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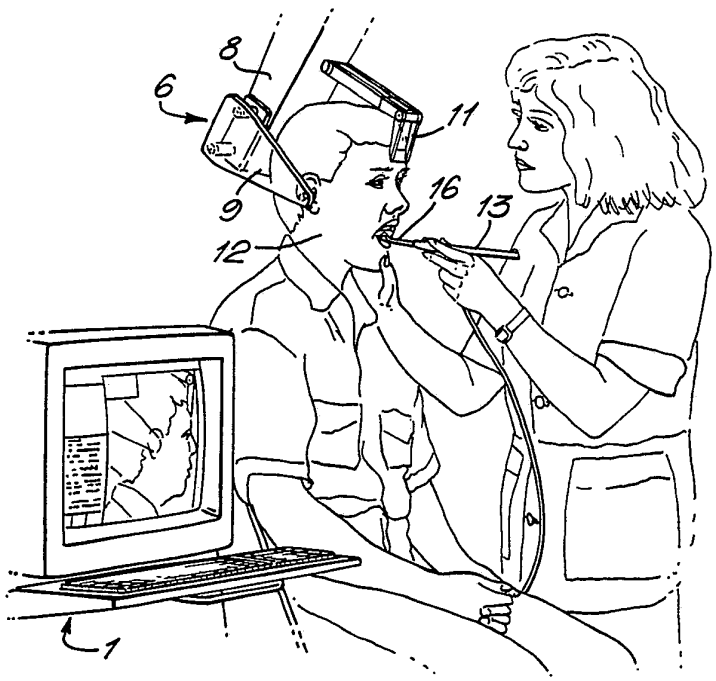

(57) Abstract

In the generation of cephalometric images, for example in orthodontic analysis, a probe (13) linked to a computer (1) is used to determine directly the positions of anatomical points of the head (12) of a subject which is held in place by a restrainer (6). The position of the tip of the probe is determined using sonic transmitters (14) and receivers (4). The points located by the probe are used to determine the positions of anatomical landmarks for cephalometric tracings including, by means of extrapolation, some that are inaccessible to the probe. These are then used to produce a cephalometric tracing which can be superimposed on a video image of the subject's head. The use of x-rays or invasive techniques is avoided.

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Method and Apparatus for Generating Cephalometric Images

This invention relates to improvements in the location of anatomical landmarks for use e.g. in the generation of cephalometric images. Such images are used in orthodontic analysis.

The invention relates particularly, to apparatus and a method for generating cephalometric tracings by computer by direct measurement on the face and head of a subject so as to eliminate the requirement of subjecting the subject to x-ray radiation.

Lateral cephalograms (full-head x-rays, side view x-rays) are a well-known primary orthodontic analysis tool. Frontal view x-rays have been used to a lesser extend, in part because radiation dosage levels are several times higher and only twenty to thirty percent more information is obtained. Traditionally, a tracing is made of the lateral cephalogram (herein referred to as a "cephalometric tracing") and specific skeletal, dental and soft tissue measurements are then calculated from the tracing. The usual procedure is as follows:

First, a piece of standard tracing paper is fixed to the x-ray film. Next, outlines of key anatomical features are traced with a lead pencil. Then, various lines are drawn by connecting the anatomical landmarks with the aid of a straight edge. The particular lines depend upon the particular analysis or treatment of the patient which has been selected by the orthodontist. The distances between landmarks and angles between pairs of lines are calculated using a ruler and protractor. This information, called "cephalometrics", is used to

describe the patient's condition in an objective manner which can be communicated with others and used in research, education or diagnosis. If used for diagnosis, the values of these measurements can be the basis for determination of a specific treatment plan for a patient.

The location of certain "landmarks" within the facial complex is the primary information from which cephalometric analysis is made. The preparation of the tracing and identification of the precise location of the landmark teeth involve a certain amount of estimating and the process is far from being an exact science. A complete cephalometric analysis typically requires approximately one hour.

Although there are several variations of the general cephalometric analysis, most rely on similar sets of measurements. For example, certain numerical values indicate whether or not to use headgear in treatment. Other measurements suggest a style of headgear to be used. Still others aid in elastic (rubber band) selection. Specific values indicate the magnitude and direction of incisor or molar movement required.

If orthodontic treatment of a patient is being carried out, a number of cephalomeric x-rays are sometimes taken and tracings made in order to monitor the patient's progress toward the desired treatment goal. Additional cephalograms are taken at the end of treatment, and several years after completion of treatment, to determine the level of treatment success. In recent years, there has been reluctance to take such a number of x-rays as a result of concern over radiation exposure. Consequently, more recently orthodontists have not had access to valuable information which could facilitate and improve disagnosis and treatment.

Viewed from one aspect the invention provides a method for determining the location of a plurality of anatomical landmarks required for use in generating a cephalometric tracing of a human or animal head, comprising the steps of using a probe to identify directly the positions of pre-determined features on the head, generating digititized digital data representative of such positions, and calculating the location of the required anatomical landmarks from such digitized data.

Viewed from another aspect the invention provides a method of determining the positions of a plurality of anatomical landmarks of a human or animal head, at least one of which landmarks is inaccessible from outside of the tissue of the head, comprising the steps of setting a point or plane of reference with respect to the head, positioning a probe tip on a plurality of pre-determined features on the head, generating data indicative of the respective positions of the probe tip with respect to the point or plane of reference when on such features, and processing such data to determine the positions of the anatomical landmarks, such processing of the data including the use of the data corresponding to a plurality of the probe tip positions in order to determine by extrapolation the position of an anatomical landmark inacessible to the probe.

