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(54) METHOD FOR DEFINING A FINISH LINE OF A DENTAL PROSTHESIS

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Related U.S. Patent Documents

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A61C 5/77 (2017.01)
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CPC ***A61C 5/77*** (2017.02); ***A61C 9/0046*** (2013.01); ***A61C 13/0004*** (2013.01); ***G16H 20/40*** (2018.01)

(58) **Field of Classification Search**
CPC A61C 5/77; A61C 9/0046; A61C 13/0004; G16H 20/40
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,937,928 A * 7/1990 van der Zel 29/896.1
5,372,502 A 12/1994 Massen et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 0565174 B1 11/1998
EP 0565175 B1 12/1998
(Continued)

OTHER PUBLICATIONS

3 Shape A/S et al vs *Align Technology*, PTAB IPR2019-00132, Docket Report, Retrieved from: http://search.docketnavigator.com/patent/case/193587/2?print=True, 2020, 3 pages.
(Continued)

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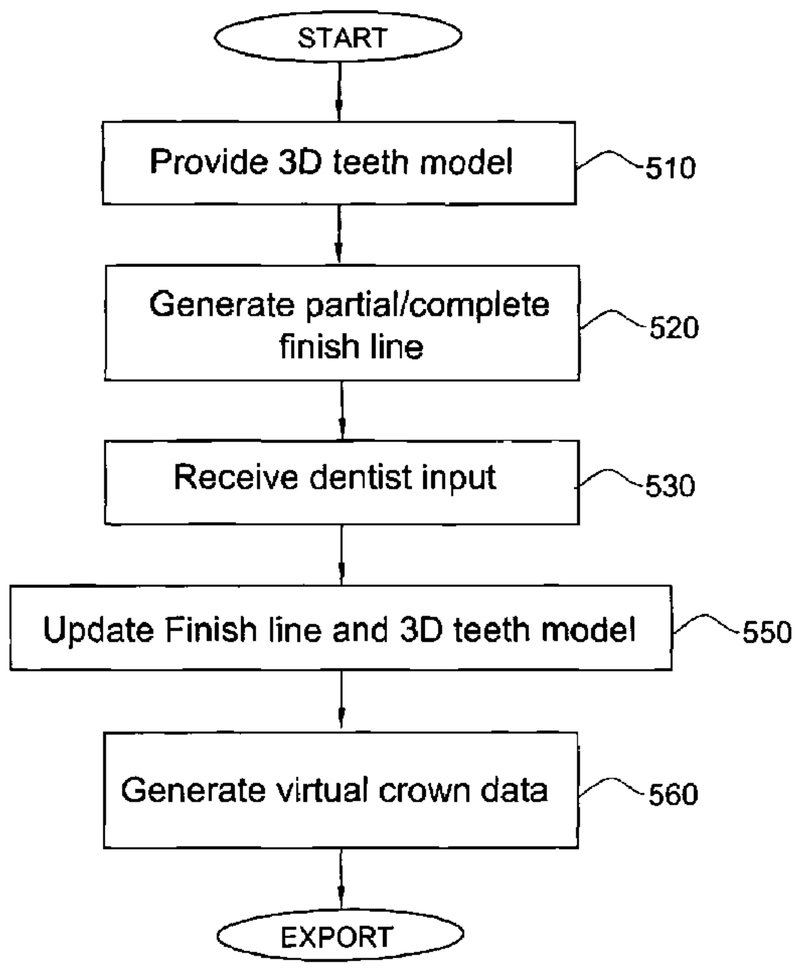
(74) *Attorney, Agent, or Firm* — Sterne, Kessler, Goldstein & Fox P.L.L.C.

(57) **ABSTRACT**

A computer-based prosthodontic method is provided, for enabling a dental practitioner to define a finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation. The method comprises the following steps: providing a three-dimensional (3D) digital data relating to the patient's dentition, the 3D data includes data representative of the surface topology of the preparation and its surroundings; generating first finish line data representative of at least a portion of the finish line and superimposing an image of the finish line on an image of the dentition; obtaining second finish line data determined on the basis of input received from a dental practitioner; and using the second finish line data to update the first finish line data and superimposing the updated data on the dentition image.

20 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

G16H 20/40	(2018.01)
A61C 9/00	(2006.01)
A61C 13/00	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,417,572	A	5/1995	Kawai et al.	G05B 19/4207 433/213
5,880,962	A	3/1999	Andersson et al.	
6,049,743	A *	4/2000	Baba	G16H 50/50 433/172
6,409,504	B1	6/2002	Jones et al.	
6,575,751	B1	6/2003	Lehmann et al.	
7,112,065	B2	9/2006	Kopelman et al.	
7,488,174	B2	2/2009	Kopelman et al.	
2002/0037489	A1	3/2002	Jones et al.	
2002/0064759	A1 *	5/2002	Durbin	A61C 9/00 433/213
2003/0207235	A1 *	11/2003	der Zel	433/223
2005/0080503	A1	4/2005	Kopelman et al.	
2006/0275737	A1	12/2006	Kopelman et al.	

FOREIGN PATENT DOCUMENTS

WO	WO 97/03622		2/1997
WO	WO-9703622	A1	2/1997
WO	WO 00/08415		2/2000
WO	WO-0008415	A1	2/2000
WO	WO-0025677	A1	5/2000

OTHER PUBLICATIONS

Align Technology, Inc vs *3 Shape A/S et al.* DDE-1-17-cv-01646, Docket Report, Retrieved from: http://search.docketnavigator.com/patent/case/171284/3?print=True, 2020, 37 pages.

Align Technology, Inc vs *3 Shape A/S et al.* DDE-1-17-cv-01646, Memorandum Opinion on Motion to Dismiss, Sep. 7, 2018, 36 pages.

Align Technology, Inc vs *3 Shape A/S et al.* DDE-1-17-cv-01646, Memorandum Opinion on Motion to Dismiss, Jul. 5, 2019, 15 pages.

International Search Report directed to related International Patent Application No. PCT/IL03/00600, dated Feb. 23, 2004; 1 page.

Supplementary European Search Report directed to related European Patent Application No. 03738479.9, dated Nov. 17, 2008; 2 pages.

Non-Final Office Action for U.S. Appl. No. 11/504,588, dated Jan. 8, 2008; 7 pages.

Notice of Allowance for U.S. Appl. No. 11/504,588, dated Oct. 7, 2008; 6 pages.

Non-Final Office Action for U.S. Appl. No. 10/623,707, dated Jan. 27, 2006; 8 pages.

Notice of Allowance for U.S. Appl. No. 10/623,707, dated May 18, 2006; 4 pages.

3 Shape A/S et al vs *Align Technology*, PTAB IPR2019-00132, Final Written Decision (Paper 33), Jun. 1, 2020, 56 pages.

Agnini et al., "Digital Dental Revolution The Learning Curve", 2015, Italy, Quintessence Pub. Co., 54 pages.

Ng et al., "A Comparison of the Marginal Fit of Crowns Fabricated with Digital and Conventional Methods", 2015, The Journal of Prosthetic Dentistry, vol. 112, No. 3, 6 pages.

Yuksel et al., "Influence of Marginal Fit and Cement Type on Microleakage of All-Ceramic Crown Systems", May-Jun. 2011, Braz Oral Res., vol. 25, No. 3, 6 pages.

