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(54) **DIGITAL CAMERA, IMAGING DEVICE AND METHOD FOR DIGITAL IMAGING**

DIGITALE KAMERA, BILDGEBUNGSGERÄT UND VERFAHREN ZUR DIGITALEN BILDGEBUNG

CAMERA NUMERIQUE, IMAGEUR ET PROCEDE D'IMAGERIE NUMERIQUE

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## Description

**[0001]** This invention relates to a digital camera according to the preamble of claim 1, to an imaging device and to a method for digital imaging.

**[0002]** In particular, the invention relates to dental panoramic and other tomographic imaging, and to a digital camera and imaging device used in cephalometric imaging, in which the area covered by means for receiving the image information is essentially smaller than the projection of the object to be imaged on the image-forming surface. In this context, the image-forming surface denotes the virtual plane or surface on which the projection of the object to be imaged is formed.

**[0003]** Further, the invention relates to a method for digital imaging in which method the object to be imaged is radiated and the radiation is detected by means for receiving the image information, the area covered by which being essentially smaller than the projection of the object to be imaged on the image-forming surface.

**[0004]** Various tomographic and transillumination imaging methods are used in many kinds of applications. Among others, in the medical and biotechnological imaging applications, it is typical to direct x-ray, gamma, or beta radiation through the object to be imaged and further to the image-forming surface. Digital imaging methods have been developed at the side of the traditional film-based imaging methods, and in these methods semiconductor sensors, such as CDD sensors (Charge-Coupled Device) or CMOS sensors (Complementary Metal-Oxide Semiconductor) are used as image-forming surfaces. Typically, in such semiconductor sensors, x-rays are first converted to radiation the wavelength of which is in the region of visible light but the developing technology is also introducing sensors in which x-rays can be directly converted to electric form.

**[0005]** Despite the many advantages offered by the digital imaging devices, they have not become as generalised as expected in so many visions. The prices of digital cameras have been one of the essential factors having had influence on this. The semiconductor sensors used in the cameras are typically made of silicon and, along with the growth of the size of the sensor, its manufacturing costs per surface area grow exponentially. This is why, in the applications requiring a wide imaging surface, cameras comprising of one semiconductor sensor will become very expensive.

**[0006]** The invention presented in this application has been developed in view of the needs of dental x-ray imaging, and thus, it will be illustrated below primarily in the light of the applications of this field. Naturally, the invention is also suitable for use in connection with many other imaging forms.

**[0007]** The dental x-ray imaging is divided in three main sections, out of which in the so-called intraoral imaging it is typical to image individual, or a few teeth, in the so-called panoramic imaging the dental arch is imaged to a plane as a layer, i.e. as a tomographic image, and in the so-called skull or cephalometric imaging the skull area as a whole is imaged as a transillumination image. Further, many devices used for panoramic imaging are suitable for taking even other cross sectional images of various areas of the dental arch. The present invention is particularly suitable for use in connection with the panoramic and other tomographic imaging forms and with the skull imaging, all of which being typically made by the same imaging device. Particularly in the cephalometric imaging, the need for image information receiving means with large surface area has appeared problematic from the point-of-view of the commercialisation of the digital imaging applications. Taking a skull image with a sensor having a directly matching size with the area to be imaged would require use of tens of times bigger sensors as typically used in panoramic imaging.

**[0008]** As the dental skull image is a transillumination image it is traditionally taken by using so wide a beam and film that the desired area has been able to be imaged as one single shot. On the other hand, in panoramic imaging a tomographic image is typically produced by using a narrow beam and the area to be imaged is scanned by it, whereby the tomographic effect for imaging the desired anatomic layer is created by continuously changing the entry angle of the beam in relation to the object as the beam travels over the area to be imaged. In this so-called narrow beam tomography method, the movement of the imaging means (the radiation source and the image information receiver) is implemented in a controlled way so that the receiver is moving in relation to the beam with a transversal speed corresponding the vertical scanning speed of the beam in the area to be imaged, multiplied with a magnifying factor, i.e. a coefficient that is the relation between the distance from the image information receiver of the focus of the beam (=radiation source) and the distance from the area to be imaged. In this definition, the detector primarily refers to the radiographic film, whereby, in the digital imaging, the movement of the image information receiver in relation to the anatomic layer to be imaged can be replaced by a suitable electric function, as a charge transfer on the surface of the semiconductor sensor. Mathematically, this imaging equation can be presented in the following form:

$$v_F = ( L_{FF} / L_{OF} ) \times v_O \quad ,$$

where $v_F$ = speed of film transfer, or an electric function by the sensor corresponding to it, $L_{FF}$ = distance of film or any respective element from the focus of the radiation source, $L_{OF}$ = distance of the object to be imaged from the focus of the radiation source and $v_O$ = forward speed, parallel to the image-forming surface, of the beam in the object. Therefore, the precondition to a successful panoramic imaging is that, during the imaging, the respective positions of the means to receive the image information, of the area to be imaged, and the radiation source in relation to each other, continuously remain, as precisely as possible, in compliance with this theoretical imaging equation.

**[0009]** In the digital panoramic imaging, the scanning movement of the beam is followed by a narrow sensor from which the image data is read out during the scan. As the panoramic and cephalometric images have typically been taken by the same x-ray imaging device, it has been a natural idea to use the so-called scanning slot imaging technology also for taking the transillumination images of the skull area (e.g. "Direct digital extraoral radiology of the head and neck with a solid-state linear radiographic detector", McDavid, W.D. et al., Oral Surg Med Oral Pathol 1992; 74:811-7). This is how the sensor surface area needed for imaging has been able to get considerably reduced. In some of such applications, however, the scan has been implemented in a way causing at least theoretical errors in the image, i.e. as the beam is positioned to meet the image information receiver perpendicularly and the scanning of the object is carried out by either conveying the object perpendicularly through the beam, or by positioning the object in a fixed position and by moving the radiation source and the image information receiver with a parallel synchronized movement past the object. These kinds of imaging modes do not produce genuine transillumination images but, as a matter of fact, tomographic images where the size of the tomographic effect depends on the width of the beam used. In addition to this, interpreting of the images obtained in this way is not familiar to the doctors, as their projection geometry is different in the horizontal and vertical directions, thus deviating from the traditional geometry of a transillumination x-ray image.

**[0010]** From the point-of-view of practical applications, use of the same sensor both in the cephalometric and panoramic imagings would be desirable, among others regarding the administration of the camera production and the sensor storage solutions, as the costs of starting the production and, as the manufactured numbers would get larger, the costs per unit, could thus be reduced. In digital panoramic imaging the height of a typically used sensor is, regarding the cephalometric imaging, however, sufficient only in a few special applications, which is why two different sensors have to be manufactured for the market. Therefore, the scanning slot imaging as such does not provide a solution based on which one could manage with only one single sensor.

**[0011]** A feasible possibility as such would be to use a cephalometric imaging sensor in panoramic imaging in such a way that the sensor height would be utilized only partly, but even this solution is problematic from the commercial point-of-view. The sensor that is sufficiently high for cephalometric imaging is more expensive than two panoramic sensors, i.e., with today’s prices, the camera needed for cephalometric imaging might cost even more than the rest of the imaging equipment altogether. As typically only about one third of the panoramic devices are provided with means for cephalometric imaging, regarding this and the points presented above, it is very understandable that the digital cephalometric imaging applications have not become significantly more general.

**[0012]** Use of the same digital camera for panoramic and cephalometric imagings has been considered e.g. in the US-A-5 579 366 . This publication primarily discusses one dimensional digital cameras, to the evident idea of using a sensor that is high enough even for cephalometric imaging applications, i.e. a camera that is expensive and overdimensioned from the point-of-view of the needs of mere panoramic imaging. In the scanning cephalometric imaging, a longer sensor than in the panoramic imaging is needed, in any case, whether the imaging scan is made horizontally or vertically.

