set having at least one point with geometry and colorimetric measurements.

470. Thiel425/Thiel576 do not explicitly disclose determining the object color by computing a weighted average of sub-scan values derived for corresponding points in overlapping sub-scans at that object surface’s point.

471. However, performing this weighted average of overlapping sub-scans was very well known in the art, e.g., as taught by Szeliski and Matsumoto.

b) Szeliski

472. Szeliski provides a method for “computing texture map color values for any geometry and choice of texture map coordinates.” (Ex.1006, 28:44-46.) Szeliski further teaches a method for mapping multiple images, using focal length and 3D rotation, to build an image mosaic by “registering a sequence of images by

recovering their transformation matrices M_k .” (Ex.1006, 7:4-18, 14:24-29.) Each of Szeliski’s transformations correspond to “one image and represents the mapping between the image pixels of I_k and viewing directions in the world (i.e., a 3D world coordinate system).” (*Id.*)

473. As illustrated at Szeliski’s Step 3250 in Figure 32, Szeliski teaches a method for using a weighted average calculation to blend color data from corresponding pixels (i.e., points) in overlapping images. (*Id.*, Fig. 32; 30:20-49.)

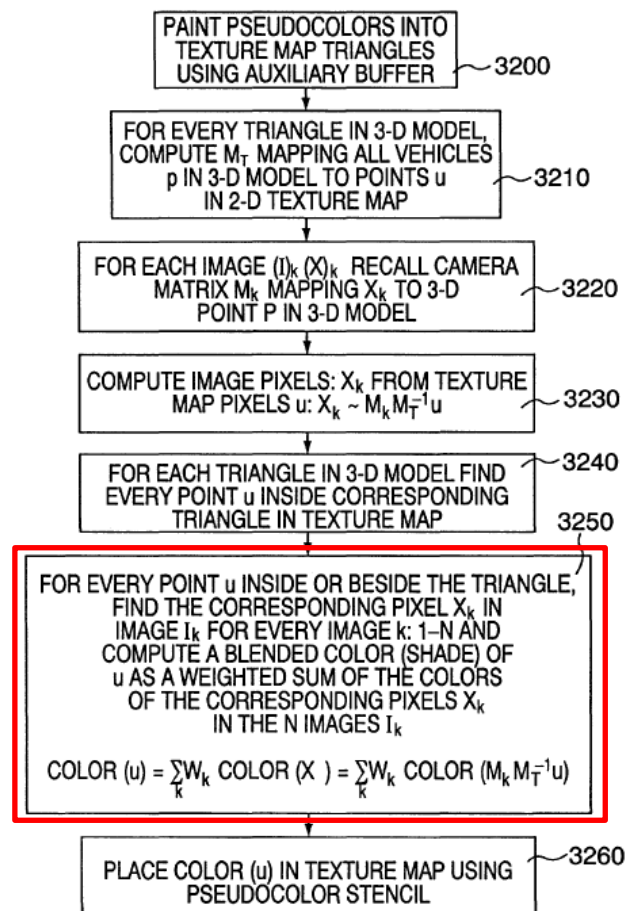


FIG. 32

(Ex.1006, Fig. 32 (annotated).)

474. More specifically, for every point, “a mapping to the corresponding pixel in every overlapping image is found, and those corresponding pixel values (colors or intensities) are blended to form a composited pixel value.” (*Id.*, 30:20-24.) The composite pixel value is calculated from corresponding pixels in overlapping images using a weighted average according to the following equation:

$$\text{COLOR}(u) = \sum_k W_k \text{COLOR}(X_k) = \sum_k W_k \text{COLOR}(M_k M_T^{-1} u)$$

(*Id.*, Fig. 32 (annotated).) Szeliski thus teaches blending the “color (shade) of u as a weighted sum of the colors of the corresponding pixels X_k in the n images I_k .” (*Id.*)

475. As explained in greater detail below, a POSITA would have been motivated to combine the teachings of Thiel425 and Thiel576 with those of Szeliski.

476. Therefore, the combination of Thiel425, Thiel576, and Szeliski teaches or suggests that “determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface” as recited in claim 1.

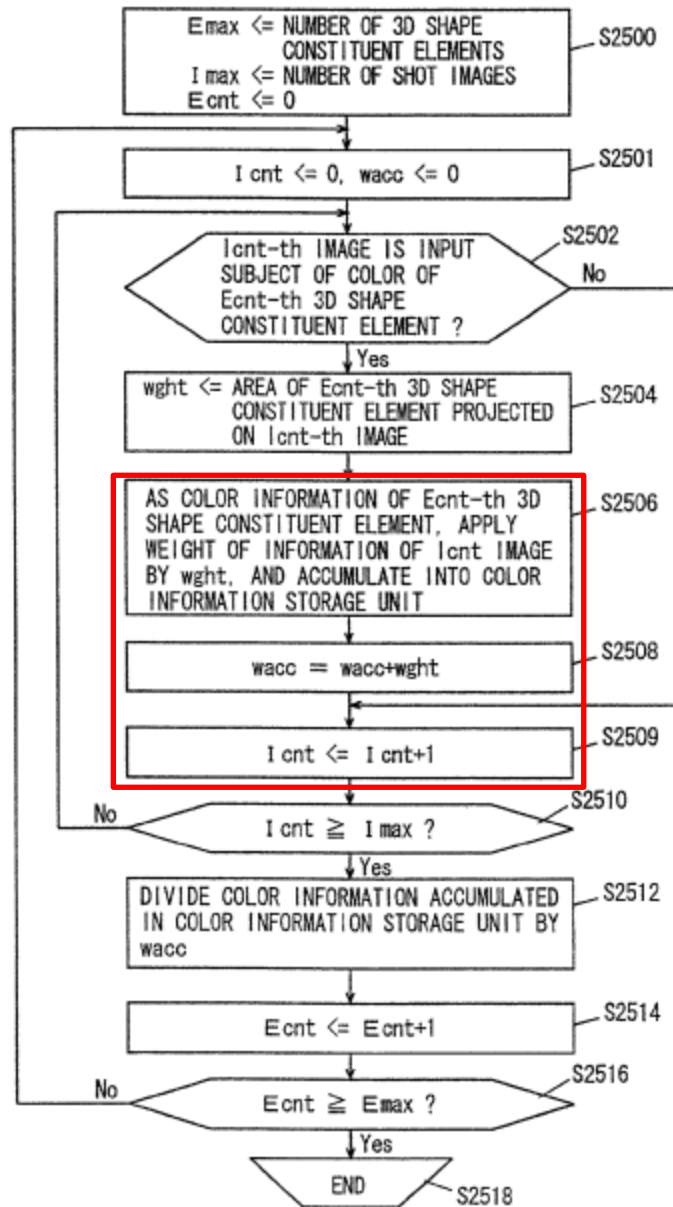
c) **Matsumoto**

477. Matsumoto discloses a weighted mean process that is applied to image information (color, density, or luminance) and results in improved texture information for a 3D model of higher accuracy. (Ex.1007, 5:30-34, 7:48-50.)

478. Matsumoto further teaches or suggests “capturing a plurality of object images information by shooting an object of interest from different viewpoints” and “assigning texture information obtained by carrying out a weighted mean process for all the object image information according to the area corresponding to the three-dimensional shape constituent element.” (*Id.*, 8:32-37.)

479. As illustrated at step S2509 in Figure 19 below, Matsumoto’s weighted mean process teaches that the “*Icnt*-th reference image information subjected to a weight of variable *wght* is stored in color information storage unit 240 as the texture information of the *Ecnt*-th three-dimensional shape constituent element (step S2506).” (*Id.*, 27:36-39.) The values of “variable *wght*” are then “accumulated for variable *wacc* (step S2508).” (*Id.*, 27:41-43.)

FIG. 19



(Ex.1007, Fig. 19 (annotated).)

480. In view of the foregoing, Matsumoto teaches determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface.

481. As explained in greater detail below, a POSITA would have been motivated to combine the teachings of Thiel⁴²⁵ and Thiel⁵⁷⁶ with those of Matsumoto.

482. Therefore, the combination of Thiel⁴²⁵, Thiel⁵⁷⁶, and Matsumoto teaches or suggests that “determining the object color comprises computing a weighted average of sub-scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface” as recited in claim 1.

d) Motivation to Combine

483. Combining the teachings of Thiel⁴²⁵/Thiel⁵⁷⁶ with those of Szeliski and Matsumoto would have been obvious to a POSITA for at least the following reasons.

484. *First*, like Thiel⁵⁷⁶, Thiel⁴²⁵, Szeliski and Matsumoto are each directed to providing clear and accurate color images of a 3D object. Also, like Thiel⁵⁷⁶, Thiel⁴²⁵, Szeliski and Matsumoto are each directed to constructing and rendering 3D object models with color images (textures) and concerned with image quality and alignment.

485. For example, Szeliski teaches a mosaic or “stitching” method for aligning and compositing overlapping images into a 3D model. For example, “for every point in a given triangle of the 3D model, thus defining the pixels in the corresponding triangle in texture space.” In Szeliski’s step 3250, “for every point

in a bounding box surrounding a given triangle in texture space, a mapping to the corresponding pixel in every overlapping image is found, and those corresponding pixel values (colors or intensities) are blended to form a composited pixel value” based on a weighted average. (Ex.1006, 30:18-30)

486. Image mosaic stitching/registration methods, like the methods taught by Szeliski, were commonly used in the dental industry to create 3D models. For example, in “Digital Dental Revolution,” a textbook that provides an overview of intraoral scanners and image processing methods where overlapping scans are stitched together to produce a 3D virtual model. (Ex.1014, 102-103, Figs. 32, 33.)

487. Similarly, Matsumoto teaches a weighted mean process that is applied to image information (color, density or luminance) and results in improved texture/color information and a 3D model of higher accuracy. (Ex.1007, 5:30-34, 7:48-50.) More specifically, as described above, Matsumoto teaches a weighted mean process for images captured from differing view-points, and using the collected image data to create a 3D model. (*Id.*, 8:32-37.)

488. *Second*, a POSITA would have been motivated to augment the Thiel576 and Thiel425 combination’s image processing techniques with those of Szeliski’s and Matsumoto’s techniques. The Thiel576 and Thiel425 combination teaches generating multiple images by adjusting the focal length of the illuminating beam and combining the images produced thereby to create a 3D representation of

the object. (Section XIV.C.8.) However, the Thiel576 and Thiel425 combination does not detail a specific way to combine the multiple color image sub-scans to create the 3D representation of the object and maintain an appropriate color of each pixel in the images. Thus, it would have been obvious to modify and improve the Thiel576 and Thiel425 combination with Szeliski's method for computing a blended color as a weighted sum of the colors of corresponding pixels . Moreover, Matsumoto's techniques for combining pixels of color by determining their mean value would have also been an obvious modification to improve the Thiel576 and Thiel425 combination. As such, a POSITA would have found it obvious to combine weighted averages, as taught by the teachings of Szeliski and Matsumoto, when combining the sub-scan images to form a 3D representation of the object in Thiel576/425.

489. *Third*, the combining of the imaging processing techniques of the Thiel576 and Thiel425 combination with those of Szeliski's and Matsumoto's techniques would requires nothing more than additional processing. As I stated above in Section XIV.C.8, the combination of Thiel576 and Thiel425 teaches a data processor in communication with a color sensor to analyze 2D images received therefrom. Similarly, Szeliski explains that its methods are performed by computer systems using "program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks." (Ex.1006, 7:52-

60.) Yet further, Matsumoto explains that “the object extraction apparatus includes a computer 130” and that “[c]omputer 130 detects and extracts an object portion in the object image according to a program 301.” (Ex.1007, 30:29-35.)

490. Based on the foregoing, and a POSITA’s experience, a POSITA would have understood that the method for processing images, as described in each of the Thiel576, Thiel425, Szeliski, Matsumoto, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Szeliski’s and Matsumoto’s image processing modules, it would have been obvious to enhance software (and algorithms), of the Thiel576 and Thiel425 combination, using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance the Thiel576 and Thiel425 combination’s method for processing images to include a Szeliski-style method for combining image data from multiple scans, accounting for scanner movement, and determining a scanned object’s color using data from multiple images and a Matsumoto-style method for improving the color and texture continuity of the image data, resulting in a more accurate 3D model.