Viewed from another aspect the invention provides apparatus for generating a cephalometric tracing of a human or animal head, comprising; means for determining a point or plane of reference with respect to the head; a probe having a tip to be placed at a plurality of selected positions on the head and/or in the mouth, said probe having means for transmitting one or more signals when the tip is at a selected position; means for receiving signals transmitted by the probe; data

processing means programmed to process data associated with the received signals so as to provide data representative of the positions of the probe tip with reference to the head corresponding to the selected positions and to determine therefrom anatomical landmarks; means for displaying an image of at least part of the head from a chosen direction; and means for displaying on said image a cephalometric tracing from the same direction and to the same scale, formed by joining the appropriate anatomical landmarks.

Thus, it is possible in accordance with the present invention to obtain anatomical landmarks and cephalometric tracings without the use of x-rays.

In carrying out the invention in practice, typically a subject's head is fixed with respect to a point of reference for the physical measurements to be taken directly from the patient. The head need not be fixed if a plane of reference is established and digitized. Physical measurements of preselected landmarks on the patient's head are then generated in digitized form and utilized in a computer program to calculate diagnostic data points as required for use in a cephalometric tracing. The computer then generates the cephalometric tracing by connecting the data points, and, if desired, adding straight lines and calculating angles and linear measurements as may be required for the particular orthodontic diagnosis system to be used. Additionally, at the time the digitized data is being generated, an electronic recording is made of the patient's head in the same planes in which the cephalometric tracings are to lie, and this recording is subsequently reproduced in visible form and combined with the cephalometric tracing as an overlay, one on the other.

While it is possible to generate digitized data in

either three-dimensional form or two-dimensional form, in the preferred embodiment three-dimensional data is generated and is converted to two-dimensional data for presentation as a cephalometric tracing as, at present, three-dimensional cephalometric tracings are not normally used in practice.

There are certain main categories of data which are used in most cephalometric systems. The first is a subject classification by facial type. Subjects with short, wide faces generally respond differently to specific types of treatments than patients with long, narrow faces.

Positional data utilizing several external and accessible internal landmarks can be used to adequately categorize any patient by facial type.

Relation of the upper jaw (maxilla) to lower jaw (mandible) is another useful element to be determined. This information is used by the orthodontist to determine if stimulation or inhibition of mandibular or maxillary growth is required to achieve a balanced profile. The degree of incisor protrusion, angle of inclination, and the interrelations between upper and lower incisors can be found using a system which generates positional data. This information allows the orthodontist to reposition the teeth in harmony with both jaws, with each other, and with the soft tissue profile (nose, lips and chin).

There are a number of cephalometric analysis systems currently in use. The Downs Analysis is described in Downs, W.B., Variation in facial relationships: Their Significance In Treatment and Prognosis, 34 American Journal of Orthodontics, 812-840 (1948). The Steiner Analysis is described in Steiner, C.C., Cephalometrics

For You And Me, 39 American Journal of Orthondontics, 729-755 (1953). The Ricketts Analysis, both frontal and lateral, is described in Ricketts, et al., Orthondontics Diagnosis And Planning, published by Rocky Mountain Orthodontics of Denver, Colorado in 1982. The McNamara Analysis is described in McNamara, J.A., A Method Of Cephalometric Evaluations, 86 American Journal Of Orthodontics, 449-468 (1984). The Vari-Simplex Analysis is described in Alexander, R.G., The Vari-Simplex Discipline, published by Ormco Corporation of Glendora, California in 1987.

While the paricular data points used vary from system to system, all systems are based upon the basic skull and tooth structure. Consequently, certain landmarks used to generate by computer the required data points for a particular system selected for use cannot be measured directly by a non-invasive technique. Since statistical studies are available which correlate these landmarks to directly measurable landmarks and data points, algorithms can be generated by those skilled in the art to be used in software programs to enable a computer to generate the cephalometric tracing, based upon the directly measured landmarks. The landmarks particularly useful in this respect in the practice of the method of the present invention which are generated by use of the algorithms from the directly measured data are the roots of the teeth, and the incisors in particular, and the skeletal landmarks such as the sella and the pogonion.

The use of a computer to generate a cephalometric tracing is known in the art. For example the Ricketts et al. publication referred to above shows, in Figure 165, a computer generated lateral cephalometric tracing. However, the tracing shown therein was derived from a secondary source of dimensional data, i.e., an x-ray. Consequently, the dimensional information is inaccurate

for reasons inherent in the use of x-ray procedures as the source of dimensional data, such as non-linear distortion, as well as requiring that the patient be subjected to x-ray radiation in order to obtain the data.

The method and apparatus of the present invention eliminate these disadvantages by deriving dimensional information directly from the subject, rather than using a secondary source such as an x-ray negative.

In a preferred embodiment the initial step of the method comprises fixing the patient's head in space relative to a reference point to be used as the data base for the measurements. For this purpose, conventional orthodontic head restraints may be used. Alternatively, for example, a sensor could be fixed to the patient's head so as to provide a reference point for the measurements. The patient's head would not then be required to be immobilized. After a point or plane of reference is appropriately established with respect to the patient's head, ditigized dimensional data is directly generated from the patient's head by suitable means. Various methods of generating such digitized information are presently known per se. Examples of three different methods are given in Rekow, D., Computer-Aided Design And Manufacturing In Dentistry; A Review Of The State Of The Art, 58 The Journal Of Orthodontic Dentistry 512-516 (1987). A sonic ranging system may be utilized. U.S. Patent No. 3,821,469 describes a three-dimensional sonic ranging system. Electromechanical systems can be used to generate such digitized information directly and other methods may also be applicable. Consequently, in its broadest aspect the method of the present invention is not limited to any particular system for generating the digitized dimensional data, so long as the data is

generated directly from the subject, rather than from a secondary source.

