

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

DENTAL IMAGING TECHNOLOGIES CORPORATION

Petitioner

v.

3SHAPE A/S

Patent Owner

U.S. Patent No. 11,076,146 to Fisker *et al.*

Issue Date: July 27, 2021

Title: FOCUS SCANNING APPARATUS

**Petition for *Inter Partes* Review of U.S. Patent No. 11,076,146
under 35 U.S.C. §§ 311-319 and 37 C.F.R. § 42.100 *et seq.***

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	STATEMENT OF PRECISE RELIEF REQUESTED	1
III.	OVERVIEW OF THE '146 PATENT AND FILE HISTORY	3
	A. The '146 Patent	3
	B. Prosecution History of the '146 Patent	5
IV.	OVERVIEW OF PRIOR ART.....	6
	A. Babayoff.....	6
	B. Zhang.....	8
	C. Knighton.....	9
	D. Hanson.....	11
	E. Gandyra	12
V.	LEVEL OF ORDINARY SKILL IN THE ART	13
VI.	CLAIM CONSTRUCTION.....	14
VII.	GROUND 1: CLAIMS 21, 23-27, AND 29 ARE OBVIOUS OVER BABAYOFF AND ZHANG AND KNIGHTON.....	14
	A. A POSA Would Have Been Motivated to Combine Babayoff with Zhang and Knighton.....	14
	B. Claim 21	16
	C. Claim 23	38
	D. Claim 24	41
	E. Claim 25	43
	F. Claim 26	44

G.	Claim 27	45
H.	Claim 29	48
VIII. GROUND 2: CLAIMS 1, 3-6, 8-13, 15, 20, AND 22 ARE OBVIOUS OVER BABAYOFF AND ZHANG AND KNIGHTON AND HANSON		49
A.	Motivation to Combine Babayoff and Zhang and Knighton and Hanson.....	49
B.	Claim 1	50
C.	Claim 3	63
D.	Claim 4	64
E.	Claim 5	64
F.	Claim 6	64
G.	Claim 8	65
H.	Claim 9	66
I.	Claim 10	66
J.	Claim 11	67
K.	Claim 12	67
L.	Claim 13	68
M.	Claim 15	68
N.	Claim 20	68
O.	Claim 22	70
IX. GROUND 3: CLAIM 2 IS OBVIOUS OVER BABAYOFF AND ZHANG AND KNIGHT AND HANSON AND GANDYRA		71
A.	Claim 2	71

X.	MANDATORY NOTICES PURSUANT TO 37 C.F.R. § 42.8	72
A.	Real Party-In-Interest (37 C.F.R. § 42.8(b)(1))	72
B.	Related Matters (37 C.F.R. § 42.8(b)(2)).....	72
C.	Counsel and Service Information (37 C.F.R. § 42.8(b)(3), 42.8(b)(4))	73
D.	Payment of Fees	74
XI.	GROUND FOR STANDING.....	74
XII.	DISCRETIONARY ANALYSIS FOR REVIEW.....	75
XIII.	CONCLUSION	75

TABLE OF EXHIBITS

Exhibit No.	Description
1001	U.S. Patent No. 11,076,146 (“the ’146 patent”)
1002	Declaration of Dr. Mohit Gupta (“Gupta Decl.”)
1003	<i>Curriculum Vitae</i> of Dr. Mohit Gupta
1004	Prosecution History of U.S. Patent No. 11,076,146
1005	U.S. Patent App. Pub. No. 2008/0024768 to Noam Babayoff (“Babayoff”)
1006	T. Wilson <i>et al.</i> , “Real-time three-dimensional imaging of macroscopic structures,” <i>Journal of Microscopy</i> , Vol. 191, Pt. 2, August 1998, pp. 116-118 (“Wilson”)
1007	U.S. Patent App. Pub. No. 2005/0237581 to Knighton <i>et al.</i> (“Knighton”)
1008	U.S. Patent App. Pub. No. 2003/0043089 to Hanson <i>et al.</i> (“Hanson”)
1009	U.S. Patent App. Pub. No. 2009/0087050 to Michael Gandyra (“Gandyra”)
1010	M. A. A. Neil <i>et al.</i> , “Method of obtaining optical sectioning by using structured light in a conventional microscope,” <i>Optics Letters</i> , Vol. 22, No. 24, December 15, 1997, pp. 1905-1907 (“Neil”)
1011	L. Zhang <i>et al.</i> , “Projection Defocus Analysis for Scene Capture and Image Display,” <i>ACM SIGGRAPH 2006</i> , July 2006, pp. 907-915 (“Zhang”)
1012	Declaration of Dr. James L. Mullins (“Mullins Decl.”)

LIST OF CHALLENGED CLAIMS

Claim	Limitation
1[pre]	An intraoral scanner for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, the intraoral scanner comprising:
1[a]	at least one camera accommodating an array of sensor elements;
1[b]	a pattern generator configured to generate, using a light source, a probe light with a plurality of configurations in the form of a time-varying illumination pattern;
1[c]	an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object with the time-varying illumination pattern, and for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;
1[d]	a tip configured to be inserted into the oral cavity; and
1[e]	a hardware processor configured to:
1[e][1]	selectively switch a color of the probe light, thereby illuminating the object with different colors at different times;
1[e][2]	record different images by the at least one camera at the different times, thereby recording images of the object with the different colors; and
1[e][3]	combine the different colors from the different images, thereby obtaining the color of the surface of the object,
1[f]	wherein the intraoral scanner is wireless, and wherein the at least one camera is a high-speed camera.
2	The intraoral scanner according to claim 1, wherein the pattern generator includes at least one translucent and/or transparent

Claim	Limitation
	pattern element.
3	The intraoral scanner according to claim 1, wherein the pattern generator is based on a projector such as a liquid crystal display (LCD) projector or a digital light processing (DLP) projector.
4	The intraoral scanner according to claim 1, wherein the different colors are provided by at least three monochromatic light sources of the light source.
5	The intraoral scanner according to claim 4, wherein the at least three monochromatic light sources are light-emitting diodes (LEDs) or a segmented LED.
6	The intraoral scanner according to claim 4, wherein the hardware processor is configured to selectively switch the color of the probe light by switching on and off the at least three monochromatic light sources.
8	The intraoral scanner according to claim 1, wherein the probe light is directed towards the object in a direction substantially parallel with the longitudinal axis of the tip, and wherein the probe light is further reflected towards the object by a single reflective mirror located in the tip.
9	The intraoral scanner according to claim 1, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.
10	The intraoral scanner according to claim 1, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.

Claim	Limitation
11	The intraoral scanner according to claim 9, wherein the data for the 3D geometry is wirelessly transmitted to a workstation.
12	The intraoral scanner according to claim 9, wherein the hardware processor processes the raw 3D data into data for the 3D geometry in real time.
13	The intraoral scanner according to claim 1, wherein a temporal correlation measure is computed with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed.
15	The intraoral scanner according to claim 13, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.
20	The intraoral scanner according to claim 1, wherein the intraoral scanner further comprises polarization optics.
21[pre]	A method for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, said method comprising the steps of:
21[a]	using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern;
21[b]	transmitting the probe light, through a tip of intraoral scanner inserted into the oral cavity, towards the object along an optical path, thereby illuminating at least a part of the object with the time-varying illumination pattern;
21[c]	transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a plurality of 2D images,

Claim	Limitation
21[d]	wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;
21[e]	selectively switching a color of the probe light, thereby illuminating the object with different colors at different times;
21[f]	recording different images by the at least one camera at the different times, thereby recording images of the object with the different colors;
21[g]	combining the different colors from the different images to obtain the color of the surface of the object; and
21[h]	wirelessly transmitting the data for the 3D geometry.
22	The method according to claim 21, wherein the plurality of 2D images is recorded using a high-speed camera.
23	The method according to claim 21, wherein the method further comprises a step of locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.
24	The method according to claim 21, wherein the method further comprises a step of locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.
25	The method according to claim 23, wherein the step of wirelessly transmitting the data for the 3D geometry is to a workstation.
26	The method according to claim 23, wherein the step of locally processing is in real time.

Claim	Limitation
27	The method according to claim 21, where the method further comprises a step of computing a temporal correlation measure with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed.
29	The method according to claim 27, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.

I. INTRODUCTION

Petitioner Dental Imaging Technologies Corporation (“Petitioner” or “DITC”), in accordance with 35 U.S.C. §§ 311-319 and 37 C.F.R. § 42.100 *et seq.*, respectfully requests *inter partes* review of Claims 1-6, 8-13, 15, 20-27, and 29 (the “Challenged Claims”) of U.S. Patent No. 11,076,146 (“the ’146 patent”) (EX. 1001), which, according to USPTO records, is assigned to 3Shape A/S (“Patent Owner”).

II. STATEMENT OF PRECISE RELIEF REQUESTED

Petitioner respectfully requests that claims 1-6, 8-13, 15, 20-27, and 29 of the ’146 patent be canceled based on the following grounds:

Ground 1: Claims 21, 23-27, and 29 of the ’146 patent are unpatentable under pre-AIA 35 U.S.C. § 103 as obvious based on U.S. Patent App. Pub. No. 2008/0024768 to Babayoff (“Babayoff”) (Ex. 1005) in view of L. Zhang *et al.*, “Projection Defocus Analysis for Scene Capture and Image Display,” ACM SIGGRAPH 2006, July 2006, pp. 907-915 (“Zhang”) (Ex. 1011) and U.S. Patent App. Pub. No. 2005/0237581 to Knighton *et al.* (“Knighton”) (Ex. 1007).

Ground 2: Claims 1, 3-6, 8-13, 15, 20, and 22 of the ’146 patent are unpatentable under pre-AIA 35 U.S.C. § 103 as obvious based on Babayoff in view of Zhang and Knighton and U.S. Patent App. Pub. No. 2003/0043089 to Hanson *et al.* (“Hanson”) (Ex. 1008).

Ground 3: Claim 2 of the '146 patent is unpatentable under pre-AIA 35 U.S.C. § 103 as obvious based on Babayoff in view of Zhang and Knighton and Hanson and U.S. Patent App. Pub. No. 2009/0087050 to Gandyra (“Gandyra”) (Ex. 1009).

The '146 patent was filed on March 19, 2021, and claims priority to U.S. Provisional Patent Application No. 61/187,744, filed on June 17, 2009. For purposes of this IPR, June 17, 2009 is assumed to be the “effective date,” although Petitioner reserves the right to challenge that date in other proceedings.

Babayoff published on January 31, 2008. Ex. 1005, Cover. Zhang published in July 2006. Ex. 1011, p. 907; Ex. 1012, Declaration of Dr. James L. Mullins (“Mullins Decl.”), ¶¶71-89. Dr. Mullins states that Zhang (Ex. 1011) is an *authentic* document and would have been *publicly accessible* through the Library of Congress no later than August 25, 2006. Ex. 1012, ¶89. Knighton published on October 27, 2005. Ex. 1007, Cover. Hanson published on March 6, 2003. Ex. 1008, Cover. Therefore, Babayoff, Zhang, Knighton, and Hanson are prior art under pre-AIA 35 U.S.C. § 102(b). Gandyra was filed on August 18, 2008 and published on April 2, 2009. Ex. 1009, Cover. Therefore, Gandyra is prior art under at least pre-AIA 35 U.S.C. § 102(e).

Babayoff, Zhang, Knighton, Hanson, and Gandyra were not considered by the Patent Office during prosecution. While a reference (U.S. 2005/0283065)

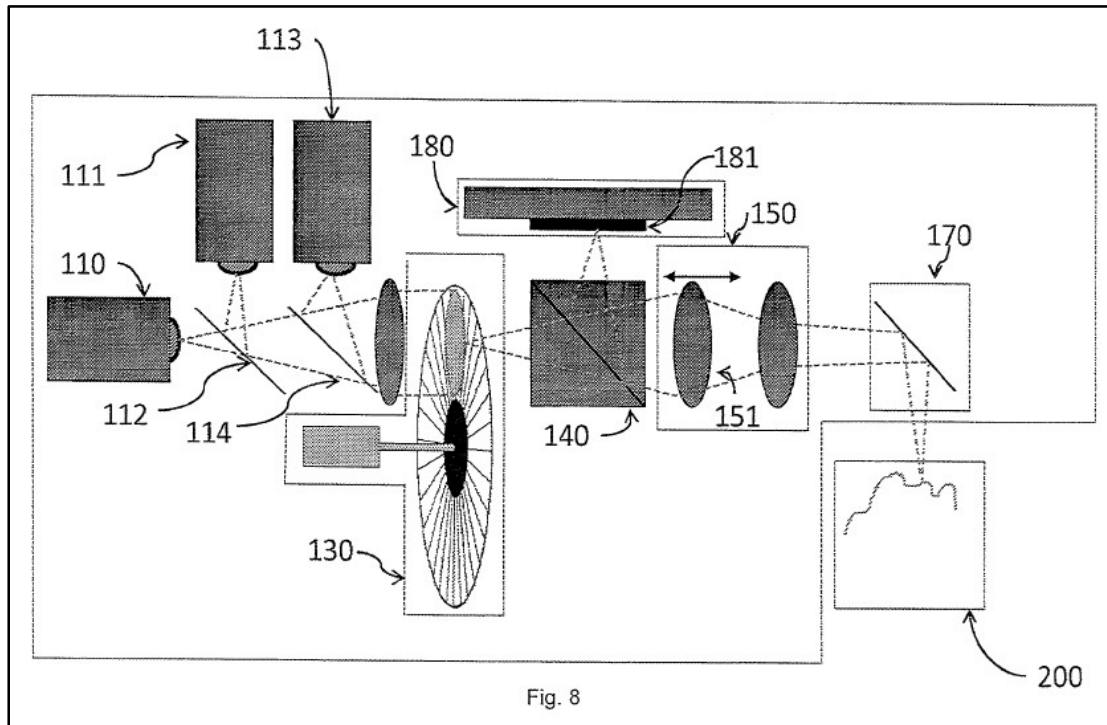
similar to Babayoff was considered, it was not considered in combination with Zhang, Knighton, Hanson, or Gandyra. Ex. 1001.

As detailed in the Grounds below, this Petition presents “a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition.” 35 U.S.C. § 314(a). Therefore, the threshold requirement is met for *inter partes* review.

III. OVERVIEW OF THE '146 PATENT AND FILE HISTORY

A. The '146 Patent

The '146 patent relates to a scanner for intraoral scanning of objects such as teeth. Ex. 1001, Abstract, 1:24-30. The scanner obtains the 3D geometry of at least part of the surface of the object and also determines the color of at least part of the surface of the object. *Id.*, 2:43-45, 33:45-34:18. An example of the device for scanning for surface shape and color is shown in FIG. 8:



Id., FIG. 8.

The scanner includes a pattern generator to create a pattern of light, such as a line pattern or checkerboard pattern, on the object being scanned. *Id.*, 8:38-57, 27:20-28, 28:4-13. The pattern is made to be time-varying by rotating and/or translating a pattern element such that the pattern moves across the object being scanned. *Id.*, 3:9-14, 4:62-65, 8:38-58, 10:57-59. The scanner further varies the position of a focal plane for the scanner and obtains images with the time-varying pattern on the object at the different focal plane positions. *Id.*, 3:34-46, 6:62-7:50, 12:1-5. The scanner then uses images from the focal plane positions to determine, for each pixel, the focal plane for which the pixel is most in-focus and uses that information to determine the 3D surface information. *Id.*, 3:59-4:8.

The '146 patent states that a time varying pattern is: a pattern that varies in time (*Id.*, 4:62-65); and can be created by moving a pattern across the object being scanned (*Id.*, 3:11-14, 8:54-57, 10:57-59). The '146 patent contrasts a time varying pattern with a static pattern by indicating that a time varying pattern can be generated by rotating and/or translating a pattern element to move the pattern across the object while a pattern element generating a static pattern does not need to be moved during a scan. *Id.*, 8:54-57.

The scanner further includes three light sources that emit red, green, and blue light. *Id.*, 33:45-48. In the preferred embodiment, one light source is switched on at a time, and an image is taken of the object for each of the light sources individually. *Id.*, 33:53-60. The color of the surface of the object is then determined based on the amplitude signal for each color in the captured images. *Id.*, 33:64-67.

The scanner head may be wireless. *Id.*, 9:16-21. The camera used to obtain the images can be a high-speed camera with multiple analog-to-digital (A/D) converters per line of pixels. *Id.*, 8:1-8. The '146 patent states that a standard camera has one A/D converter per line of pixels, but that a “high-speed” camera accommodates multiple A/D converters per line of pixels. *Id.*

B. Prosecution History of the '146 Patent

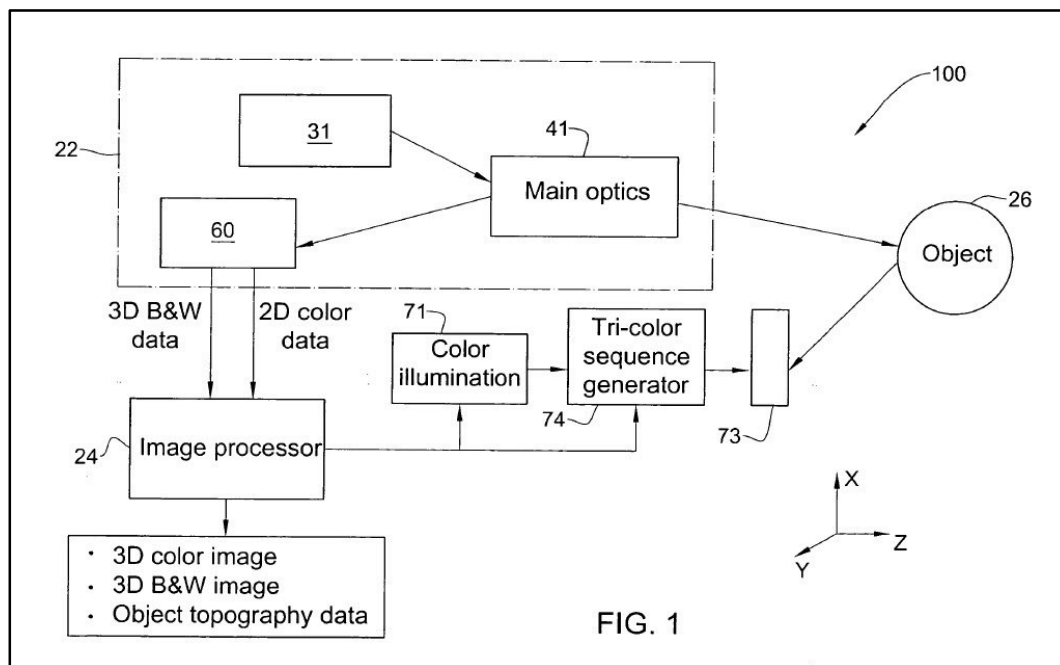
The issued claims of the '146 patent were added by preliminary amendment

prior to examination, and the claims went directly to allowance. Ex. 1004.