491. *Fourth*, a POSITA would have had a reasonable expectation of success when enhancing Thiel425’s image processing method with that of Thiel576 and either Szeliski or Matsumoto because such a modification would have been a routine matter for a POSITA.

492. For at least the foregoing reasons, a POSITA would have found it obvious to enhance image processing methods of the Thiel576 and Thiel425 combination with the methods of Szeliski or Matsumoto and that the combinations of (a) Thiel425, Thiel576, and Szeliski and (b) Thiel425, Thiel576, and Matsumoto both teach this limitation.

D. Claim 22

493. Claim elements [22.2]-[22.4] are substantially similar to elements [1.1]-[1.4.b] above. The difference being that claim elements [22.2]-[22.4] are written as method steps (in gerund form), whereas claim 1 recites apparatus features and corresponding functionalities. The combination of Thiel425 and Thiel576 teaches or suggests these elements for at least the reasons that I provided above in Sections XIV.C.3-7.

1. [22.P]: “A method of recording surface geometry and surface color of an object”

a) Thiel425

494. Thiel425 teaches a handheld dental camera (focus scanner) for performing optical 3D object measurements (surface geometry). (Ex.1012, [0013].) The focus scanner comprises a polychromatic light source emitting an illuminating beam onto an object’s surface, a scanning unit for changing the focal depths of the illuminating beam as required for chromatic confocal measurements, and a color sensor for capturing each of the wavelengths of the reflected light from the object’s

surface and configured to determine the optical 3D measurement. (*Id.*, [0085]).

Thiel425 further teaches that each chromatic depth range overlaps, such that the color sensor receives data sets of different chromatic depth ranges that at least partially overlap (a stack of 2D images). (*Id.*, [0013]-[0014], [0023].)

495. Thus, although Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object and determining the surface geometry of the object therefrom, it does not explicitly disclose determining surface color of the 3D object. However, it would have been obvious to a POSITA to determine both the geometry and colorimetric measurements of the 3D object from the stack of 2D color images at two different focus depths, e.g., in view of Thiel576.

b) Thiel576

496. Thiel576 teaches a device (focus scanner) comprising a polychromatic light source for emitting a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. (Ex.1013, [0008], [0016], [0087].) The focus scanner also comprises a color sensor for receiving a beam reflected from the

object's surface that is used to determine the surface color measurements (surface color).

497. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to determine the object's surface color as taught in Thiel576, since Thiel425 already considers sensing and processing of multiple colors (wavelengths) at different focal depths.

498. Therefore, the combination of Thiel425 and Thiel 576 teaches or suggests a "focus scanner for recording surface geometry and surface color of an object" as recited in claim 22.

c) Motivation to Combine

499. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

2. [22.1]: "obtaining a focus scanner according to claim 1."

500. As I explained above, the '244 Patent is unclear how or who obtains the focus scanner. A POSITA would have understood that the plain and ordinary meaning of "obtaining a focus scanner" would be to somehow gain possession of a scanner.

501. Both the '244 Patent and Thiel425 disclose a handheld device that can be held, manipulated, or obtained by a user. For example, the '244 Patent discloses a “handheld part of a scanner system with components inside a housing 100.” (Ex.1001, 15:63-64.) Likewise, Thiel425 teaches or suggests “a handheld dental camera” configured to perform “three-dimensional, optical measurements.” (Ex.1012, Abstract, [0047], (“a user cannot hold the camera steadily for more than very short periods of time.”).) Thus, a POSITA would have understood that Thiel425 teaches or suggests “obtaining a focus scanner,” as recited in claim 22.

3. [22.2]: “illuminating the surface of said object with multichromatic probe light from said multichromatic light source”

502. Claim element [22.2] is substantially similar to claim element [1.2] above. The difference being that claim element [22.2] is written as a method step (in gerund form). As I explained in Section XIV.C.2., Thiel425 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

503. Thiel425 teaches that the dental camera comprises a polychromatic light source configured to emit “an illuminating beam (8) that can be focused, at least in terms of one wavelength thereof, onto the surface of an object of interest by means of the chromatic objective.” (*Id.*, [0013].) Thiel 425 further states that

“polychromatic light source 3 has a spectral range of two or more wavelengths.”
(*Id.*, [0080].)

504. A polychromatic light source and a multichromatic light source each refer to a light source having two or more colors. A POSITA would understand that poly and multi are synonyms, in this context. So Thiel425’s polychromatic light source teaches “a multichromatic probe light for illumination of the object.”

505. Thus, Thiel425 teaches or suggests “illuminating the surface of said object with multichromatic probe light from said multichromatic light source,” as recited in claim 22.

4. [22.3]: “capturing a series of 2D images of said object using said color image sensor”

506. Claim element [22.3] draws from concepts of claim elements [1.2] and [1.3.b] above. More specifically, claim element [1.3.b] recites “capturing a series of the 2D images” while claim element [1.2] recites “a color image sensor...for capturing one or more 2D images.” As I explained in Sections XIV.C.3 and XIV.C.5, Thiel425 teaches or suggests this claim element. The explanations that I provided in those sections are also applicable here.

507. Thiel425 teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength.” (*Id.*, [0085].) A POSITA would have understood that a CCD camera comprises a plurality of sensor elements (image

sensor pixels) arranged in an array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

508. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

509. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061], (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

510. In view of the foregoing and based on Thiel425, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel425's CCD camera suggests at least a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

511. Thus, Thiel425 teaches a focus scanner that is "capturing a series of 2D images of said object using said color image sensor," as recited in claim 22.

5. [22.4]: "deriving both surface geometry information and surface color information for a block of image sensor pixels at least partly from one captured 2D image."

512. Claim element [22.4] is substantially similar to claim elements [1.4.a]-[1.4.b] above. The difference being that claim element [22.4] is written as a method step (in gerund form). As I explained in Sections XIV.C.6-7, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

a) Thiel425

513. In view of the '244 Patent, a POSITA would have understood a "block" or "group" of sensor pixels as including all sensor pixels in the array of pixels or a subset thereof.

514. As I explained in Sections XIV.C.1.a and Section XIV.C.6, Thiel425's data processing system in communication with its color image sensor

and derives a stack of 2D images from data received by the color image sensor. As I also explained in Section XIV.C.1.a, Thiel425 further teaches a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object.

515. Thus, as I explained in Section XIV.C.7.a, although Thiel425 teaches determining surface geometry information of the object of interest from an image in the stack of 2D images, it does not explicitly disclose determining surface color information of the object of interest from at least one of the images in the stack of 2D images. However, it would have been obvious to a POSITA to determine surface color information from at least one image in the stack of 2D images of Thiel425, e.g., in view of Thiel576.

b) Thiel576

516. As I explained in Section XIV.C.7.b, Thiel576 teaches a device (focus scanner) that emits a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. As I also explained in Section XIV.C.7.b, Thiel576 further teaches that the device receive beam reflected from the object's surface that is used to determine the surface color measurements (surface color information).

517. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to derive surface color measurements a color information simultaneous to its deriving surface geometry information in view of Thiel576, since Thiel425's device already operates on the stack of 2D color images (at least one of the 2D images used to derived the surface geometry information) derived from different focal depths..

c) Motivation to Combine

518. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 for at least the reasons described in Section XIV.C.1.c above.

E. Claim 24: “wherein the multichromatic light source, the color image sensor, and at least a portion of the data processing system are included in a hand held unit.”

519. Thiel425 teaches that “[t]he handheld dental camera 1 comprises a scanning unit which, in this exemplary embodiment, comprises a chromatic objective 2, a polychromatic light source 3, a pivotal mirror 5, and a beam splitter 6, and which is capable of being moved along the longitudinal axis A within the handheld dental camera 1. The handheld dental camera 1 further comprises a color sensor 4, a deflector 7, for example a deflection mirror, and a connector 11 to which a data processing unit 12 can be connected.” (Ex.1012, [0077].)

520. Thus, Thiel425 teaches or suggests “wherein the multichromatic light source, the color image sensor, and at least a portion of the data processing system are included in a hand held unit” as recited in claim 24

XV. The combinations of (a) Thiel425, Thiel576, and Yamada and (b) Thiel425, Thiel576, and Suzuki render claim 29 obvious.

521. Claim 29 is reproduced below with labeled limitations for ease of discussion.

1. [29.P]: “A focus scanner for recording surface geometry and surface color of an object”

522. Claim element [29.P] is identical to claim element [1.P] above. As I explained in Section XIV.C.1, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

a) Thiel425

523. Thiel425 teaches a handheld dental camera (focus scanner) for performing optical 3D object measurements (surface geometry). (Ex.1012, [0013].) The focus scanner comprises a polychromatic light source emitting an illuminating beam onto an object’s surface, a scanning unit for changing the focal depths of the illuminating beam as required for chromatic confocal measurements, and a color sensor for capturing each of the wavelengths of the reflected light from the object’s surface and configured to determine the optical 3D measurement. (*Id.*, [0085]). Thiel425 further teaches that each chromatic depth range overlaps, such that the

color sensor receives data sets of different chromatic depth ranges that at least partially overlap (a stack of 2D images). (*Id.*, [0013]-[0014], [0023].)

524. Thus, although Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object and determining the surface geometry of the object therefrom, it does not explicitly disclose determining surface color of the 3D object. However, it would have been obvious to a POSITA to determine both the geometry and colorimetric measurements of the 3D object from the stack of 2D color images at two different focus depths, e.g., in view of Thiel576.

b) Thiel576

525. Thiel576 teaches a device (focus scanner) comprising a polychromatic light source for emitting a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. (Ex.1013, [0008], [0016], [0087].) The focus scanner also comprises a color sensor for receiving a beam reflected from the object's surface that is used to determine the surface color measurements (surface color).

526. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to determine the object's surface color as taught in Thiel576, since Thiel425 already considers sensing and processing of multiple colors (wavelengths) at different focal depths.

527. Therefore, the combination of Thiel425 and Thiel 576 teaches or suggests a "focus scanner for recording surface geometry and surface color of an object" as recited in claim 29.

c) Motivation to Combine

528. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

2. [29.1]: "a multichromatic light source configured for providing a multichromatic probe light for illumination of the object"

529. Claim element [29.1] is identical to claim element [1.1] above. As I explained in Section XIV.C.2, Thiel425 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

530. Thiel425 teaches that the dental camera comprises a polychromatic light source configured to emit "an illuminating beam (8) that can be focused, at least in terms of one wavelength thereof, onto the surface of an object of interest

by means of the chromatic objective.” (Ex.1012, [0013].) Thiel 425 further states that “polychromatic light source 3 has a spectral range of two or more wavelengths.” (*Id.*, [0080].)

531. A polychromatic light source and a multichromatic light source each refer to a light source having two or more colors. A POSITA would understand that poly and multi are synonyms, in this context. So Thiel425’s polychromatic light source teaches “a multichromatic probe light for illumination of the object.” Thus, Thiel425 teaches or suggests this element.

532. Thus, Thiel425 teaches or suggests “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 29.

3. [29.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

533. Claim element [29.2] is identical to claim element [1.2] above. As I explained in Section XIV.C.3, Thiel425 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

534. Thiel425 teaches a color sensor (the image sensor), such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength (2D image).” (Ex.1012, [0085].) A POSITA would have understood that Thiel425’s CCD camera suggests a color image sensor

comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, because CCD sensors typically utilize a color filter array. (See Ex.1011, [0001], (“cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array”).) Thus, Thiel425 teaches or suggests this element.

535. Thus, Thiel425 teaches or suggests “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object” as recited in claim 29.

4. **[29.3.a-b]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”**

536. Claim elements [29.3.a]-[29.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections XIV.C.4-5, Thiel425 teaches or suggests these claim elements. The explanations that I provided in those section are also applicable here.

537. Thiel425 teaches that “[t]he scanning unit 20 is a unit that is moved [translated] in the direction of the arrow 21 within the handheld dental camera 1 along the longitudinal axis A [optical axis] of the handheld dental camera 1, for example, by means of an electronically controlled electric motor, so

that the focal points 13, 14 of the illuminating beam 8 are moved along the z axis.”
(Ex.1012, [0084].)

538. Thiel425’s use of a motor to move the scanning unit 20 along the longitudinal axis A of the camera suggests or teaches or suggests “translating a focus plane along an optical axis of the focus scanner.”

