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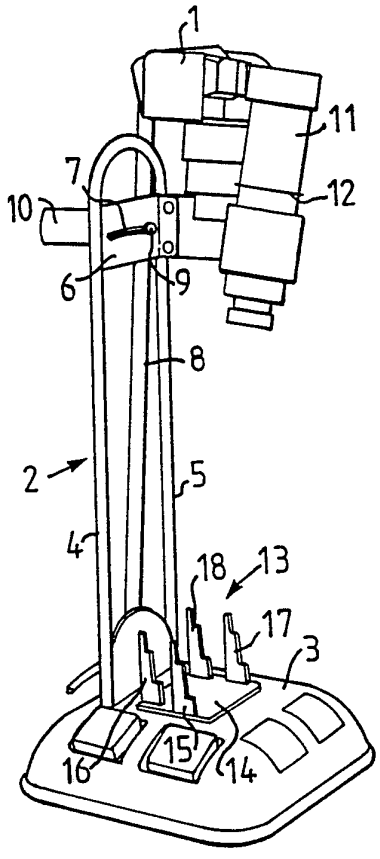
(54) Title: METHOD OF DOCUMENTATION AND MEASUREMENT WITHIN DENTISTRY AND A DEVICE FOR CARRYING OUT THE METHOD

(57) Abstract

This invention relates to a method of making stereophotographic documentation and photogrammetric measurement of impressions or of models of jaws. The method is characterized by the combination of the following moments: the impression or the model of a jaw is placed on a reference object (13), which in its turn is placed on a bottom plate (3) in a photo device comprising a camera (1) mounted in a frame (2) at a distance from the bottom plate and a light source (11) for illuminating the object on the reference object; a picture of the impression or the model of a jaw is taken by means of the camera (1), when this one has taken a position at an angle distance from the vertical line, whereafter a second picture is taken of the impression or the model of a jaw when the camera (1) has taken the corresponding position on the other side of the vertical line; the two pictures (19, 20) are placed on a tray (21) which is intended to cooperate with a stereoscope in that way that the two pictures can be seen three-dimensionally in the stereoscope; the pictures (19, 20) are brought to cooperate with a dator, which is so programmed that three-dimensional coordinates for picture points can be determined, which makes determination of desired distances and angles possible. The invention also relates to an apparatus which is usable for carrying out the method.



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Method of documentation and measurement within dentistry and a device for carrying out the method

The present invention relates to a method of making stereophotographic documentation and photogrammetric measurement of impressions or of models of jaws. The invention also relates to an apparatus useable for carrying out the method.

Within dentistry plaster models are frequently made, which among all are used for visual screening and measurement of bite conditions (jaw properties), sliding callipers or the like being used for the measurement. According to current regulations, jaw models belong to patient records and must be kept during a minimum period of three years. In most cases there is required a considerably longer storage time due to long time periods of treatment, which accordingly means that large storage spaces are needed for the plaster models during a long period of time.

Three-dimensional photographs of jaw models may to a certain extent replace plaster models. Such three-dimensional photographs may well be used for documentation provided that measurements can be performed in these three-dimensional fotographs. Thus, such photographs can be used for storage purposes instead of plaster models, which reduces the need of large storage spaces.

This invention relates to a photographic method that has been developed for documentation of jaw properties. Three-dimensional photographs are made from plaster models or impressions, the plaster models or the impressions being able to be documented in desired directions and perspectives. With the aid of computer programs optional distances and angles within the three-dimensional photographs of the jaws can be determined after that measurement points have been digitized.

According to the invention these purposes are achieved by a method of the kind mentioned by way of introduction, which is characterized by the combination of the following moments.

- The impression or the model of a jaw is placed on a reference object which in its turn is placed on a base plate of a photographic apparatus comprising a camera mounted on a stand at a distance from the bottom plate and a light source for

illuminating the article on the reference object;

- One photograph of the impression or the model of a jaw is exposed with the aid of the camera when this one has taken a position at an angle distance from the vertical line, whereafter a second photograph is exposed of the impression or the model of a jaw when the camera has taken a corresponding position on the other side of the vertical line;

- The two photographs are placed on a tray which is intended to cooperate with a stereoscope in such a way that the two exposed photographs may be viewed three-dimensionally in the stereoscope;

- The photographs in magnified condition are brought to cooperate with a computer which is so programmed that three-dimensional coordinates for optional image points can be determined which allows calculation of desired distances and angles.

A preferred embodiment of an apparatus for carrying out the method is shown in the accompanying drawings, where Fig. 1 shows a stereophotographic apparatus according to the invention; Fig. 2 shows the use of a stereoscope and Fig. 3 shows a reference object for use together with the invention.