IV. OVERVIEW OF PRIOR ART

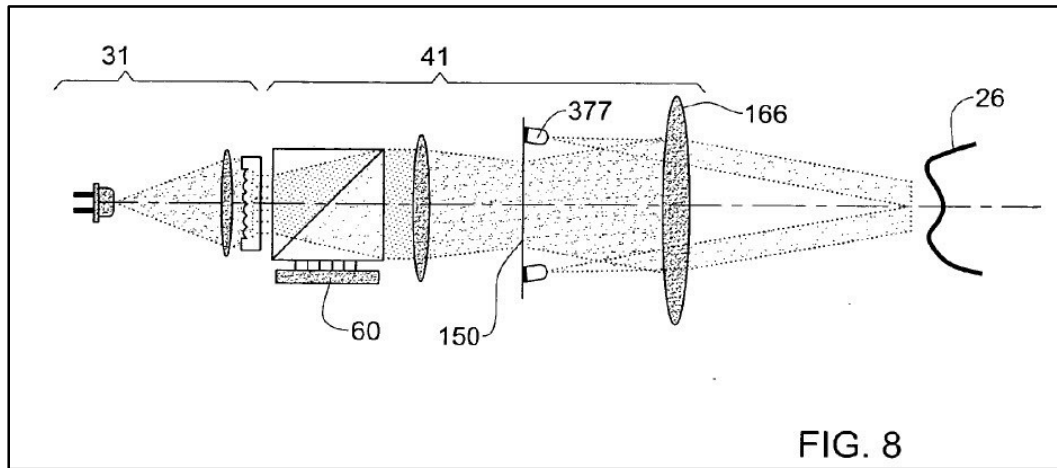
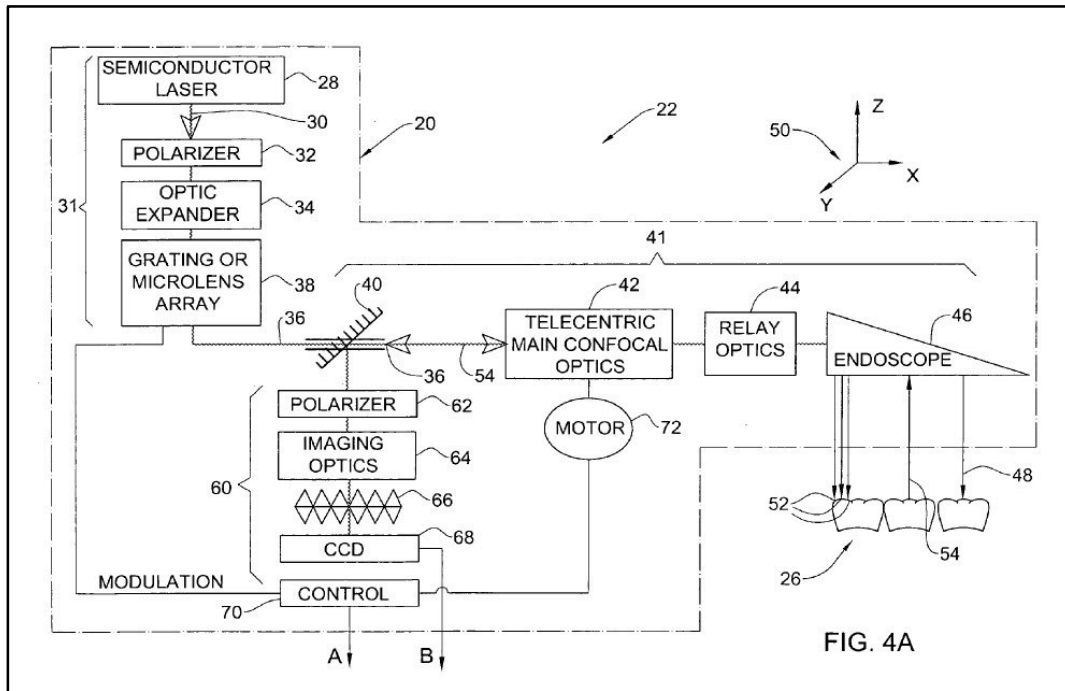
A. Babayoff

Babayoff discloses a scanner for the intraoral scanning of objects such as teeth. Ex. 1005, Abstract, [0001], [0009], [0129]. The scanner obtains the 3D geometry of at least part of the surface of the object and also determines the color of at least part of the surface of the object. *Id.*, [0010]-[0015], [0021]-[0048], [0063]-[0066], [0129]-[0131], [0134]-[0150]. An example embodiment of the device for scanning for surface shape and color is shown in FIG. 1:



Id., FIG. 1.

Babayoff teaches examples of the scanner in FIGS. 4A and 8 as follows:



The scanner is a confocal scanner, varies the position of a focal plane, and obtains images of the object at the different focal plane positions using an image sensor. *Id.*, [0010]-[0011], [0032], [0142]. The scanner then uses images from the focal plane positions to determine, for each pixel, the focal plane for which the pixel is most in-focus and uses that information to determine the 3D surface

information for the pixel. *Id.*, [0013]-[0015], [0034], [0143].

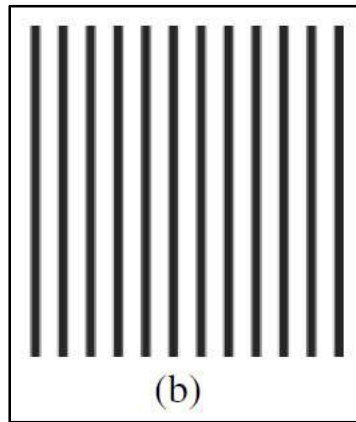
The scanner further includes three light sources that emit red, green, and blue light. *Id.*, [0063]-[0066], [0079], [0130], [0157]. In a preferred embodiment, only one light source is switched on at a time, and an image is taken of the object for each of the light sources individually. *Id.* The color of the surface of the object is then determined based on the signal for each color in the captured images. *Id.*, [0063], [0079], [0130], [0145].

B. Zhang

Similar to Babayoff, Zhang discloses a coaxial imaging system, and Zhang explains that an alternative to a camera focus/defocus method for obtaining 3D shape information is a projection defocus method in which an illumination pattern is shifted across a scene to allow for measuring depth information for a 3D shape. Ex. 1011, pp. 907-910, Figs. 1, 2. Zhang explains that multiple images are taken as the illumination pattern is shifted across the scene, and depth information is determined for each camera pixel using the images and knowledge of the illumination pattern. *Id.* Zhang provides an example of the illumination pattern as a stripe pattern that is shifted across the scene and can be formed, for example, by a Digital Light Processing (DLP) or Liquid Crystal Display (LCD) projector. *Id.*, pp. 907, 909, Fig. 2.

An example of the illumination pattern that is shifted across the scene is

shown in Figure 2(b) of Zhang as follows:



Id., Fig. 2(b). Zhang provides example scenes on which the depth recovery method of Zhang was performed, and one of the example scenes includes toy teeth. *Id.*, Fig. 4.

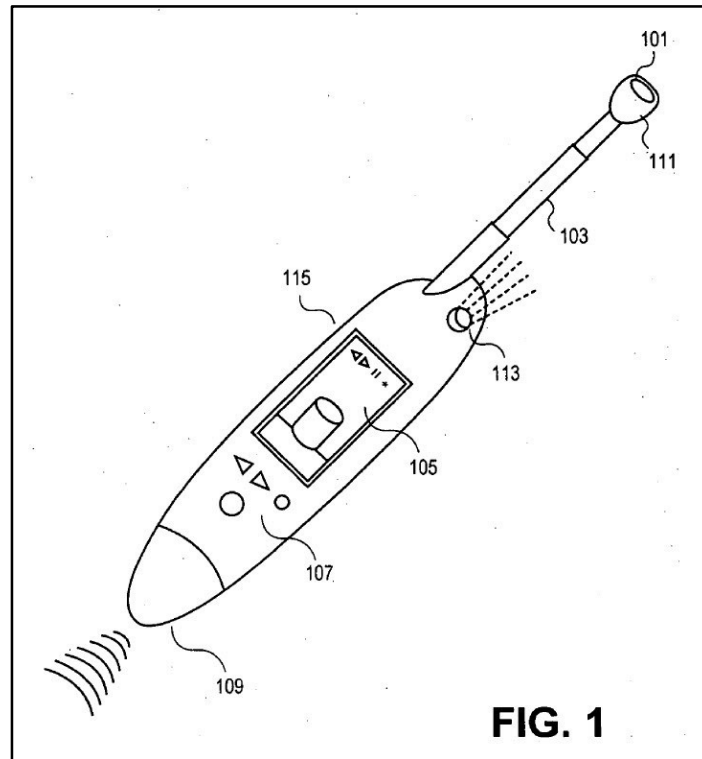
Zhang provides the motivation for using a projection defocus method with a shifting illumination pattern as an alternative to a camera focus/defocus method by explaining that the projection defocus method for obtaining 3D shape information is more accurate near depth discontinuities, is simple, has lower computational complexity, is not subject to local minima, and is independent of scene geometry and texture, which makes it superior to camera defocus for depth estimation. *Id.*, pp. 907-908, 914.

C. Knighton

Knighton discloses a hand-held scanner similar to Babayoff's for scanning an object to obtain 3D information for the surface of the object. Ex. 1007, Abstract, [0024]-[0025], [0033], [0038], [0045], [0049], [0093], FIGS. 1, 3. Knighton

similarly discloses the capture of multiple images at distinct focus positions and then producing a depth map for the three-dimensional data based on the light intensities from the captured images. *Id.*, [0026]-[0027], [0047]-[0053], FIG. 4. Knighton teaches that the processor 301 for performing the processing can be included in the hand-held device such that the processing is performed locally at the hand-held device to generate the 3D geometry data. *Id.*, [0025], [0029], [0038]-[0039], [0041], [0049], [0054], [0093], FIG. 3. Knighton further explains that the hand-held device can include a communications device and an antenna for wirelessly transmitting the data for the 3D geometry. *Id.*, [0033], [0038], [0045], [0049], [0054], [0093], FIGS. 1, 3.

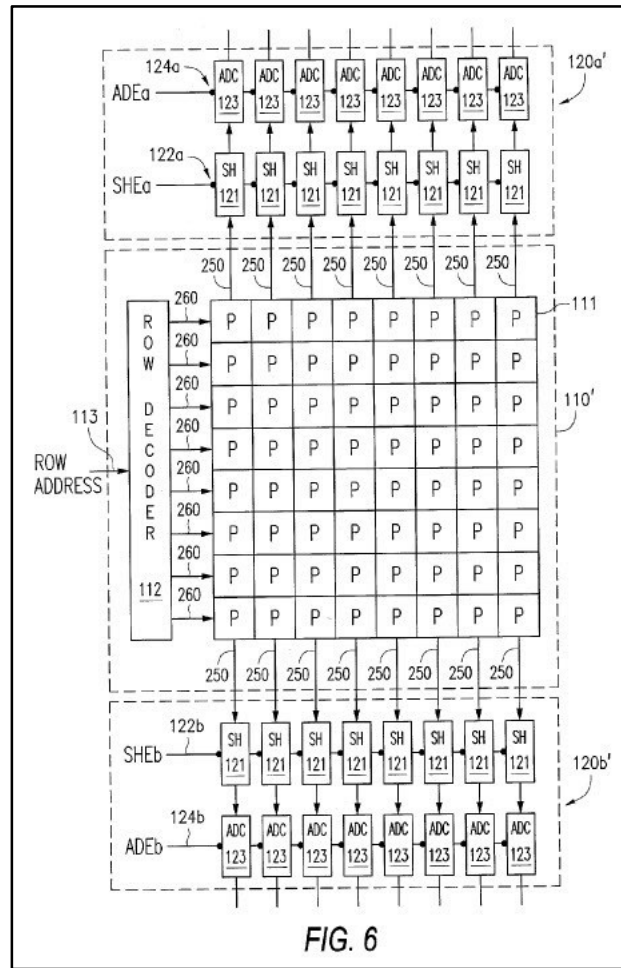
FIG. 1 of Knighton depicts the wireless communication device 109 wirelessly transmitting data from the hand-held scanner.



Id., FIG. 1. Knighton explains that the wireless communication device 109 may be a radio frequency (RF) transmitter, cellular device, IEEE 802.11 device, or similar transmitter, and may support the Bluetooth standard, TCP/IP communication, and similar communication standards. *Id.*, [0033].

D. Hanson

Hanson discloses that an image sensor can have multiple A/D converters per line of pixels in a pixel array to increase the speed of the image sensor. Ex. 1008, Abstract, [0017], [0028], [0030]-[0037], FIGS. 3, 5, 6. FIG. 6 of Hanson shows a pixel array 110' as well as analog processing and digitizing circuits 120a', 120b', which each include a plurality of A/D converters 123.

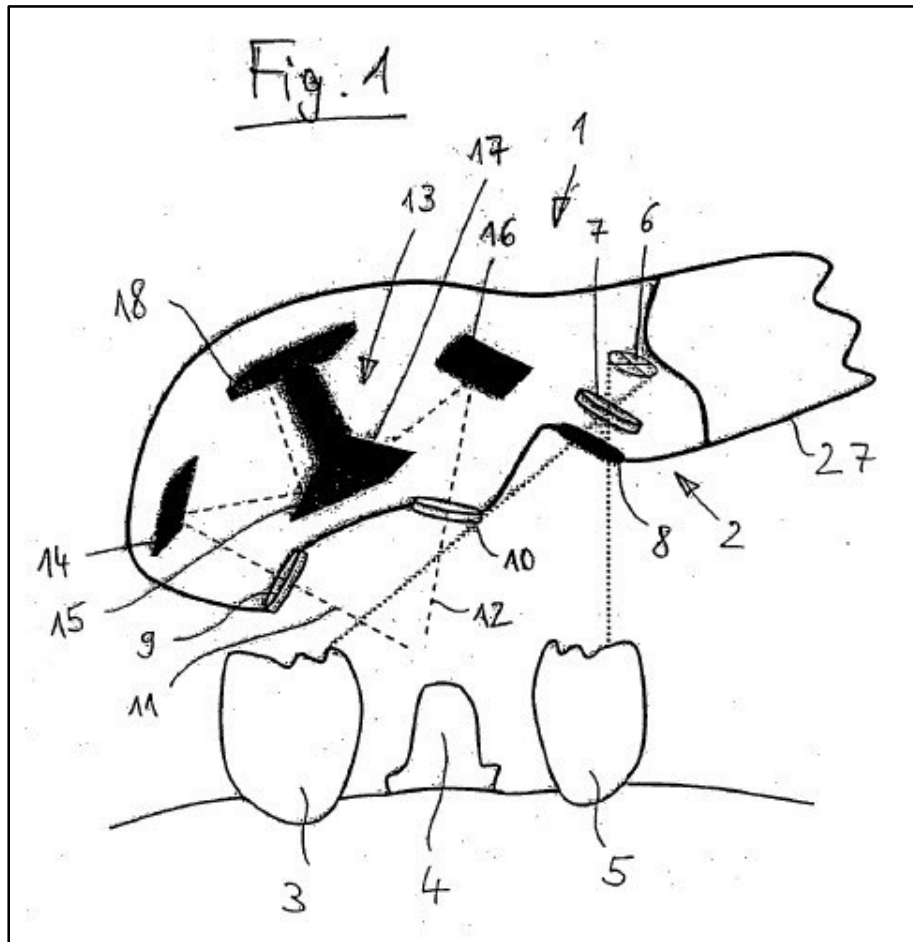


Id., FIG. 6.

Hanson explains that having the multiple A/D converters 123 allows for the image sensor to be “high speed.” *Id.*, [0017], [0028], [0030]-[0037].

E. Gandyra

Gandyra also discloses an intraoral scanner for scanning teeth and teaches the use of a time-variable illumination pattern for the scanning. Ex. 1009, Abstract, [0001], [0030], [0038], FIG. 1. An example of the intraoral scanner is shown in FIG. 1:



Gandyra teaches that the pattern can be any graphical pattern such as lines, and further teaches that the pattern can be produced using a pattern transparency, which is a transparent pattern element. *Id.*, [0030], [0038]. Gandyra also teaches that the time-varying pattern can be produced using a transmitted-light LCD or a DLP projection. *Id.*, [0030], [0038].

V. LEVEL OF ORDINARY SKILL IN THE ART

As explained in the Declaration of Dr. Mohit Gupta (Ex. 1002) (“Gupta Decl.”), a person of ordinary skill in the art (“POSA”) as of the effective filing date

of the '146 patent would have had a bachelor's degree in Computer Engineering, Computer Science, Electrical Engineering, Physics, or an equivalent field, as well as at least one or two years of design experience, or alternatively, at least five years of comparable industry experience. In particular, a POSA would have had experience with and knowledge of 3D imaging systems and 3D modeling techniques. Ex. 1002, ¶25.

VI. CLAIM CONSTRUCTION

No terms in the challenged claims have been construed in any civil action. Petitioner submits that, for purposes of this proceeding, all claim terms should be given their ordinary and customary meaning.

VII. GROUND 1: CLAIMS 21, 23-27, AND 29 ARE OBVIOUS OVER BABAYOFF AND ZHANG AND KNIGHTON

A. A POSA Would Have Been Motivated to Combine Babayoff with Zhang and Knighton

Babayoff discloses a scanner for the intraoral scanning of objects such as teeth. Ex. 1005, Abstract, [0001]. Babayoff uses the *illumination source 31*, which includes a *light* and a *grating* called the *module 38* to create a *static pattern* while capturing images. *Id.*, [0134], [0135], FIGS. 4A, 8. Babayoff employs at least partially a *camera defocus method* to determine depth information from the captured 2D images. In particular, the scanner in Babayoff uses images from multiple focal plane positions to determine, for each pixel, the focal plane for

which the pixel is most *in-focus* and uses that information to determine the 3D surface information. *Id.*, [0013]-[0015].