In a presently preferred embodiment, a sonic ranging system with a hand-held probe is used to generate the data. The digitized dimensional information is generated by measurements of preselected landmarks on the patient's head. This dimensional data is utilized to calculate the required diagnostic data points for the particular analysis system being used. A computer program designed for the particular system of analysis is utilized to process the digitized data to calculate the diagnostic points for the cephalometric tracing. Once the data points are calculated, the cephalometric tracing is generated by use of a computer and a graphical plotter or other type of display to connect the data points so as to produce the tracing.

Obviously, it is within the capability of the computer program utilized to include the generation and superposition of straight lines required for the conventional pictorial presentation of the analysis, as well as measurements of the required angles for the conventional presentation of the completed tracing.

In the preferred embodiment several different analysis systems can be selected.

Each analysis system provides for different lines, angular measurements, and value print-outs. A master program which generates all required information for number of systems, and selects therefrom the particular data required for the diagnostic system used, specified by the practitioner, is presently preferred. However, obviously programs may be utilized which are limited to particular diagnostic systems. The computer program, irrespective of the system of diagnosis selected,

generates dimensional data for the hidden landmarks by the use of algorithms based upon statistical data as to their location, in order to produce the cephalometric tracing in its currently conventional form.

In the presently preferred embodiment, three-dimensional digitized data is generated. Among the advantages of the method and apparatus is that a frontal cephalometric tracing can be generated as easily as a lateral tracing. Conventionally, frontal tracings have not been widely used, because of the greatly increased amount of radiation required for their generation as compared to the radiation required for the lateral x-ray. However, frontal tracings are extremely useful in practice of orthodontics or othognathic surgery in many instances, and their preparation is now practical by using the preferred embodiment, which generates the required three-dimensional data from which the computer program can derive the frontal tracing.

For orthodontic analysis, it is also useful to have a picture of the patient's head corresponding to the tracing, so that one may be overlaid on the other for comparison purposes. The preferred method and apparatus provides for the generation of such a picture by making an electronic recording of the subject at the time of the generation of the dimensional data. This video recording is then reproduced in conjunction with the presentation of the tracing, as either electronically overlaid or printed out and manually overlaid on the tracing.

In an optional embodiment the probe can be used in a "data stream" mode and is moved over the head to provide a tracing of the profile of the head which is displayed on the monitor as desired.

While the preferred embodiment initially generates three-dimensional data, it is within the scope of the invention to generate two-dimensional data initially, rather than converting the three-dimensional data subsequently to two-dimensional data in the process of generating the tracing. By initially generating only two-dimensional data, the ability of the method and apparatus to produce both lateral and frontal tracings from the same set of digitized information is lost. However the complexity of the work station, including software programs and physical components, is greatly simplified if only two-dimensional data is to be acquired. Consequently, as frontal tracings are currently seldom used, for many applications of the present method, obtaining digitized two-dimensional data initially will suffice.

Because the method is non-invasive and does not involve irradiation of the subject's head, progress of orthodontic treatment can be radily monitored and recorded for archival purposes, as well as for facilitating the determination of the efficacy of the treatment being undertaken. The present method and apparatus permit a practitioner, if desired, to monitor the movement of even a single tooth during treatment, and to make any appropriate adjustments or modifications in the procedures as may be appropriate to ensure that the subject reaches an optimum result, without subjecting the subject to excesive radiation or invasive techniques.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which :-

Figure 1 is a general view of a complete system for use in accordance with the invention;

Figure 2 is an enlarged view of part of the system, showing it in use;

Figure 3 is a view of a probe used on the system, with two alternative tips;

Figure 4 is a diagrammatic view showing how the position of the probe tip is identified;

Figure 5 is a view of a display showing the head of a subject on which anatomical landmarks have been superimposed;

Figure 6 is a view of a cephalometric tracing obtained using the system; and

Figure 7 is a view of the tracing superimposed on the head of the subject.

As shown in Figs. 1 to 4, the system includes data processing equipment 1 provided with a video display monitor, a support frame 2, a video camera 3 with a telephoto lens mounted on the frame, an array of sonic receivers 4 mounted on a sub-frame 5 attached to the frame, and a head restrainer 6 attached to the frame, positioned over a seat 7. The head restrainer comprises a downwardly projecting arm 8 on the side of the frame remote from the camera. At the lower end of the arm are two spaced plates 9 with projections 10 for locating in the ears of a subject, and a further arm with an adjustable end portion 11 to engage the forehead of the subject. Fig. 2 shows a subject in place. With the arrangement shown, the head 12 of the subject is held firmly but gently in place.

The data processing equipment typically includes a

microcomputer with a computer graphics board for high speed image enhancement and manipulation; a high resolution monitor with adequate pixel resolution for accurate landmark location on the display; optionally a light pen for the interactive entry of data or commands; optionally a printer for hard copy output; and suitable software. The imaging system may use e.g. a 256 grey scale.

The video camera 3 is used to provide an image of the head of the subject which is processed and stored digitally. A typical image is shown in Fig. 2 and is displayed in a freeze frame form.

The system also comprises a probe 13 which is linked to the data processing equipment by a suitable cable. The probe has a pair of spaced sonic transmitters 14, a pair of interchangeable extensions 15 and 16, and an activating button 17. The extension 15 is adapted for use outside of the head and has a tip 18. The extension 16 is adapted for use inside the mouth and has a tip 19 at the end of a curved portion 20. The extensions can be firmly located in the probe and whichever is used, the tip 18 or 19 will be in an identical position relative to the remainder of the probe. Alternatively, interchangeable probes could be provided for the different purposes.