539. Thiel425 teaches that by means of the scanning unit, the handheld dental camera (focus scanner) provides focal points of different wavelengths over various depth measurement ranges of the object that can adjoin or overlap each other (a stack of 2D images) along the z-axis of the object (different focus plane positions) and be measured successively. (*Id.*, [0013].)

540. Thus, Thiel425 teaches or suggests “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 29.

5. **[29.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

541. Claim elements [29.4.a]-[29.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections XIV.C.6-7, the combination of Thiel425 and Thiel576 teaches or suggests these claim elements. The explanations that I provided in those section are also applicable here.

a) Thiel425

542. As I stated in Section XIV.C.6, in view of the '244 Patent, a POSITA would have understood a “block” or “group” of sensor pixels as including all sensor pixels in the array of pixels or a subset thereof.

543. As I explained in Section XIV.C.1.a and Section XIV.C.6, Thiel425's data processing system in communication with its color image sensor and derives a stack of 2D images from data received by the color image sensor. As I also explained in Section XIV.C.1.a, Thiel425 further teaches a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object.

544. Thus, although Thiel425 teaches determining surface geometry information of the object of interest from an image in the stack of 2D images, it

does not explicitly disclose determining surface color information of the object of interest from at least one of the images in the stack of 2D images. However, as I stated in Section XIV.C.7.a, it would have been obvious to a POSITA to determine surface color information from at least one image in the stack of 2D images of Thiel425, e.g., in view of Thiel576.

b) Thiel576

545. As I explained in Section XIV.C.7.b, Thiel576 teaches a device (focus scanner) that emits a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. As I also explained in Section XIV.C.7.b, Thiel576 further teaches that the device receive beam reflected from the object's surface that is used to determine the surface color measurements (surface color information).

546. Thus, as I also explained in Section XIV.C.7.b, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to derive surface color measurements a color information simultaneous to its deriving surface geometry information in view of Thiel576, since Thiel425's device already operates on the stack of 2D color images

(at least one of the 2D images used to derived the surface geometry information)
derived from different focal depths..

c) Motivation to Combine

547. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

- 6. [29.5]: “where the data processing system further is configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the derived surface color information or the sub-scan color caused by the pixel saturation.”**

a) Thiel425 and Thiel576

548. As I previously explained in Sections XIV.C.1.a and XIV.C.6, Thiel425's data processing system in communication with its color image sensor (Section X.C.6.) and derives a stack of 2D images from data received by the color image sensor (Section X.C.1.a). As I also previously explained in Section XIV.C.7, Thiel425/Thiel576 teaches or suggests deriving surface color from the stack of 2D images of Thiel425.

549. Thiel425/Thiel576 does not explicitly disclose detecting saturated pixels in the 2D images and mitigating or removing errors in the derived surface color information or the sub-scan color caused by the pixel saturation. However, this was known in the art, e.g., as explicitly taught by Yamada or Suzuki.

b) Yamada

550. Yamada discloses a method for correcting false color caused by chromatic aberration, such as a false-color pixels caused by pixel saturation, and for generating and outputting high-quality image data. (Ex.1008, Abstract.) Specifically, Yamada's image processing apparatus includes "a white-saturation detection unit for detecting a white saturated pixel from image data." (*Id.*, [0011].) Yamada's image processing apparatus teaches a saturation detecting step, which is "a step of executing processing for selecting a white-saturated pixel having a luminance higher than or equal to a predetermined threshold." (*Id.*, [0036].)

551. After a saturated pixel has been detected, Yamada mitigates the error caused by the saturation using pixel-value correction. (*Id.*, [0030]-[0032].) Yamada's pixel-value correcting step is a step of selecting pixels, other than the false-color pixels or the white-saturated pixels, from pixels that exist the neighborhood of a white-saturated pixels and executing compensation interpolation processing based on the selected pixels. (*Id.*, [0030]-[0032], [0085].) Thus, Yamada teaches or suggests detecting saturated pixels and then mitigating the error in the sub-scan color caused by the pixel saturation and thereby teaches this feature.

c) Suzuki

552. Suzuki discloses a digital camera imaging unit that specifies (i.e., detects) a position of a defective pixel, such as a white defect (i.e., saturated pixel), among a plurality of pixels. (Ex.1009, Abstract, [0058].) Suzuki's camera further includes a region specification unit that specifies a region in the image data in which image noise occurs due to the defective (i.e., saturated) pixel. (*Id.*, Abstract, [0063]-[0065].) Suzuki's camera also includes a correction unit that corrects a pixel value of each of the pixels in the region based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region. (*Id.*, Abstract, [0066]-[0069].)

553. Thus, a POSITA would have understood that Suzuki teaches a data processing system configured to detecting saturated pixels in the captured 2D images and for mitigating or removing the error in the sub-scan color caused by the pixel saturation. Thus, Suzuki teaches this claim.

d) Motivation to Combine

554. Combining the teachings of Thiel425 and Thiel576 with those of either Yamada or Suzuki would have been obvious to a POSITA for at least the following reasons.

555. *First*, like Thiel425 and Thiel576, Yamada and Suzuki are each directed to providing clear and accurate images of an object. Also, like Thiel425

and Thiel576, Yamada and Suzuki are each directed to constructing and rendering 3D images and concerned with image quality and alignment.

556. *Second*, a POSITA would have been motivated to enhance Thiel425/Thiel576's image processing techniques with those of Yamada's and Suzuki's techniques. Thiel425/Thiel576 teaches generating multiple images by adjusting the focal length of the illuminating beam and combining the images to create a 3D representation of the object. (Section XIV.C.7.c.) However, Thiel425/Thiel576 do not account for image saturation . Thus, Yamada's method for mitigating detected saturation caused in pixels of images would have been an obvious modification to improve Thiel425/Thiel576. Moreover, Suzuki's techniques for resolving false color caused by chromatic aberration, as used in Thiel425/Thiel576, would have been an obvious modification to improve Thiel425/Thiel576. As such, a POSITA would have found it obvious to remove errors, as taught by teachings of Yamada and Suzuki, when combining images to form the 3D representation of the object in Thiel576/425.

557. *Third*, the combining of the imaging processing techniques of Thiel425/Thiel576 with those of Yamada's and Suzuki's techniques would requires nothing more than additional processing. As I previously stated, the combination of Thiel425 and Thiel576 teaches a data processor in communication with a color sensor to analyze 2D images received therefrom. Similarly, Yamada

explains that its methods may be controlled or implemented using a computer program that is executed by a general-purpose computer system that can execute various program codes via storage media. (Ex.1008, [0048].) Yet further, Suzuki explains that its methods may be carried out on “a computer capable of executing various functions by installing various programs, for example, a general-purpose personal computer.” (Ex.1009, [0136].)

558. Based on the foregoing, and a POSITA’s experience, a POSITA would have understood that the image processing method, as described in each of the Thiel425, Thiel576, Yamada, Suzuki, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Yamada’s and Suzuki’s image processing modules, it would have been obvious to enhance Thiel425/Thiel576’s software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance Thiel425/Thiel576’s method for processing images to include a Yamada-style method for resolving saturation in the images and a Suzuki-style method for resolving false identifications of color.

559. *Fourth*, a POSITA would have had a reasonable expectation of success when enhancing Thiel425/Thiel576’s image processing method with that of either Yamada or Suzuki. Such a modification would have been a routine matter for a POSITA because the methods of Yamada and Suzuki would not require any

additional hardware and could be implemented within Thiel425/Thiel576's data processor by adding, or altering, the computer code that controls the image processing algorithms.

560. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Thiel425/Thiel576's image processing methods based on the methods of Yamada or Suzuki. Thus the combinations of Thiel425, Thiel576, and Yamada or Suzuki teach or suggest this claim element.

XVI. The combination of Thiel425, Thiel576, and Tanaka renders claims 31 and 32 obvious.

A. Claim 31

561. Claim 31 is reproduced below with labeled limitations for ease of discussion.

1. [31.P]: "A focus scanner for recording surface geometry and surface color of an object"

562. Claim element [31.P] is identical to claim element [1.P] above. As I explained in Section XIV.C.1, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

a) Thiel425

563. Thiel425 teaches a handheld dental camera (focus scanner) for performing optical 3D object measurements (surface geometry). (Ex.1012, [0013].) The focus scanner comprises a polychromatic light source emitting an illuminating

beam onto an object's surface, a scanning unit for changing the focal depths of the illuminating beam as required for chromatic confocal measurements, and a color sensor for capturing each of the wavelengths of the reflected light from the object's surface and configured to determine the optical 3D measurement. (*Id.*, [0085]).

Thiel425 further teaches that each chromatic depth range overlaps, such that the color sensor receives data sets of different chromatic depth ranges that at least partially overlap (a stack of 2D images). (*Id.*, [0013]-[0014], [0023].)

564. Thus, although Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object and determining the surface geometry of the object therefrom, it does not explicitly disclose determining surface color of the 3D object. However, it would have been obvious to a POSITA to determine both the geometry and colorimetric measurements of the 3D object from the stack of 2D color images at two different focus depths, e.g., in view of Thiel576.

b) Thiel576

565. Thiel576 teaches a device (focus scanner) comprising a polychromatic light source for emitting a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of fuzzy circles are

reproduced on the object surface plane. (Ex.1013, [0008], [0016], [0087].) The focus scanner also comprises a color sensor for receiving a beam reflected from the object's surface that is used to determine the surface color measurements (surface color).

566. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to determine the object's surface color as taught in Thiel576, since Thiel425 already considers sensing and processing of multiple colors (wavelengths) at different focal depths.

567. Therefore, the combination of Thiel425 and Thiel 576 teaches or suggests a "focus scanner for recording surface geometry and surface color of an object" as recited in claim 31.

c) Motivation to Combine

568. A POSITA would have been motivated to enhance Thiel425's image processing methods with Thiel576's methods at least for the reasons described in Section XIV.C.1.c above.

2. [31.1]: "a multichromatic light source configured for providing a multichromatic probe light for illumination of the object"

569. Claim element [31.1] is identical to claim element [1.1] above. As I explained in Section XIV.C.2, the combination of Thiel425 and Thiel576 teaches

or suggests this claim element. The explanations that I provided in that section are also applicable here.

570. Thiel425 teaches that the dental camera comprises a polychromatic light source configured to emit “an illuminating beam (8) that can be focused, at least in terms of one wavelength thereof, onto the surface of an object of interest by means of the chromatic objective.” (Ex.1012, [0013].) Thiel 425 further states that “polychromatic light source 3 has a spectral range of two or more wavelengths.” (*Id.*, [0080].)

571. A polychromatic light source and a multichromatic light source each refer to a light source having two or more colors. A POSITA would understand that poly and multi are synonyms, in this context. Thus, Thiel425’s polychromatic light source teaches a multichromatic probe light for illumination of the object.

572. Thus, the combination of Thiel425 and Thiel576 teaches or suggests “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object” as recited in claim 31.

3. [31.2.a]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

573. Element [31.2.a] is identical to claim element [1.2] above. As I explained in Section XIV.C.3, the combination of Thiel425 and Thiel576 teaches

or suggests this claim element. The explanations that I provided in that section are also applicable here.

574. Thiel⁴²⁵ teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength.” (Ex.1012, [0085].) A POSITA would have understood that a CCD sensor comprises a plurality of sensor elements (image sensor pixels) arranged in an array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

575. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

576. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

577. In view of the foregoing and based on Thiel425, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel425’s CCD camera suggests at least a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

578. Thus, the combination of Thiel425 and Thiel576 teaches or suggests “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object” as recited in claim 31.