Zhang discloses a coaxial imaging system like Babayoff and shows an example in which it is used to image *teeth* of a toy. Ex. 1011, pp. 907-910, Figs. 1, 2, 4. Zhang explains that an *alternative* to a *camera defocus method* for obtaining 3D shape information is a *projection defocus method* in which an illumination pattern is *shifted* across a scene to allow for measuring depth information. *Id.*, pp. 907-910, Figs. 1, 2. To perform the projection defocus method instead of the camera defocus method, the *illumination source 31* in Babayoff would be *replaced with the DLP or LCD projector of Zhang* to create a *time-varying illumination pattern*. Then, the 2D images would be captured as the pattern is shifted, and the equations of Zhang would be used to determine the depth information. Ex. 1002, ¶¶57-58. A POSA would have understood how to size the projector to fit within a hand-held device, as is exemplified by Gandyra. *Id.*; Ex. 1009, [0030], [0038]. Gandyra shows in FIG. 2 that a *DLP or LCD projector* can be included in a *hand-held device for scanning teeth*. *Id.*, FIG. 2, [0030], [0038].

Zhang itself provides the *motivation* for using a *projection defocus method* as an alternative to the *camera defocus method* by explaining that the *projection defocus method* is *more accurate* near depth discontinuities, is *simple*, has *lower computational complexity*, is *not subject to local minima*, and is *independent of*

scene geometry and texture, which makes it *superior* to camera defocus for depth estimation. Ex. 1011, pp. 907-908, 914; Ex. 1002, ¶¶57-58.

Babayoff does not explicitly state that communication of data from the hand-held scanner is wireless. Knighton discloses a *hand-held scanner* similar to Babayoff's for scanning an object. Ex. 1007, Abstract, FIGS. 1, 3. Knighton further explains that the *hand-held scanner* can include a *communications device* for *wirelessly* transmitting the data for the 3D geometry. *Id.*, [0033], [0045].

It would have been obvious to a POSA to modify the hand-held device of Babayoff based on the teaching of Knighton to include the *wireless communication device 109* to *wirelessly* transmit the *data for the 3D geometry*. Ex. 1002, ¶78. A POSA would have been *motivated* to modify the device of Babayoff to use *wireless communication* as taught by Knighton because it would allow for the device to be *wireless* and, therefore, *easier to carry around* with *improved usability* in that the device would be *more maneuverable* with respect to an object being imaged. Ex. 1002, ¶82.

B. Claim 21

[preamble] A method for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, said method comprising the steps of:

To the extent that the preamble of claim 21 is limiting, Babayoff discloses the features of the preamble. Ex. 1002, ¶49. Babayoff discloses a method for

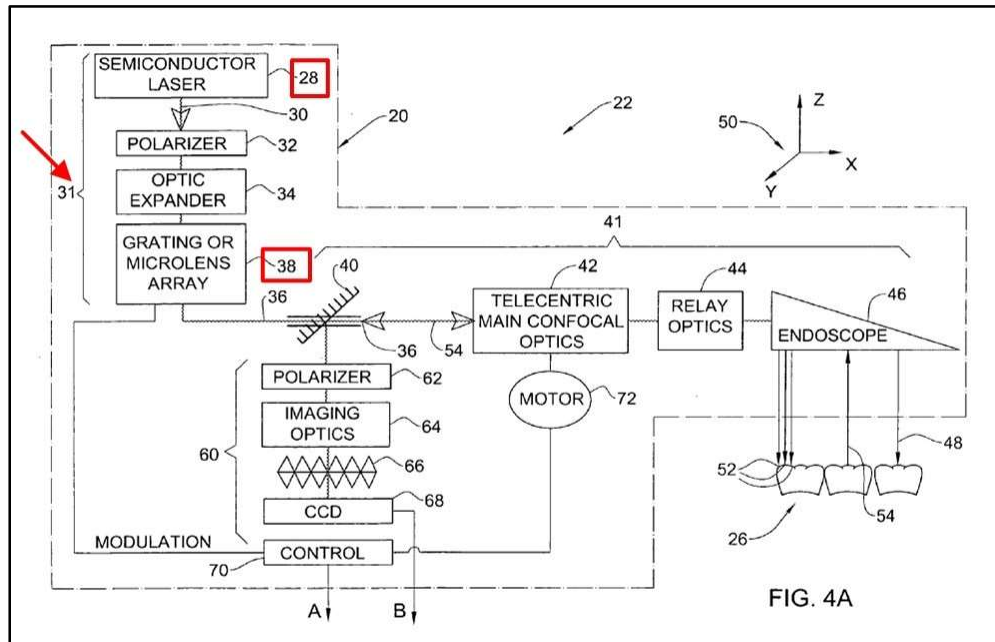
determining the surface topology and associated color of a structure, such as a teeth segment in an oral cavity. Ex. 1005, Abstract, [0009], [0021], [0023]. Babayoff shows an example structure to be scanned as the object 26 in FIGS. 4A, 5C, and 8, which is explained by Babayoff to be *one or more teeth* in an *intraoral cavity*. *Id.*, Abstract, [0009], [0129], [0183], FIGS. 4A, 5C, 8. Babayoff states that the surface topology that is determined of the object is a *3D surface topology*, which provides the *3D geometry of the object*. *Id.*, Abstract, [0010], [0020]-[0022], [0129], [0131], [0143], FIGS. 2A, 2B. Babayoff discloses that the *color of the object* is also determined and is associated with the 3D geometry of the object to provide a 3D digital representation of the object including *color*. *Id.*, Abstract, [0001], [0009], [0020]-[0022], [0028], [0129]-[0131]. Thus, Babayoff discloses a method for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, because Babayoff discloses determining the 3D geometry and color of the surface of teeth in an oral cavity.

[a] using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern;

Babayoff in combination with Zhang satisfies these limitations of claim 21. Ex. 1002, ¶¶50-58. The *light source* in Babayoff is part of the *illumination source 31*, which is also called the *illuminating unit 31*, as shown for example in the embodiments of FIGS. 4A and 8. Ex. 1005, [0030], [0134], [0135], [0139], [0156]-

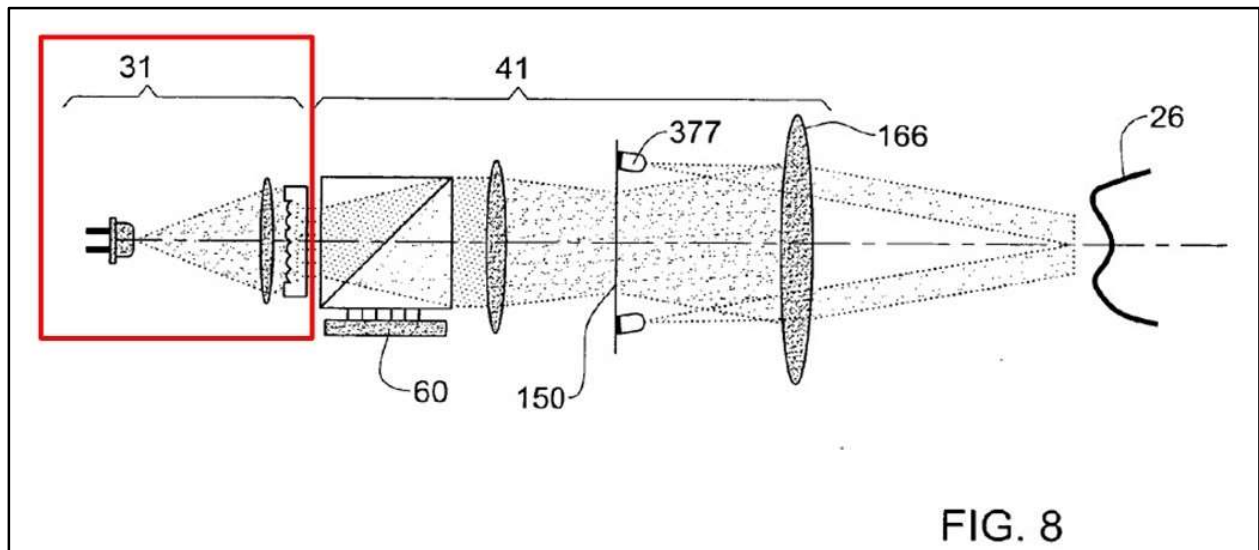
[0157], FIGS. 1, 4A, 8. Namely, FIG. 4A of Babayoff shows the **light source** as the **semiconductor laser unit 28**, and FIG. 8 of Babayoff shows a **light** as the **light source**. *Id.* The **pattern generator** in Babayoff is also part of the **illumination source 31**, and is shown in FIGS. 4A and 8 as a **grating** or **micro-lens array** called the **module 38**. *Id.*, [0135], FIGS. 4A, 8. Babayoff explains that the module 38 splits the parent light beam 30 into a plurality of incident light beams 36. *Id.* The plurality of incident light beams 36 travel through the main optics 41 to provide the incident light beams 48, which are an array of light beams and therefore form a pattern on the surface of the object 26. *Id.*, [0135]-[0139], FIGS. 1, 4A, 8. Ex. 1002, ¶50. The **incident light beams 36** that become the **incident light beams 48** are a **probe light**. Ex. 1005, [0135]-[0139], FIGS. 1, 4A, 8. Ex. 1002, ¶50.

FIG. 4A of Babayoff is annotated in red below to show the illumination source 31 that includes the semiconductor laser unit 28 as well as the module 38 that is a grating or micro-lens array, which provides the incident light beams 36 that become the incident light beams 48.



Ex. 1005, FIG. 4A (annotated).

FIG. 8 of Babayoff is annotated in red below to similarly show the illumination source 31, a portion of which is a light source.



Id., FIG. 8 (annotated).

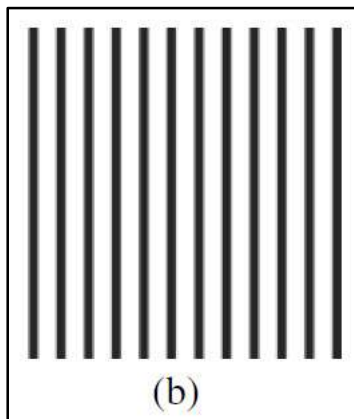
Babayoff discloses a method for determining a Z or depth coordinate for

each location on the object 26 for the 3D representation. *Id.*, [0010]-[0015], [0139]-[0143]. In particular, Babayoff provides motor 72 that is linked to the telecentric confocal optics 42 for changing the relative location of the focal plane of the optics 42 along the Z-axis. *Id.*, [0142], FIG. 4A. As explained in Babayoff, the motor 72 displaces the optical element 42 to change the focal plane location and then an image is captured by the image-capturing module 80 for that focal plane location. *Id.* This process is repeated for different focal plane locations with an image taken for each focal plane location, and the motor 72 is used to change between the focal plane locations. *Id.*, [0011], [0032], [0139]-[0142]. Babayoff then determines the Z-axis depth coordinate for each (X, Y) location by analyzing the light intensity at the location in the captured images. *Id.*, [0012]-[0015], [0139], [0143]. For determining the depth coordinates, therefore, Babayoff takes an image at each focal plane position using the light pattern as created by the illumination source 31. *Id.*, [0011], [0032], [0139]-[0142], FIGS. 4A, 8.

Babayoff does not explicitly disclose that the light pattern is time-varying. However, Zhang is in the same field as Babayoff because Zhang also discloses a confocal or coaxial imaging system like Babayoff for obtaining 3D shape information of objects including teeth, and Zhang discloses to use a *light source* and a *pattern generator* to generate a probe light with a plurality of configurations in the form of a *time-varying illumination pattern*. Ex. 1002, ¶54; Ex. 1011, pp.

907-910, Figs. 1, 2, 4, 9. As discussed above, Babayoff employs at least partially a *camera defocus method* for determining the depth coordinates. Ex. 1005, [0011], [0032], [0139]-[0142], FIGS. 4A, 8. Zhang discloses that *an alternative to a camera defocus method* for determining the depth coordinates is *a projection defocus method* in which *an illumination pattern is shifted across the object being imaged* to measure depth. Ex. 1011, pp. 907-910, 914-915, Figs. 1, 2.

Zhang provides an example of the *illumination pattern* as *a stripe pattern that is shifted across the scene* and can be formed, for example, by a *Digital Light Processing (DLP)* or *Liquid Crystal Display (LCD) projector*. *Id.*, pp. 907, 909, Fig. 2. An example of the *illumination pattern* that is *shifted across the scene* is shown in Figure 2(b) of Zhang as follows:



Id., Fig. 2(b).

The '146 patent states that a *time varying pattern* can be created by *moving a pattern across the object being scanned*. Ex. 1001, 3:11-14, 8:54-57, 10:57-59.

The *illumination pattern* of Zhang that is *shifted across the scene* at time intervals, therefore, is a *time-varying illumination pattern*. Ex. 1011, p. 909, Fig. 2(b). The *DLP or LCD projector* of Zhang is the *light source* and *pattern generator* to generate the *probe light* with the plurality of configurations in the form of the *time-varying illumination pattern*. *Id.*, pp. 907, 909, Figs. 1, 2. The *plurality of configurations* are *the stripes being translated across the scene*. *Id.*

It would have been obvious to a POSA, therefore, to *replace the illumination source 31* in Babayoff *with the DLP or LCD projector of Zhang* to create a *time-varying illumination pattern* and to determine depth using the *projection defocus method* of Zhang rather than the method of Babayoff, because Zhang's projection defocus method is more accurate near depth discontinuities, is simple, has lower computational complexity, is not subject to local minima, and is independent of scene geometry and texture. Ex. 1002, ¶57. Being independent of scene geometry is an advantage because then any type of scene can be imaged. In the combination, the *DLP or LCD projector* would be the *light source* and the *pattern generator* to generate the probe light with the plurality of configurations in the form of a time-varying illumination pattern, which is the *stripe pattern that is shifted across the scene*.

Motivation to Combine Babayoff and Zhang:

Zhang provides the *motivation* for using a *projection defocus method* with a

shifting illumination pattern *as an alternative to a camera defocus method* by explaining that the projection defocus method for obtaining 3D shape information is more accurate near depth discontinuities, is simple, has lower computational complexity, is not subject to local minima, and is independent of scene geometry and texture, which makes it superior to camera defocus for depth estimation. Ex. 1011, pp. 907-908, 914. A POSA, therefore, would have been motivated to *replace the illumination source 31* in Babayoff *with the DLP or LCD projector of Zhang* to create a *time-varying illumination pattern* and to determine depth using the *projection defocus method* of Zhang rather than the method of Babayoff in order to obtain those advantages.

A POSA would have expected such a combination to work for its intended purpose because Zhang already applied the time-varying illumination pattern technique to structures that are on the same scale as parts of teeth, including toys with *teeth*, so it would be expected to work for imaging teeth. Ex. 1002, ¶58; Ex. 1011, Figs. 4, 9. Further, the modification to the Babayoff device to include a *DLP or LCD projector* as taught by Zhang *in place of the illumination source 31* would have been straightforward for a POSA to implement because it is just the substitution of one known element for another. Ex. 1002, ¶58.

A POSA would have understood how to size the projector to fit within a hand-held device as is exemplified by Gandyra. *Id.*; Ex. 1009, [0030], [0038].

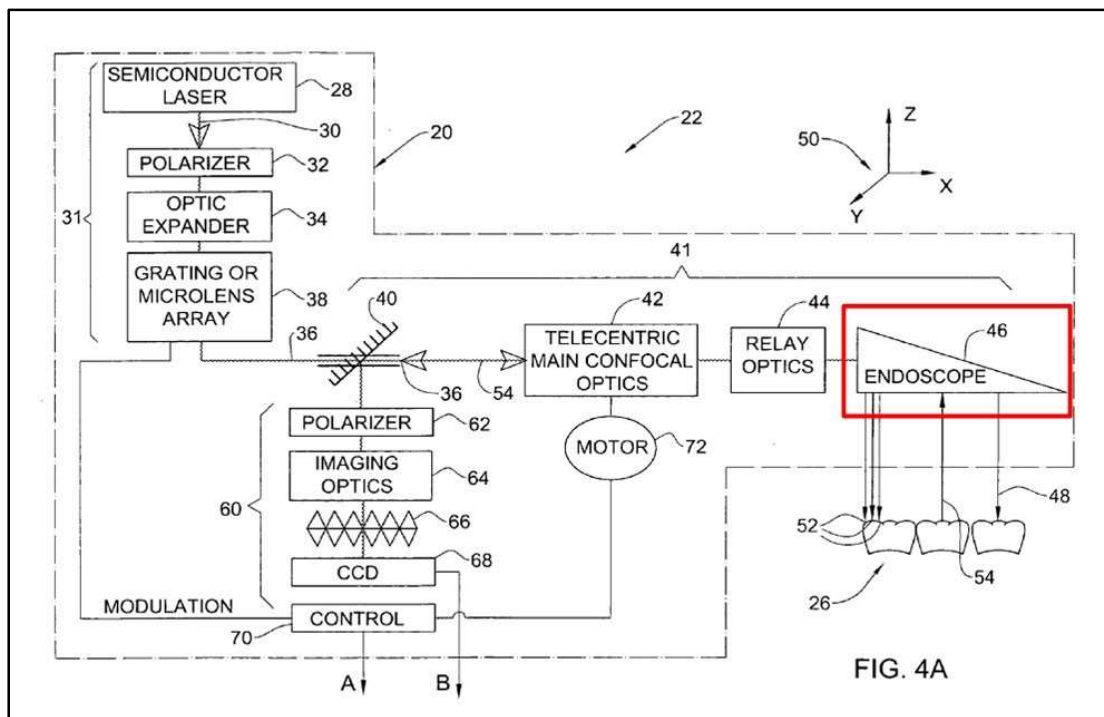
Gandyra shows in FIG. 2 that a ***DLP or LCD projector*** can be included in a ***hand-held device for scanning teeth***. *Id.*, FIG. 2, [0030], [0038]. The '146 patent itself also claims in dependent claim 3 to use a DLP or LCD projector as the pattern generator. Ex. 1001, claim 3. The only support for that claim is one sentence in the '146 patent specification that says “[a] varying illumination pattern may generated by a LCD or DLP based projector.” *Id.*, 13:37-38. Thus, the '146 patent itself is written with the understanding that a POSA would understand how to include an LCD or DLP projector in a hand-held scanning device. A POSA, therefore, would have been able to replace the illumination source 31 in Babayoff with the DLP or LCD projector as taught by Zhang. Ex. 1002, ¶58.