In this particular embodiment the probe can be based on a Model GP-8-3D Sonic Digitizer, manufactured by Science Accessories Corporation of Southport, Connecticut, USA.

The four sonic receivers 4 are connected to the data processing equipment and are positioned adjacent the four corners of the sub-frame 5. They are adapted to receive sonic signals from the probe, which are produced by the two spaced transmitters 14 when the activating

button is pressed. Since the position of the tip 18 or 19 relative to the transmitters is known, the data processing equipment can work on data provided by the receivers 4 to establish the position in space of the tip of the probe when the activating button is pressed, using the time taken for each receiver to detect the signal, and triangulation techniques. Since in use the head of a subject will be in a known fixed position, if the activating button is pressed whilst the tip of the probe is touching a feature on the head, then the position of that feature relative to the head can be calculated and of course stored.

Figure 2 shows the probe with tip 19 being used inside the mouth of a subject, with the tip on a chosen part of a chosen tooth. If the activating button 17 is pressed by the user, then the position of that part will be calculated and recorded.

Fig. 3 shows diagrammatically a probe with the activating button pressed, transmitters 14 emitting sound waves that are picked up by the receivers 4.

In use, once the subject is in position and the system correctly set up, the user can select a particular type of cephalometric analysis required. In this embodiment there are fourteen options, as follows :-

Ricketts lateral
Ricketts frontal
Vari-Simplex
Holdaway
Alabama
Jarabak
Steiner
Downs
Burstons

McNamara
Tweed
Grummons frontal
Standard lateral
Standard frontal

The various different analyses require different combinations of anatomical landmarks to be identified. Some of these are within the tissue of the head and cannot be located with the probe. The system generates a list of anatomical points to be identified for the chosen analysis and whilst some of these will in fact be landmarks, some will not. The list is displayed in a logical order to prompt the user to move around the face in a logical and convenient fashion, with the need to change the probe extension only once if readings both inside and outside the mouth are required. In a typical exercise, the external points will be identified, theren points within the mouth with the teeth in occlusion, and then a bite block is inserted and other points identified in the mouth. Usually about 15 to 30 points have to be located. Some points will be readily observable and easy to locate; some may require palpation to be located; and some may require a little practice. However, all can be recognised eventually and located with the tip of the probe. The system display highlights the next point to be located during a routine to locate points for the chosen analysis. Once the user has located the appropriate point, the activating button 17 on the probe is pressed and the position of the probe tip, and thus the anatomical point, is recorded. The points can then be displayed superimposed on the video image of the subject.

In a preferred system, as shown in Figure 5 the display includes the video image of the subject's head 21, on which are marked points already digitized such as 22,

the point currently being digitized 23, and the point last digitized 24. Also displayed is a text box 25 containing instructions and a diagram 26 showing where the points are to be found. The system facilitates the spotting of errors and their correction.

When a point has been located the landmark position may be known, or it may need to be calculated if it is not one that can be located directly.

By way of example, the landmark "sella" can be calculated based upon the locations of the following points :-

1. A point on the cranium at a 90 degree angle to Frankfort Horizontal through orbitale.

2. A point at the back of the head which is the extension of the line through nasion and porion.

3. A point on the top of the head at a 45 degree angle to Frankfort at porion.

Such a "hidden" landmark can be calculated from these points by the use of a suitable algorithm based upon statistical data from studies which correlate the positions of hidden landmarks (identified using e.g. x-ray techniques) to directly measurable points.

The data received by the system relates to the three dimensionsal positions of the landmarks but the output to the display shows the landmarks projected in two directions.

Once the landmark positions are known, the data processing equipment can produce the desired cephalometric tracing to be displayed on the monitor by

joining the various landmarks. If desired, two different types of tracing can be carried out and displayed superimposed along any desired axis.

Figure 6 shows two cephalometric tracings 26 and 27 superimposed, each also including part of the profile of the face.

A cephalometric tracing can be displayed on the camera image of the subject, as shown in Figure 7 where a tracing 28 is superimposed on the subject's head 21. In this particular case, the profile obtained by the probe can be used to check on alignment of the two images. It can be omitted if desired.

The image displayed can be manipulated as desired, modified, have freehand drawings or text added, and so forth.

The optional light pen can be used to perform many functions in an interactive manner on the display, including moving and rotating the images. For example, a modified facial profile could be generated and the cephalometric tracing modified also. This could be used to illustrate the results of different orthodontic treatments.

The data for a particular subject may be compared with norms obtained by ststistical analysis, which may be adjusted for age , race, and sex. On the display significant deviations from the norm could be highlighted if desired. Comparative tabulated results could be displayed.

All data for a subject can be stored on suitable media such as magnetic or optical disks, and retrieved, updated or modified as desired. Information and images

may be printed out using optional printers.

Both frontal and lateral analyses can be carried out. A camera with a telephoto lens can be used, if desired, to obtain intra-oral images.

It will be appreciated that the apparatus and method described herein may be modified. The results obtained by the method and apparatus are of use in orthodontic treatment and diagnosis but can also be used in research, education and so forth where a facial and dental profile are desired.

CLAIMS

1. A method for determining the location of a plurality of anatomical landmarks required for use in generating a cephalometric tracing of a human or animal head, comprising the steps of using a probe to identify directly the positions of pre-determined features on the head, generating digititized digital data representative of such positions, and calculating the location of the required anatomical landmarks from such digitized data.

2. A method as claimed in claim 1, including the step of connecting the anatomical landmarks to produce a cephalometric tracing.