The Merriam-Webster Dictionary, Eleventh Edition, Meriam-Webster Incorporated 2005, Massachusetts, 7 pages.

* cited by examiner

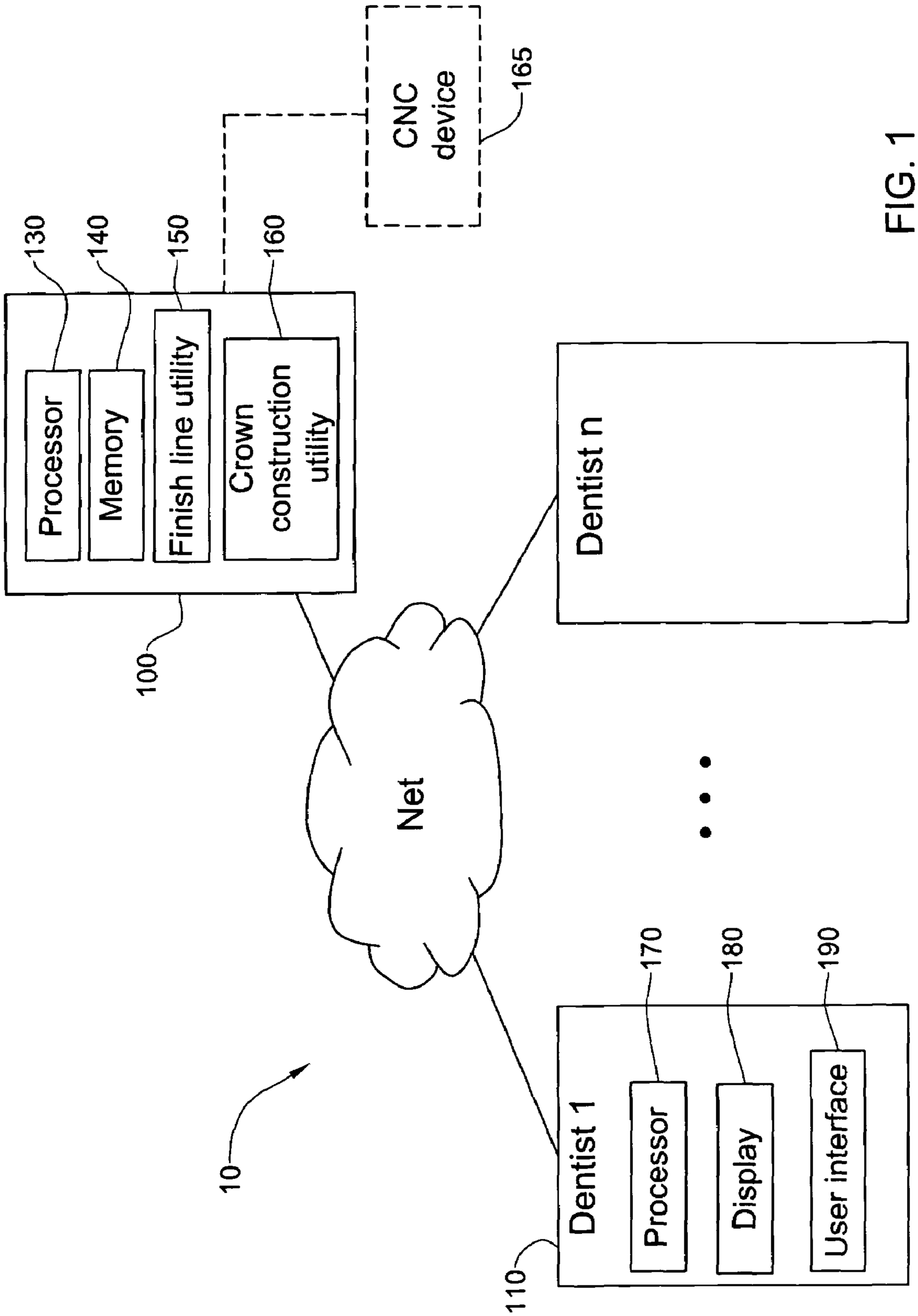

CNC device
165
130
140
150
160
Processor
Memory
Finish line utility
Crown construction utility
100
Net
Dentist n
10
Dentist 1
170
180
190
Processor
Display
User interface
110

FIG. 1

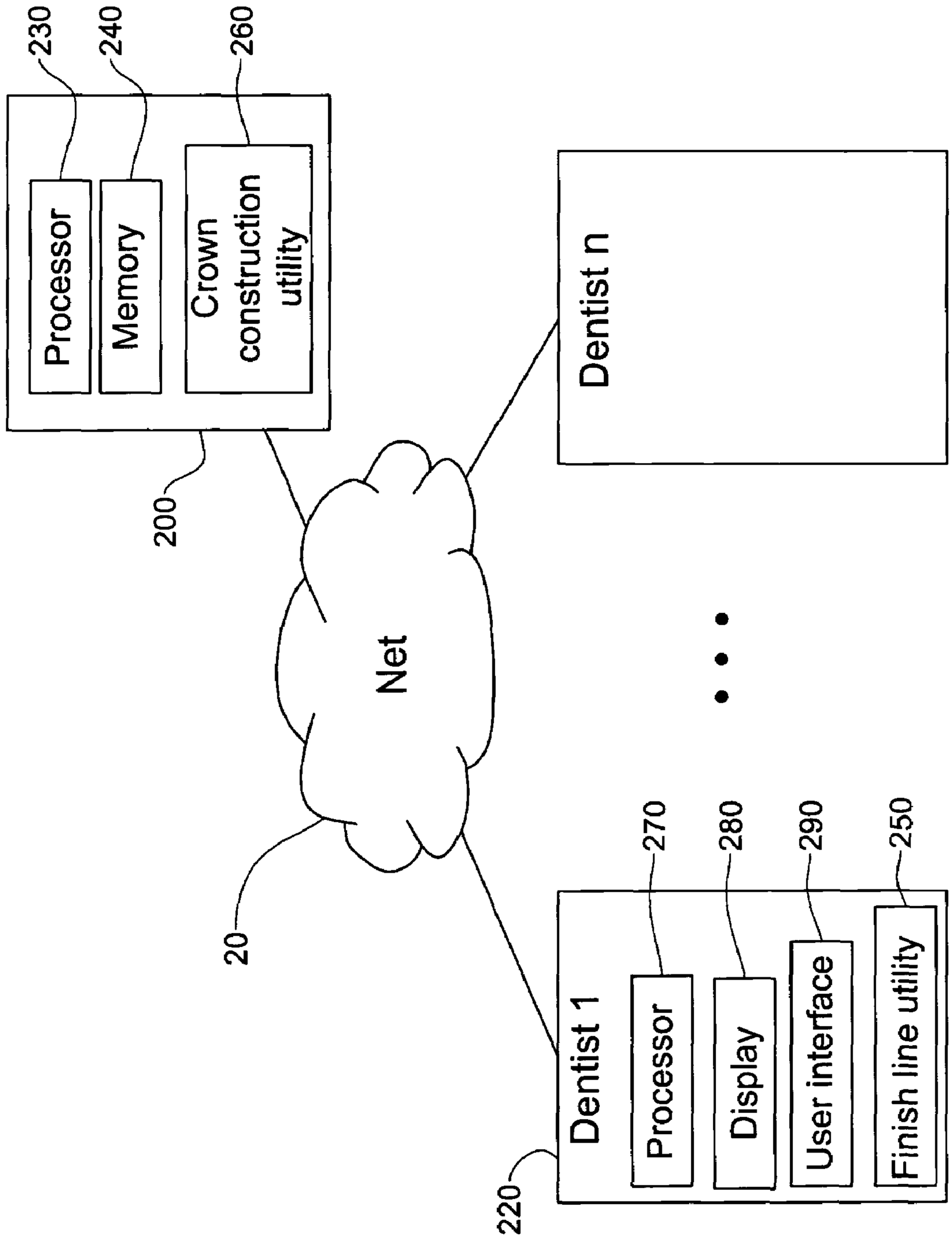

230
240
260
Processor
Memory
Crown construction utility
200
Net
20
Dentist n
270
280
290
250
Dentist 1
Processor
Display
User interface
Finish line utility
220