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

Babayoff in combination with Zhang satisfies these limitations of claim 21. Ex. 1002, ¶¶59-66. As discussed *supra*, the illumination source 31 in Babayoff is replaced by the DLP or LCD projector, as taught by Zhang, which provides the ***probe light*** with the time-varying illumination pattern. Ex. 1005, FIGS. 1, 4A, 8; Ex. 1011, pp. 907-909. Babayoff explains that the scanner in Babayoff is used for scanning an ***intraoral*** cavity, and shows in FIGS. 4A, 5C, and 8 that the scanned object can be ***one or more teeth in an intraoral cavity***. Ex. 1005, Abstract, [0001],

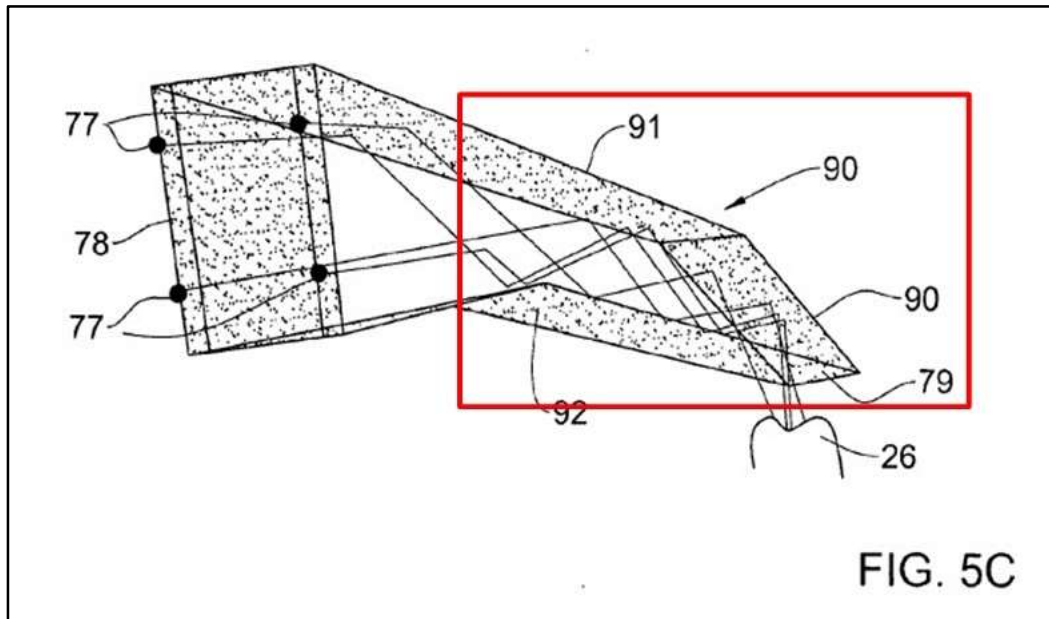
[0021], [0183]. Babayoff teaches that the probe light is transmitted through a *tip* of the intraoral scanner that is inserted into the oral cavity, such as part of the *endoscope 46* that can be in the form of a *probing member 90*. *Id.*, [0137], [0146], FIGS. 4A, 5C.

The below annotated version of FIG. 4A highlights the endoscope 46:



Id., FIG. 4A (annotated).

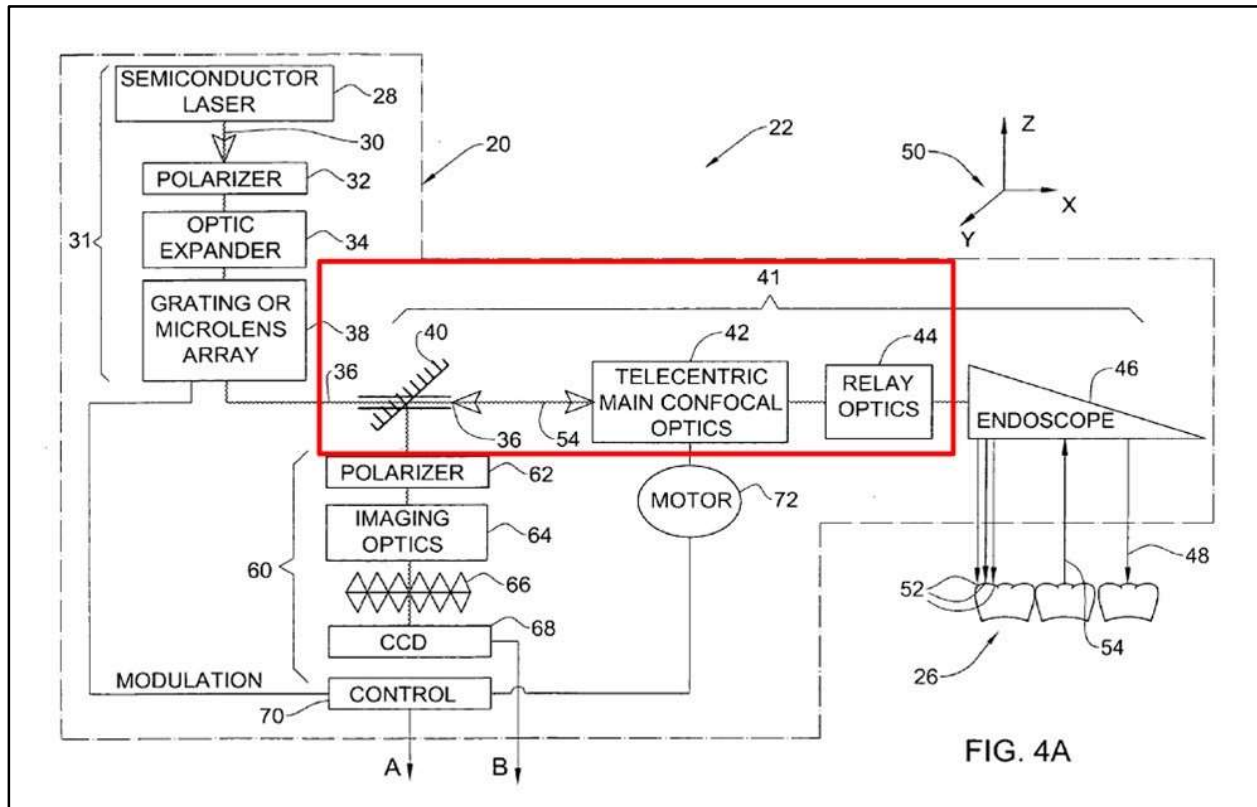
The below annotated version of FIG. 5C highlights an example of an end of the probing member 90:



Id., FIG. 5C (annotated).

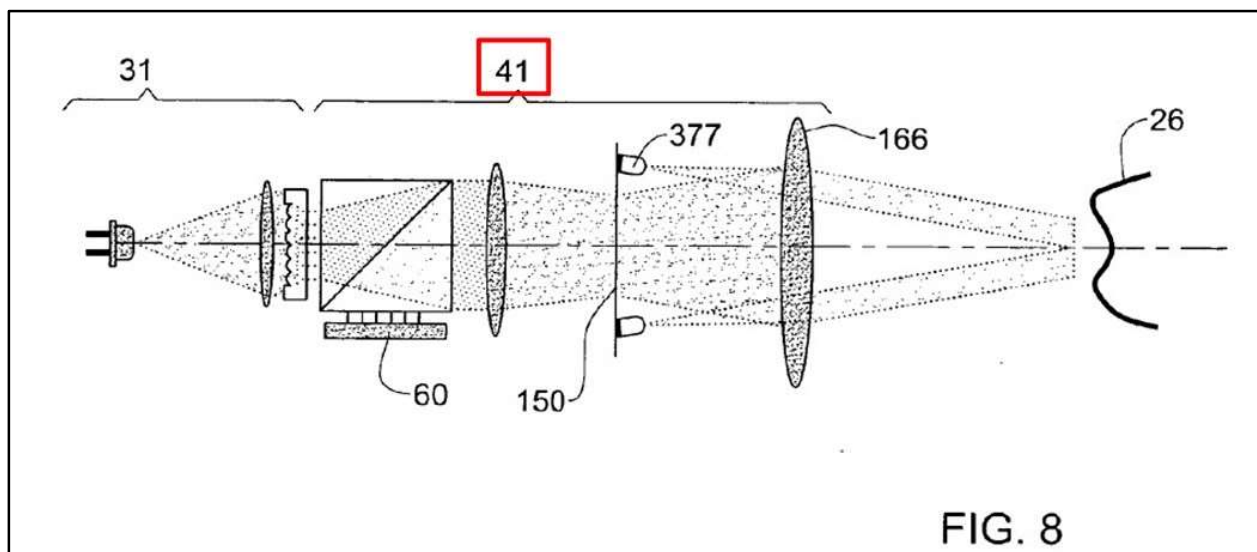
The **optical path** for the probe light in Babayoff includes at least part of the **main optics 41**, such as the **confocal optics 42** and the **relay optics 44**. *Id.*, [0137]-[0139], FIGS. 4A, 8. Babayoff shows that the probe light is **transmitted toward the object 26** along the optical path provided by the **main optics 41** and goes through the **tip** such as part of the **endoscope 46**. *Id.*, [0134]-[0139], FIGS. 4A, 5C, 8.

The below annotated version of FIG. 4A highlights part of the main optics 41 through which the probe light is transmitted:



Id., FIG. 4A (annotated).

Similarly, the below annotated version of FIG. 8 highlights part of the main optics 41 through which the light is transmitted:



Id., FIG. 8.

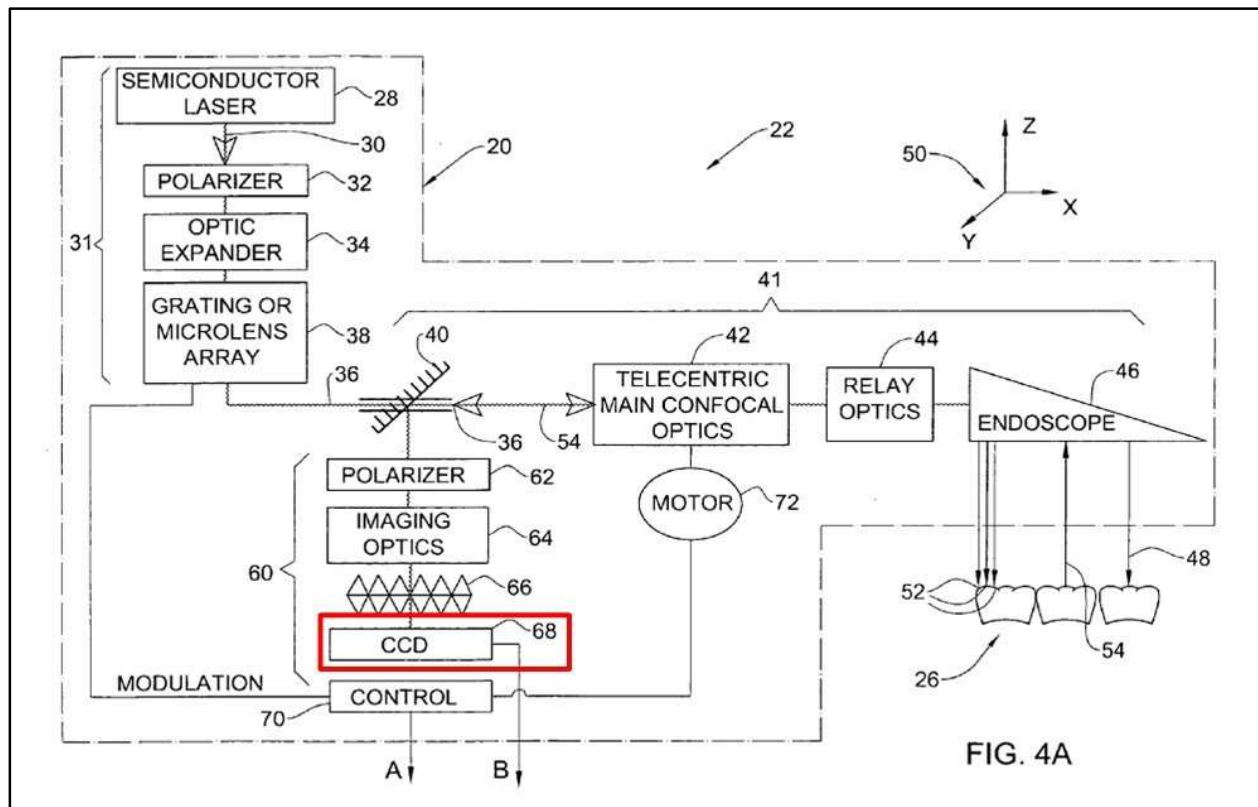
The probe light, therefore, is transmitted through the *tip* of the intraoral scanner, such as part of the *endoscope 46* that can be in the form of a *probing member 90*. The probe light is transmitted toward the object 26 along an optical path, which includes at least part of the *main optics 41*, such as the *confocal optics 42* and the *relay optics 44*. By having the illumination source 31 of Babayoff replaced by the projector of Zhang to provide the probe light with the time-varying illumination pattern, at least part of the object 26 in Babayoff would thereby be illuminated with the time-varying illumination pattern. Ex. 1002, ¶66.

[c] transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a plurality of 2D images,

Babayoff in combination with Zhang satisfies these limitations of claim 21. Ex. 1002, ¶¶67-70. Babayoff shows that at least part of the *light* returned from the *object 26* is transmitted to an *image sensor*, which is *part of the detection optics 60*. Ex. 1005, [0002], [0011], [0033], [0042], [0129], [0134]-[0141], [0145], FIGS. 1, 4A, 8. The *image sensor* in Babayoff is called a *camera* and accommodates an *array of sensor elements*, which Babayoff explains could be, for example, *an array of charge coupled devices (CCD) 68*. *Id.*, [0042], [0129], [0140]-[0141], [0145], FIG. 4A. Babayoff explains in paragraph [0140] that the *returned light beams 54* from the object 26 travel initially along the opposite direction of the

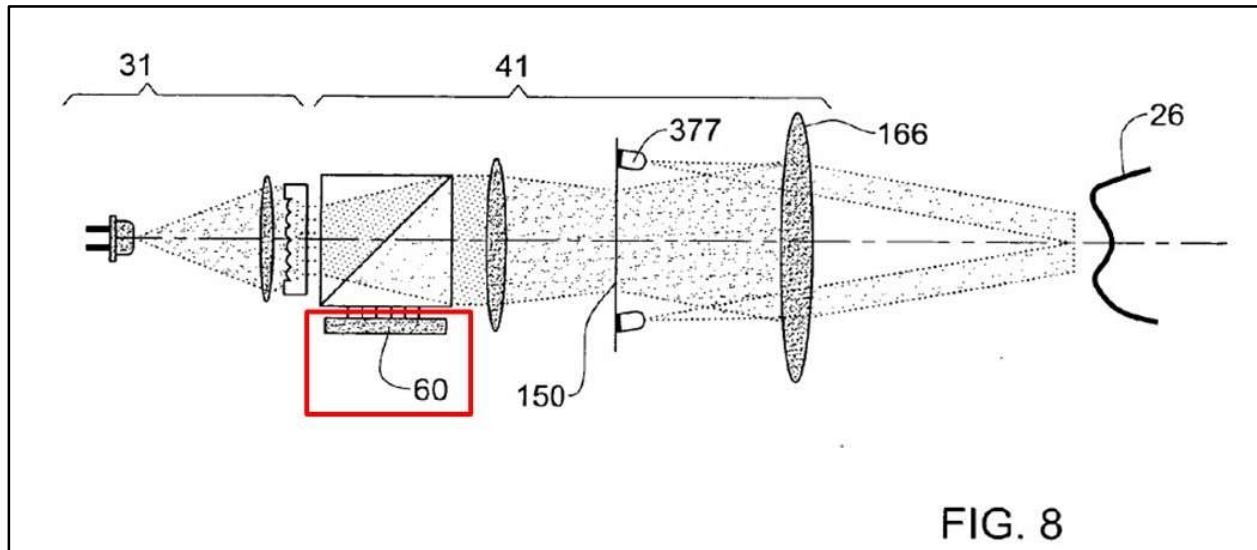
optical path traveled by the incident light beams and are then reflected by the mirror 40 in the direction of the detection optics 60 where the *camera* uses the array of sensing elements to form each 2D image. *Id.*, [0011], [0139]-[0143], FIGS. 4A, 8.

The below annotated version of FIG. 4A highlights the **CCD 68 camera** of Babayoff in red:



Id., FIG. 4A (annotated).

Similarly, the below annotated version of FIG. 8 highlights the *detection optics 60* in red, which includes the *image sensor*:



Id., FIG. 8 (annotated).

Just as in Babayoff, Zhang also uses a *camera* with a *plurality of pixels*, so the combination would work with the camera of Babayoff. Ex. 1011, pp. 907-909.