3. A method of determining the positions of a plurality of anatomical landmarks of a human or animal head, at least one of which landmarks is inaccessible from outside of the tissue of the head, comprising the steps of setting a point or plane of reference with respect to the head, positioning a probe tip on a plurality of pre-determined features on the head, generating data indicative of the respective positions of the probe tip with respect to the point or plane of reference when on such features, and processing such data to determine the positions of the anatomical landmarks, such processing of the data including the use of the data corresponding to a plurality of the probe tip positions in order to determine by extrapolation the position of an anatomical landmark inacessible to the probe.

4. A method as claimed in claim 1, 2 or 3 including the step of providing a visual display of the positions of the pre-determined features on a representation of at least part of the head.

5. A method as claimed in claim 1 or 3 including the step of providing a visual display in the form of a cephalometric tracing in which the anatomical landmarks are joined by lines.

6. A method as claimed in claim 5 in which the visual display is reproduced on a representation of at least part of the head.

7. A method as claimed in claim 6 in which the representation of the head is in the form of a camera image of the head obtained from the same direction as that of the visual display of the anatomical landmarks or cephalometric tracing.

8. A method as claimed in claim 5, 6 or 7 in which the cephalometric tracing includes a profile of part of the head obtained by moving the probe tip over the head.

9. A method as claimed in any of claims 4 to 8 in which the positions of the anatomical landmarks are determined in three dimensional form and converted for display in two dimensional form.

10. A method as claimed in any preceding claim in which data processing means is used to calculate the distances between selected anatomical landmarks and/or the angles between lines connecting selected anatomical landmarks.

11. A method as claimed in any preceding claim, for use in orthodontic analysis.

12. A method as claimed in any preceding claim, in which at least some of the predetermined features on the head are in the mouth.

13. Apparatus for generating a cephalometric tracing of a human or animal head, comprising; means for determining a point or plane of reference with respect to the head; a probe having a tip to be placed at a plurality of selected positions on the head and/or in the mouth, said probe having means for transmitting one or more signals when the tip is at a selected position; means for receiving signals transmitted by the probe; data processing means programmed to process data associated with the received signals so as to provide data representative of the positions of the probe tip with reference to the head corresponding to the selected positions and to determine therefrom anatomical landmarks; means for displaying an image of at least part of the head from a chosen direction; and means for displaying on said image a cephalometric tracing from the same direction and to the same scale, formed by joining the appropriate anatomical landmarks.

14. Apparatus as claimed in claim 13, wherein the means for determining the point or plane of reference includes means for fixing the head in position.

15. Apparatus as claimed in claim 13, wherein the means for determining the point or plane of referennce includes means for producing an orientation reference signal, adapted to be attached to the head.

16. Apparatus as claimed in claim 13, 14 or 15 wherein the probe has interchangeable members carrying tips respectively adapted for use on the outside of the head or inside the mouth.

17. Apparatus as claimed in claim 13, 14, or 15 wherein interchangeable probes are provided, respectively adapted for use on the outside of the head or inside the

mouth.

18. Apparatus as claimed in any of claims 13 to 17, wherein the signals produced by the probe are sonic.

19. Apparatus as claimed in any of claims 13 to 18, including a camera to provide the image of the head and means for digitally storing the image.

20. Apparatus as claimed in any of claims 13 to 19, wherein the data processing means is programmed to use data corresponding to at least one of the probe tip positions in accordance with predetermined criteria in order to determine the position of an anatomical landmark within the tissue of the head.

21. Apparatus as claimed in any of claims 13 to 20, including means for providing output advising a user of the apparatus as to the selected positions at which the probe tip should be placed.

22. Apparatus as claimed in any of claims 13 to 21, adapted to produce a cephalometric tracing for use in orthodontic analysis.