Referring to Fig. 1 is shown there the stereophotografic apparatus. This one comprises a camera arranged on a stand 2. This stand 2 comprises a base plate 3 from which two essentially vertical rods 4, 5 project, which are placed at a distance from each other and at their upper parts connected by means of a plate 6 in which there is made an arched slot 7. The lower end of an essentially vertical rod 8 is pivotably arranged in the base plate 3. The camera 1 is fastened to the upper end of the rod 8 and is directed towards the central portion of the base plate. The rod 8 is intended to cooperate with the plate 6 in that way that it can be pivoted in the vertical plane between the outer positions of the slot 7. For this purpose there is a projection 9 arranged on the rod 8 for engagement with the slot 7.

According to this embodiment the projection 9 comprises a screw that penetrates the rod 8 and is screwed into a handle 10 which is positioned on the other side of the rod 8. By means of the handle 10 the rod 8 can be brought along the slot 7 and be

locked in a certain position in this one. This arrangement allows the camera to be angled in relation to the base plate 3 on both sides of the vertical line so that a line drawn from the camera when this one has taken one of its two outer positions in relation to the central portion of the base plate, forms an angle which is essentially the same as the angle which is formed when the camera has taken its other outer position on the other side of the vertical line. Due to that fact stereophotographs may be exposed of an object placed in the central portion of the base plate.

The photographic apparatus also comprises a projector 11 the purpose of which partly is to illuminate the object to be photographed, partly to be able to receive a grid indicated by the numeral 12. This grid may have an optional pattern and its purpose is to provide land marks on the object to be photographed. The land marks facilitate the identification of the measurement points.

In Fig. 1 there is also shown a reference object 13 on which the article to be photographed is intended to be positioned. This reference object comprises an essentially plane plate 14, which is intended to be placed in the central portion of the base plate 3 in a space made for this purpose. On each side of the reference object two stationary, narrow means at a distance from each other project from the plate 13. These means are indicated by the numerals 15-18 and have step form with three levels. On each level in each means 15-18 there is made a reference point, which points accordingly will be indicated on the photographs.

Computerized measurements within the three-dimensional photographs are made possible by this arrangement with reference points. The plate 14 of the reference object 13 is preferably provided with a plus sign, i.e. two straight, perpendicular lines which are engraved on the top side of the plate 14 which is preferably made of metal. These lines has such an extension that they are seen outside the object which is intended to be photographed on the plate 14. Due to that fact the outer portions of the lines will be indicated on the photographs.

In Fig. 2 there is shown a stereoscope intended to be used when viewing two photographs 19, 20 of an object, which are exposed when the rod has taken its two outer positions (see Fig. 1, 2). These two photographs are attached to a tray 21 which is intended to be placed in a space, made for this purpose and arranged in a part 22 of the stereoscope. The top side of the tray 21 is preferably provided with a straight line, which extends in the longitudinal direction of the tray, and two lines, essentially perpendicularly arranged in relation to the straight line and positioned at a distance from each other so that two plus signs are formed on the top side of the tray 21. When mounting the two photographs 19, 20 on the tray 21, the photographs are arranged in that way that the perpendicular lines of the one photograph are placed on top of the one plus sign while the perpendicular lines of the second photograph are placed on top of the second plus sign. Due to that fact, it is possible to orient the photographs at the mounting on the tray so that the photographs can be viewed three-dimensionally.

The stereoscope comprises a device with means 23 similar to spectacles which means is provided with two lenses 24, 25 and which is fastened to a rod 26 which in its turn is fastened to the part 22. The distance between the centres of the two photographs 19, 20 placed on the tray 20 is essentially the same as the distance between the centres of the two lenses of the stereoscope.

By viewing the two photographs in the stereoscope, a deep-viewing is possible so that a three-dimensional image of the object shown on the two photographs is received, i.e. the object is perceived in the same way as in reality.

In Fig. 3 is the reference device shown more closely. From this figure appears that each means 15-18 has a triangle-like form with two catheters 27, 28 forming an essentially right angle to each other and with a hypotenuse 29 provided with three levels 30-32. Each pair 15, 16; 17, 18 of means has essentially the same positioning on each side of the transverse centre line L of the plate 14.

As has been mentioned previously, each level 30-32 has a reference point. Moreover, a reference point is indicated on the plate 14 in front of each means 15-18. Thus, in this case

the reference object is provided with 16 reference points. By having reference points on different levels in the reference object it is possible also to make measurements in the depth direction (z-direction) by the computer. Thus, the reference object can be considered as a three-dimensional ruler.

As has been mentioned previously, a computer is intended to be utilized for measuring angles and distances. The computer programs commanding the computer reconstruct three-dimensional coordinates (x, y, z) for measurement points registered in pairs of the photograhps. When the coordinates for measurement points are known, optional distances and angles may be determined. Of course, it is possible to modify the invention within the scope of the following claims. Thus, for instance the reference object may have another form than the shown. The essential thing is that the reference object is provided with reference points on different levels.