FIG. 2

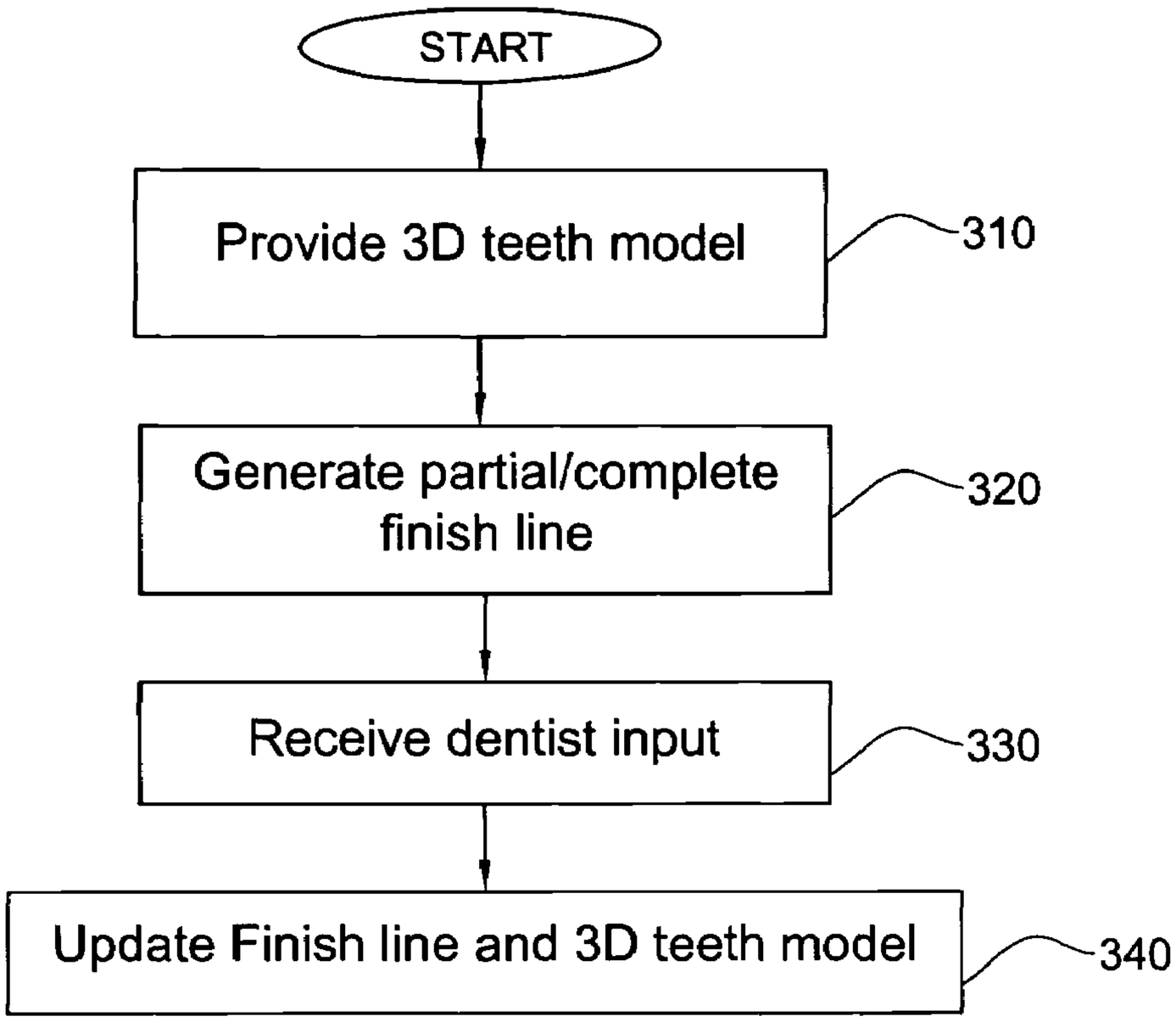

START
Provide 3D teeth model
310
Generate partial/complete finish line
320
Receive dentist input
330
Update Finish line and 3D teeth model
340