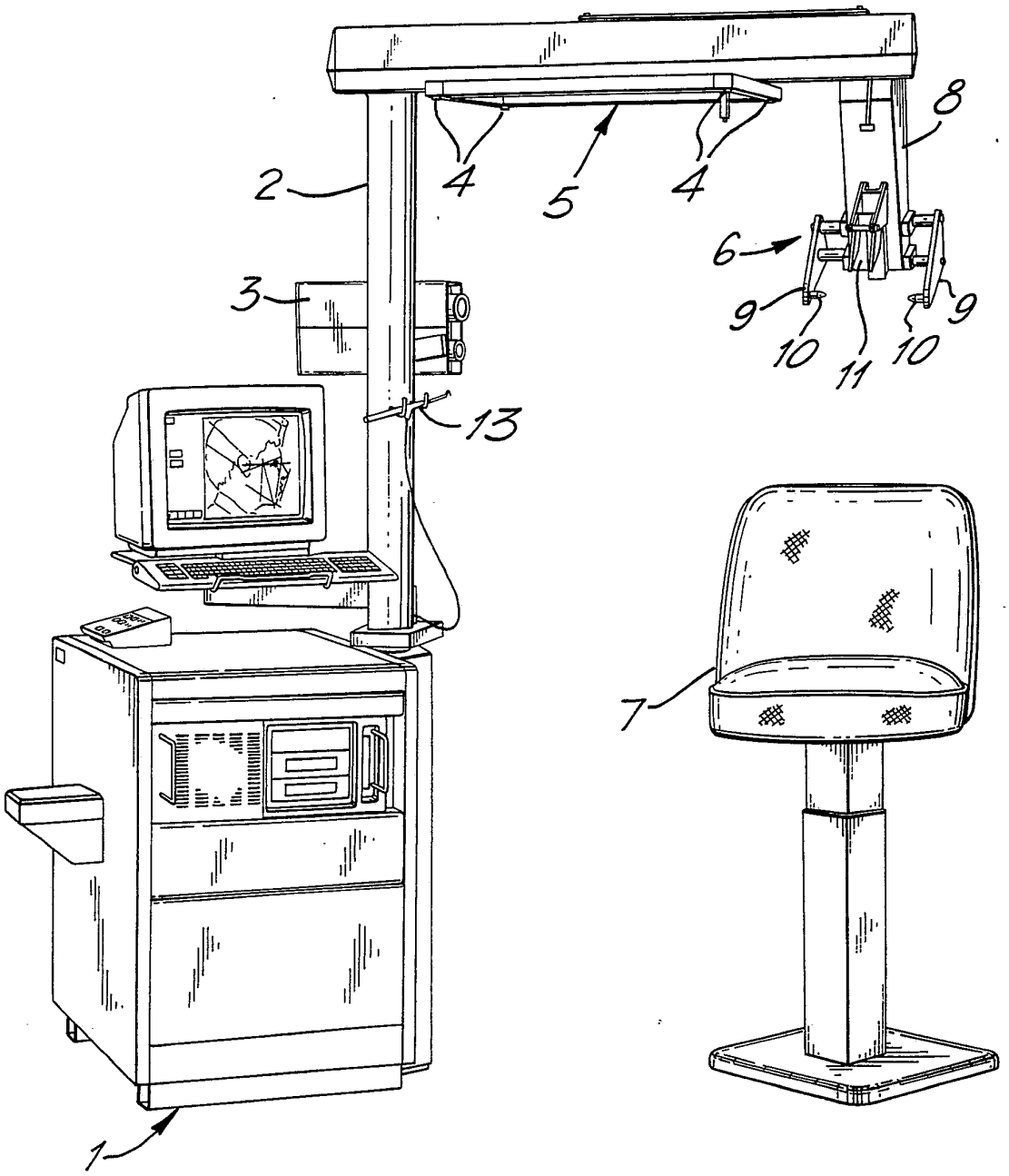

FIG.1.

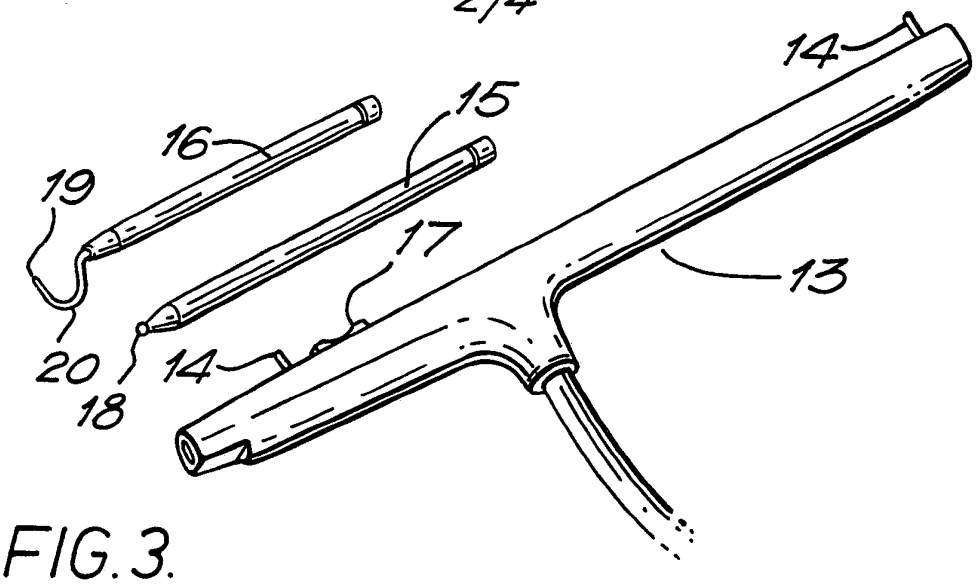

FIG. 3.