[d] wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;

Babayoff in combination with Zhang satisfies these limitations of claim 21. Ex. 1002, ¶¶71-72. As discussed *supra*, the device 100 of Babayoff as modified by Zhang would use the projector of Zhang to shift the *time-varying illumination pattern* across the object being imaged and would *capture a plurality of 2D images* with the camera. Ex. 1005, [0011], [0142], FIG. 4A; Ex. 1011, pp. 907-910, 915, Fig. 1. Then, the *projection defocus method* described in Zhang would be used to *determine the Z or depth coordinate for each (X, Y) position* based on the plurality of 2D images and knowledge of the time-varying illumination pattern. Ex. 1011, pp. 907-910. The result is the 3D geometry for the object. *Id.* Zhang

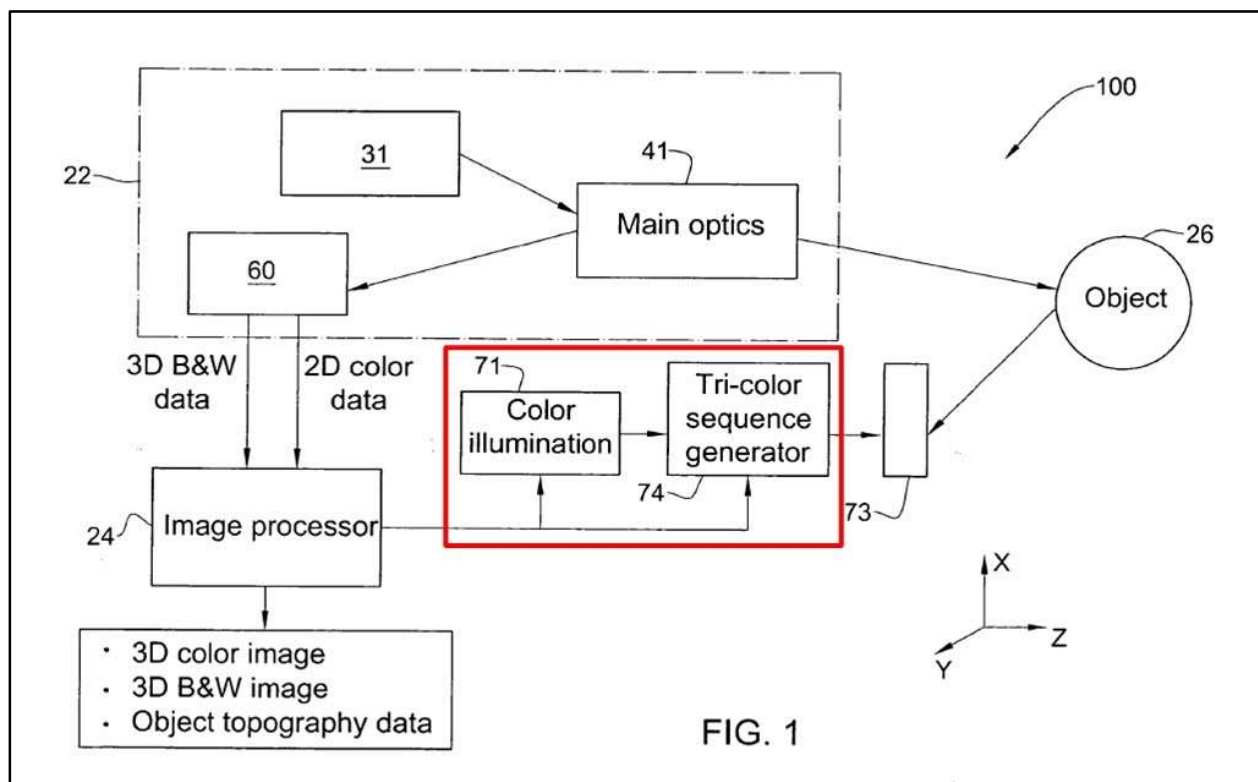
explains that the *determination of the depth values* is *based* on *both* the *scene radiance as captured in the 2D images* and on *the projection illumination pattern*, which allows for the equations in Zhang to be valid for estimating depth. *Id.*, p. 909. The 3D geometry, therefore, is determined based on the plurality of 2D images and the time-varying illumination pattern. *Id.* For a particular illumination pattern, the determination can be made using a pre-computed lookup table, which is valid for the pattern, and the plurality of 2D images as described in Zhang. *Id.*, p. 910.

It would have been obvious to a POSA to determine the 3D geometry using the *projection defocus method* of Zhang in the device of Babayoff because Zhang explains that the projection defocus method is more accurate near depth discontinuities, is simple, has lower computational complexity, is not subject to local minima, and is independent of scene geometry and texture. *Id.*, pp. 907-908, 914; Ex. 1002, ¶72. A POSA would have had an expectation of success with the combination because it uses the projection defocus method of Zhang with the time-varying illumination pattern for determining depth in place of the method of Babayoff, which is exactly what Zhang taught to do to obtain the noted advantages. *Id.*, ¶72.

[e] selectively switching a color of the probe light, thereby illuminating the object with different colors at different times;

Babayoff discloses these limitations of claim 21. Ex. 1002, ¶¶73-75. Babayoff teaches use of a *tri-color sequence generator 74* to selectively switch among *three differently-colored illumination radiations* to *illuminate the object 26* with *different colors* at *different times*. Ex. 1005, [0044], [0063]-[0064], [0079], [0130]-[0131], [0145]-[0151], [0155]-[0157], FIG. 1.

FIG. 1 of Babayoff is annotated below in red to highlight the *tri-color light sources 71* and the *tri-color sequence generator 74*:



Id., FIG. 1 (annotated).

Babayoff explains that the *tri-color light sources 71* are one or more light

sources that provide illumination to the object 26 in a *plurality of different colors* such as red, green, and blue. *Id.*, [0145]. The *tri-color sequence generator 74* is controlled to provide the three-color illuminations in a predetermined sequence. *Id.* [0130], [0145]. FIGS. 5A and 5C of Babayoff show exemplary locations of tri-color LED's 77 for providing the light in the different colors. *Id.*, FIGS. [0146], 5A, 5C. FIG. 8 similarly shows another exemplary location for the tri-color light sources 377. *Id.*, [0157], FIGS. 8, 9. Babayoff, therefore, selectively switches a color of the probe light using the tri-color sequence generator 74, thereby illuminating the object 26 with different colors, such as red, green, and blue, at different times.

[f] recording different images by the at least one camera at the different times, thereby recording images of the object with the different colors;

Babayoff discloses these limitations of claim 21. Ex. 1002, ¶76. Babayoff teaches to illuminate the object 26 sequentially with the three different colored lights such as red, green, and blue, and to *capture a monochromatic image corresponding to each color* via the *detection optics 60* that includes the *camera* such as the *CCD 68 camera*. Ex. 1005, [0044]-[0045], [0079], [0092], [0130], [0145], FIGS. 1, 4A, 8. Babayoff, therefore, teaches to record different images by the CCD 68 camera at the different times, which are the times at which each of the colors illuminate the object 26, and thereby how to record images of the object 26

with the different colors. *Id.*

[g] combining the different colors from the different images to obtain the color of the surface of the object; and

Babayoff discloses these limitations of claim 21. Ex. 1002, ¶77. Babayoff teaches that the *processor 24* processes the *three differently colored monochromatic images* and *combines* the same to provide a *full color image of the object 26*. Ex. 1005, [0046], [0063], [0079], [0092], [0130], [0145], FIG. 1. Babayoff explains that the processor 24 aligns the color image with the 3D entity previously created to provide color values to the entity by mapping the color values to the entity, which provides the *color of the surface of the object 26* for the 3D representation. *Id.*, [0009], [0065], [0131], FIG. 1.

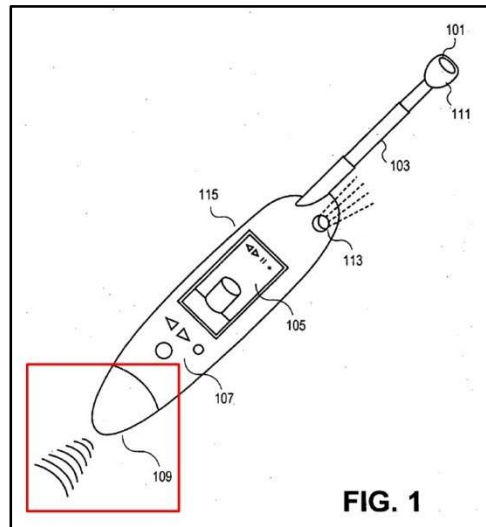
[h] wirelessly transmitting the data for the 3D geometry.

Babayoff in combination with Zhang and Knighton satisfies this limitation of claim 21. Ex. 1002, ¶¶78-82. Babayoff discloses that the device can be a hand-held device in which the hand-held device includes the endoscope 46, the illumination unit 31, the main optics 41, color illumination 71, tri-color sequence generator 74, and detector optics 60. Ex. 1005, [0179], FIGS. 1, 4A, 8. Babayoff does not explicitly disclose that the hand-held device uses wireless transmission, but does provide a modem 88 for transmission of the 3D data. *Id.*, [0065], [0093], [0180]. Knighton is in the same field as Babayoff and teaches to have a *hand-held scanner wirelessly transmit data for the 3D geometry* of an object. Ex. 1007,

Abstract, [0024]-[0025], [0033], [0038], [0045], [0049], [0093], FIGS. 1, 3.

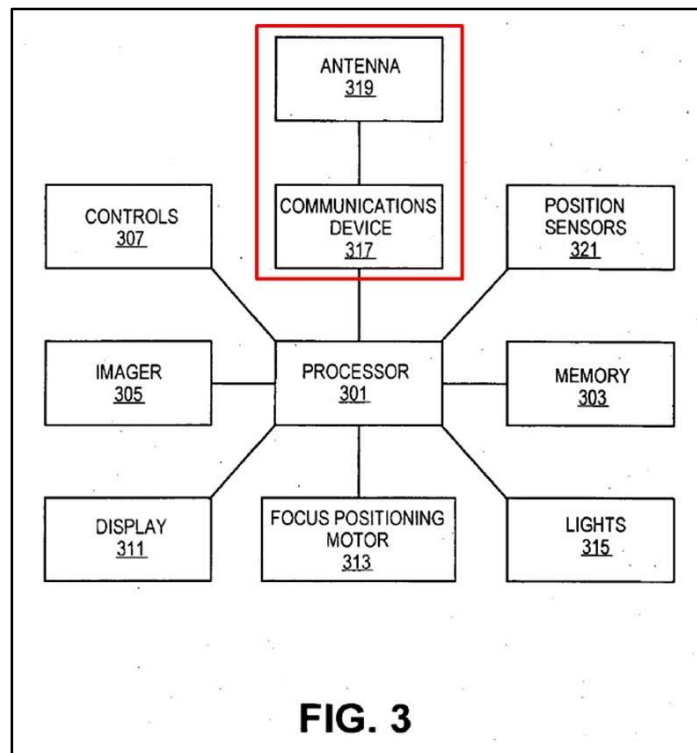
The processing performed in Knighton is similar to the processing performed in Babayoff and Zhang because Knighton similarly discloses to *capture multiple images* and then to *produce a depth map for three dimensional data* based on the light intensities from the captured images. Ex. 1007, [0026]-[0027], [0047]-[0053], FIG. 4. Knighton teaches that the *processor 301* for performing the processing *can be included in the hand-held device* such that *the processing is performed locally* at the hand-held device to generate the *3D geometry data*. *Id.*, [0025], [0029], [0038]-[0039], [0041], [0049], [0054], [0093], FIG. 3. Knighton explains that the hand-held device can include the *communications device 317* and the *antenna 319* for *wirelessly transmitting the data for the 3D geometry*. *Id.*, [0033], [0038], [0045], [0049], [0054], [0093], FIGS. 1, 3.

An annotated version of FIG. 1 of Knighton is shown below with the *wireless communication device 109* and wireless communication symbol highlighted in red:



Id., FIG. 1 (annotated).

FIG. 3 of Knighton is annotated below to show in red the *communications device 317* and the *antenna 319* of the *hand-held* scanner device for the wireless transmission.



Id., FIG. 3 (annotated).

It would have been obvious to a POSA to modify the hand-held device of Babayoff based on the teaching of Knighton to include the ***processor 301*** in the device of Babayoff to process data for the 3D geometry locally in the device using the method of Zhang, and to include the ***wireless communication device 109*** in the device of Babayoff to ***wirelessly*** transmit the ***data for the 3D geometry***. Ex. 1002, ¶78. A POSA would have expected such a modification to be successful because Knighton discloses a ***hand-held*** scanner including those components for those purposes, so those components could be incorporated into the ***hand-held*** scanner of Babayoff for ***performing the same intended purpose***. *Id.*

Knighton explains that the ***wireless communication device 109*** may be a radio frequency (RF) transmitter, cellular device, IEEE 802.11 device, or similar transmitter, and may support the Bluetooth standard, TCP/IP communication, and similar communication standards. Ex. 1007, [0033]. Knighton, therefore, recognized that there were already ***standard*** wireless communication devices that could be used for this purpose. The only support for the “wireless” limitation in the ’146 patent is one statement in the ’146 patent specification that says “the scanner head may be wireless....” Ex. 1001, 9:17-21. Thus, the ’146 patent itself is written with the understanding that a POSA would understand how to include circuitry for wireless communication in a hand-held scanning device.

Motivation to Combine Babayoff and Knighton:

A POSA would have been *motivated* to modify the device of Babayoff to *locally process data* and use *wireless communication* as taught by Knighton because it would allow for the device to be *wireless* and, therefore, *easier to carry around* with *improved usability* in that the device would be *more maneuverable* with respect to an object being imaged. Ex. 1002, ¶82; Ex. 1007, [0033], [0038], [0045], FIG. 1. Performing *local processing* at the *hand-held* device as taught by Knighton allows for avoiding the need to transmit *all* of the *raw* image data. *Id.*, [0038], [0054], [0093]. Knighton demonstrates that *wireless communication* was one of the *known options* for *hand-held scanning devices* that scan three-dimensional objects. *Id.*, [0033], [0045], FIGS. 1, 3.

C. Claim 23

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

Babayoff in combination with Zhang and Knighton satisfies these limitations of claim 23. Ex. 1002, ¶¶83-87. Babayoff discloses that the processor 24 determines the depth values for each point illuminated on the object 26 based on the plurality of 2D images. Ex. 1005, [0011]-[0015], [0129]-[0131], [0142]-[0143], FIGS. 1, 4B. In the combination of Babayoff with Zhang, the processor 24 of

Babayoff would use the projection defocus method described in Zhang to determine the depth coordinate for each position based on plurality of 2D images and knowledge of the time-varying illumination pattern. Ex. 1011, pp. 907-910; Ex. 1002, ¶83. Babayoff discloses that the processor 24 provides the entity E that comprises the array of (X, Y, Z) points and is a 3D geometry of the surface topology of the object 26. Ex. 1005, [0129], [0131], [0143], [0183]. Babayoff further discloses that a modem 88 is used to transmit the determined 3D surface topology data. *Id.*, [0180]. Babayoff does not explicitly disclose that the processor 24 is local on the intraoral scanner or that the transmission by the modem 88 is wireless.

Knighton, however, performs similar processing as Babayoff and Zhang—determining depth values based on a plurality of 2D images and producing a 3D geometry representation of the surface of the object. Ex. 1007, [0024]-[0025], [0029], [0033], [0038]-[0041], [0045], [0049], [0052], [0054], [0093], FIGS. 1, 3, 4. Knighton further teaches that the processing can be performed by the ***processor 301*** that is ***local to the hand-held scanning device***, and that the transmission of the data can be performed ***wirelessly*** using the communications device 317 of the hand-held scanning device. *Id.*

In particular, Knighton teaches that the processing to determine the 3D geometry can be performed ***local*** to the hand-held scanning device using the

processor 301 that is *internal* to the hand-held scanning device. *Id.*, [0025], [0029], [0049], [0054], [0093], FIG. 3. Knighton uses the 2D images to produce a component depth map with 3D information, and the component depth map is then meshed to create the 3D model of the surface of the object. *Id.*, [0052], [0054], [0094]. Knighton explains that the processing to generate the 3D model data can be done *locally* on the hand-held scanning device and that the transmission of the data from the hand-held scanning device can be done *wirelessly* using a *wireless communications device*. *Id.*, [0033], [0045], [0049], [0051], [0054], [0093]. Knighton explains that the scanning device may store raw data, intermediate data, or processed data. *Id.*, [0093]. This allows for the hand-held scanning device in Knighton to wirelessly *transmit the processed 3D model data instead of the raw data*. *Id.*, [0045], [0049], [0051], [0093]; Ex. 1002, ¶86. Knighton explains that rather than offloading all the captured data to a host processor, the processing can be performed *locally* to the hand-held scanning device *so that it would not be necessary to transmit the raw data*. Ex. 1007, [0049], [0051].

It would have been obvious to a POSA to perform the processing for the 3D geometry as taught by Zhang *locally* on the hand-held device in Babyoff as is done in Knighton because it would *reduce the amount of data that needs to be transmitted* and have the processing *performed within* the scanner to make it more *self-contained*, and it would have also been obvious to use *wireless* transmission

for the data for the 3D geometry in Babayoff as is done in Knighton because it would allow for the hand-held device to be *wireless* and, therefore, *easier to carry around* with *improved usability* in that the device would be *move maneuverable*, and Babayoff and Zhang are concerned with generating the 3D representation of an object just as is Knighton. Ex. 1002, ¶87. Performing *local processing* at the hand-held device as taught by Knighton allows for *avoiding* the need to transmit *all* of the *raw* image data, and is one of the *known processing options* specifically taught by Knighton. Ex. 1007, [0033], [0038], [0045], FIG. 1. Knighton also demonstrates that *wireless* communication was one of the *known options* for hand-held scanning devices that scan three-dimensional objects to make the device *more usable*. *Id.*, [0033], [0045], FIGS. 1, 3. A POSA would have expected the modification of the hand-held scanner in Babayoff to be *successful* because the hand-held scanning device in Knighton is *used for the same purpose* and *already shows how to do the local processing and wireless transmission*. Ex. 1002, ¶87.

D. Claim 24

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

Claim 24 of the '146 patent is the same as claim 23 of the '146 patent, except it changes the recitation of “instead of the raw 3D data” to “at a reduced

data rate in comparison with transmission of raw 3D data” in the claim language. Babayoff in combination with Zhang and Knighton satisfies these limitations of claim 24, therefore, for the same reasons provided above with reference to claim 23. Ex. 1002, ¶¶88-92.

Regarding the added limitation in claim 24 of “the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data,” Babayoff in combination with Zhang and Knighton also satisfies this limitation of claim 24. Knighton notes that it is possible to perform the processing to create the 3D representation of the object either *externally* from the scanning device, *internally* to the scanning device, or *partially externally and internally*. Ex. 1007, [0093].

In the case where all the processing is done *externally* in Knighton, *all* the captured 2D images are transmitted to an external host processor for further processing. *Id.*, [0049]. In the case where all the processing is performed *internally* in Knighton, the internal processor to the scanning device would perform all the processing including creating the depth map of the 3D model locally on the scanning device from the captured 2D images, and then *the finished 3D geometry would be transmitted* from the scanning device. Ex. 1007, [0049], [0054], [0093]; Ex. 1002, ¶90.