4. **[31.2.b]: “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter”**

a) Thiel425/Thiel576

579. As described in the preceding Section, Thiel425 and Thiel 576 teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength.” (Ex.1012, [0085].) Thiel 425 and Thiel576 also explain that color sensing and color (spectral) analysis in chromatic confocal measuring methods is performed by means of three color filters. (Ex.1012, [0004].) Thiel576 alternatively uses the alternative term diaphragm to describe such color filters to selective allow specific color wavelengths to pass. (Ex.1013, [0004].) A POSITA would have understood that a CCD sensor comprises a plurality of sensor elements (image sensor pixels) that utilize a Bayer pattern color filter array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter

array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

580. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

581. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

582. In view of the foregoing and based on Thiel⁴²⁵, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel⁴²⁵’s CCD camera suggests at least a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

583. However, to the extent that Patent Owner argues that Thiel425 and Thiel576 do not teach or suggest this limitation, it was known in the art, e.g., as taught by Tanaka.

b) Tanaka

584. Tanaka acknowledges an color imaging apparatuses having a Bayer color filter is well-known. (Ex.1010, [0003]-[0004] (“A primary-color Bayer array as a color array most widely used in the single-plate color imaging element includes green (G) pixels arranged in a check pattern and red (R) and blue (B) arranged line-sequentially”).) Tanaka also teaches a color imaging apparatus having a color filter array comprised of R, G, and B filters periodically arranged in horizontal and vertical lines. (*Id.*, [0020].) Accordingly, a POSITA would have found it obvious to include a color filter, as described in Tanaka, in Thiel425/Thiel576’s device.

585. Therefore, the combination of Thiel425, Thiel576, and Tanaka teaches or suggests “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter” as recited in claim 31.

c) Motivation to Combine

586. A POSITA would have been motivated to enhance the Thiel425/Thiel576 device with the color filter array of Tanaka for at least the following reasons.

587. First, Thiel425, Thiel576, and Tanaka are analogous art because they each disclose a color scanning apparatus having a processing means (or computing system) to analyze and process captured images, as does the challenged '244 Patent.

588. Because Thiel425 and Thiel576 are aimed at providing a device that permits optical 3D scanning and color measurements of an object, a POSITA would have been motivated to make the minor modification required to include Tanaka's color filter array and pattern. The resulting combination is little more than use of a known image apparatus and known light filtering technique to improve image resolution and quality—e.g., produce a more accurate and clear image by improving resolution and suppressing the generation of false color. (Ex.1010, [0077].)

589. A POSITA thus would have improved image processing systems and methods, like Thiel425 and Thiel576, in the same way that Tanaka suggests—namely, providing a color filter array comprising R, G, and B colors arranged in an

array pattern P, thereby suppressing the generation of color more (false color) and improving resolution. (*Id.*, [0074]-[0077].)

590. As discussed above, Thiel425 teaches a device comprising a color filter for providing color measurement of an object. (Sections XIV.C.3). Tanaka teaches an apparatus having a color filter array with a scheme that suppresses false color generation and improves image resolution. (*Id.*, [0024]-[0026].) To achieve the benefits of Tanaka's color filter array, it would have been obvious to a POSITA to enhance Thiel425/Thiel576's device to include Tanaka's color filter array and to enhance Thiel425/Thiel576's software to accommodate and account for it. Therefore, a POSITA would have been motivated and had a reasonable expectation of success to enhance enhancing Thiel425/Thiel576's device to include Tanaka's color filter array.

591. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Thiel425/Thiel576's device to include Tanaka's enhanced color filter array arrangements for color image processing.

5. [31.3.a-b] “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”

592. Claim elements [31.3.a]-[31.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections XIV.C.4-5, Thiel425 teaches or

suggests these claim elements. The explanations that I provided in those section are also applicable here.

593. Thiel425 teaches that “[t]he scanning unit 20 is a unit that is moved [translated] in the direction of the arrow 21 within the handheld dental camera 1 along the longitudinal axis A [optical axis] of the handheld dental camera 1, for example, by means of an electronically controlled electric motor, so that the focal points 13, 14 of the illuminating beam 8 are moved along the z axis.” (Ex.1012, [0084].)

594. Thiel425’s use of a motor to move the scanning unit 20 along the longitudinal axis A of the camera suggests or teaches or suggests “translating a focus plane along an optical axis of the focus scanner.”

595. Thiel425 further teaches that by means of the scanning unit, the handheld dental camera (focus scanner) provides focal points of different wavelengths over various depth measurement ranges of the object that can adjoin or overlap each other (a stack of 2D images) along the z-axis of the object (different focus plane positions) and be measured successively. (*Id.*, [0013].)

596. Thus, the combination of Thiel425 and Thiel576 teaches or suggests “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images,

each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 31.

- 6. [31.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

597. Claim elements [31.4.a]-[31.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections XIV.C.6-7, the combination of Thiel425 and Thiel576 teaches or suggests these claim elements. The explanations that I provided in those section are also applicable here.

a) Thiel425

598. In view of the '244 Patent, a POSITA would have understood a “block” or “group” of sensor pixels as including all sensor pixels in the array of pixels or a subset thereof. (Section XIV.C.6)

599. As I explained in Sections XIV.C.1.a and XIV.C.6, Thiel425’s data processing system in communication with its color image sensor and derives a stack of 2D images from data received by the color image sensor. As I also explained in Section XIV.C.1.a, Thiel425 further teaches a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object.

600. Thus, although Thiel425 teaches determining surface geometry information of the object of interest from an image in the stack of 2D images (Section XIV.C.7.a.), it does not explicitly disclose determining surface color information of the object of interest from at least one of the images in the stack of 2D images. However, it would have been obvious to a POSITA to determine surface color information from at least one image in the stack of 2D images of Thiel425, e.g., in view of Thiel576.

b) Thiel576

601. As I explained in Section XIV.C.7.b, Thiel576 teaches a device (focus scanner) that emits a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. As I also explained in Section XIV.C.7.b, Thiel576 further teaches that the device receive beam reflected from the object's surface that is used to determine the surface color measurements (surface color information).

602. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to derive surface color measurements a color information simultaneous to its deriving surface geometry information in view of Thiel576, since Thiel425's device already

operates on the stack of 2D color images (at least one of the 2D images used to derived the surface geometry information) derived from different focal depths.

(Section XIV.C.7.b.)

c) Motivation to Combine

603. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

- 7. [31.5]: “where the data processing system further is configured to derive the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source, and where the color filter array is such that its proportion of pixels with color filters that match the selected wavelength range of the spectrum is larger than 50%.”**

a) Thiel425/Thiel576

604. As I explained in Section XIV.C.3 above, Thiel425 teaches that the data processing system is configured to derive surface geometry information from light received by the color sensor, and that the color sensor can be a CCD sensor.

605. A POSITA would have understood that a CCD camera, as in Thiel425, comprises a color filter array (e.g., a Bayer filter) made up of three color filters (e.g., red, green, and blue) that each allow light of a particular wavelength (a selected wavelength range of the spectrum) to propagate there through. For example, in the background section of the Cai reference, Cai explains that CCD

sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

606. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

607. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

608. In view of the foregoing and based on Thiel425, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel425's CCD camera suggests at least a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

609. However, to the extent that the Patent Owner argues that Thiel425 and Thiel576 do not explicitly disclose deriving the surface geometry information from light in a selected wavelength range of the spectrum provided by the multichromatic light source, as well as the color filter array being such that its proportion of pixels with color filters that match the selected wavelength range of the spectrum is larger than 50, it was known in the prior art, e.g., as shown by Tanaka

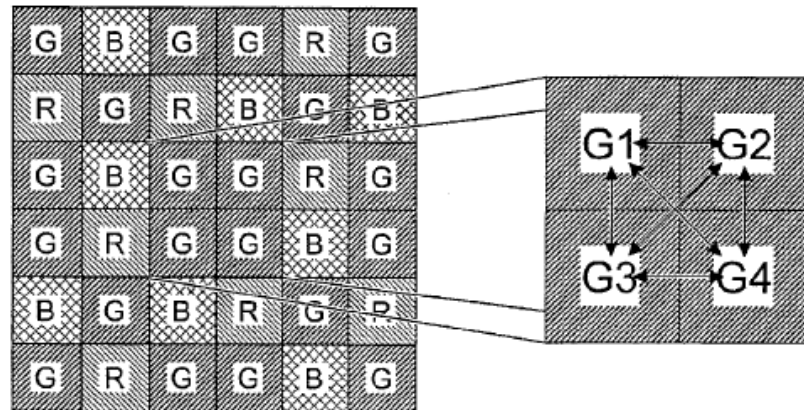
b) Tanaka

610. Tanaka teaches a color imaging apparatus having “a plurality of pixels” and “a color filter array arranged on the plurality of pixels.” (Ex.1010, [0024].) Tanaka's color filter array includes filters corresponding to “a first color that most contributes to obtaining luminance signals and second filters corresponding to two or more second colors.” (*Id.*)

611. As illustrated in Figure 5, Tanaka's basic array pattern of 6x6 pixels included in the color filter array of the color imaging element of the first

embodiment are divided into A arrays and the B arrays of 3x3 pixels.” (*Id.*, [0050].)

FIG.5



(Ex.1010, Fig. 5.)

As illustrated, of the 36 color filters illustrated in Tanaka’s Figure 5, twenty (20) of the filters are green (G) filters, which is more than 50% of the filters. Thus, Tanaka teaches this claim element.

c) Motivation to Combine

612. A POSITA would have been motivated to enhance Thiel425/Thiel576’s device with the color filter array of Tanaka at least for the reasons described in Section XIV.C.1.c above.

B. Claim 32

613. Claim 32 is reproduced below with labeled limitations for ease of discussion.

1. [32.P]: “A focus scanner for recording surface geometry and surface color of an object”

614. Claim element [32.P] is identical to claim element [1.P] above. As I explained in Section XIV.C.1, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

a) Thiel425

615. Thiel425 teaches a handheld dental camera (focus scanner) for performing optical 3D object measurements (surface geometry). (Ex.1012, [0013].) The focus scanner comprises a polychromatic light source emitting an illuminating beam onto an object’s surface, a scanning unit for changing the focal depths of the illuminating beam as required for chromatic confocal measurements, and a color sensor for capturing each of the wavelengths of the reflected light from the object’s surface and configured to determine the optical 3D measurement. (*Id.*, [0085]). Thiel425 further teaches that each chromatic depth range overlaps, such that the color sensor receives data sets of different chromatic depth ranges that at least partially overlap (a stack of 2D images). (*Id.*, [0013]-[0014], [0023].)

616. Thus, although Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object and determining the surface geometry of the object therefrom, it does not explicitly disclose determining surface color of the 3D object. However, it would

have been obvious to a POSITA to determine both the geometry and colorimetric measurements of the 3D object from the stack of 2D color images at two different focus depths, e.g., in view of Thiel576.

b) Thiel576

617. Thiel576 teaches a device (focus scanner) comprising a polychromatic light source for emitting a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. (Ex.1013, [0008], [0016], [0087].) The focus scanner also comprises a color sensor for receiving a beam reflected from the object's surface that is used to determine the surface color measurements (surface color).

618. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to determine the object's surface color as taught in Thiel576, since Thiel425 already considers sensing and processing of multiple colors (wavelengths) at different focal depths.

619. Therefore, the combination of Thiel425 and Thiel 576 teaches or suggests a “focus scanner for recording surface geometry and surface color of an object” as recited in claim 32.

c) Motivation to Combine

620. A POSITA would have been motivated to enhance Thiel425’s image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

2. [32.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object”

621. Claim element [32.1] is identical to claim element [1.1] above. As I explained in Section XIV.C.2, Thiel425 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

622. Thiel425 teaches that the dental camera comprises a polychromatic light source configured to emit “an illuminating beam (8) that can be focused, at least in terms of one wavelength thereof, onto the surface of an object of interest by means of the chromatic objective.” (Ex.1012, [0013].) Thiel 425 further states that “polychromatic light source 3 has a spectral range of two or more wavelengths.” (*Id.*, [0080].)

623. A polychromatic light source and a multichromatic light source each refer to a light source having two or more colors. A POSITA would understand

that poly and multi are synonyms, in this context. Thus, Thiel425's polychromatic light source teaches a multichromatic probe light for illumination of the object.

624. Thus, Thiel425 teaches or suggests "a multichromatic light source configured for providing a multichromatic probe light for illumination of the object," as recited in claim 32.

3. [32.2]: "a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object"

625. Claim element [32.2] is identical to claim element [1.2] above. As I explained in Section XIV.C.3, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

626. Thiel425 teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is "capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength." (*Id.*, [0085].) A POSITA would have understood that a CCD camera comprises a plurality of sensor elements (image sensor pixels) arranged in an array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains

one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

627. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

628. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

629. In view of the foregoing and based on Thiel⁴²⁵, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel⁴²⁵’s CCD camera suggests at least a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

630. Thus, Thiel425 teaches or suggests “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object,” as recited in claim 32.