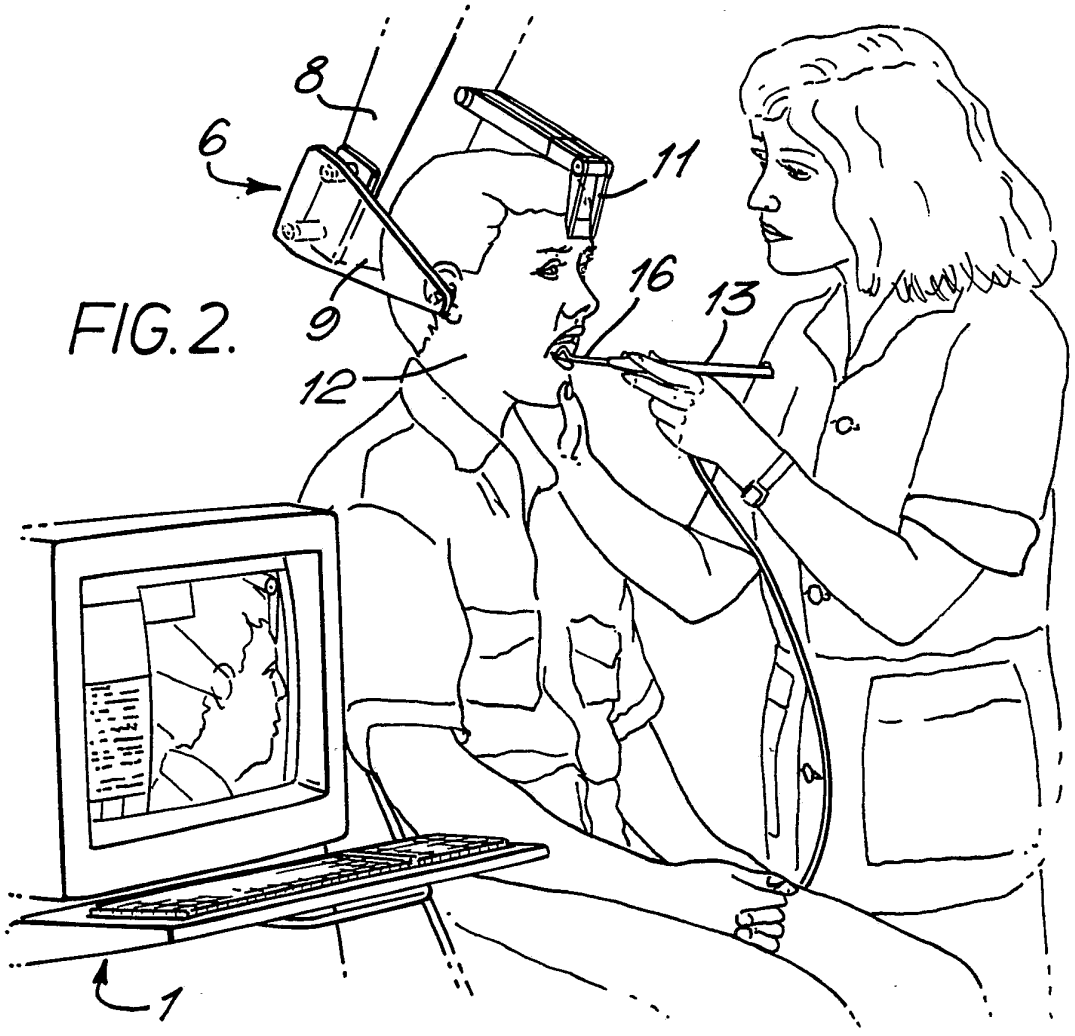

FIG. 2.

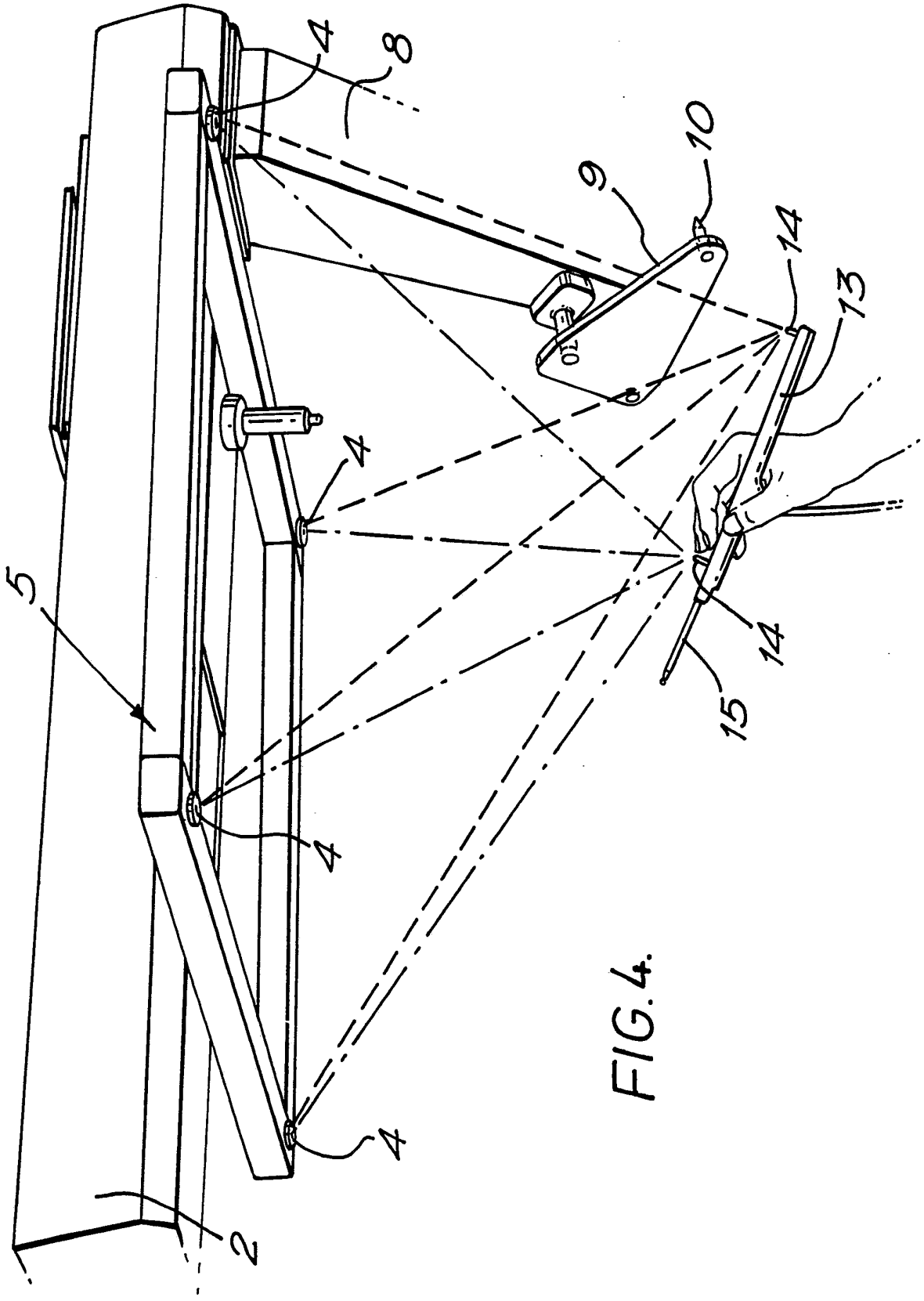

FIG. 4.