Knighton explains that a composite image generated from the 2D images is a

much smaller data set than the total pixels captured. Ex. 1007, [0052]. The depth map and 3D coordinates for the 3D geometry would also represent *a smaller data set*. *Id.*, [0052]; Ex. 1002, ¶91. By performing processing *locally* at the scanning device in Knighton, therefore, *the amount of data that would need to be wirelessly transmitted* from the scanning device is *reduced*, which allows for a *reduced data rate* for transmission of the data resulting from the processing as compared to the *raw* data before processing. Ex. 1007, [0033], [0045], [0049], [0051]-[0054], [0093]; Ex. 1002, ¶91.

It would have been obvious to a POSA to perform the processing for the 3D geometry as taught by Zhang *locally* on the hand-held device in Babyoff as is done in Knighton because it would *reduce the amount of data that needs to be transmitted* and, thus, the *required data rate* for transmission and allow for such processing to be *self-contained* within the scanner itself, and it would have also been obvious to use *wireless* transmission for the data for the 3D geometry in Babayoff as is done in Knighton because it would allow for the hand-held device to be *wireless* and, therefore, *easier to carry around* with *improved usability* in that the device would be *more maneuverable*. Ex. 1002, ¶92.

E. Claim 25

The method according to claim 23, wherein the step of wirelessly transmitting the data for the 3D geometry is to a workstation.

Babayoff in combination with Knighton satisfies this limitation of claim 25.

Ex. 1002, ¶93. Babayoff discloses that the data for the 3D geometry is transmitted through a communication medium to a recipient. Ex. 1005, [0065], [0093], [0180]. Knighton shows that the transmission can be a *wireless* transmission, and also explicitly states that the transmission can be to an *external computing device* such as a “workstation.” Ex. 1007, [0033], [0045]. It would have been obvious to a POSA to use the wireless transmission to a *workstation* from Knighton for the hand-held device of Babayoff because Knighton specifically states to transmit data like the 3D data of Babayoff *wirelessly* to a *workstation*, which would allow for *displaying the data at the workstation* for *further viewing* the data to inspect the 3D geometry. Ex. 1002, ¶93.

F. Claim 26

The method according to claim 23, wherein the step of locally processing is in real time.

Babayoff in combination with Zhang and Knighton satisfies this limitation of claim 26. Ex. 1002, ¶94. As discussed above for claim 23, it would have been obvious to a POSA to have local processing for the device of Babayoff as is done in Knighton. Knighton further discloses that the calculation of the depth map and the three dimensional representation may be accomplished *during a scan of the target object*. Ex. 1007, [0081]. By performing the processing to calculate the depth map and 3D representation *during a scan* of the target object, the processing is being done *in real time*. *Id.*; Ex. 1002, ¶94. Also, as discussed above, the

processing in Knighton can be done locally on the hand-held scanning device. Ex. 1007, [0049], [0054], [0093]. Zhang explains that the determination of the 3D data could be done using a pre-computed lookup table. Ex. 1011, p. 910. It would have been obvious to a POSA to employ the local processing in *real time* as taught by Knighton *during a scan* of the object in the hand-held device of Babayoff using the pre-computed lookup table of Zhang because it would have allowed for fast processing of the data in *real time* so that the *results* would be *available faster*. Ex. 1002, ¶94. That would allow for *using the scan time to also perform processing* as taught by Knighton. Ex. 1007, [0081].

G. Claim 27

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

Babayoff in combination with Zhang and Knighton satisfies these limitations. Ex. 1002, ¶¶95-97. Zhang computes scene depths by projecting a time-varying illumination pattern on the scene. Ex. 1011, pp. 908-909. Specifically, a pattern with periodic vertical stripes is shifted across the scene, one (projector) pixel at a time in the horizontal direction. *Id.* For each shift of the pattern, an image is captured. The set of intensities captured at a given camera image pixel as the pattern is shifted is called the temporal radiance profile of that pixel. *Id.* The scene

points at different distances to the projector exhibit different amounts of blur in their temporal radiance profile. For example, for a scene point that is perfectly in focus, the temporal profile will have minimal blur, and will appear like a perfect square wave (since the projected pattern is a square wave). Ex. 1002, ¶95. On the other hand, for a scene point that is out of focus, the temporal profile will be blurred. *Id.*

This blur in the temporal profile can be used for depth recovery. *Id.* The blur can be estimated by computing the ***correlation*** of the temporal radiance profile with the projected pattern (a square wave). *Id.* Zhang performs this estimation by ***computing the Fourier transform*** of the ***temporal radiance profile***. *Id.*; Ex. 1011, pp. 908-909. The rate at which the Fourier coefficients diminish is a measure of the amount of defocus. *Id.* Therefore, Zhang measures the ratio of the second and third coefficients and uses it as a measure of depth. *Id.* The exact mapping from the ratio to depth is determined via a one-time calibration procedure. *Id.*, p. 910. Zhang, therefore, computes a ***temporal correlation measure*** as the ***correlation of the temporal radiance profile*** (which is a ***sensor signal***) with the ***projected pattern***, and Zhang performs this estimation by computing the Fourier transform of the temporal radiance profile *Id.*, pp. 908-910.

Knighton teaches that correlation calculations may occur ***local*** to the image capture device. Ex. 1007, [0058]. Knighton also explains that correlation

calculations may be accomplished *during a scan* of the target, which would be *while* the plurality of configurations in the form of a time-varying illumination pattern are changed. *Id.*, [0081]. It would have been obvious to a POSA, therefore, to compute a *temporal correlation measure* as the *correlation of the temporal radiance profile* (which is a *sensor signal*) with the *projected pattern* as is done in Zhang *locally* at the camera and *during a scan* as taught by Knighton because it would *reduce the amount of data that needs to be transmitted* as explained by Knighton and allow for the processing to be *self-contained* in the scanner itself. *Id.*, [0049], [0051]; Ex. 1002, ¶96.

As *another example*, Knighton discloses in FIG. 10 a method for aligning image data to a three-dimensional representation that includes computing a *correlation* measure. Ex. 1007, [0079]-[0082], FIG. 10. The method includes generating a depth map from *image data*, which are *sensor signals*. *Id.*, [0079]. Knighton teaches that *correlation calculations* may occur *local* to the image capture device. *Id.*, [0058]. The image data for determining the depth map would be captured at different times by moving the pattern of Zhang while capturing the images as discussed *supra* in the analysis for claim 21. The *depth map* determined from the images is *correlated* to a three-dimensional representation, which is the *correlation measure*. *Id.*, [0080]. Knighton explains that the calculation may be accomplished *during a scan* of the target, which would be *while* the plurality of

configurations in the form of a time-varying illumination pattern are changed. *Id.*, [0081]. It would have been obvious to a POSA to use the correlation of Knighton in the scanner of Babayoff to generate the three dimensional representations with ***greater accuracy*** and to do the calculations during a scan of the target as in Knighton to ***speed up*** the calculations. Ex. 1002, ¶97.

H. Claim 29

The method according to claim 27, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.

Babayoff in combination with Zhang and Knighton satisfies these limitations. Ex. 1002, ¶98. As discussed *supra*, the blur in Zhang can be estimated by computing the ***correlation*** of the ***temporal radiance profile*** with the ***projected pattern*** (a square wave), and Zhang performs this estimation by computing the Fourier transform of the temporal radiance profile. Ex. 1011, pp. 908-909. That correlation is a ***temporal correlation measure*** and is ***based on a reference signal***, which is ***specified by the discrete-time Fourier series***, that is ***based on knowledge of configurations of the time-varying illumination pattern***. *Id.*, p. 909; Ex. 1002, ¶98.

**VIII. GROUND 2: CLAIMS 1, 3-6, 8-13, 15, 20, AND 22 ARE OBVIOUS
OVER BABAYOFF AND ZHANG AND KNIGHTON AND HANSON**

**A. Motivation to Combine Babayoff and Zhang and Knighton and
Hanson**

The motivation to combine Babayoff, Zhang, and Knighton was discussed above under Ground 1 and also applies to Ground 2.

Regarding the camera being a high-speed camera, Babayoff teaches that the camera must be *high-speed* in order to *keep the time interval between acquisition of images* to a *minimum amount of time*, such as preferably between about *0 and 20 milliseconds*. Ex. 1005, [0027], [0072], [0145]. To have such a *low time interval between acquisitions*, the camera is *high-speed*. *Id.*; Ex. 1002, ¶142.

To the extent that the phrase “high-speed camera” in the ’146 patent is interpreted to mean that the camera must have *multiple analog-to-digital (A/D) converters per line of pixels* in the camera, the use of multiple A/D converters per line of pixels for the camera in Babayoff would have been obvious to a POSA. *Id.*, ¶143. Knighton points out that the *image sensor* for a scanner could be one of a *CCD type* or one of a *CMOS type*. Ex. 1007, [0005], [0024]. Furthermore, Hanson discloses that a *CMOS image sensor* can have *multiple A/D converters per line of pixels* in a pixel array to *increase the speed* of the image sensor. Ex. 1008, [0017], [0028], [0030]-[0037], FIGS. 3, 5, 6.

It would have been obvious to a POSA to use an *image sensor* as shown in

Hanson with *multiple A/D converters per line of pixels* as the image sensor for the camera in Babayoff, because Babayoff indicates that it is preferable to have a *short time interval*, in the range of about *0 to 20 milliseconds*, between image acquisitions, and Hanson shows an example of an image sensor that would provide that benefit. Ex. 1002, ¶145.

B. Claim 1

[preamble] An intraoral scanner for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, the intraoral scanner comprising:

To the extent that the preamble of claim 1 is limiting, Babayoff discloses the features of the preamble. Ex. 1002, ¶¶99-100. The intraoral scanner in Babayoff is the device 100 shown in FIG. 1. Ex. 1005, Abstract, [0001], [0009], [0128]-[0149], [0179], FIG. 1. Example embodiments for parts of the device are shown in FIGS. 4A and 8 of Babayoff. *Id.*, FIGS. 4A, 8.

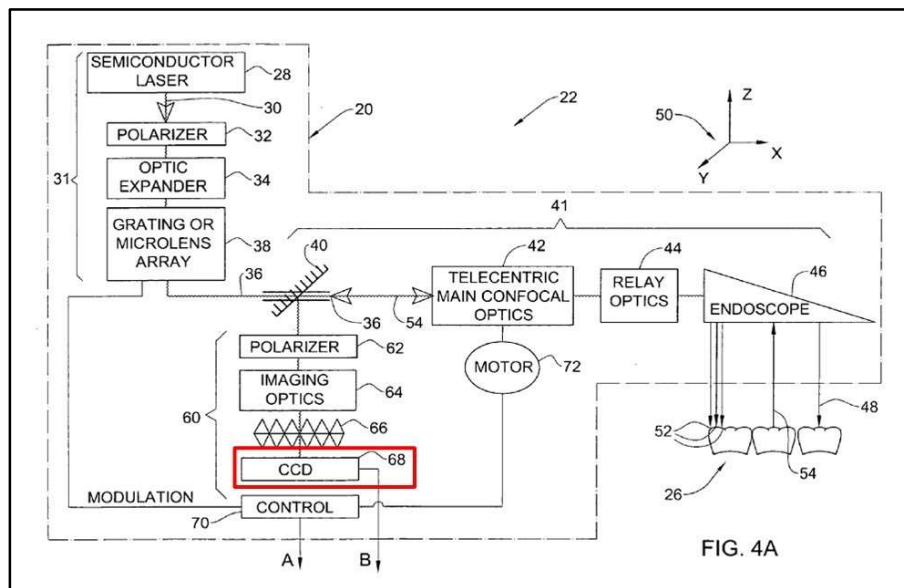
The recitation in the preamble of claim 1 of the '146 patent of “determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity” is the same as the recitation in the preamble of claim 21 and, therefore, the above analysis for the preamble of claim 21 under Ground 1 also applies for the preamble of claim 1.

[a] at least one camera accommodating an array of sensor elements;

Babayoff discloses these limitations of claim 1. Ex. 1002, ¶¶101-104. The at

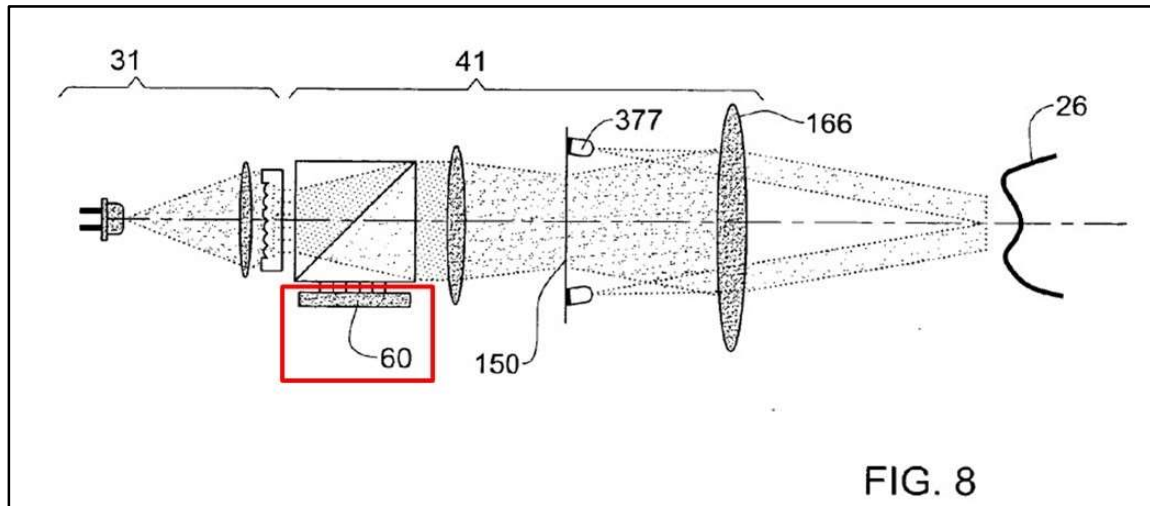
least one camera in the device of Babayoff is an image sensor that is part of the detection optics 60. Ex. 1005, [0002], [0011], [0033], [0042], [0129], [0134]-[0141], [0145], FIGS. 1, 4A, 8. The image sensor in Babayoff is called a camera and is described as having an array of sensor elements, which Babayoff explains could be, for example, an array of charge coupled devices (CCD) 68. *Id.*, [0042], [0129], [0140]-[0141], [0145], FIG. 4A.

The below annotated version of FIG. 4A highlights the CCD 68 camera in red.



Id., FIG. 4A (annotated).

Similarly, the below annotated version of FIG. 8 highlights the detection optics 60 in red, which includes the image sensor that is the camera.



Id., FIG. 8 (annotated).

[b] a pattern generator configured to generate, using a light source, a probe light with a plurality of configurations in the form of a time-varying illumination pattern;

Babayoff in combination with Zhang satisfies these limitations of claim 1. Ex. 1002, ¶¶105-114. These limitations of claim 1 of the '146 patent correspond to the limitations in part [a] of claim 21, which recites “using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern” and, therefore, the above analysis for claim 21[a] under Ground 1 also applies for claim 1[b].

[c] an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object with the time-varying illumination pattern, and for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;

Babayoff in combination with Zhang satisfies these limitations of claim 1.

Ex. 1002, ¶¶115-124. The optical system in Babayoff includes at least part of the main optics 41, such as the confocal optics 42 and the relay optics 44, which form an optical path. Ex. 1005, [0137]-[0139], FIGS. 4A, 8.

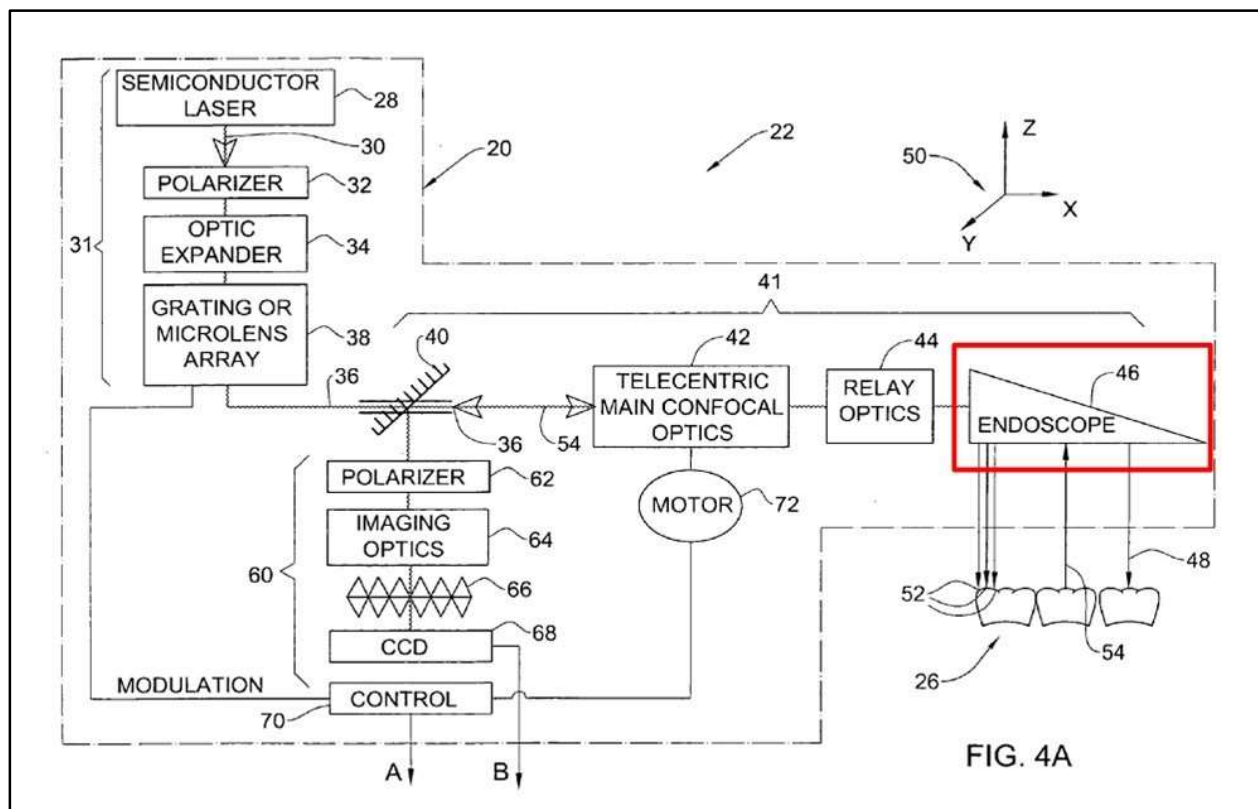
The recitation in claim 1[c] of the '146 patent of “transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object with the time-varying illumination pattern, and for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern” is the same as the recitation in parts [b], [c], and [d] of claim 21 of “transmitting the probe light ... towards the object along an optical path, thereby illuminating at least a part of the object with the time-varying illumination pattern; transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern.” Therefore, the above analysis for claim 21[b], [c], and [d] under Ground 1 also applies for claim 1[c].