4. **[32.3.a-b]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”**

631. Claim elements [32.3.a]-[32.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections XIV.C.4-5, the combination of Thiel425 and Thiel576 teaches or suggests these claim elements. The explanations that I provided in those section are also applicable here.

632. Thiel425 additionally discloses that “[t]he scanning unit 20 is a unit that is moved (i.e., translated) in the direction of the arrow 21 within the handheld dental camera 1 along the longitudinal axis A [i.e., optical axis] of the handheld dental camera 1, for example, by means of an electronically controlled electric motor, so that the focal points 13, 14 of the illuminating beam 8 are moved along the z axis,” (Ex.1012, [0084].)

633. Thiel425’s use of a motor to move the scanning unit 20 along the longitudinal axis A of the camera teaches or suggests “translating a focus plane along an optical axis of the focus scanner.”

634. Thiel425 teaches that by means of the scanning unit, the handheld dental camera (focus scanner) provides focal points of different wavelengths over various depth measurement ranges of the object that can adjoin or overlap each other (a stack of 2D images) along the z-axis of the object (different focus plane positions) and be measured successively. (*Id.*, [0013].) Thus, Thiel425 teaches this claim element.

635. Thus, Thiel425 teaches or suggests “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 32.

5. **[32.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

636. Claim elements [32.4.a]-[32.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections XIV.C.6-7, the combination of Thiel425 and Thiel576 teaches or suggests these claim elements. The explanations that I provided in those section are also applicable here.

a) Thiel425

637. In view of the '244 Patent, a POSITA would have understood a “block” or “group” of sensor pixels as including all sensor pixels in the array of pixels or a subset thereof.

638. As I explained in Sections XIV.C.1.a and XIV.C.6, Thiel425's data processing system in communication with its color image sensor and derives a stack of 2D images from data received by the color image sensor. As I also explained in Section XIV.C.1.a, Thiel425 further teaches a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object.

639. Thus, as I previously stated in Section XIV.C.7.a, although Thiel425 teaches determining surface geometry information of the object of interest from an image in the stack of 2D images, it does not explicitly disclose determining surface color information of the object of interest from at least one of the images in the stack of 2D images. However, it would have been obvious to a POSITA to determine surface color information from at least one image in the stack of 2D images of Thiel425, e.g., in view of Thiel576.

b) Thiel576

640. As I explained in Section XIV.C.7.b, Thiel576 teaches a device (focus scanner) that emits a broad-band illuminating beam on an object and an objective

for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. As I also explained in Section XIV.C.7.b, Thiel576 further teaches that the device receive beam reflected from the object's surface that is used to determine the surface color measurements (surface color information).

641. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to derive surface color measurements a color information simultaneous to its deriving surface geometry information in view of Thiel576, since Thiel425's device already operates on the stack of 2D color images (at least one of the 2D images used to derived the surface geometry information) derived from different focal depths.

c) Motivation to Combine

642. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

6. **[32.5]: “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter, and where the filters are arranged in a plurality of cells of 6×6 color filters, where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and (5,2) are of the W3 type.”**

a) Thiel425/Thiel576

643. As I explained in Section XVI.C.4, the combination of Thiel425 and Thiel576 teaches or suggests element [32.5.a]. The explanations that I provided in that section are also applicable here.

644. Thiel425 teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength.” (Ex.1012, [0085].) A POSITA would have understood that a CCD sensor comprises a plurality of sensor elements (image sensor pixels) that utilize a Bayer pattern color filter array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and

blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

645. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

646. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

647. In view of the foregoing and based on Thiel⁴²⁵, Cai, Fisker, Colonna de Lega, and many other references, a POSITA would have understood that Thiel⁴²⁵’s CCD camera suggests at least a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object, and thereby renders this claim limitation obvious.

648. To the extent that the Patent Owner argues that Thiel425 and Thiel576 does not explicitly disclose “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter,” it is well-known and obvious in the prior art, e.g., as taught by Tanaka.

649. Thiel425 and Thiel576 do not explicitly disclose “where the filters are arranged in a plurality of cells of 6×6 color filters, where the color filters in positions (2,2) and (5,5) of each cell are of the W1 type, the color filters in positions (2,5) and (5,2) are of the W3 type” as recited in claim 32. However, this is also well-known and obvious in the prior art, e.g., as taught by Tanaka.

b) Tanaka

650. Tanaka acknowledges an color imaging apparatuses having a Bayer color filter is well-known. (Ex.1010, [0003]-[0004] (“A primary-color Bayer array as a color array most widely used in the single-plate color imaging element includes green (G) pixels arranged in a check pattern and red (R) and blue (B) arranged line-sequentially”).) Tanaka also teaches a color imaging apparatus having a color filter array comprised of R, G, and B filters periodically arranged in horizontal and vertical lines. (*Id.*, [0020].) Accordingly, a POSITA would have

found it obvious to include a color filter, as described in Tanaka, in Thiel425/Thiel576's device.

651. Therefore, the combination of Thiel425, Thiel576, and Tanaka teaches or suggests “where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter” as recited in claim 31.

c) Motivation to Combine

652. A POSITA would have been motivated to enhance Thiel425/Thiel576's device with the color filter array of Tanaka at least for the reasons described in Section XIV.C.1.c above.

XVII. The combinations of (a) Thiel425, Thiel576, Fisker, and Suzuki and (b) Thiel425, Thiel576, Fisker, and Cai render claim 34 obvious.

A. Claim 34

653. Claim 34 is reproduced below with labeled limitations for ease of discussion.

1. [34.P]: “A focus scanner for recording surface geometry and surface color of an object”

654. Claim element [34.P] is identical to claim element [1.P] above. As I explained in Section XIV.C.1, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

a) Thiel425

655. Thiel425 teaches a handheld dental camera (focus scanner) for performing optical 3D object measurements (surface geometry). (Ex.1012, [0013].) The focus scanner comprises a polychromatic light source emitting an illuminating beam onto an object's surface, a scanning unit for changing the focal depths of the illuminating beam as required for chromatic confocal measurements, and a color sensor for capturing each of the wavelengths of the reflected light from the object's surface and configured to determine the optical 3D measurement. (*Id.*, [0085]). Thiel425 further teaches that each chromatic depth range overlaps, such that the color sensor receives data sets of different chromatic depth ranges that at least partially overlap (a stack of 2D images). (*Id.*, [0013]-[0014], [0023].)

656. Thus, although Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object and determining the surface geometry of the object therefrom, it does not explicitly disclose determining surface color of the 3D object. However, it would have been obvious to a POSITA to determine both the geometry and colorimetric measurements of the 3D object from the stack of 2D color images at two different focus depths, e.g., in view of Thiel576.

b) Thiel576

657. Thiel576 teaches a device (focus scanner) comprising a polychromatic light source for emitting a broad-band illuminating beam on an object and an objective for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. (Ex.1013, [0008], [0016], [0087].) The focus scanner also comprises a color sensor for receiving a beam reflected from the object's surface that is used to determine the surface color measurements (surface color).

658. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to determine the object's surface color as taught in Thiel576, since Thiel425 already considers sensing and processing of multiple colors (wavelengths) at different focal depths.

659. Therefore, the combination of Thiel425 and Thiel 576 teaches or suggests a "focus scanner for recording surface geometry and surface color of an object" as recited in claim 34.

c) Motivation to Combine

660. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

2. [34.1]: “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object”

661. Claim element [34.1] is identical to claim element [1.1] above. As I explained in Section XIV.C.2, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

662. Thiel425 teaches that the dental camera comprises a polychromatic light source configured to emit “an illuminating beam (8) that can be focused, at least in terms of one wavelength thereof, onto the surface of an object of interest by means of the chromatic objective.” (Ex.1012, [0013].) Thiel 425 further states that “polychromatic light source 3 has a spectral range of two or more wavelengths.” (*Id.*, [0080].)

663. A polychromatic light source and a multichromatic light source each refer to a light source having two or more colors. A POSITA would understand that poly and multi are synonyms, in this context. Thus, Thiel425's polychromatic light source teaches a multichromatic probe light for illumination of the object.

664. Thus, Thiel425 teaches or suggests “a multichromatic light source configured for providing a multichromatic probe light for illumination of the object,” as recited in claim 34.

3. [34.2]: “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object”

665. Claim element [34.2] is identical to claim element [1.2] above. As I explained in Section XIV.C.3, the combination of Thiel425 and Thiel576 teaches or suggests this claim element. The explanations that I provided in that section are also applicable here.

666. Thiel425 teaches a color sensor 4 [the image sensor], such as a CCD sensor, that is “capable of detecting a wavelength spectrum and of reproducing the intensity of the individual wavelength.” (Ex.1012, [0085].) A POSITA would have understood that a CCD camera comprises a plurality of sensor elements (image sensor pixels) arranged in an array. For example, in the background section of the Cai reference, Cai explains that CCD sensors typically have an array of image sensor pixels for capturing images of light received:

Single and multi-sensor cameras are predominant in image or video capture systems. The cameras typically employ CCD or CMOS sensors that utilize a Bayer pattern color filter array (where each pixel only contains one color value). When using a Bayer pattern color filter array, the captured image is a mosaic of red, green, and

blue (RGB) colors where each pixel is missing two of the three color values. Accordingly, these missing color values need to be interpolated to obtain an approximation of the full RGB values for each pixel to provide a richer output image.

(Ex.1011, [0001].)

667. Fisker also teaches using a camera accommodating a standard CCD chip with sensor elements (pixels) that may accommodate a Bayer color filter to provide a color registration in each sensor element. (Ex.1005, [0070], [0152].)

668. Colonna de Lega likewise teaches using one or more color filters at the image-recording device such as a CCD sensor. (Ex.1017, [0061] (“one or more color filters can be included in the system to filter the wavelength of light forming the images at the image-recording device. The one or more color filters can be arranged to be an integral component of the image-recording device or as separate from the image-recording device.”))

669. In view of the foregoing, and based on Thiel425, Cai, Fisker, Colonna de Lega, a POSITA would have understood that Thiel425’s CCD camera teaches or suggests a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object.

670. Thus, Thiel425 teaches or suggests “a color image sensor comprising an array of image sensor pixels for capturing one or more 2D images of light received from said object,” as recited in claim 34.

4. **[34.3.a-b]: “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images”**

671. Claim elements [34.3.a]-[34.3.b] are identical to claim elements [1.3.a]-[1.3.b] above. As I explained in Sections XIV.C.4-5, the combination of Thiel425 and Thiel576 teaches or suggests these claim elements. The explanations that I provided in those sections are also applicable here.

672. Thiel425 additionally discloses that “[t]he scanning unit 20 is a unit that is moved (i.e., translated) in the direction of the arrow 21 within the handheld dental camera 1 along the longitudinal axis A (i.e., optical axis) of the handheld dental camera 1, for example, by means of an electronically controlled electric motor, so that the focal points 13, 14 of the illuminating beam 8 are moved along the z axis.” (Ex.1012, [0084].)

673. Thiel425’s use of a motor to move the scanning unit 20 along the longitudinal axis A of the camera suggests or teaches or suggests “translating a focus plane along an optical axis of the focus scanner.”

674. Thiel425 further teaches that by means of the scanning unit, the handheld dental camera (focus scanner) provides focal points of different wavelengths over various depth measurement ranges of the object that can adjoin or overlap each other (a stack of 2D images) along the z-axis of the object (different focus plane positions) and be measured successively. (*Id.*, [0013].) Thus, Thiel425 teaches this claim element.

675. Thus, Thiel425 teaches or suggests “wherein the focus scanner is configured to operate by translating a focus plane along an optical axis of the focus scanner and capturing a series of the 2D images, each 2D image of the series is at a different focus plane position such that the series of captured 2D images forms a stack of 2D images,” as recited in claim 34.

5. **[34.4.a-b]: “a data processing system configured to derive surface geometry information for a block of said image sensor pixels from the 2D images in the stack of 2D images captured by said color image sensor, the data processing system also configured to derive surface color information for the block of said image sensor pixels from at least one of the 2D images used to derive the surface geometry information”**

676. Claim elements [34.4.a]-[34.4.b] are identical to claim elements [1.4.a]-[1.4.b] above. As I explained in Sections XIV.C.6-7, the combination of Thiel425 and Thiel576 teaches or suggests these claim elements. The explanations that I provided in those section are also applicable here.

a) Thiel425

677. In view of the '244 Patent, a POSITA would have understood a “block” or “group” of sensor pixels as including all sensor pixels in the array of pixels or a subset thereof.