FIG. 3

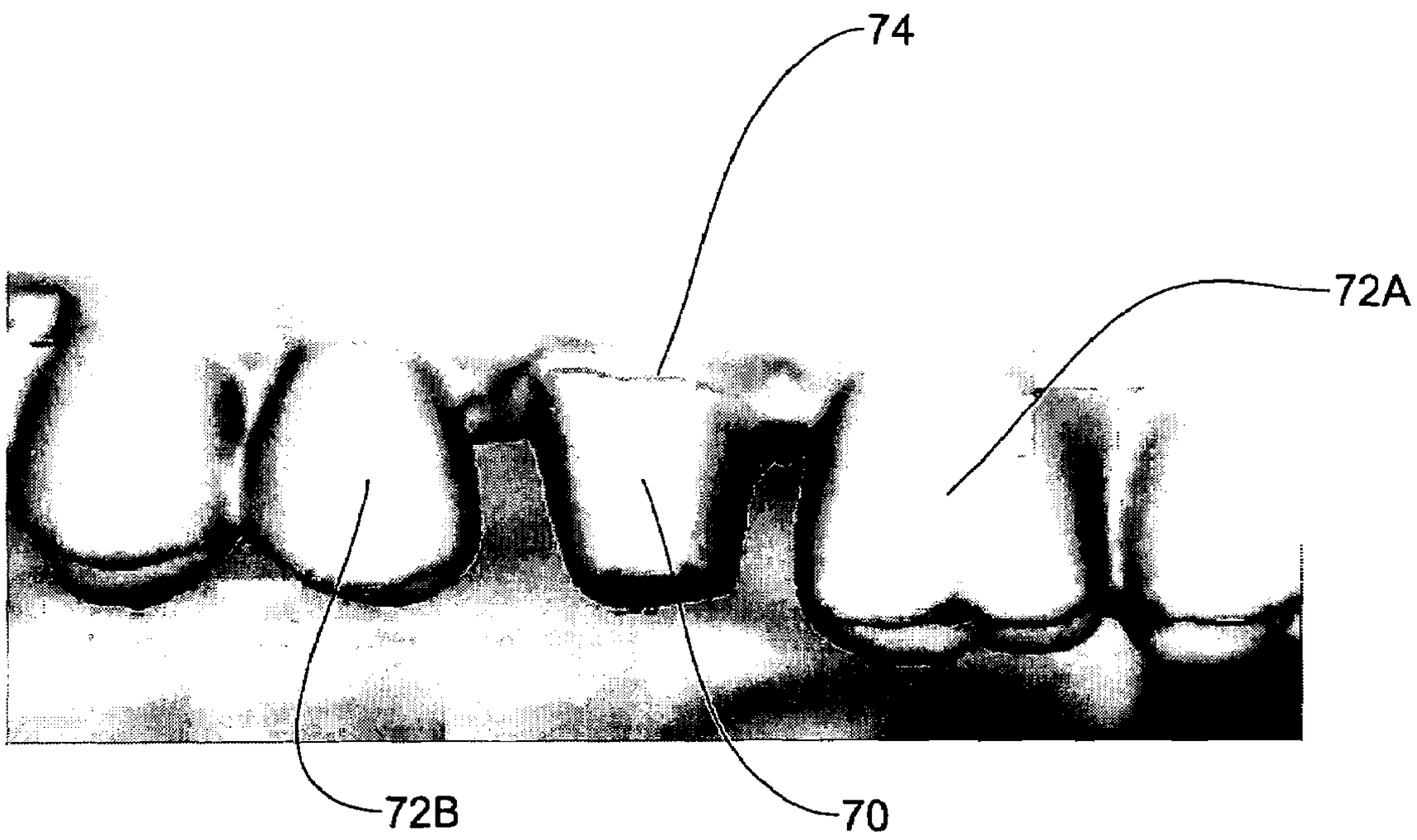

74
72A
72B
70

FIG. 4

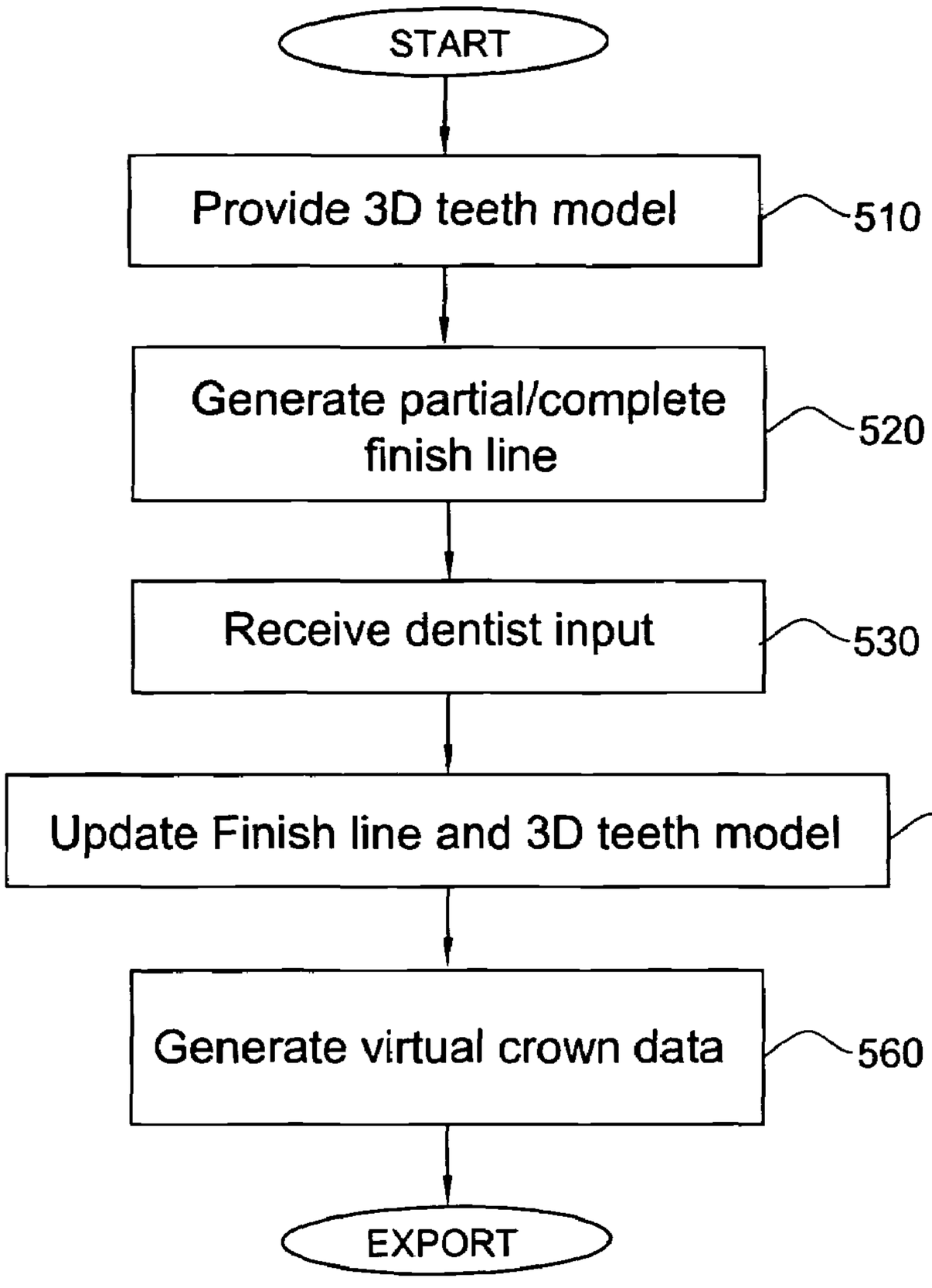

START
Provide 3D teeth model
510
Generate partial/complete finish line
520
Receive dentist input
530
Update Finish line and 3D teeth model
550
Generate virtual crown data
560
EXPORT