[d] a tip configured to be inserted into the oral cavity; and

Babayoff discloses this limitation of claim 1. Ex. 1002, ¶¶125-129. The tip in Babayoff is the endoscope 46 that can be in the form of a probing member 90.

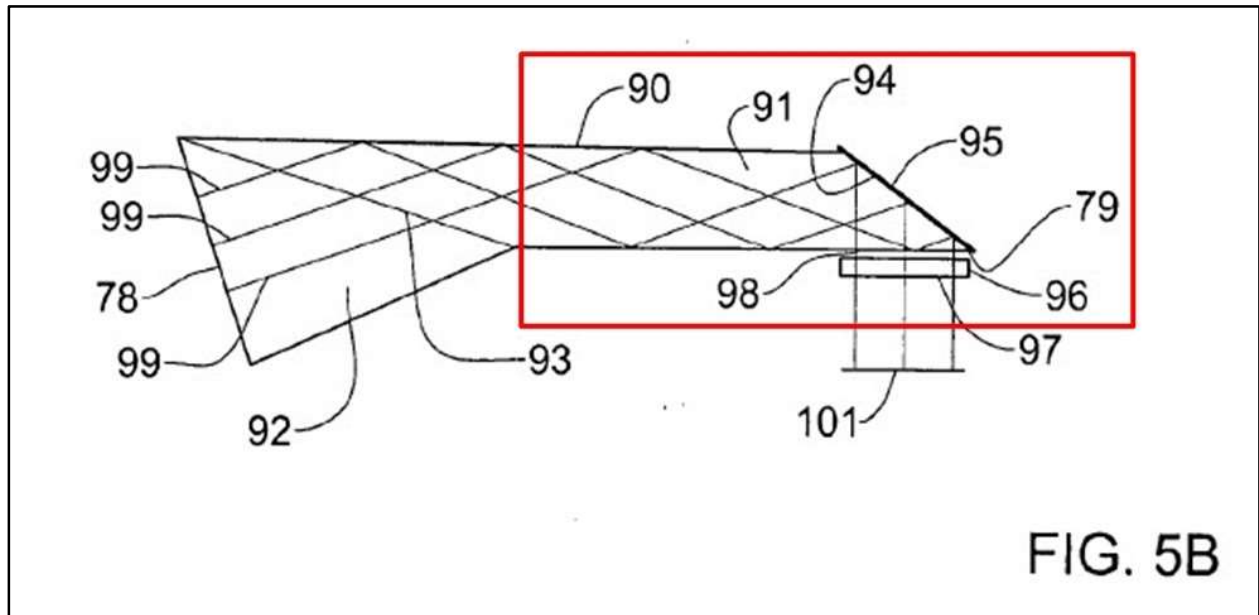
Ex. 1005, [0137], [0146], FIGS. 4A, 5A, 5B, 5C. An endoscope is a structure that is designed to be inserted into a body cavity, which in Babayoff is the mouth. *Id.*, Abstract, [0001], [0021], [0183], FIGS. 4A, 5C, 8. Babayoff shows that the probe light is transmitted through the tip of the intraoral scanner that is inserted into the oral cavity to scan one or more teeth. *Id.*, [0137], [0146], FIGS. 4A, 5C, 8.

The below annotated version of FIG. 4A highlights the endoscope 46.



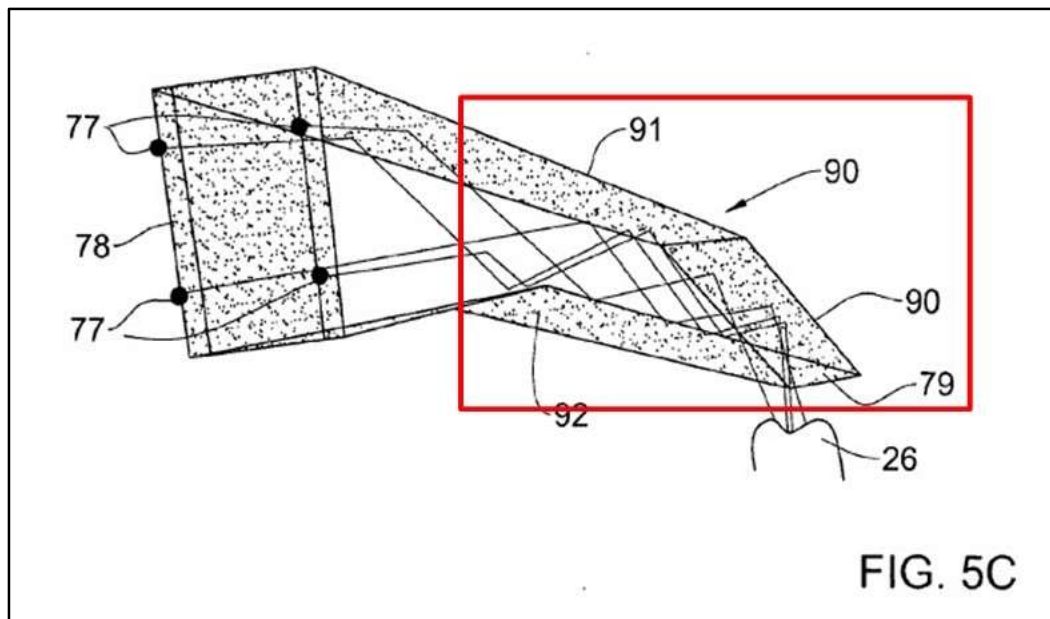
Id., FIG. 4A (annotated).

The below annotated version of FIG. 5B highlights an example of an end of the probing member 90.



Id., FIG. 5B (annotated).

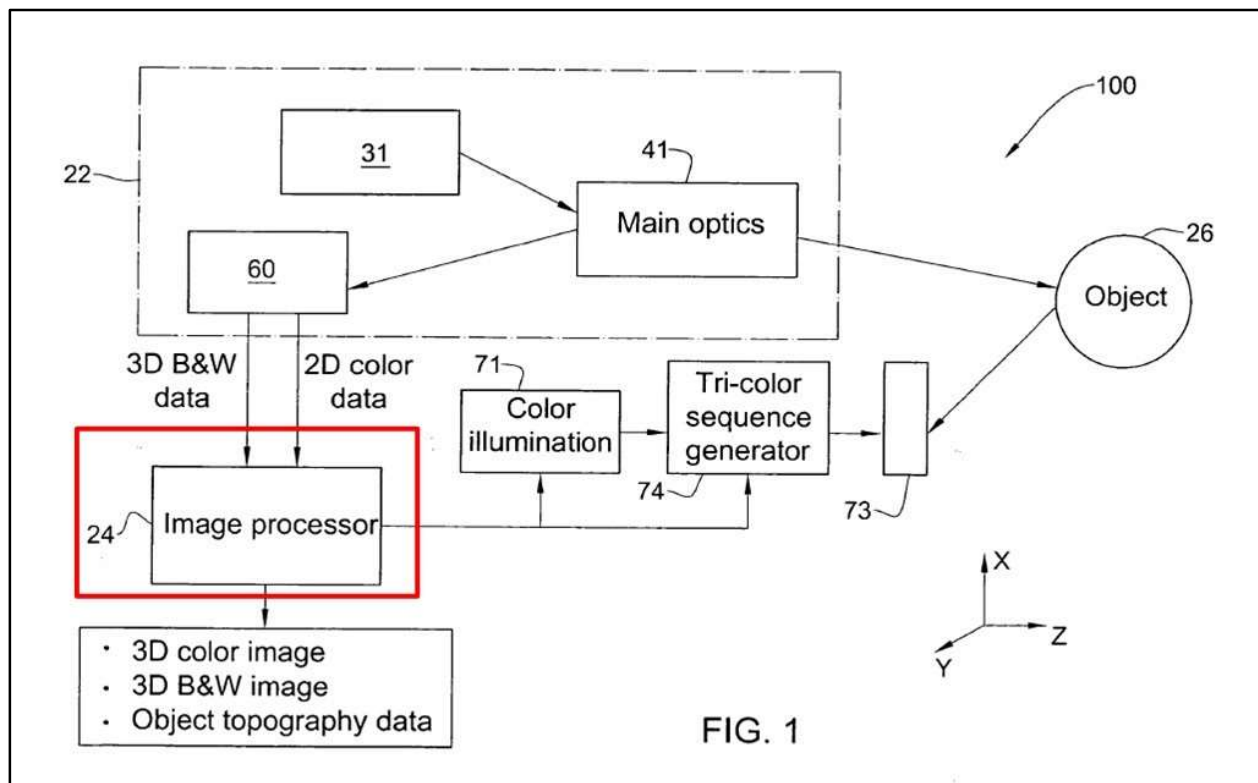
The below annotated version of FIG. 5C highlights another example of an end of the probing member 90.



Id., FIG. 5C (annotated).

[e] a hardware processor configured to:

Babayoff discloses this limitation of claim 1. Ex. 1002, ¶¶130-131. The hardware processor in Babayoff is the processor 24. Ex. 1005, [0129]-[0131], [0133], [0141], [0145], FIG. 1, 4B. An annotated version of FIG. 1 of Babayoff is provided below that highlights the processor 24.



Id., FIG. 1 (annotated).

Babayoff explains that the processor 24, also called the processing unit 24, controls the tri-color sequence generator 74 to provide the three different colored illuminations of the object 26. *Id.*, [0145]. Babayoff also explains that the processor 24 uses the CCD camera to grab the images for processing by the

processor 24. *Id.*, [0141]. Babayoff further explains that the processor 24 combines the three differently colored monochromatic images to provide a full color image of the surface of the object 26. *Id.*, [0130].

Similar to Babayoff, Knighton also discloses a processor 301 for performing processing, and Knighton teaches that the *processor 301* for performing the processing *can be included in the hand-held device* such that *the processing is performed locally* at the hand-held device to generate the *3D geometry data*. Ex. 1007, [0025], [0029], [0038]-[0039], [0041], [0049], [0054], [0093], FIG. 3. Knighton teaches that the processor 301 may be a general purpose processor or a specialized processor. *Id.*, [0038]. It would have been obvious to a POSA to have the processor 24 of Babayoff be local to the hand-held scanner as is the processor 301 in Knighton because that would allow for the scanner to be *self-contained* with the processing within itself and allow for the scanner to be *wireless*. *Id.*, [0025], [0029], [0038]-[0039], [0041], [0049], [0054], [0093], FIG. 3; Ex. 1002, ¶141.

[e][1] [the hardware processor configured to:] selectively switch a color of the probe light, thereby illuminating the object with different colors at different times;

Babayoff satisfies these limitations of claim 1. Ex. 1002, ¶¶132-134. Babayoff teaches to use a *tri-color sequence generator 74* to *selectively switch* among *three differently-colored illumination radiations* to illuminate the *object*

26 with *different colors* at *different times*. Ex. 1005, [0044], [0063]-[0064], [0079], [0130]-[0131], [0145]-[0151], [0155]-[0157], FIG. 1. Babayoff explains that the *processor 24*, also called the processing unit 24, *controls the tri-color sequence generator 74* to provide the three different colored illuminations of the object 26. *Id.*, [0145]. Thus, the *processor 24* is *configured to selectively switch* the color. The “selectively switch” function in claim 1[e][1] is the same as the method step in claim 21[e] and, therefore, the above analysis for claim 21[e] under Ground 1 also applies for claim 1[e][1].

[e][2] [the hardware processor configured to] ... record different images by the at least one camera at the different times, thereby recording images of the object with the different colors; and

Babayoff satisfies these limitations of claim 1. Ex. 1002, ¶135. Babayoff teaches to illuminate the object 26 sequentially with the *three different colored lights* such as red, green, and blue, and to *capture* a monochromatic image *corresponding to each color* via the *detection optics 60* that includes the *camera* such as the *CCD 68 camera*. Ex. 1005, [0145], FIGS. 1, 4A, 8. Babayoff also explains that the *processor 24* uses the *CCD camera* to *grab* the images for processing by the processor 24. *Id.*, [0044]-[0045], [0063], [0141], [0145]. Babayoff, therefore, teaches to configure the *processor 24* to record different images by the *camera* at the *different times*, which are the *times at which each of the colors illuminate the object 26*, and thereby how to *record images* of the

object 26 with the *different colors*. *Id.*

[e][3] [the hardware processor configured to] ... combine the different colors from the different images, thereby obtaining the color of the surface of the object,

Babayoff satisfies these limitations of claim 1. Ex. 1002, ¶136. Babayoff teaches that the *processor 24* processes the *three differently colored monochromatic images* and *combines* the same to *provide a full color image* of the *object 26*. Ex. 1005, [0046], [0063], [0079], [0092], [0130], [0145], FIG. 1. Babayoff explains that the *processor 24* aligns the color image with the 3D entity previously created to provide color values to the entity by mapping the color values to the entity, which *provides the color of the surface of the object 26* for the 3D representation. *Id.*, [0009], [0065], [0131], FIG. 1.

[f] wherein the intraoral scanner is wireless, and wherein the at least one camera is a high-speed camera.

Babayoff in combination with Knighton and Hanson satisfies these limitations of claim 1. Ex. 1002, ¶¶137-145.

“wherein the intraoral scanner is wireless”:

The limitation in claim 1 of the ’146 patent that the “intraoral scanner is wireless” corresponds to the method limitation in step [h] of claim 21 of “wirelessly transmitting the data for the 3D geometry.” Therefore, the above analysis for claim 21[h] under Ground 1 also applies for the wireless limitation of claim 1[f].

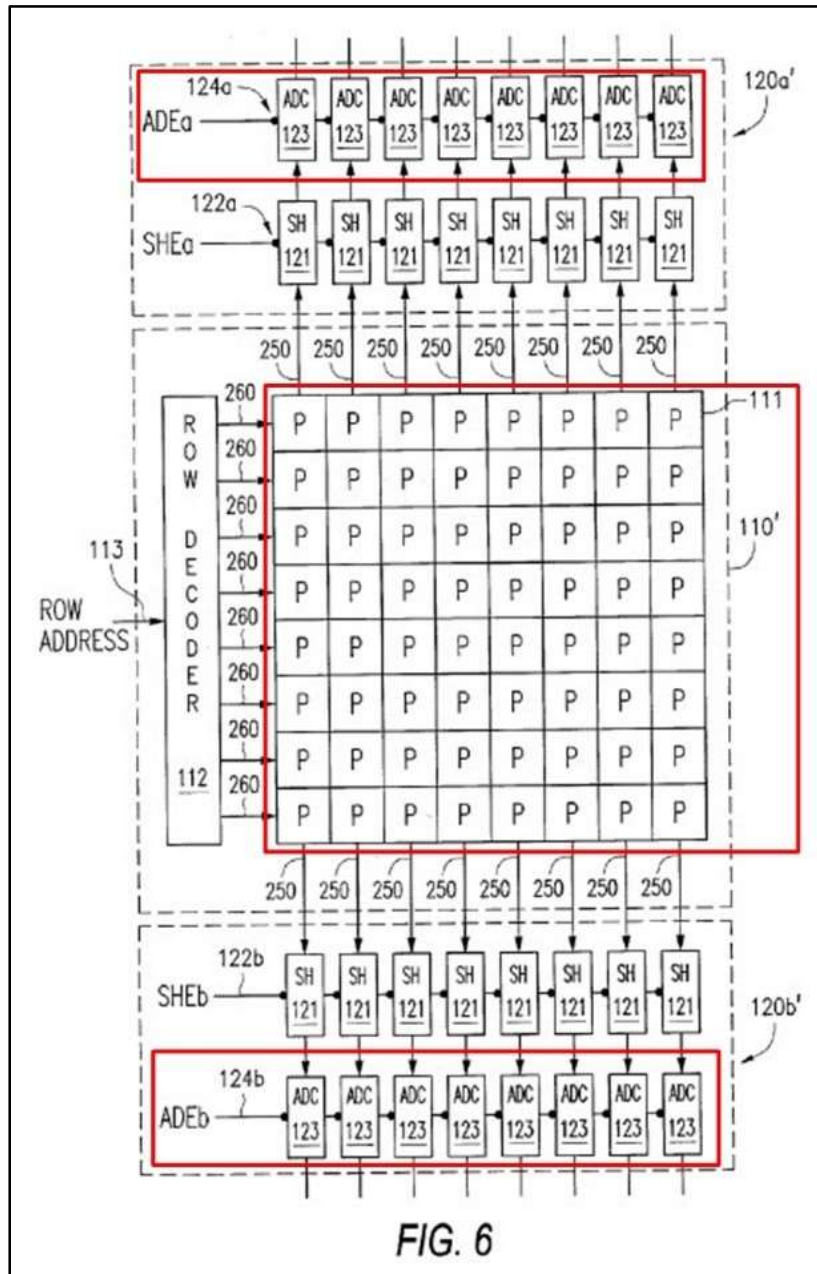
“wherein the at least one camera is a high-speed camera”:

Regarding the camera being a high-speed camera, Babayoff teaches that the camera must be *high-speed* in order to *keep the time interval between acquisition of images* to a *minimum amount of time*. Ex. 1005, [0027], [0072], [0145]. In particular, Babayoff teaches that the *time interval between acquisition of images by the camera* is preferably between about *0 and 20 milliseconds*. *Id.* To have such a *low time interval between acquisitions*, the *camera* is *high-speed*. *Id.*; Ex. 1002, ¶142.