678. As I explained in Sections XIV.C.1.a and XIV.C.6, Thiel425's data processing system in communication with its color image sensor and derives a stack of 2D images from data received by the color image sensor. As I also explained in Section XIV.C.1.a, Thiel425 further teaches a stack of 2D images derived from wavelengths having different focus depths being emitted onto the object.

679. Thus, as I previously stated in Section XIV.C.7.a, although Thiel425 teaches determining surface geometry information of the object of interest from an image in the stack of 2D images, it does not explicitly disclose determining surface color information of the object of interest from at least one of the images in the stack of 2D images. However, it would have been obvious to a POSITA to determine surface color information from at least one image in the stack of 2D images of Thiel425, e.g., in view of Thiel576.

b) Thiel576

680. As I explained in Section XIV.C.7.b, Thiel576 teaches a device (focus scanner) that emits a broad-band illuminating beam on an object and an objective

for focusing the illuminating beam at two focus depths, one on the object's surface and the other along the optical axis but out of the plane of the object's surface, such that out-of-focus images in the form of a fuzzy circle are reproduced on the object surface plane. As I also explained in Section XIV.C.7.b, Thiel576 further teaches that the device receive beam reflected from the object's surface that is used to determine the surface color measurements (surface color information).

681. Thus, it would have been obvious to a POSITA to enhance the spectral analysis and imaging processing methods of Thiel425's device to derive surface color measurements a color information simultaneous to its deriving surface geometry information in view of Thiel576, since Thiel425's device already operates on the stack of 2D color images (at least one of the 2D images used to derived the surface geometry information) derived from different focal depths.

c) Motivation to Combine

682. A POSITA would have been motivated to enhance Thiel425's image processing methods with the methods of Thiel576 at least for the reasons described in Section XIV.C.1.c above.

6. [34.4.c]: “where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern”

a) **Thiel425/Thiel576**

683. As I explained in Section XIV.C.7, Thiel425 teaches capturing a stack of 2D images derived from wavelengths having different, overlapping focus depths emitted onto the object. As I also previously explained in Section XIV.C.7, the combination of Thiel425 and Thiel576 teaches deriving the surface geometry measurements and surface color information of the surface of the object based on the stack of 2D images. However, Thiel425/Thiel576 does not disclose calculating a correlation measure between the overlapping images in the stack and a weight function determined based on a spatial pattern. However, doing so is well known in the art, e.g., as taught by Fisker.

b) **Fisker**

684. As I explained in X.B.6, Fisker teaches or suggests deriving the surface geometry information and surface color information. Fisker further teaches a “means for evaluating a correlation measure at each focus plane position between at least one image pixel and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern.”

(Ex.1005, [0001].) Because Fisker evaluates a correlation measure at “each focus plane,” Fisker teaches calculating a correlation measure for several 2D images. Thus, Fisker teaches this limitation.

c) Motivation to Combine

685. Combining the teachings of Thiel425/Thiel576 with those of Fisker would have been obvious to a POSITA for at least the following reasons.

686. *First*, like Thiel425/Thiel576, Fisker is directed to providing clear and accurate color images of an object. Also, like Thiel425/Thiel576, Fisker is directed to constructing and rendering 3D images and concerned with image quality and alignment. (Ex.1005, [0263].) For example, Fisker teaches a “fused image” that is generated by “combining all the in-focus regions of the series” of images. Fisker further teaches that the fused image “can be interpreted as the reference signal and the reference vector/set of weight values...for the n pixels in the pixel group...” (*Id.*, [0263]-[0264].) Fisker’s color is further “expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude.” (*Id.*, [0279].)

687. *Second*, a POSITA would have found been motivated to enhance the image processing techniques of Thiel425/Thiel576 with those of Fisker. As I previously explained in Section XIV.C.8, Thiel425/Thiel576 teach generating

multiple images that each have color information. However, Thiel425/Thiel576 does not teach combining the images by using a correlation measure between images and a weight function. Thus, the implementation of Fisker's means for pattern generation and for evaluating a correlation measurement at each focus plane position would have been an obvious modification to improve the Thiel425/Thiel576's device.

688. *Third*, the combining of the imaging processing techniques of Thiel425/Thiel576 with those of Fisker would requires nothing more than additional processing. Fisker specifically provides nothing more than a data processing unit for performing its method. (Ex.1005, [0192].)

689. Based on the foregoing, and a POSITA's experience, a POSITA would have understood that the method for processing images, as described in each of Thiel425, Thiel576, and Fisker, is conducted based on computer programs/software using processing means. Thus, to achieve the benefits of Fisker's image processing modules, it would have been obvious to enhance Thiel425/Thiel576's software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance Thiel425/Thiel576's method for processing images to include a Fisker-style method for spatial resolution of the 3D representation of the object.

690. *Fourth*, a POSITA would have had a reasonable expectation of success when enhancing Thiel425/Thiel576's image processing method with that of Fisker's. Such a modification would have been a routine matter for a POSITA because implementing Fisker's method would not require any additional hardware and could be implemented by adding to, or altering, the computer code that controls the image processing algorithms.

691. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Thiel425/Thiel576's image processing methods with the methods of Fisker and that the combination of Thiel425, Thiel576, and Fisker teaches or suggests this limitation.

7. [34.4.d]: “identifying the position along the optical axis at which the corresponding correlation measure has a maximum value”

a) Thiel425/Thiel576

692. Thiel425 suggests or teaches “translating a focus plane along an optical axis of the focus scanner” as recited in part by claim 31.3.a. (Section XVI.C.5.) Thiel425/Thiel576 does not teach “calculating of a correlation measure between the portion of 2D images” as recited in part in the limitation of claim 34.4.c. (Section XVII.C.6.) Likewise, Thiel425/Thiel576 also does not teach “identifying the position along the optical axis at which the corresponding

correlation measure has a maximum value” as recited in this limitation However, this limitation is well known in the art, e.g., as taught by Fisker.

b) Fisker

693. As I have explained in Sections XII.B.6 and XII.B.9 above, Fisker teaches that different regions (i.e., a block of image sensor pixels) of the scanned surface will be in focus in different images. (Ex.1005, [0261].) Fisker further describes a “fused image” that is generated by “combining all the in-focus regions of the series” of images using stitching and/or registering process where “partial scans” are combined. (*Id.*, [0175], [0263].) Fisker’s in-focus regions are “found as those of maximum intensity variance (indicating maximum contrast) over the entire said series of images.” (*Id.*, [0262].) Thus, Fisker teaches this limitation.

c) Motivation to Combine

694. As I previously stated in Section XVII.A.6.c, enhancing Thiel425/Thiel425’s imaging processing methods with those of Fisker would have been obvious to a POSITA. Specifically, as stated in Section XVII.A.6.c, the implementation of Fisker’s means for pattern generation and for evaluating a correlation measurement at each focus plane position would have been an obvious modification to improve the Thiel425/Thiel576’s device. As such, it would have obvious to a POSITA to identify a position along the optical axis that the corresponding measure has a maximum value in evaluating the correlation

measurement. Thus, a POSITA would have found it obvious to enhance Thiel425/Thiel576's image processing methods with those of Fisker and that the combination of Thiel425, Thiel576, and Fisker teaches this limitation.

8. **[34.4.e]: “where the data processing system further is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels”**

a) Thiel425/Thiel576

695. . As I previously stated in Sections XVI.A.6-8, Thiel425's data processing system in communication with its color image sensor and that the color image sensor receives data sets from different, overlapping chromatic depth ranges. Thus, a POSITA would have understood two different data sets acquired from different pairs of overlapping chromatic depth ranges of Thiel425 as being two sub-scans.

696. As I previously stated in Sections XVI.A.1 and XVI.A.6-8, Thiel425/Thiel576 teaches that each pair of the data sets (sub-scan) of Thiel425 can have colorimetric measurements of the object's surface (surface color information). Thiel425/Thiel576 also does not teach “determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for

the corresponding block of image sensor pixels” as recited in part in this limitation. However, this limitation is well known in the art, e.g., as taught by Fisker.

b) Fisker

697. As I explained in Section XII.B.7, Fisker teaches deriving the sub-scan color for a point on a generated sub-scan using a correlation measure. Fisker’s scanner is “adapted to *obtain the color* of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned.” (Ex.1005., [0151].)

698. Fisker teaches that “[t]he pattern is applied to provide illumination with an embedded spatial structure on the object being scanned. Determining in-focus information relates to calculating a correlation measure of this spatially structured light signal (which we term input signal) with the variation of the pattern itself (which we term reference signal). In general the magnitude of the correlation measure is high if the input signal coincides with the reference signal”. (Ex.1005, [0074].)

699. Like the ’244 Patent, Fisker’s correlation measure is defined “mathematically with a discrete set of measurements as a dot product computed from a signal vector, $I=(I_1,\dots,I_n)$, with $n>1$ elements representing sensor signals and a reference signal vector, $f=(f_1,\dots,f_n)$, of same length as said signal

vector of reference weights. (Ex. 1005 [0076]). Furthermore, as I restate below, the actual correlation measure function A is identical to the function used in the '244 Patent.

700. Moreover, as in the '244 patent, Fisker teaches that the correlation measure is computed on signal vectors that represent sensor signals, available as 2D digital color images captured at each focus element position, i.e. images with a finite number of discrete pixels. (*See id.*, [0077], [0080]). Fisker additionally evaluates the above correlation measure at “all focus element positions” and thus Fisker teaches calculating a correlation measure for several 2D images. (*Id.*, [0078].)

701. Like the '244 Patent, Fisker's correlation measure is a “measure between the weight function and the recorded light signal” that “translates to a pixel values of an image” and the correlation measure is computed using several image sensor pixels. (Ex.1005, [0052].) That is, Fisker teaches calculating a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function.

702. The similarities between the correlation measures disclosed in the '244 Patent and that of Fisker are further exemplified by the following table:

'244 Patent	Fisker
<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>('244 Patent, 6:1-12.)</p>	<p>One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I=(I_1 \dots I_n)$, with $n>1$ elements representing sensor signals and a reference vector, $f=(f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by</p> $A = f \cdot I = \sum_{i=1}^n f_i I_i$ <p>(Ex.1005, [0076].)</p>

703. Fisker's method includes reconstructing the surface color using an appropriate weighting corresponding to the maximum amplitude/correlation measure. (Ex.1005, [0157]-[0158], [0279]-[0280].) Fisker's data processing system is "adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned." (Ex.1005, [0151].) Fisker's image sensor "provides color registration at each element," based on the amplitude of light received at each of the sensor elements. (See Ex.1005, [0151]-[0157].) The amplitude is determined for at least one color at every focal plane position. (*Id.*, [0158].) So, at every focus position the amplitude of light received at the sensor elements is used to compute the maximum of the correlation measure

function, to determine surface topology and the surface color e.g. an RGB color coordinate, for each surface element. This surface color is reconstructed by appropriate weighting of the image sensor amplitude signal for each color corresponding to the maximum correlation function. (Ex.1005 , [0151]-[0158] and [0279]-[0280].))

c) Motivation to Combine

704. For the same reasons I described in Section XVII.6.c, enhancing Thiel425/Thiel425's imaging processing methods with those of Fisker would have been obvious to a POSITA. Specifically, as stated in Section X.A.2.c, the implementation of Fisker's means for pattern generation and for evaluating a correlation measurement at each focus plane position would have been an obvious modification to improve the Thiel425/Thiel576's device. As such, it would have been obvious to a POSITA to identify a position along the optical axis that the corresponding measure has a maximum value in evaluating the correlation measurement. Thus, a POSITA would have found it obvious to enhance Thiel425/Thiel576's image processing methods with those of Fisker and that the combination of Thiel425, Thiel576, and Fisker teaches this limitation.