FIG. 5

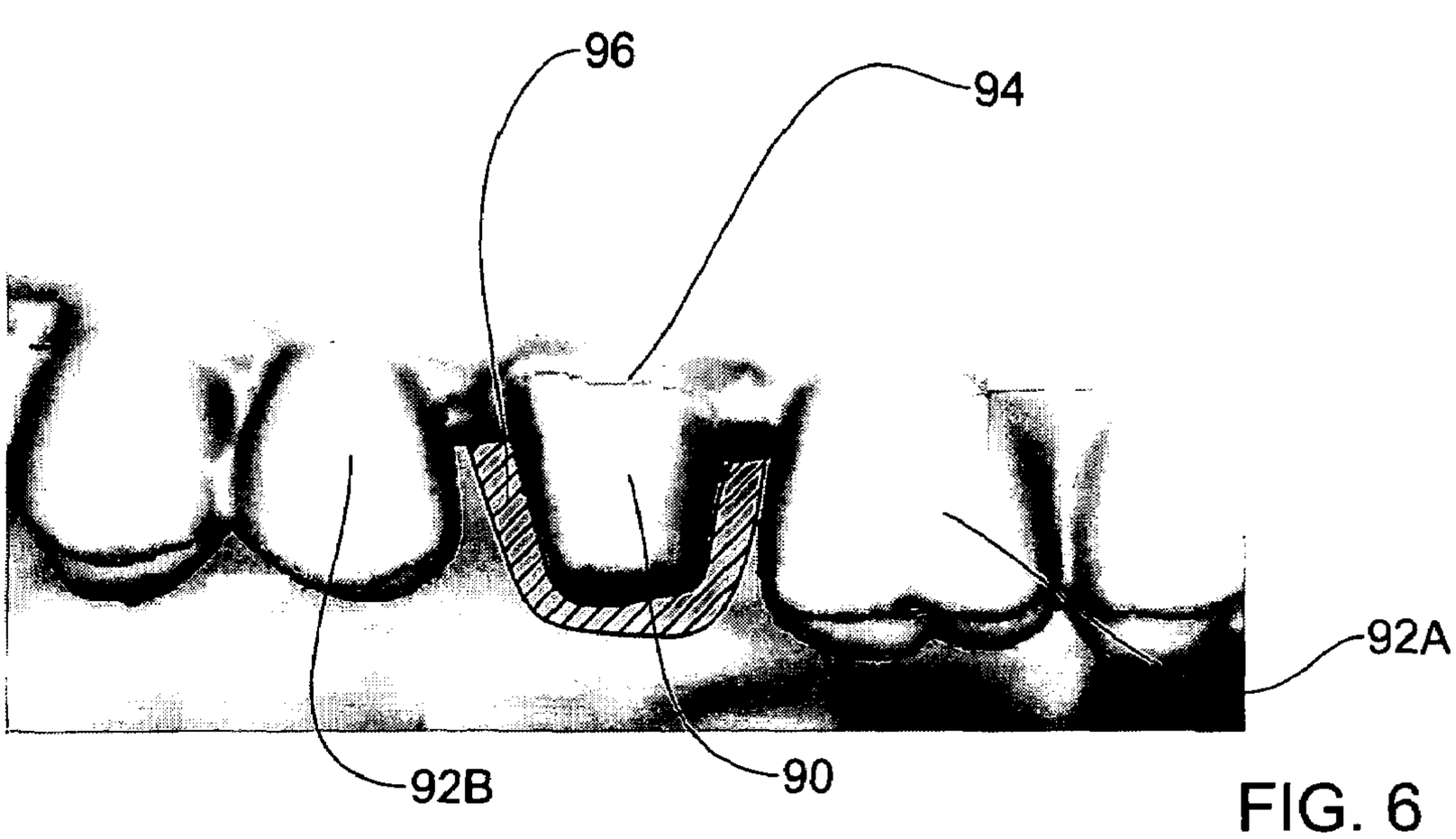

96
94
92A
92B
90

FIG. 6

METHOD FOR DEFINING A FINISH LINE OF A DENTAL PROSTHESIS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

This *is a reissue* application claims benefit *of U.S. Pat. No. 7,112,065* (*U.S. patent application Ser. No. 10/623,707, filed Jul. 22, 2003*) *which claims benefit* of U.S. Provisional Patent Application No. 60/397,672 filed Jul. 22, 2002**[**, the**]**. *The* entire contents of which are hereby incorporated by reference in their entirety.

FIELD OF THE INVENTION

This invention relates to the filed of prosthodontics.

BACKGROUND OF THE INVENTION

An artificial dental prosthesis such as a crown covers portions of a tooth surface and is normally fabricated away from the patient's mouth, in a lab, and then installed in the mouth by the dentist.

The artificial crowns are prepared based on a working cast (also known by the term "master cast"). It is on the cast that all the technical steps leading to the completed restoration must be performed. In preparing artificial crowns, best mechanical compatibility between the abutment tooth (hereinafter referred to as the preparation) and the crown is desired, to ensure complete imperviousness of the restored structure. Thus, the more precisely the working cast reproduces the anatomy of the mouth in the areas to be treated, the more accurate will be the spatial position as will be the static and dynamic relationships within the mouth after treatment. An accurate working cast is thus important to produce a biomechanically acceptable restoration.

The precision of the cast depends on several factors, including, inter alia, the accuracy of the impressions and wax bites, the material from which the cast is constructed, and the identification of the anatomic contours and of the finish line (also referred to at times by the term "chamfer line" and "marginal line"), etc.

The finish line, by definition, is the apical limit of the abutment tooth model (the "preparation") and the margin of the reconstruction must end on it, i.e. it represents the point of transition between the biologic and artificial parts.

Being able to identify the zone that is apical to the finish line in absolute precision is fundamentally important for two reasons: (1) it allows to define the preparation limit with certainty, and (2) being intact, it maintains the anatomic characteristics of that tooth.

According to current practice, after diagnosing that a patient needs a crown, the dentist cuts the tooth to be reconstructed and prepares two impressions and a wax bite of the patient's jaws. Based on the impressions, wax bite and on written instructions of the dentist, a technician prepares in a lab the corresponding cast, and the relevant tooth within the preparation is temporary separated from the plaster so that the area with the anatomic information (the area defining the anatomic contour) and the finish line are exposed. At this point, the finish line is manually marked by the lab technician in ink on the preparation, and this finish line is an important parameter used in constructing the crown. Alternatively, a virtual three-dimensional (3D) image of the working cast is obtained e.g. in a manner as described in international publication No. WO97/03622, or in international publication No. WO00/08415, and the lab technician marks the finish line in the three dimensional environment.

U.S. Pat. No. 5,417,572 discloses a computer-based method for extracting a finish line for designing an artificial crown. Amounts of variation of data representing the shape of an abutment tooth are determined, and a train of points is extracted from the amounts of variation. Then a developed view of the surface shape of the abutment tooth is displayed, and the obtained train of points is also displayed in the developed view. The finish line for designing the artificial crown is determined, based on thus displayed train of points.

There are times when the finish line is not clear and the transition between the cut area to the biological area is not well defined. In such cases the technician either estimate himself where the line is or returns the cast (or the 3D virtual model) to the dentist for him to complete the finish line. In other cases, the boundaries between the cut area and the natural area of the tooth are blurred such that only the dentist himself is able to assess the cut area (the so-called 'knife edges'), and to define the finish line.

SUMMARY OF THE INVENTION

According to one of its aspects, the present invention provides a computer-based prosthodontic method for enabling a dental practitioner (e.g. a dentist) to define a finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation, comprising:

(a) providing a three-dimensional (3D) digital data relating to the patient's dentition, the 3D data includes data representative of the surface topology of said preparation and its surroundings;

(b) generating first finish line data representative of at least a portion of said finish line and superimposing an image of said finish line on an image of said dentition;

(c) obtaining second finish line data determined on the basis of input received from a dental practitioner; and

(d) using said second finish line data to update said first finish line data and superimposing the updated data on the dentition image.

The updating of the first finish line data comprises defining a portion of the finish line not defined in the first finish line data or changing a portion of said first finish line data.

According to another aspect, the present invention provides a computer-based method for constructing a crown to be fitted on a tooth preparation in a subject. The method comprises defining a finish line on the preparation to obtain finish line data and employing the finish line data in constructing the crown. The finish line is determined in a manner as defined above.

The present invention is best implemented over a computer network. Thus, according to yet another aspect, the present invention provides a computer-based system for enabling a dental practitioner to define a finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation. The system comprises one or more central server utilities and a plurality of practitioner computerized machines connected to the server utility through a computer network, e.g. through the Internet.