**[0013]** The actual invention according to the US-A-5 579 366 concerns the camera interface arrangements that seem to be easy to use as such but that also include potential sources for problems. Use of the same camera in different imaging positions requires its repeated transfer between the panoramic and the cephalometric imaging stations and these measures will always imply a risk of damaging the expensive camera, e.g. as a consequence of dropping it. Often repeated removals and attachments set requirements of their own also to the mechanical, and particularly to the electric interface solutions of the camera. In practice, the problem of the interface solution according to the the publication might prove to be the precise and steady positioning of the camera in the imaging device, which is critical, in particular, in scanning slot imaging.

**[0014]** Also in connection with other imaging applications, different solutions have been developed to solve the surface area/price problem of the semiconductor sensors. Typically in these solutions, sensors covering only a part of the image-forming surface are used, which are then moved or transferred during the exposure, or between individual exposures. E.g. in the mammographic devices different mosaic or chessboard pattern built sensors have been used, which are then moved between two or several different exposures. Typically, the different modular realisations are expensive and to make them function in practice, too, the combination of the modules has to be carried out with extreme precision - especially when the intention by combining them is to construct a uniform sensor surface based on modules.

**[0015]** The WO 95/12133 A1 presents a modular sensor arrangement, based on the formation of a kind of zig-zag pattern, to be used in different radiographic and tomographic imaging applications. This as such technically excellent solution has not, however, been shown to become a commercial success, at least not in connection with medical imaging - probably at least partly due to the fact that, e.g. a uniform panoramic image cannot be achieved by this kind of a sensor. In the sensor arrangement according to the Publication, the sensor modules are all the time moving, in she direction of the scanning movement, in different stages, i.e. in relation to the rotational centre they are in each moment of time in different positions and are continuously imaging the object from different projections, i.e. they form images based on different imaging geometries. Therefore, such a sensor arrangement creates an image formed of stripes of the different projections, parallel with the scanning movement, where on the borders of them there may be points of incontinuency. In particular, in the (dental) medical radiographic imaging, these kinds of faults in images are not acceptable.

**[0016]** D3 discloses a generic digital camera having the features of the preamble of claim 1.'

**[0017]** Further, WO-A-9512133 and EP-A-0858773, respectively discloses a digital camera for x-ray imaging.

**[0018]** Therefore, the object of this invention is to develop digital imaging technology to reduce the problems presented above. In particular, the object is to develop a camera that is relatively inexpensive to manufacture and to acquire, suitable for scanning slot imaging, an imaging device for the use of this kind of camera, and an imaging method based on a corresponding technology. In this way, the investments to digital technology become more justifiable and the threshold for its introduction lower. The digital technology, among other, will make the doctor's work easier as it enables getting images of better quality, and thus more precise diagnoses, but even saving the pictures and administration of them in electric form - together with the rest of the documentation concerning the patients and the administration of the reception.

**[0019]** Advantageously the invention provides such a camera that can be used in more than one form of imaging, particularly in both tomographic and transillumination imagings, especially in the same imaging device, and possibly in its different imaging positions. Advantageously the invention also provides such a method for digital imaging according to which the same camera can be used to take both tomographic images and transillumination images - even of objects of different sizes.

**[0020]** Advantageously the invention provides a camera the sensor surface of which could simply and with moderate cost be modified, implying that one of the objectives of the invention is to provide this kind of a camera using a modular sensor arrangement. Advantageously the invention provides a modular sensor arrangement for the camera in such a way that the characteristics of the camera can be easily changed, without the need to change its basic structure, when one further additional objective of the invention is to provide the modular sensor arrangement for the camera so that it will be easy to add modules to the camera in order to increase the sensor surface of the camera, or so that the way it is used can be altered so that different imaging modes and imaging of objects of different sizes will be possible with the same camera.

**[0021]** Advantageously the invention provides such a camera suitable for dental panoramic and other tomographic imaging, that can be used, or that can be relatively easily and economically be modified so that it will also be suitable for dental cephalometric imaging.