To the extent that the phrase “high-speed camera” in the ’146 patent is interpreted to mean that the camera must have *multiple analog-to-digital (A/D) converters per line of pixels* in the camera, the use of multiple A/D converters per line of pixels for the camera in Babayoff would have been obvious to a POSA. *Id.*, ¶143. In particular, in the same type of hand-held three-dimensional scanner as Babayoff, Knighton points out that the *image sensor* could be one of a *charge coupled device (CCD) type* or could be one of a *complementary metal oxide semiconductor (CMOS) type*. Ex. 1007, [0005], [0024]. Knighton points out that in either type (*i.e.*, CCD or CMOS), there would be an *array of sensor elements* each representing a pixel. *Id.* It would have been obvious to a POSA to use a *CMOS image sensor* in the device of Babayoff in place of the *CCD image sensor* of Babayoff because Knighton demonstrates that a *CMOS image sensor* was a

known available substitute for a **CCD image sensor** in this same context. *Id.*; Ex. 1002, ¶104. A POSA would also have known that a **CMOS image sensor** was a *known available substitute* for a **CCD image sensor**. *Id.*

Furthermore, Hanson discloses that a **CMOS image sensor** can have *multiple A/D converters per line of pixels* in a pixel array to *increase the speed* of the image sensor. Ex. 1008, [0017], [0028], [0030]-[0037], FIGS. 3, 5, 6. FIG. 6 of Hanson is annotated below in red to highlight the pixel array 110' and the *analog processing and digitizing circuits 120a', 120b'*, which *each include a plurality of A/D converters 123*:



Id., FIG. 6 (annotated).

As shown in FIG. 6 of Hanson, the **CMOS image sensor** has **multiple A/D converters 123 per line of pixels P in the pixel array 110'**. Hanson explains that having the multiple A/D converters 123 allows for the CMOS image sensor to be

“high speed.” *Id.*, [0017], [0028], [0030]-[0037]. It would have been obvious to a POSA to use a *high-speed CMOS image sensor* as shown in Hanson with *multiple A/D converters per line of pixels* as the image sensor for the camera in Babayoff, because Babayoff indicates that it is preferable to have a *short time interval*, in the range of about *0 to 20 milliseconds*, between image acquisitions, and Hanson shows an example of an image sensor that would provide that benefit for *high-speed* capture of images. Ex. 1002, ¶145. A POSA would have expected the use of Hanson’s CMOS image sensor in Babayoff to be successful because it applies a straightforward insertion of the image sensor of Hanson in place of the image sensor of Babayoff that performs the same function. *Id.*, ¶145.

C. Claim 3

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

Claim 3 is obvious based on the combination provided for claim 1. Ex. 1002, ¶146. As discussed *supra* in the analysis for claim 1, the pattern generator in Babayoff as modified by Zhang is the projector of Zhang, which Zhang explicitly states could be a *digital light processing (DLP)* or *liquid crystal display (LCD)* projector. Ex. 1011, pp. 907, 909.

D. Claim 4

The intraoral scanner according to claim 1, wherein the different colors are provided by at least three monochromatic light sources of the light source.

Babayoff discloses this limitation of claim 4. Ex. 1002, ¶147. Babayoff discloses that the different colors can be provided by LEDs, and states that *each LED* can provide illumination in *one* of at least three colors, such that some of the LEDs provide a blue illumination, while other LEDs provide green illumination, and while yet other LEDs provide red illumination. Ex. 1005, [0044], [0048], [0057], [0145], [0149], [0157].

E. Claim 5

The intraoral scanner according to claim 4, wherein the at least three monochromatic light sources are light-emitting diodes (LEDs) or a segmented LED.

Babayoff discloses this limitation of claim 5. Ex. 1002, ¶148. Babayoff discloses that the at least three monochromatic light sources in Babayoff are *light-emitting diodes (LEDs)*. Ex. 1005, [0057], [0149], [0157].

F. Claim 6

The intraoral scanner according to claim 4, wherein the hardware processor is configured to selectively switch the color of the probe light by switching on and off the at least three monochromatic light sources.

Babayoff discloses this limitation of claim 6. Ex. 1002, ¶149. Babayoff explains that the processor 24, also called the processing unit 24, controls the tri-

color sequence generator 74 to provide the three different colored illuminations of the object 26. Ex. 1005, [0145]. The tri-color sequence generator 74 is controlled by the processor 24 to selectively switch the color of the probe light by ***switching on and off the LEDs***, which are the at least three monochromatic light sources. *Id.*, [0044]-[0045], [0048], [0057], [0063]-[0064], [0079], [0130], [0145], [0149], [0157]; Ex. 1002, ¶149.

G. Claim 8

The intraoral scanner according to claim 1, wherein the probe light is directed towards the object in a direction substantially parallel with the longitudinal axis of the tip, and wherein the probe light is further reflected towards the object by a single reflective mirror located in the tip.

Babayoff in combination with Zhang discloses the limitations of claim 8. Ex. 1002, ¶150. As discussed *supra*, Babayoff as modified by Zhang provides the probe light. The tip is part of the endoscopic probing member 46 of Babayoff. Ex. 1005, [0138], FIGS. 4A. As shown in FIG. 4A of Babayoff, the probe light, which would be on the ***path of the incident light beams 36***, is directed towards the object 26 in a direction ***substantially parallel*** with the longitudinal axis of the endoscopic probing member 46. *Id.*, [0135], [0138], FIG. 4A. The probe light is then further reflected towards the object 26 by a ***single reflective mirror*** located in the endoscopic probing member 46 as described in paragraph [0138] of Babayoff and shown by FIG. 4A. *Id.*, [0138], FIG. 4A. Babayoff also shows an example of the

endoscope in the form of a probing member 90 in FIG. 5B in which the light rays 99 travel down the probing member and bounce on the *mirror 95* such that they are reflected out through the sensing face 97. *Id.*, [0146], FIG. 5B.

H. Claim 9

The intraoral scanner according to claim 1, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.

Babayoff in combination with Zhang and Knighton satisfies the limitations of claim 9. Ex. 1002, ¶151. The added limitations in claim 9 are device limitations that correspond to the method limitations in claim 23 and, therefore, the above analysis for claim 23 under Ground 1 also applies for claim 9. Both Babayoff and Knighton disclose that it is a processor that performs the processing as discussed above in the analysis, so the structure of the “hardware processor” configured to perform the limitations is disclosed by the combination.

I. Claim 10

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

Babayoff in combination with Zhang and Knighton satisfies the limitations of claim 10. Ex. 1002, ¶152. The added limitations in claim 10 are device

limitations that correspond to the method limitations in claim 24 and, therefore, the above analysis for claim 24 under Ground 1 also applies for claim 10. Both Babayoff and Knighton disclose that it is a processor that performs the processing as discussed above in the analysis, so the structure of the “hardware processor” configured to perform the limitations is disclosed by the combination.

J. Claim 11

The intraoral scanner according to claim 9, wherein the data for the 3D geometry is wirelessly transmitted to a workstation.

Babayoff in combination with Knighton satisfies the limitation of claim 11. Ex. 1002, ¶153. The added limitation in the device claim 11 corresponds to the limitation in method claim 25 and, therefore, the above analysis for claim 25 under Ground 1 also applies for claim 11.

K. Claim 12

The intraoral scanner according to claim 9, wherein the hardware processor processes the raw 3D data into data for the 3D geometry in real time.

Babayoff in combination with Zhang and Knighton satisfies the limitation of claim 12. Ex. 1002, ¶154. The added limitation in claim 12 is a device limitation that corresponds to the method limitation in claim 26 and, therefore, the above analysis for claim 26 under Ground 1 also applies for claim 12. Both Babayoff and Knighton disclose that it is a processor that performs the processing as discussed above in the analysis, so the structure of the “hardware processor” to perform the

limitation is disclosed by the combination.

L. Claim 13

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

Babayoff in combination with Zhang and Knighton satisfies the limitations of claim 13. Ex. 1002, ¶155. The added limitations in the device claim 13 correspond to the limitations in method claim 27 and, therefore, the above analysis for claim 27 under Ground 1 also applies for claim 13.

M. Claim 15

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

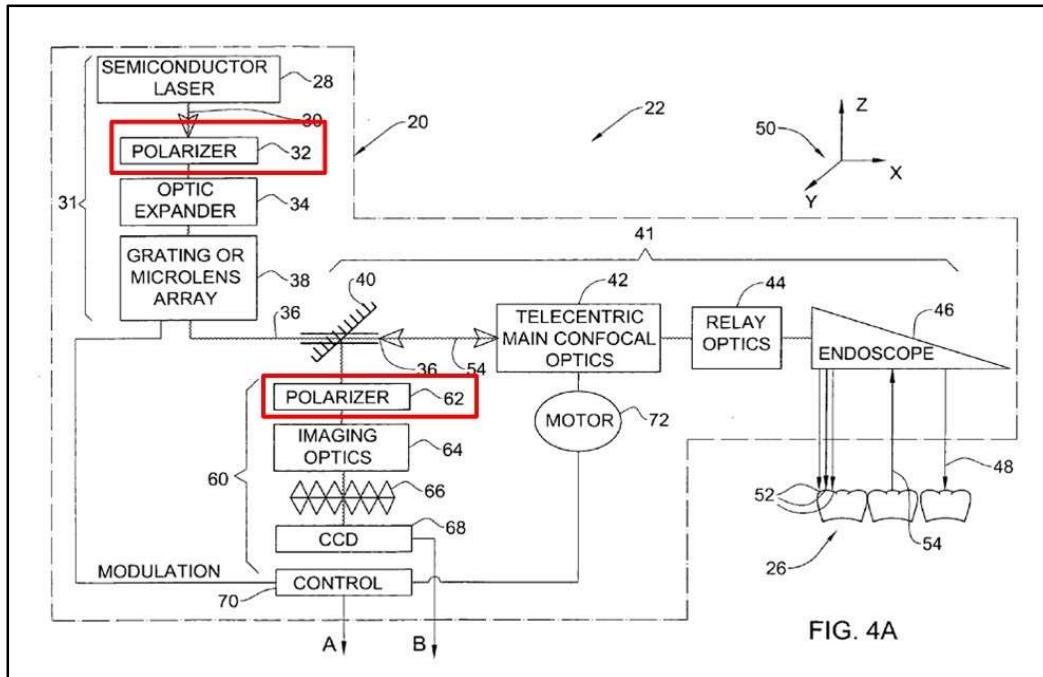
Babayoff in combination with Zhang and Knighton satisfies the limitations of claim 15. Ex. 1002, ¶156. The added limitations in the device claim 15 correspond to the limitations in method claim 29 and, therefore, the above analysis for claim 29 under Ground 1 also applies for claim 15.

N. Claim 20

The intraoral scanner according to claim 1, wherein the intraoral scanner further comprises polarization optics.

Babayoff discloses this limitation of claim 20. Ex. 1002, ¶¶157-158. The intraoral scanner in Babayoff includes the *polarizer 32*, which gives rise to

polarization of the light passing through it, and also includes the **polarizer 62**. Ex. 1005, [0135], [0140], FIG. 4A. An annotated version of FIG. 4A of Babayoff is shown below with the polarizer 32 and the polarizer 62 highlighted, which are **polarization optics**:



Id., FIG. 4A (annotated).

Babayoff also shows and describes further exemplary uses of polarization optics in the device of Babayoff. *Id.*, [0037], [0051]-[0054], [0087]-[0090], [0168], FIG. 11. A POSA, therefore, would have used the polarization optics as taught by Babayoff in the combination. Ex. 1002, ¶¶157-158.

O. Claim 22

The method according to claim 21, wherein the plurality of 2D images is recorded using a high-speed camera.

Babayoff in combination with Knighton and Hanson discloses this limitation of claim 22. Ex. 1002, ¶159. The limitation in this method claim 22 corresponds to the last limitation in the device claim of independent 1 and, therefore, is obvious for the same reasons provided above with respect to limitation [f] of claim 1 under Ground 2. Hanson discloses that a CMOS image sensor can have *multiple A/D converters per line of pixels* in a pixel array and is “high speed.” Ex. 1008, Abstract, [0017], [0028], [0030]-[0037], FIGS. 3, 5, 6. It would have been obvious to a POSA to use a high-speed CMOS image sensor with *multiple A/D converters per line of pixels* as shown in Hanson as the image sensor for the camera in Babayoff, because Babayoff indicates that it is preferable to have a short time interval (about 0 to 20 milliseconds) between image acquisitions, and Hanson shows an example of an image sensor that would provide that benefit. Ex. 1005, [0027], [0072], [0145]; Ex. 1002, ¶159.

**IX. GROUND 3: CLAIM 2 IS OBVIOUS OVER BABAYOFF AND
ZHANG AND KNIGHT AND HANSON AND GANDYRA**

A. Claim 2

The intraoral scanner according to claim 1, wherein the pattern generator includes at least one translucent and/or transparent pattern element.

Claim 2 is obvious based on the combination provided for claim 1 in Ground 2 above further in combination with Gandyra. Ex. 1002, ¶160. As discussed *supra* in the analysis for claim 1, Zhang shows the use of a projector to make the pattern for the time-varying illumination pattern. Ex. 1011, pp. 907, 909. Gandyra discloses an intraoral scanner for scanning teeth and also teaches in paragraph [0038] the use of a time-variable illumination pattern for the scanning. Ex. 1009, Abstract, [0001], [0030], [0038], FIG. 1. Gandyra teaches that the pattern can be any graphical pattern such as lines, and further teaches that the pattern can be produced using a *DLP projection* or, *alternatively*, using the *pattern transparency* 7, which is a *transparent pattern element*. *Id.*, [0030], [0038]. It would have been obvious to a POSA to use the *pattern transparency* of Gandyra to modify the device noted in the combination discussed in the analysis of claim 1 in place of the projector to produce the time-varying illumination pattern because Gandyra shows that the use of such a *pattern transparency* with a light is a *known alternative* to a *DLP projector* for producing the time-varying illumination pattern in the context of scanning teeth. Ex. 1002, ¶160. The use of a pattern transparency in place of the

DLP projector to create the pattern may result in cost savings.

A POSA would have understood how to make a time-varying illumination pattern with the pattern transparency because it is taught by Gandyra. Ex. 1009, Abstract, [0001], [0030], [0038], FIG. 1. Moreover, the Wilson reference (Ex. 1006) shows that a POSA would have understood how to make a time-varying illumination pattern with a pattern transparency. In particular, Wilson shows to use a piezoelectric device (piezo) to move the pattern element or grid, such as a pattern transparency, so as to shift the pattern across the object being imaged. Ex. 1006, pp. 117-118, Figs. 1, 2; Ex. 1002, ¶39.

X. MANDATORY NOTICES PURSUANT TO 37 C.F.R. § 42.8

A. Real Party-In-Interest (37 C.F.R. § 42.8(b)(1))

Pursuant to 37 C.F.R. § 42.8(b)(1), Petitioner certifies that DITC is the real party-in-interest in this matter. Petitioner also identifies an additional real party-in-interest, Carestream Dental LLC, which was the original defendant in related district court litigation (*3Shape A/S v. Carestream Dental LLC*, *see infra*) and which as of April 20, 2022 has no past or future liabilities associated with the claims, accused products, or associated business in that litigation.

B. Related Matters (37 C.F.R. § 42.8(b)(2))

Pursuant to 37 C.F.R. § 42.8(b)(2), Petitioner hereby states that the '146 patent is a subject of civil action *3Shape A/S v. Carestream Dental LLC et al.*,

Civil No. 1:22-cv-01829 (N.D. Ga.), which was transferred from the Western District of Texas and was previously styled as *3Shape A/S v. Carestream Dental LLC*, Civil No. 6:21-cv-01110 (W.D. Tex.), filed October 26, 2021. The '146 patent is also a subject of civil action *3Shape A/S v. Medit Corporation*, Civil No. 6:22-cv-00443 (W.D. Tex.), filed May 2, 2022.

C. Counsel and Service Information (37 C.F.R. § 42.8(b)(3), 42.8(b)(4))

Pursuant to 37 C.F.R. §§ 42.8(b)(3) and 42.10(a), Petitioner provides the following counsel and service information. Pursuant to 37 C.F.R. § 42.10(b), a Power of Attorney accompanies this Petition.

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

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D. Payment of Fees

The Office is authorized to charge fees for this Petition to Deposit Account No. 50-5708. Any additional fees that might be due are also authorized.

XI. GROUNDS FOR STANDING

Pursuant to 37 C.F.R. § 42.104(a), Petitioner certifies that the '146 patent is available for *inter partes* review and that Petitioner is not barred or estopped from

requesting *inter partes* review of any claim of the '146 patent on the grounds identified herein. This Petition is filed in accordance with 37 C.F.R. § 42.106(a) along with a Power of Attorney and an Exhibit List pursuant to 37 C.F.R. § 42.10(b) and § 42.63(e).

XII. DISCRETIONARY ANALYSIS

In addition to the strong merits presented herein, Petitioner also hereby provides a *Sotera*-type stipulation and stipulates that if the PTAB institutes *inter partes* review in relation to any petition filed by DITC with respect to the '146 patent, the Petitioner will not pursue in the district court litigation any ground raised or that could have been reasonably raised in the instituted IPR with respect to the patent claim subject to the instituted IPR. This stipulation precludes discretionary denial under §314(a). *See* Director Vidal Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation, at 3-5, 7-8 (June 21, 2022).

Regarding §325(d), the '146 patent has not previously been challenged at the PTAB. Nor was any reference relied upon herein as part of any ground cited during prosecution or considered by the Examiner. Accordingly, discretionary denial under §325(d) and *General Plastic* is not warranted.

XIII. CONCLUSION

Petitioner respectfully requests that Trial be instituted and that claims 1-6, 8-

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

13, 15, 20-27, and 29 of the '146 patent be canceled.

Respectfully submitted,

Dated: December 19, 2022

By: /s/ John T. McKee
John T. McKee (Reg. No. 65,926)

Counsel for Petitioner

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the word count for the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 11,076,146 totals 13,789 words, which complies with the 14,000 allowed under 37 CFR § 42.24(a)(1)(i). This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the word limit.

Dated: December 19, 2022

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 11,076,146 together with all exhibits and other papers filed therewith was served on December 19, 2022, by FedEx directed to the attorneys of record for the patent at the following address:

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