If a further reference object is made that is a patrice to the above as a matrice already described reference object, the two reference objects may be put together.

If a model of the upper jaw and of the lower jaw, oriented correctly in relation to each other, are brought into the compound block of matrice and patrice and are attached to respective unit, the matrice and the patrice with models may be brought apart. The upper and the lower jaw models are then photographed separately and three-dimensional coordinates are reconstructed with available computer programs. Since the two reference objects have known, common reference points, all coordinates for the upper and lower jaw models may be brought to coincide with the coordinate system that is determined by the one or the other reference object. When this has been done, determination of distances and angles beween the upper and lower jaws may be performed.

Claims

1. A method of making stereophotographic documentation and photogrammetric measurement of impressions or models of jaws, c h a r a c t e r i z e d in the combination of the following moments:

- The impression or the model of a jaw is placed on a reference object (13), which in its turn is placed on a bottom plate (3) of a photographic apparatus comprising a camera (1) mounted on a stand (2) at a distance from the bottom plate (13), and a light source (11) for illuminating the article on the reference object;

- A photograph of the impression or the model of the jaw is exposed by means of the camera (1) when this one has taken a position at an angle distance from the vertical line, whereafter a second photograph is exposed of the impression or the model of a jaw when the camera (1) has taken a corresponding position on the other side of the vertical line;

- The two photograhps (19, 20) are placed on a tray (21) which is intended to cooperate with a stereoscope in that way that the two photographs can be viewed three-dimensionally in the stereoscopes;

- The photographs (19, 20) in magnified condition are brought to cooperate with a computer which is so programmed that three-dimensional coordinates for optional image points can be determined which allows calculation of desired distances and angles.

2. A method according to claim 1, a further reference object being available, which is a patrice to the existing reference object considered as a matrice, c h a r a c t e r i z e d in the combination of the following moments:

- The two reference objects are put together whereafter a lower jaw model and an upper jaw model, correctly oriented in relation to each other, are brought into the compound block of matrice and patrice;

- The lower and the upper jaw model are attached to respective unit, whereafter the matrice and the patrice with models are brought apart and photograhped separately;

- Three-dimensional coordinates for optional image points are reconstructed by means of computer programs so that

calculation of distances and angles between the upper jaw and the lower jaw can be made by means of the computer.

3. An apparatus useable for carrying out the method according to claim 1 or 2, c h a r a c t e r i z e d in the combination of the following features:

- A photographic apparatus comprising a camera (1) mounted on a stand (2), a light source (11) for illuminating the object, that shall be photographed and a bottom plate (3) placed at a distance from the camera (1);

- A reference object (13) intended to receive the article and to be placed on the bottom plate (3) of the photographic apparatus;

- A stereoscope on which a tray (21) having two photographs (19, 20) which are exposed by the camera (1) in positions on each side of the vertical line and at essentially the same angled distance from this one is provided for visual viewing of the photographs:

- A computer with programs for reconstruction of three-dimensional coordinates for calculation of distances of angles in images of an article.

4. An apparatus according to claim 3, c h a r a c t e r i z e d in that the reference object (13) comprises an essentially plane plate (14) having means (15-18) on each side of a central line (L), each means (15-18) having levels (30-32) which function as reference points.

5. An apparatus according to claim 4, two means (15, 16; 17, 18) being positioned on each side of the central line (L), c h a r c t e r i z e d in that the two means (15, 16; 17, 18) of each pair are positioned at a distance from each other, and that each means (15-18) has the form of a right-angled triangel with two catheters (27, 28) and a hypotenuse (29), the hypotenuse (29) having a step-like form with three levels (30-32).

6. An apparatus according to claim 4 or 5, c h a r a c t e r i z e d in that a further reference object is available, which is a patrice to the reference object (13) existing as a matrice, and that each reference object is intended to cooperate with an article, for instance a model of the upper jaw and the lower jaw.

7. An apparatus according to any one of the claims 3-6, c h a r a c t e r i z e d in that the stand (2) comprises two essentially parallel, vertical rods (4, 5), which at their lower parts are fastened to the base plate (3) and at their upper parts are united by means a plate (6) which is provided with an arched slot (7).

8. An apparatus according to claim 7, c h a r a c t e r i z e d in that the camera (1) is attached to the upper end of a rod (8) in such a way that it is directed towards the central portion of the base plate (3), that the lower end of the rod (8) is pivotably arranged in the base plate and that the rod (8) is provided with a projection (9) which is intended to cooperate with a slot (7) in such a way that the rod (8) can be pivoted in the vertical plane between the outer positions of the slot (7).

9. An apparatus according to claim 8, c h a r a c t e r i z e d in that the projection (9) comprises a screw which penetrates the rod (8) and is screwed into a handle (10), which is positioned on the other side of the rod (8) and by means of which the rod (8) can be brought along the slot (7) and be locked in relation to this one.