**[0022]** Advantageously the invention provides a modular sensor arrangement for the camera so that the camera can be used utilizing only a part of it, especially in tomographic imaging utilizing only one module, that of the sensor arrangement.

**[0023]** Advantageously the invention also implements the sensor arrangement so that the possibly broken individual sensor module could easily be replaceable by a new one, possibly by a module that is identical with the other modules.

**[0024]** Advantageously the invention is provides such a modular sensor system for the camera that the sensor surfaces of the modules and/or the circuit boards belonging to the modules can be positioned also on different levels.

**[0025]** Advantageously the invention provides an imaging device in which the same camera according to invention can be used for both tomographic and transillumination imaging, in particular, for both dental panoramic and cephalometric imaging.

**[0026]** Advantageously the invention provides such an imaging device whereby a camera according to the invention can easily and safely be moved from one imaging station to another and positioned precisely in its correct imaging position.

**[0027]** Advantageously the invention implements the camera connection arrangement so that it will consist of at least two structurally different connectors, to connect the camera correctly to its imaging stations for at least two different imaging purposes.

**[0028]** Advantageously the invention provides such an imaging device in the imaging positions of which, designed for at least two different imaging purposes, there are structurally different connecting arrangements for connecting the camera to the imaging device.

**[0029]** Advantageously the invention utilizes the connection arrangements of the camera to direct the image information received from certain modules of the camera out from the camera via signal paths exclusively assigned to these modules - in particular, to direct the image information from one module for tomographic imaging out from the camera via a connection arrangement exclusively suitable for a tomographic imaging station.

**[0030]** Advantageously the invention realizes the usability of the camera in more than one point of use so that the removal and connection of it would include as few risks as possible for damaging the camera itself, as well as its connecting structures.

**[0031]** Advantageously the invention realizes the connecting arrangement of the camera so that its electric connecting parts would be as little vulnerable as possible to mechanical stress that might, in time, damage them and lead to intermittent power contact failures, or even to a permanent failure.

**[0032]** Advantageously the invention realizes the connection arrangement of the camera so that it can be positioned to its imaging station relatively simply but in the same time as precisely and for being as non-movable as possible.

**[0033]** Advantageously the invention realizes the connection arrangement of the camera so that it will ensure a stable and safe mounting of it in the imaging device, in order to minimize the electrical safety risks that could be caused by e.g. unusually strong external forces upon the camera. These forceps can be caused by e.g. stumbling on the camera so that the connection structures would bend and cause shortcuts and thus potential damages to the imaging device and the camera, or even personal injuries as a consequence of an electric shock.

**[0034]** Advantageously the invention provides such an imaging device where the connection arrangements intended for the camera have been realized by using separate mechanical and electric connection structures.

**[0035]** Advantageously the invention realizes the connection arrangement so that its mechanical and electric connection structures have been separated from each other, e.g. placed physically on different surfaces of the camera housing.

**[0036]** Advantageously the invention realizes the connection arrangement so that fixing of the camera will take place in a compulsory sequence of - positioning - locking of the mechanical connection - electric coupling.

**[0037]** The essential characteristics of the invention are presented in detail in the attached claims. One of the main characteristics of these is a modular sensor arrangement of a digital camera that consists of, in view of sensor surfaces or their projections on a certain plane, in particular, the point projections in relation to the focus of the radiation source, an overlapping assembly formed by at least two sensor modules - or of a structure including at least the first module, and with means arranged for connecting at least another module functionally to the structure to provide this kind of an assembly; whereby the first module has been arranged to be used for scanning tomographic imaging, and whereby this said module has been arranged to be available for scanning transillumination imaging together with at least another sensor module. In the same way, in the method according to these characteristics, particularly one module unit of the modular sensor assembly is used for tomographic imaging, whereby this same module, together with at least another module belonging to this sensor assembly, is also used for transillumination imaging, whereby imaging of even larger areas than the areas that can be imaged by this first module will become possible.