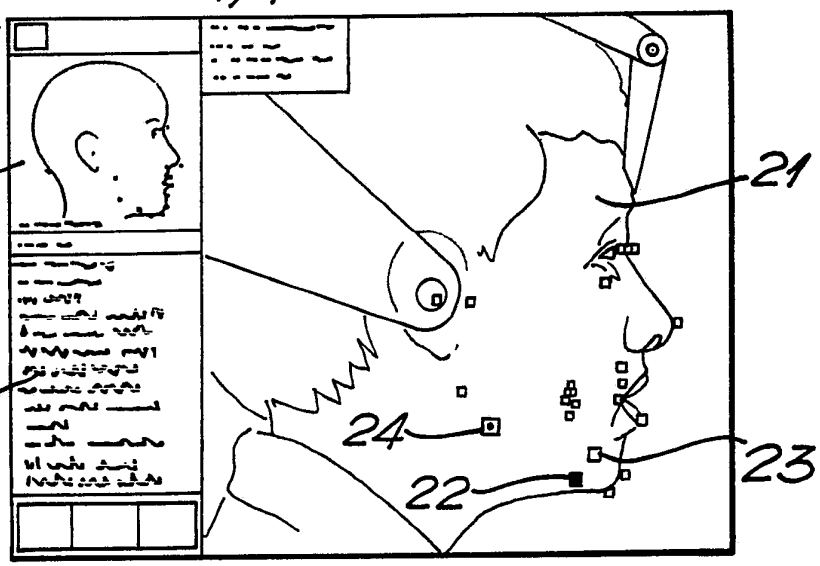

FIG. 5.

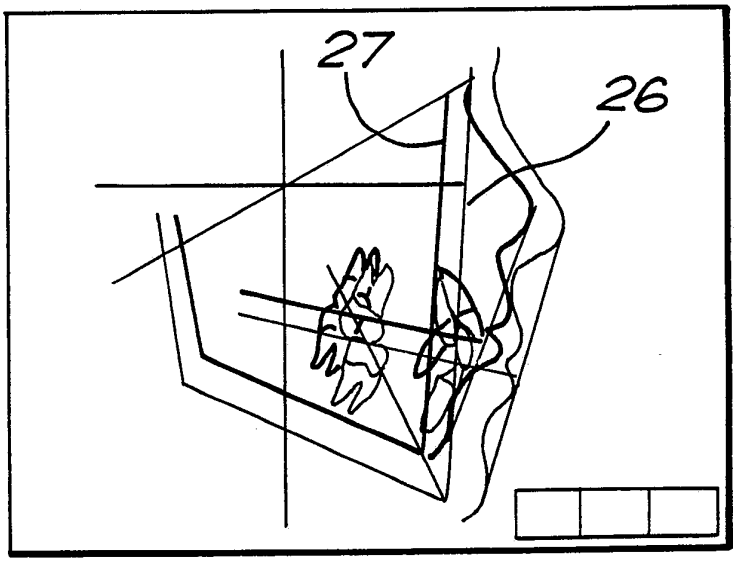

FIG. 6.

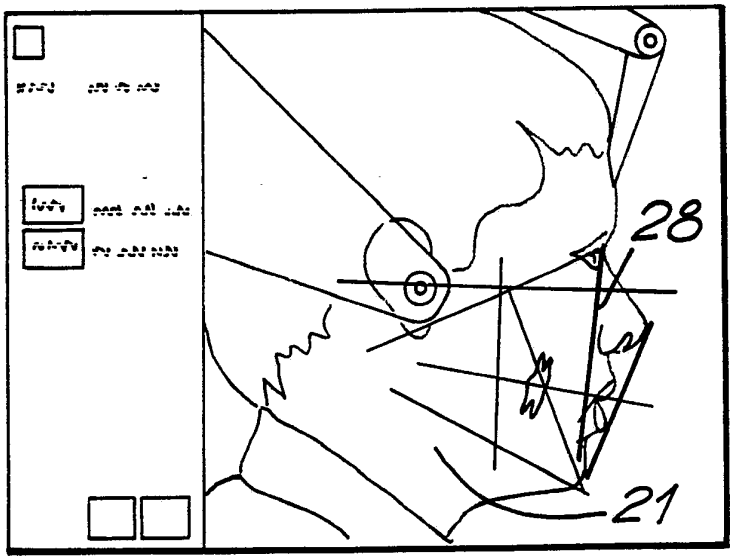

FIG. 7.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 90/00360

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 A61B5/103 ; A61C19/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	A61B ; G01S ; A61C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	WO,A,8809151 (SCHLÖNDORFF G.) 01 December 1988 see abstract; figures 1-8	1, 13-17, 22
Y	US,A,3708663 (W.BIEDERMAN) 02 January 1973 see abstract; figures 1-4	1, 13-17, 22
A		19
A	DE,A,3620404 (D.EDINGER) 07 January 1988 see abstract; figures 1, 2	3, 4, 18
A	US,A,3777305 (R.G.STOUTMEYER) 04 December 1973 see abstract; figures 1, 2	18
A	US,A,4182312 (D.R.MUSHABAC) 08 January 1980 see abstract; figures 1-3	1, 12, 13, 17

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
27 APRIL 1990	16 MAY 1990
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	HUNT B.W.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 90/00360

SA 34015

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-8809151	01-12-88	DE-A,C 3717871	22-12-88
		AU-A- 1805688	21-12-88
		EP-A- 0359773	28-03-90
US-A-3708663	02-01-73	None	
DE-A-3620404	07-01-88	None	
US-A-3777305	04-12-73	None	
US-A-4182312	08-01-80	None	

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82