9. [34.4.f]: “where the data processing system further is configured for...computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of surrounding points on the sub-scan.”

a) **Thiel425/Thiel576**

705. As I described in Section XVII.A.5.a, Thiel425/Thiel576 teaches determining color information for a number of points on a sub-scan. However Thiel425/Thiel576 does not disclose determining an average color for the number of points on the sub-scan by computing an average of sub-scan colors of surrounding points on the sub-scan. However, this is well known in the art, e.g., as illustrated by Fisker, Suzuki, and Cai.

b) **Fisker**

706. Fisker teaches deriving the sub-scan color for a point on a generated sub-scan using a correlation measure and reconstructing the surface color using an appropriate weighting corresponding to the maximum amplitude/correlation measure.

707. Fisker teaches a “fused image” that is generated by “combining all the in-focus regions of the series” of images. (Ex.1005, [0263].)

708. Fisker also teaches converting the 2D color image data into a 3D surface data in each sub-scan and then “merging and/or combining 3D data for the interior and exterior part of the ear provided, thereby providing a full 3D model of

a human ear.” (Ex. 1005, [0032] and [0173].) Furthermore, Fisker elaborates, “An embodiment of a color 3D scanner is shown in FIG 9. Three light sources 110, 111, and 113 emit red, green, and blue light. The light sources are maybe LEDs or lasers. The light is merged together to overlap or essentially overlap. This maybe achieved by means of two appropriately coated plates 112 and 114. Plate 112 transmits the light from 110 and reflects the light from 111. Plate 114 transmits the light from 110 and 111 and reflects the light from 113. The color measurement is performed as follows: For a given focus position the amplitude of the time-varying pattern projected onto the probed object is determined for each sensor element in the sensor 181 by one of the above mentioned methods for each of the light sources individually. In the preferred embodiment only one light source is switched on at the time, and the light sources are switched on after turn. In this embodiment the optical system 150 maybe achromatic. After determining the amplitude for each light source the focus position is shifted to the next position and the process is repeated. The color expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude. ” (Id., [0279].

709. While Fisker describes a weighting scheme for expressing color values for the scanned pixels, Patent Owner may argue that Fisker does not teach or suggest this limitation. (*Id.*) However, computing a weighted average of sub-

scan color values derived for corresponding points in overlapping sub-scans at that point of the object surface is well known in the prior art, e.g., as taught by Suzuki and Cai.

c) Suzuki

710. As described above, Suzuki discloses a digital camera imaging unit that specifies (i.e., detects) a position of a defective pixel among a plurality of pixels. (Ex.1009, Abstract, [0058].) Suzuki's camera includes a correction unit that corrects the pixel values of each of the pixels in the region based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region. (See Ex.1009, Abstract, [0066]-[0069].) Suzuki's formula (1), illustrated below, further teaches a formula for determining a pixel value using a weighted average of the surrounding pixels:

$$VA = (VA1 \times 6 + VA2 \times 12 + VA3 \times 4 + VA4 \times 12 + VA5 \times 6 + VA6 \times 4 + VA7 \times 6 + VA8 \times 3) \div (6 + 12 + 4 + 12 + 6 + 4 + 6 + 3) \quad (1)$$

(See *id.*, [0072]-[0073] (“In formula (1), VA indicates the pixel value of the attention pixel at the position A after correction, and VA1 to VA8 respectively indicate the pixel values at position A1 to position A8. In addition, the weighting for each of the pixel values VA1 to VA8 is set based on the inverse of the additional value of the distance in the horizontal direction and the distance in the vertical direction from the position A of the attention pixel.”))

711. Suzuki's teachings and formula teach computing an averaged sub-scan color for a number of points of the sub-scan, where the computing comprises an averaging of sub-scan colors of surrounding points on the sub-scan.

d) Cai

712. Cai discloses an architecture that "employs multiple different algorithms for calculating the target pixel based on real and virtual source pixels based on the location of the source pixel." (*See* Ex.1011, [0006].) The disclosed architecture and algorithms decode a source image and "performs reconstruction directly from the source mosaic pattern (e.g., Bayer) to the target mosaic pattern (e.g., Bayer) to reduce memory size and improve communication bandwidth." (*Id.*, [0005].)

713. Cai further teaches a method for obtaining an interpolated color value from adjacent real pixel values of the same color. (*See id.*, [0021] ("where a red pixel R8 in the target image maps to a center position of four surrounding real red pixels, the target red pixel R8 is interpolated by the simple average of the color values of the surrounding real pixels in the source image such that interpolated pixel $R8 = (R2 + R4 + R12 + R14) / 4$.")) Cai also teaches this claim limitation.

e) Motivation to Combine

714. For at least the same reasons that I discussed in Section XVII.6.c, a POSITA would have found it obvious to combine the teachings of Thiel425 and Thiel576 with those of Fisker.

715. Moreover, a POSITA would have found it obvious to combine the teachings of Thiel425, Thiel576, and Fisker with those of Suzuki and Cai for at least the following reasons.

716. *First*, Thiel425, Thiel576, Fisker, Suzuki, and Cai are analogous art because they each use a processing means (or computing system) to analyze and process captured images, as does the challenged '244 Patent. Thiel425, Thiel576, Fisker, and Suzuki are directed to a computer system for constructing and rendering 3D images. (Ex.1005, [0001]; Ex.1009, Abstract.) Fisker and Cai are each disclose methods for improving data processing efficiency and improving data transfer capabilities. (Ex.1005, [0001]; Ex.1011, Abstract.) And Thiel425, Thiel576, Fisker, and Suzuki are concerned with image quality.

717. For example, Suzuki discloses a method for detecting a pixel color error within a captured image and then correcting the erroneous pixel color based on a weighted average of pixel values located at the periphery of an error region. (Ex.1009, Abstract, [0066]-[0069].) A POSA would have recognized the benefit for enhancing Thiel425/Thiel576/Fisker's image processing to include Suzuki's

method for determining pixel color based on a weighted average of surrounding pixels, because doing so would improve image quality.

718. Likewise, Cai discloses multiple algorithms for calculating a pixel value by obtaining an interpolated color value from adjacent real pixel values of the same color, and thereby improving image quality. (Ex.1011, [0006], [0020].) Cai's image processing methods also save memory and improve the communication bandwidth by performing its methods directly from a Bayer pattern. A POSITA would have recognized the benefit for enhancing Theil425/Thiel576/Fisker's image processing to include Cai's methods because doing so would improve memory and computing efficiency.

719. A POSITA would have been motivated to make the minor modification required to Theil425/Thiel576/Fisker's image processing method to include Suzuki's and Cai's similar pixel correction method. The resulting combination is little more than use of a known image processor and known image processing technique to improve image quality—e.g., produce a more accurate and clear image having more accurate color data. A POSITA thus would have improved image processing systems and methods, like Theil425/Thiel576/Fisker's, in the same way that that Suzuki suggests—specifying a defective pixel and correct the pixel value of each defective pixel in the region, based on a weighted average of pixels values of a plurality of pixels located at a periphery of the region

(Ex.1009, Abstract and [0063]-[0069]) and in the way that Cai suggests-- reconstruction an image by interpolated color value from adjacent real pixel values of the same color. (Ex.1011, [0021]) And after the combination, each feature would continue to function as intended. *KSR Int'l. Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007).

720. The '244 Patent, Thiel425, Thiel576, Fisker, Yamada, Suzuki, and Szeliski are concerned with providing clear and accurate images. As described, a POSITA would have understood the advantages of enhancing Fisker's image processor and known image processing techniques of Yamada and Suzuki. Thus, the benefits of employing a Yamada-like method and a Suzuki-like method for processing images in an image processor, such as that of Fisker, would have thus been predictable to a POSITA. *KSR*, 550 U.S. at 417.

721. As provided above, Theil425/Thiel576/Fisker's image processor and method for processing images would have benefited from Suzuki's and Cai's methods for determining a pixel's color value. Fisker teaches "a computer program product comprising program code means for causing a data processing system to perform the method when said program code means are executed on the data processing system." (Ex.1005, [0192].)

722. And Suzuki explains that its methods are carried out on "a computer capable of executing various functions by installing various programs, for

example, a general-purpose personal computer.” (Ex.1009, [0136].) Likewise, Cai’s methods are performed based on “computer-executable instructions” that can run on a computer. (Ex.1011, [0061].)

723. Based on the foregoing, and a POSITA’s experience, a POSITA would have understood that the method for processing images, as described in each of the ’244 Patent, Thiel425, Thiel576, Fisker, Suzuki, and Cai, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Suzuki’s and Cai’s image processing modules, it would have been obvious to modify Thiel425/Thiel576/Fisker’s software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to modify Thiel425/Thiel576/Fisker’s method for processing images to include the methods of Yamada and Suzuki.

724. Finally, a POSITA would have had a reasonable expectation of success when enhancing Thiel425/Thiel576/Fisker’s image processing method with that of Suzuki and Cai. Such a modification would have been a routine matter for a POSITA, because implementing Suzuki’s and Cai’s methods would not require any additional hardware and could be implemented within Fisker’s data processor by adding, or altering, the computer code that controls the image processing algorithms.

725. For at least the foregoing reasons, a POSITA would have found it obvious to modify Thiel425/Thiel576/Fisker's image processing methods and systems with the methods of Suzuki or Cai and that the combinations of (a) Thiel425, Thiel576, Fisker, and Suzuki and (b) Thiel425, Thiel576, Fisker, and Cai teach or suggest this limitation.

XVIII. The combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker render claims 2-5, 7-10, 15, 16, 18, 21, 26, and 28 obvious.

A. Thiel425, Thiel576, Szeliski, and Matsumoto

726. The combination of Thiel425, Thiel576, and Szeliski or Matsumoto teaches using sub-scans of an object to create a digital 3D representation of the object. (Sections XIV.C.8-10.) However, these references do not explicitly disclose the particulars of limitations of claims 2-5, 7-10, 15, 16, 18, 21, 26, and 28. Nonetheless, these limitations are well-known in the art, e.g., as explicitly taught by Fisker.

B. Motivation to Combine

727. Combining the teachings of Thiel425 with those of Thiel576, either Szeliski or Matsumoto, and Fisker would have been obvious to a POSITA for at least the following reasons.

728. Thiel425, Thiel576, Szeliski, Matsumoto, and Fisker are each directed to providing clear and accurate images of an object and complimentary to each other. Specifically, for example, Thiel425 teaches methods for providing accurate

geometry information for an image of an object. Thiel576 teaches methods for providing accurate color information for an image of an object. Lastly, Szeliski and Matsumoto describe methods for using weighted averages to improve color information of the object. A POSITA would have motivated to combine the teachings of Thiel425 with those of Thiel576 and either Szeliski or Matsumoto. Moreover, Fisker teaches methods for obtaining color and geometry information of an object.

729. As such, a POSITA would have been motivated make the minor modification required to the modified method of Thiel425, Thiel576 and either Szeliski or Matsumoto to include Fisker's similar method. The resulting combination is little more than the use of a known image processor and known image processing technique to improve image quality—e.g., produce a more accurate and clear image using data captured by multiple images. A POSITA thus would have improved image processing systems and methods, like Thiel425, in the same way that Thiel576 suggests—namely, measuring color information of an object, Szeliski suggests—namely, improving image quality by blending color from multiple images and to account for movements in the image (Ex.1006, Figs. 1, 32, 4:1-9), Matsumoto suggests—namely, applying a weighted mean process by assigning a weight variable to the stored color information and then accumulating

the information, (Ex.1007, 4:1-9), and Fisker suggests—namely, methods for providing geometry and color information together for an object.

730. A POSITA could have easily configured the handheld device of Thiel425 to provide the color information techniques of Thiel576 along with those of either Szeliski or Matsumoto and the image processing techniques of Fisker. Thiel425, Thiel576, Szeliski, Matsumoto and Fisker each use a processing means (or computing system) to analyze and process captured images in dentistry. Each is directed to a computer system for constructing and rendering 3D images of objects. (*See* Ex.1012, 1:3-5; *see also* Ex.1013, 1:9-12; Ex.1005, [0001]; Ex.1006, 1:9-12; Ex.1007, Abstract.) And each is similarly concerned with image quality and alignment of images of objects. As such, based on a POSITA's experience, a POSITA would have understood that the method for processing images, as described in Thiel425, Thiel576, Szeliski, Matsumoto and Fisker, is conducted based on computer programs/software using a processing means. Thus, to achieve the benefits of Thiel576, either Szeliski or Matsumoto, and Fisker's image processing modules, it would have been obvious to enhance Thiel425's software (and algorithms) using routine coding and engineering practices.