Said server utility comprises:

(a) a processor;

(b) a memory coupled to the processor for storing a three-dimensional (3D) digital data relating to the patient's dentition, the 3D data including data representative of the surface topology of the preparation and its surroundings;

(c) a dedicated utility coupled to or integrated with the processor for generating a first finish line data representative of at least a portion of said finish line and superimposing an image of said finish line on an image of said dentition;

(d) a network interface coupled to the processor for transmitter to a dental practitioner computerized device at least a portion of the 3D digital data and the first finish line data and for receiving from the practitioner device data representative of a second finish line determined on the basis of practiotioner input, wherein the second finish line data is used to update the first finish line data.

Said practitioner machine comprises:

(a) a processor;

(b) a display coupled to the processor for presenting digital data relating to the patient's dentition, the digital data includes data representative of the surface topology of the preparation and its surroundings and a first finish line data representative of at least a portion of a finish line, such that the first finish line data is superimposed on the dentition image;

(c) a user interface coupled to the processor for allowing entry of a dental practitioner input for the determination of a second finish line data, the second finish line data being used to update the first finish line data; and

(d) a communication port coupled to the processor for receiving said digital data from a remote server utility and for conveying to the remote utility data relating to said updated first finish line data.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, preferred embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

FIG. **1** shows, by way of a block diagram, a generalized system architecture in accordance with an embodiment of the invention.

FIG. **2** shows, by way of a block diagram, a generalized system architecture in accordance with another embodiment of a system of the invention.

FIG. **3** is a schematic flow chart of a method for defining and displaying a finish line in accordance with an embodiment of the invention.

FIG. **4** shows a three-dimensional virtual image constructed in accordance with the invention with a finish line shown on the applicable portion of a tooth preparation.

FIG. **5** is a schematic representation of a flow chart showing the virtual construction of a crown to obtain digital crown data.

FIG. **6** shows a three dimensional virtual image, similarly as FIG. **4**, with an added crown.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a prosthodontic method that permits a dental practitioner (e.g. a dentist) to define a finish line on a tooth preparation. FIG. **1** is a general and schematic illustration of a computer-based system in accordance with an embodiment of the present invention. The system **10** includes a server computer **100** and a number of client machines such as **110**, which can be personal computers. Each client computer communicates to the server computer **100** through a computer network **120** (e.g. Internet, Intranet) or through a dedicated communication link.

The server **100** includes, inter alia, a processor **130** and memory **140**, which is coupled to the processor **130** for storing a three-dimensional (3D) digital data relating to the patient's dentition. The 3D data includes data representative of the surface topology of the preparation and its surroundings. A software utility **150** is further coupled to processor **130** or integrated with it, for generating data representative of at least a portion of said finish line.

Rather than drawing or marking by a lab technician the finished line on a working cast or in the virtual 3D environment, the finish line is generated in the service center **100** and is conveyed, via the computer network **10**, to the dentist **1** computer **110**. Computer **110** includes, inter alia, a processor **170**, a display **180** and a user interface **190** for allowing presentation of the dentition image and for allowing entry of the dentist input regarding the finish line, for updating the digital data. The updated data is then conveyed back to the service center **100** and is used by the crown construction utility **160** for the digital and physical construction of the desired crown. The construction and fabrication of the crown can be done in a CAD/CAM (Computer-aided-design/Computer-aided-Manufacture) environment, utilizing for example, a CNC (Computer Numerical Control) device.

The present invention is not limited to the exemplary architecture of FIG. **1** and other configurations can be implemented, for example as described in FIG. **2** in which like components to those shown in FIG. **1** are given same reference numerals shifted by 100. The main difference between the system **20** of FIG. **2** and system **10** of FIG. **1** is that the finish line utility **250** is integrated in the client computer. Such architecture, for example, allows the dentist (or his assistant) to obtain at the clinic, the 3D data that relates to the patient's dentition. The dentist is then able to view 'on the spot', an image of the patient's dentition and to define the finish line immediately or at a later stage. According to this scenario, the service center **200** is provided with the 3D data of the patient's dentition including the definition of the finish line. This data is then used to construct the crown.

In both examples, the service center is provided with a finish line that is best defined by the dentist in accordance with his professional considerations, in a novel and a very efficient manner, without the need for further iterations between the lab technician and the dentist, as typically occurring in the hitherto working methodology.

Reference is now being made to FIG. **3** showing, by way of a schematic blocked diagram, the steps for defining a finish line in a virtual three-dimensional teeth model. Following start, in step **310** a 3D teeth model of at least a portion of the teeth that includes the tooth preparation on which a crown is to be constructed is inputted. Then at **320** a first finish line is generated on the tooth preparation in a manual or a semi-automated or a fully automated manner. The first finish line is superimposed on the dentition image and is displayed on a suitable display medium (*e.g., a first 3D finish line*).

FIG. **4** shows an example of such a display. A tooth preparation **70** is seen with its neighboring teeth **72**A and **72**B with a finish line **74** drawn as a continuous line on the apical limit of tooth preparation. In addition to general

physical structure of such a teeth model, the colors of the neighboring teeth **72**A and **72**B may be determined by the dentist and also be recorded to permit the technician to produce a crown that has a color resembling that of the neighboring teeth.

In addition to general physical structure of such a teeth model, the colors of the neighboring teeth **72**A and **72**B may be determined by the dentist and also recorded to permit the technician to produce a crown that has a color resembling that of the neighboring teeth.

Turning back to FIG. **3**, a second finish line data is obtained, after receiving the dentist input (*e.g., a second 3D finish line*), at step **330**. The second finish line data is used, in **340**, for updating the first finish line data (*e.g., to generate an updated first 3D finish line*). The updating comprises defining a portion of the finish line not defined in the first finish line (for example, in a 'knife edge' case) or changing a portion of the first finish line. The updated data is further imposed on the dentition image (*e.g., as the updated first 3D finish line*).

The three dimensional virtual teeth model includes at least the preparation, preferably the preparation with neighboring teeth. Typically, however, although not exclusively, the virtual teeth model includes also teeth of the jaw opposite the preparation region. Occasionally, although not necessarily, the virtual teeth model may also include all teeth of both jaws.

The teeth model, and particularly the region thereof that includes the preparation, is typically manipulable such that the virtual teeth model may be displayed and visualized from different angles.

The data for the virtual teeth model may be obtained by a variety of methods, such as that described in PCT Application No. PCT/IL96/00036 (publication No. WO97/03620) and in PCT Application No. PCT/IL99/00431 (publication No. WO00/08415). The virtual three-dimensional image may be manipulated, for example, in a manner described in PCT Application No. PCT/IL99/00577 (publication No. WO00/25677).

The generation of the finish line data can be obtained in any of the known manners For example, the finish line may be drawn by moving a cursor, by moving a stylus on a touch-sensitive screen or pad, etc. By another example, the line may be drawn by indicating a series of dots while the software then automatically connects the dots into one continuous finish line.