10. An apparatus according to any one of the claims 3-9, the light source (11) being a projector, c h a r a c t e r i z e d in that the projector (11) is provided with a grid (12) with an optional pattern, the purpose of which is to provide land marks on the photographs (19, 20).

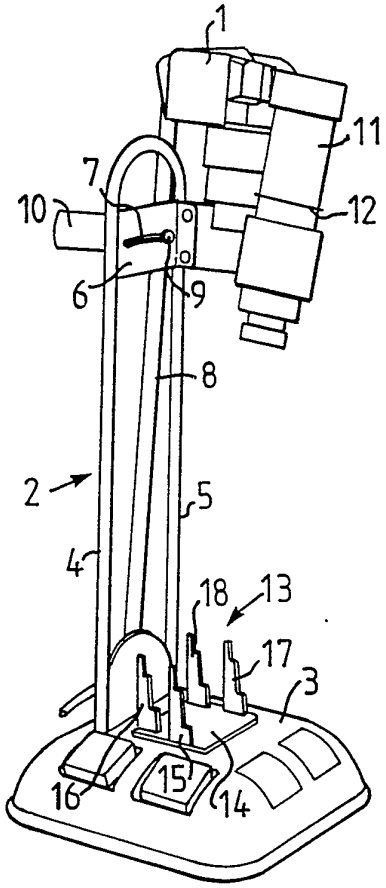

FIG. 1

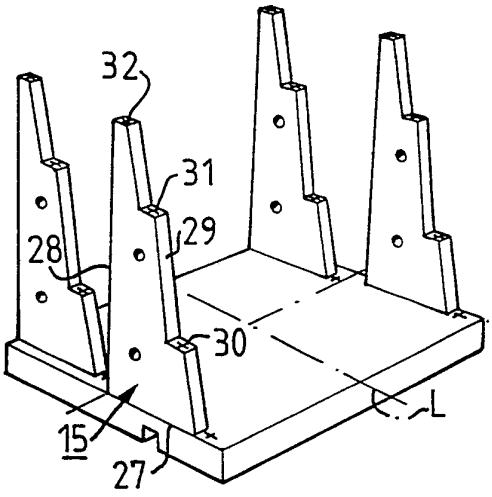

FIG. 3

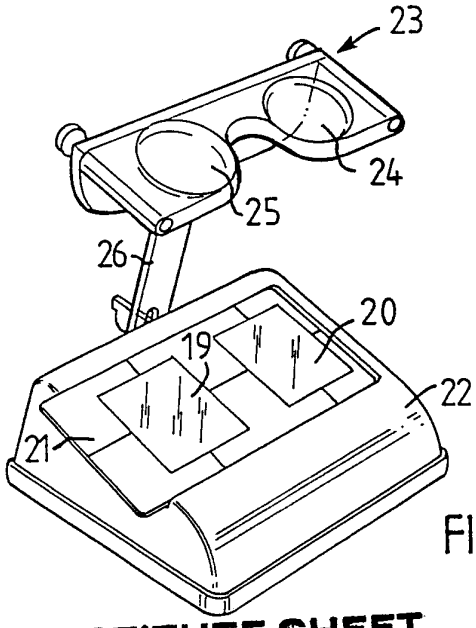

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 90/00377

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

IPC5: A 61 C 19/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	A 61 C

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

SE,DK,FI,NO classes as above

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]
A	EP, A1, 0025911 (HEITLINGER, PAUL) 1 April 1981, see the whole document --	1-10
A	EP, A1, 0054785 (MÖRMANN, WERNER H.) 30 June 1982, see the whole document --	1-10
A	EP, A2, 0206720 (COUNCIL OF GOVERNORS OF THE UNITED MEDICAL AND DENTAL SCHOOLS OF GUY'S AND ST. THOMAS'S HOSPITALS) 30 December 1986, see the whole document --	1-10
A	EP, A1, 0311214 (ELEPHANT EDELMETAAL B.V.) 12 April 1989, see the whole document --	1-10

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* Special categories of cited documents: [10]

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"&" 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
30th August 1990	1990 -09- 06
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Jack Hedlund Jack Hedlund

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 90/00377

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 Swedish Patent Office EDP file on 90-08-02
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A1- 0025911	81-04-01	AU-D-	6231980	81-03-19
		CA-A-	1157299	83-11-22
		DE-A-	2936847	81-03-19
		JP-A-	56045651	81-04-25
		US-A-	4324546	82-04-13
EP-A1- 0054785	82-06-30	JP-A-	57173053	82-10-25
		US-A-	4575805	86-03-11
EP-A2- 0206720	86-12-30	NONE		
EP-A1- 0311214	89-04-12	JP-A-	1135344	89-05-29
		NL-A-	8702391	89-05-01