731. A POSITA would have had a reasonable expectation of success when enhancing Thiel425's image processing method with that of Thiel576, either

Szeliski or Matsumoto, and Fisker. Such a modification would have been a routine matter for a POSITA.

732. A POSITA would have understood the advantages of enhancing Thiel425's image processor with the image processing techniques of Thiel576 with, either Szeliski or Matsumoto, and Fisker. Thus, the benefits of employing a Thiel576-like method along with either Szeliski-like method or Matsumoto-like method and Fisker-like method for processing images in an image processor, such as that of Thiel425, would have thus been predictable to a POSITA.

733. Thus, a POSITA would have found it obvious to enhance Thiel425's image processing methods with the methods of Thiel576, either Szeliski or Matsumoto, and Fisker.

734. Combining the teachings of Thiel576 with those of Thiel425, either Szeliski or Matsumoto, and Fisker would have been obvious to a POSITA for at least the following reasons.

735. *First*, like Thiel576, Thiel425, Szeliski, and Matsumoto, Fisker is directed at providing clear and accurate images of an object. Also, like Thiel576, Thiel425, Szeliski, and Matsumoto, Fisker is directed to constructing and rendering 3D images and concerned with image quality and alignment. For example, Fisker teaches a "fused image" that is generated by "combining all the in-focus regions of the series" of images. Fisker further teaches that the fused image "can be

interpreted as the reference signal and the reference vector/set of weight values...for the pixels in the pixel group...” (Ex.1005, [0264].) Fisker’s color is further “expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude.” (Ex.1005 [0157].)

736. *Second*, a POSITA would have found been motivated to enhance Thiel576/Thiel425/Matsumoto’s image processing techniques with those of Fisker. Thiel576/Thiel425/Szeliski/Matsumoto teaches generating multiple images each having color information and combining the images by using a weighted average of overlapping points of the images. However, Thiel576/Thiel425/Szeliski/Matsumoto does not teach a specific way to align the images when images are combined and to calculate a correlation measure between images and a weight function. Thus, the implementation of Fisker’s means for pattern generation and for evaluating a correlation measure at each focus plane position would have been an obvious modification to improve Thiel576/Thiel425/Szeliski/Matsumoto’s device.

737. *Third*, the combining of the imaging processing techniques of Thiel576/Thiel425/Szeliski/Matsumoto’s techniques with those of Fisker would require nothing more than additional processing.

Thiel576/Thiel425/Szeliski/Matsumoto teaches analyzing image to determine a 3D representation of an object. (Section XVII.A.8-10.)

738. Based on the foregoing, and a POSITA's experience, a POSITA would have understood that the method for processing images, as described in each of the Thiel576, Thiel425, Szeliski, Matsumoto, Fisker, is conducted based on computer programs/software using processing means. Thus, to achieve the benefits of Fisker's image processing modules, it would have been obvious to enhance the Thiel576 and Thiel425 combination's software (and algorithms) using routine coding and engineering practices. Therefore, a POSITA would have been motivated to enhance Thiel576/Thiel425/Szeliski/Matsumoto's method for processing images to include a Fisker-style method for spatial resolution of the 3D representation of the object.

739. *Fourth*, a POSITA would have had a reasonable expectation of success when enhancing Thiel576/Thiel425/Szeliski/Matsumoto's image processing method with that of Fisker because such a modification would have been a routine matter for a POSITA.

740. For at least the foregoing reasons, a POSITA would have found it obvious to enhance Thiel576/Thiel425/Szeliski/Matsumoto's image processing methods based on the methods of Fisker.

741. And, for the reasons that I will describe in the following Sections, the combination of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teaches or suggests the subject matter of claims 2-5, 6-10, 15, 16, 18, 21, 26, and 28.

C. Fisker

- 1. Claim 2: “The focus scanner according to claim 1, wherein the data processing system is configured for generating a sub-scan of a part of the object surface based on surface geometry information and surface color information derived from a plurality of blocks of image sensor pixels.”**

742. As I explained in Section VII.E, Fisker teaches or suggests the subject matter of claim 2. The explanations that I provided in Section VII.E are also applicable here.

743. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest a data processing system that is “configured for generating a sub-scan of a part of the object surface based on surface geometry information and surface color information derived from a plurality of blocks of image sensor pixels,” as recited in claim 2. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

2. Claim 3: “The focus scanner according to claim 1, where the scanner system comprises a pattern generating element configured for incorporating a spatial pattern in said probe light.”

744. As I explained in Section VII.F, Fisker teaches or suggests the subject matter of claim 3. The explanations that I provided in Section VII.F are also applicable here.

745. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest a scanner system comprising “a pattern generating element configured for incorporating a spatial pattern in said probe light,” as recited in claim 3. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

3. Claim 4: “The focus scanner according to claim 1, where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern.”

746. As I explained in Section VII.G, Fisker teaches or suggests the subject matter of claim 4. The explanations that I provided in Section VII.G are also applicable here.

747. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “where deriving the surface geometry information and surface color information comprises calculating for several 2D images a correlation measure between the portion of the 2D image captured by said block of image sensor pixels and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern,” as recited in claim 4. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

- 4. Claim 5: “The focus scanner according to claim 4, wherein deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical axis at which the corresponding correlation measure has a maximum value.”**

748. As I explained in Section VII.H, Fisker teaches or suggests the subject matter of claim 5. The explanations that I provided in Section VII.H are also applicable here.

749. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “wherein deriving the surface geometry information and the surface color information for a block of image sensor pixels comprises identifying the position along the optical

axis at which the corresponding correlation measure has a maximum value,” as recited in claim 5. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

5. Claim 7: “The focus scanner according to claim 6, where the maximum correlation measure value is the highest calculated correlation measure value for the block of image sensor pixels and/or the highest maximum value of the correlation measure function for the block of image sensor pixels.”

750. As I explained in Section VII.I, Fisker teaches or suggests the subject matter of claim 7. The explanations that I provided in Section VII.I are also applicable here.

751. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “where the maximum correlation measure value is the highest calculated correlation measure value for the block of image sensor pixels and/or the highest maximum value of the correlation measure function for the block of image sensor pixels,” as recited in claim 7. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

6. **Claim 8: “The focus scanner according to claim 5, wherein the data processing system is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels.”**

752. As I explained in Section VII.J, Fisker teaches or suggests the subject matter of claim 8. The explanations that I provided in Section VII.J are also applicable here.

753. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “wherein the data processing system is configured for determining a sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D image in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels,” as recited by claim 8. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

7. **Claim 9: “The focus scanner according to claim 8, wherein the data processing system is configured for deriving the sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D images in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels and on at least one additional 2D image.”**

754. As I explained in Section VII.K, Fisker teaches or suggests the subject matter of claim 9. The explanations that I provided in Section VII.K are also applicable here.

755. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “wherein the data processing system is configured for deriving the sub-scan color for a point on a generated sub-scan based on the surface color information of the 2D images in the series in which the correlation measure has its maximum value for the corresponding block of image sensor pixels and on at least one additional 2D image,” as recited in claim 8. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

8. Claim 10: “The focus scanner according to claim 9, where the data processing system is configured for interpolating surface color information of at least two 2D images in a series when determining the sub-scan color.”

756. As I explained in Section VII.L, Fisker teaches or suggests the subject matter of claim 10. The explanations that I provided in Section VII.L are also applicable here.

757. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “where the data processing system is configured for interpolating surface color information of at least two 2D images in a series when determining the sub-scan color,” as recited in claim 10. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

9. Claim 15: “The focus scanner according to claim 1, where the color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter.”

758. As I explained in Section VII.M, Fisker teaches or suggests the subject matter of claim 15. The explanations that I provided in Section VII.M are also applicable here.

759. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “where the

color image sensor comprises a color filter array comprising at least three types of colors filters, each allowing light in a known wavelength range, W1, W2, and W3 respectively, to propagate through the color filter,” as recited in claim 15. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

10. Claim 16: “The focus scanner according to claim 15, where the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source.”

760. As I explained in Section VII.N, Fisker teaches or suggests the subject matter of claim 16. The explanations that I provided in Section VII.N are also applicable here.

761. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “where the surface geometry information is derived from light in a selected wavelength range of the spectrum provided by the multichromatic light source,” as recited in claim 16. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

11. Claim 18: “The focus scanner according to claim 16, wherein the selected wavelength range matches the W2 wavelength range.”

762. As I explained in Section VII.O, Fisker teaches or suggests the subject matter of claim 18. The explanations that I provided in Section VII.O are also applicable here.

763. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “wherein the selected wavelength range matches the W2 wavelength range,” as recited in claim 18. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

12. Claim 21: “The focus scanner according to claim 3, where the information of the saturated pixel in the computing of the pattern generating element is configured to provide that the spatial pattern comprises alternating dark and bright regions arranged in a checkerboard pattern.”

764. As I explained in Section VII.F, Fisker teaches a pattern generating element configured for incorporating a spatial pattern in said probe light. Fisker further teaches that the illuminated pattern may be “a static checkerboard pattern” having dark and light (i.e., bright) regions. (Ex.1005, [0023].) For example, Fisker’s Figure 3c illustrates “a static pattern as applied in a spatial correlation embodiment of this invention.” (Ex.1005, [0249].) Fisker continues, “the

checkerboard pattern shown is preferred because calculations for this regular pattern are easiest.” (*Id.*)

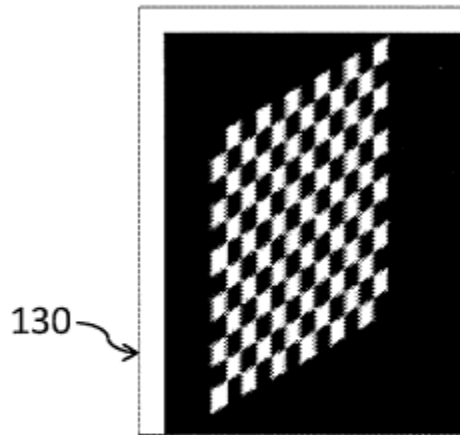


Fig. 3c

765. Fisker’s dark and light checkerboard pattern teaches alternating dark and bright regions arranged in a checkerboard pattern. Thus, Fisker teaches “where the information of the saturated pixel in the computing of the pattern generating element is configured to provide that the spatial pattern comprises alternating dark and bright regions arranged in a checkerboard pattern,” as recited in claim 21.

13. Claim 26: “The focus scanner according to claim 9, wherein said at least one additional 2D image comprises a neighboring 2D image from the series of captured 2D images.”

766. As I explained in Section VII.S, Fisker teaches or suggests the subject matter of claim 26. The explanations that I provided in Section VII.S are also applicable here.

767. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “wherein said at least one additional 2D image comprises a neighboring 2D image from the series of captured 2D images,” as recited in claim 26. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

14. Claim 28: “The focus scanner according to claim 10, where the interpolation is of surface color information of neighboring 2D images in a series.”

768. As I explained in Section VII.T, Fisker teaches or suggests the subject matter of claim 28. The explanations that I provided in Section VII.T are also applicable here.

769. Thus, the combinations of (a) Thiel425, Thiel576, Szeliski, and Fisker and (b) Thiel425, Thiel576, Matsumoto, and Fisker teach or suggest “where the interpolation is of surface color information of neighboring 2D images in a series,” as recited in claim 28. And, as I explained in Section XVIII.B above, a POSITA would have been motivated to enhance the combinations of (a) Thiel425, Thiel576, Szeliski and (b) Thiel425, Thiel576, Matsumoto with the teachings of Fisker.

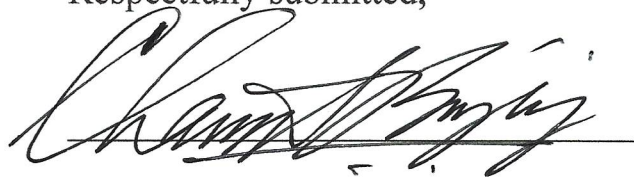
XIX. Conclusion

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

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed this 29th day of October, 2018

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Chandrajit L. Bajaj', is written over a horizontal line.

Dr. Chandrajit L. Bajaj, Ph.D.