The finish line data can be also obtained in a fully automated manner, for example as described in U.S. Pat. No. 5,417,572. Based on data indicating the 3D shape of the surface of the preparation, a train of points in the margin area is determined by calculations, and the finish line is determined by plotting the train of points on a developed view of the surface. In determining the train of points, a reference line (e.g. a central axis **22** of the 3D shape of the preparation is determined. Several crossing lines between the surface that includes the reference line and the curved plane constituting the shape of the preparation are considered, and the distances between the reference line and corresponding points onto the crossing lines are calculated. Then the inclination between the adjacent points of the adjacent crossing lines is determined. Based on the above-explained calculation, the margin area is defined at a point where the variation of the inclination exceeds a certain value.

Be the method of generating the finish line as it may be, the visual representation of the finish line data is associated with the visual representation of the 3D model such that the digital image of the model will include the finish line data. The dentist is then provided with a digital image of the patient's dentition that includes the generated finish line.

This visual model can be rendered to the dentist in several manners For example, the dentist is provided with a 3D image of the preparation and its surroundings wherein the finish line is marked, for example, by a colored line. The dentist can be allowed to enlarge the image and to manipulate it for better viewing of the model. The dentist can further be provided with 2D images of cross-sections of the preparation.

The dentist can input his instructions for example by moving a cursor to draw the finish line, by moving a stylus on a touch-sensitive screen or pad, etc. By another example, the dentist can indicates a series of dots onto the 3D or the 2D images, while the software then automatically connects the dots into one continuous finish line.

The finish line obtained according to the present invention may serve as an input in constructing a physical crown, preferably in a CAD/CAM environment. For example, the virtual image with the drawn finish line may be electronically transmitted to the lab that constructs the physical crown and when such image is displayed to the technician and based on such a display, the technician may then identify the finish line on the working cast before him.

The display is typically a computerized display provided with software permitting the technician to visualize the virtual image from different angles. As will be appreciated, the invention is not limited to any specific display means and any means for presenting the image such as, for example, in a printed format, on a computer display screen, etc., may be employed in accordance with the invention.

In accordance with another embodiment of the invention, the technician may use a virtual model with the finish line marked therein by the dentist to construct a virtual crown to be fitted over the virtual tooth preparation. Once a good crown fitting is determined, the virtual crown so obtained may be used as guidance for constructing a real life physical crown. The guidance may be a visual guidance, although, in accordance with one embodiment, digital data representative of the three dimensional structure of the virtual crown is generated and this may be fed into a computer-controlled apparatus that automatically constructs the crown based on such data.

Reference is now being made to FIG. **5** showing, by way of a schematic blocked diagram, a method for the construction of a virtual crown to generate digital data representative of such a virtual crown. In FIG. **5**, elements with the same function as in FIG. **3** were given the same reference numeral shifted by 200. After a finish line is defined by the dentist, (at **530**) and associated with the 3D model (at **550**), a virtual crown is constructed (at **550**). This may be done manually, according to some embodiments, or may be an automatic procedure carried out by a dedicated software utility. Following such construction, a virtual crown data is generated (at **560**) and such data may then be exported to a CNC device for constructing a physical crown. Reference is now being made to FIG. **6**. The same reference numerals used in FIG. **4** shifted by 20 are used to designate like components. As can be seen in FIG. **6**, a virtual crown **96** is fitted on preparation **90**.

It should be understood that the methods of the present invention, as exemplified with reference to FIGS. **3** and **5**, are best implemented in distributed systems, like the ones shown in FIGS. **1** and **2**, but are not limited to the architectures shown hereto.

It will also be understood that the system according to the invention may be a suitably programmed computer. Like-

wise, the invention contemplates a computer program being readable by a computer for executing the method of the invention. The invention further contemplates a machine-readable memory tangibly embodying a program of instructions executable by the machine for executing the method of the invention.

The invention claimed is:

[1. A computer-based prosthodontic method for enabling a dental practitioner to define a finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation, comprising:

(One) providing a three-dimensional (3D) digital data relating to the patient's dentition, said 3D data includes data representative of the surface topology of said preparation and its surroundings;

(Two) generating first finish line data representative of at least a portion of said finish line and superimposing an image of said finish line on an image of said dentition;

(Three)obtaining second finish line data determined on the basis of input received from a dental practitioner; and

(Four) using said second finish line data to update said first finish line data and superimposing the updated data on the dentition image.]

[2. A method according to claim 1, wherein the updating of the first finish line data comprises defining a portion of the finish line not defined in said first finish line data or changing a portion of said first finish line data.]

[3. A method according to claim 1, wherein the second finish line data is generated by virtually drawing a line at the apical limit of the preparation.]

[4. A method according to claim 3, wherein the line is drawn in a continuous fashion.]

[5. A method according to claim 3, wherein the line is drawn by marking dots in small intervals and then forming a line by automatically connecting the dots to one another.]

[6. A method according to claim 1, wherein the defined finish line is used as an input in constructing a crown.]

[7. A computer-based method for constructing a crown to be fitted on a tooth preparation in a subject, the method comprising defining a finish line on said preparation to obtain finish line data and employing said data in constructing the crown; the method being characterized in that defining the finish line comprises:

(One) providing a three-dimensional (3D) digital data relating to the patient's dentition, said 3D data includes data representative of the surface topology of said preparation and its surroundings;

(Two) generating first finish line data representative of at least a portion of said finish line and superimposing an image of said finish line on an image of said dentition;

(Three) obtaining second finish line data on a finish line determined on the basis of input received from a dental practitioner; and

(Four) using said second finish line data to update said first finish line data and superimposing the updated data on the dentition image.]

[8. A method according to claim 7, wherein a virtual image of the preparation with a defined finish line is presented on a suitable display medium.]

[9. A method according to claim 7, comprising:

constructing a virtual crown and virtually fitting said crown on said preparation in said virtual teeth;

generating digital data representing the three dimensional structure of the virtual crown;

employing said digital data to construct a physical crown for fitting on a tooth preparation in a patient.]

[10. A server utility of a computer-based system, for enabling a dental practitioner to define a finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation, said utility comprising:

(a) a processor;

(b) a memory coupled to the processor for storing a three-dimensional (3D) digital data relating to the patient's dentition, the 3D data including data representative of the surface topology of the preparation and its surroundings;

(c) a dedicated utility coupled to or integrated with the processor for generating a first finish line data representative of at least a portion of said finish line and superimposing an image of said finish line on an image of said dentition; and

(d) a network interface coupled to the processor for transmitter to a dental practitioner computerized device at least a portion of the 3D digital data and the first finish line data and for receiving from the practitioner device data representative of a second finish line determined on the basis of practiotioner input, wherein the second finish line data is used to update the first finish line data.]

[11. A computer-based program storage device readable by machine, tangibly embodying a program of instructions executable by the machine to perform method steps for constructing a crown to be fitted on a tooth preparation in a subject, the method comprising defining a finish line on said preparation to obtain finish line data and employing said data in constructing the crown; the method being characterized in that defining the finish line comprises:

(a) providing a three-dimensional (3D) digital data relating to the patient's dentition, said 3D data includes data representative of the surface topology of said preparation and its surroundings;

(b) generating first finish line data representative of at least a portion of said finish line and superimposing an image of said finish line on an image of said dentition;

(c) obtaining second finish line data on a finish line determined on the basis of input received from a dental practitioner; and

(d) using said second finish line data to update said first finish line data and superimposing the updated data on the dentition image.]

12. A computer-based prosthodontic method for enabling a dental practitioner to define a three-dimensional (3D) finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation, comprising:

providing 3D digital data relating to a patient's dentition, the 3D data includes data representative of a surface topology of the tooth preparation and its surroundings;

generating, on a display, a first 3D finish line data and superimposing an image of the first 3D finish line data on an image of the dentition;

generating, on the display, a second 3D finish line data created on the basis of input data received from the dental practitioner, based on their professional consideration, using a stylus on a touch-sensitive screen or pad;

after receiving the input data from the dental practitioner, using the second 3D finish line data to update a portion of the first 3D finish line data to generate an updated first 3D finish line data; and

superimposing, on the display, the updated first 3D finish line data on the dentition image,

wherein the updated first 3D finish line data is subsequently used to form the dental prosthesis of the at least one tooth to be fitted over the tooth preparation.

13. The method of claim 12, wherein the second 3D finish line data is used to update the portion of the first 3D finish line data by defining a portion of the updated first finish line not defined by the first 3D finish line data.

14. The method of claim 12, wherein the second 3D finish line data is used to change the portion of the first 3D finish line data by defining a portion of the updated first finish line that is incorrectly defined by the first 3D finish line data.

15. A computer-based prosthodontic method for enabling a dental practitioner to define a three-dimensional (3D) finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation, comprising:

providing 3D digital data relating to a patient's dentition, the 3D data includes data representative of a surface topology of the tooth preparation and its surroundings;

generating, on a display, a first 3D finish line data and superimposing an image of the first 3D finish line data on an image of the dentition;

generating, on the display, a second 3D finish line data created on the basis of input data received from the dental practitioner, based on their professional consideration, using a stylus on a touch-sensitive screen or pad, wherein the dental practitioner provides the input data for generating the second 3D finish line data by actively drawing a virtual line at the apical limit of the preparation using the stylus on the touch-sensitive screen or pad;

after receiving the input data from the dental practitioner, using the second 3D finish line data to update a portion of the first 3D finish line data to generate an updated first 3D finish line data; and

superimposing, on the display, the updated first 3D finish line data on the dentition image,

wherein the updated first 3D finish line data is subsequently used to form the dental prosthesis of the at least one tooth to be fitted over the tooth preparation.

16. The method of claim 15, wherein the virtual line is drawn as a continuous line by moving the stylus on the touch-sensitive screen or pad.

17. The method of claim 12, wherein the dental practitioner provides input data for generating the second 3D finish line data by marking dots in intervals using the stylus on the touch-sensitive screen or pad.

18. The method of claim 17, wherein generating the second 3D finish line data further comprises automatically connecting the series of dots indicated on a 2D or 3D image by the dental practitioner.

19. The method of claim 12, wherein the dental prosthesis is a crown.

20. The method of claim 12, wherein the 3D digital data relating to the patient's dentition is captured using a finish line utility integrated in a computer local to the dental practitioner.

21. The method of claim 12, wherein data may be manipulated to display the superimposed finish line and the image of the dentition from at least one of different angles and different magnifications.

22. The method of claim 12, wherein generating the first 3D finish line data further comprises, providing, on the display, at least one 2D image of a cross-section of the patient's dentition.

23. The method of claim 12, wherein the first 3D finish line data is generated in a fully automated manner.

24. The method of claim 12, wherein the first 3D finish line data is generated in a semi-automated manner.

25. The method of claim 24, wherein generating the first 3D finish line data further comprises:

plotting a train of points in a margin area; and

converting the train of points into the first 3D finish line data.

26. A server utility of a computer-based system, for enabling a dental practitioner to define a three-dimensional (3D) finish line of a dental prosthesis of at least one tooth to be fitted over a tooth preparation, comprising:

a processor;

a memory coupled to the processor for storing 3D digital data relating to a patient's dentition, the 3D data including data representative of a surface topology of the tooth preparation and its surroundings;

a dedicated utility coupled to or integrated with the processor for generating first 3D finish line data representative of at least a portion of said finish line; and

a network interface coupled to the processor for transmitting, to a computerized device of a dental practitioner, the first 3D finish line data and for receiving, from the computerized device of the dental practitioner, a second 3D finish line data determined from practitioner input, wherein the second 3D finish line data is used to generate an updated first 3D finish line data, and

wherein the memory comprises instructions, executable by the processer, the instructions being configured to:

generate, on a display, the first 3D finish line data and superimpose an image of the finish line on an image of a patient's dentition;

generate, on the display, the second 3D finish line data created on the basis of input data received from the dental practitioner, based on their professional consideration;

after receiving the input data from the dental practitioner, use the second 3D finish line data to update a portion of the first 3D finish line data to generate the updated first 3D finish line data; and

superimpose, on the display, the updated first 3D finish line data on the dentition image, wherein the updated first 3D finish line data is subsequently used to form the dental prosthesis of the at least one tooth to be fitted over the tooth preparation.

27. The system of claim 26, wherein the second 3D finish line data is used to update the portion of the first 3D finish line data by defining a portion of the updated first finish line not defined by the first 3D finish line data.

28. The system of claim 26, wherein the second 3D finish line data is used to change the portion of the first 3D finish line data by defining a portion of the updated first finish line that is incorrectly defined by the first 3D finish line data.

29. The system of claim 26, wherein the dental practitioner provides the input data for generating the second 3D finish line data by actively drawing a continuous line at an apical limit of the preparation by moving a stylus on a touch-sensitive screen or pad.

30. The system of claim 26, wherein the dental practitioner provides input data for generating the second 3D finish line data by marking dots in intervals using the stylus on the touch-sensitive screen or pad and automatically connecting the series of dots indicated on a 2D or 3D image by the dental practitioner.

31. A computer-based program storage device readable by machine, tangibly embodying a program of instructions executable by the machine to perform method steps for constructing a crown to be fitted on a tooth preparation in

a subject, the method comprising defining a three-dimensional (3D) finish line on the tooth preparation to obtain finish line data and employing the finish line data in constructing the crown, the method being characterized in that defining the 3D finish line comprises:

providing 3D digital data relating to a patient's dentition, the 3D data includes data representative of a surface topology of the tooth preparation and its surroundings;

generating, on a display, a first 3D finish line data and superimposing an image of the first 3D finish line data on an image of the dentition;

generating, on the display, a second 3D finish line data created on the basis of input data received from a dental practitioner, based on their professional consideration;

after receiving the input data from the dental practitioner, using the second 3D finish line data to update a portion of the first 3D finish line data to generate the updated first 3D finish line data; and

superimposing, on the display, the updated first 3D finish line data on the dentition image,

wherein the updated first 3D finish line data is converted into a format capable of being used to form the crown to be fitted over the tooth preparation.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : RE49,541 E
APPLICATION NO. : 16/994449
DATED : June 6, 2023
INVENTOR(S) : Kopelman et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

In Column 3, Line 17, delete “practiotioner” and insert -- practitioner --, therefor.

In Column 5, Line 41, delete “manners” and insert -- manners. --, therefor.

In Column 6, Line 4, delete “manners” and insert -- manners. --, therefor.

In the Claims

In Column 9, Claim 15 Line 29, delete “at the” and insert -- at an --, therefor.

Signed and Sealed this
Fifth Day of September, 2023

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office