**[0038]** In particular, the overlapping module assembly according to this invention means a sensor arrangement whereby the sensor modules have been positioned, in relation to each other, in an overlapping position so that

considering the sensor surfaces of the sensor modules, or their projections on the plane formed by the axles y, z of a right-angled set of coordinates x, y, z,

whereby a projection here indicates, in particular, the point projection which is imaged to said plane via the focus of the radiation source used in the imaging and the said sensor surface,

each of them covers a different area on this plane, and that,

when proceeding in the direction of the axle y,

the projection, or the said point projection of the sensor surface, of each subsequent sensor surface placed on the plane formed by the axles x, z, will cover a different area from the previous projection,

and that the projection, or the said point projection of the sensor surface, of each subsequent sensor surface placed on the plane formed by the axles x, y, will meet that of the previous projection - possibly by at least partially covering the same area.

**[0039]** The modular structure according to this definition can therefore be implemented so that, when proceeding in the direction of the axle y, each subsequent projection, on the plane formed by the axles x, z, covers a different area from the previous projection so that the borders of these areas meet.

**[0040]** When the camera with the sensor arrangement according to the invention is positioned in the imaging device using scanning slot technology according to this invention, the direction of the scanning movement of the beam is the direction of the axle z of the definition above.

**[0041]** Thus, the sensor assembly can consist of only the first sensor module used for tomographic imaging and, in addition to this, the means, such as the space required and the means attached to it for connecting at least one another sensor module functionally to this arrangement, in order to form an overlapping modular structure.

**[0042]** In the following, the invention will be described in more detail, using its preferred embodiments and referring to the attached figures, out of which

Fig. 1 shows a typical traditional panoramic and cephalometric imaging device,

Fig. 2 shows a structure of a camera housing according to the invention,

Figs. 3A-3E show some sensor module arrangements according to the invention,

Fig. 4 shows a collimator system according to one preferred embodiment of the invention used to limit the beam of an imaging device,

Figs. 5A and 5B show one way according to one preferred embodiment according to this invention to connect the camera to the panoramic and cephalometric imaging device, and

Fig. 6 shows a camera holder-connector structure in an imaging device according to one preferred embodiment according to this invention.

**[0043]** Fig. 1 shows one typical, traditional film-based panoramic and cephalometric imaging device comprising a body part 1, another body part 2 movably attached to it, with further a suspension arm 3 movably attached to the second body part 2, at the essentially opposite ends of which the radiation source 4 and the image information receiver 5 used in panoramic imaging are located. In the device according to Fig. 1, this image information receiver 5 is a film cassette, but it could also, respectively, be a digital camera attached to the suspension arm 3. In addition, positioning means for the object to be imaged are also typically used in panoramic imaging; their position in Fig. 1 is referred to by reference number 6. To control the functions of the device, it also typically comprises a user interface 7.

**[0044]** To the device according to Fig. 1 are attached means for taking cephalometric images, when it also comprises another suspension arm 8 with positioning means 9 for the object to be imaged in cephalometric imaging attached to it, as well as means 10 for positioning and attaching the image information receiver, which in the device according to Fig. 1 is a film cassette.

**[0045]** In addition, considering the digital application of this kind of device, a panoramic 11 and respectively a cephalometric 12 imaging station of the camera 5 have been indicated by reference numbers 11 and 12 in Fig. 1. These imaging stations will be later referred to in connection with the embodiments of the invention according to Figs. 5 and 6.

**[0046]** When using the imaging device shown in Fig. 1, the object to be imaged is positioned either in a desired tomographic imaging position, in the area indicated by reference number 6, between the radiation source 4 and the image information receiver 5, or in a desired cephalometric imaging position, by the positioning means 9 used in the cephalometric imaging. In tomographic imaging, a layer of the desired anatomy is imaged by moving the radiation source 4 and the image information receiver 5 in a controlled way on the essentially opposite sides of the object to be imaged so that at the same time the area to be imaged is scanned by a narrow beam. On the other hand, for cephalometric imaging, the radiation source 4 is positioned to direct the beam towards the positioning means 9 used in cephalometric imaging, and further towards the image information receiver not shown in Fig. 1. The traditional film-based devices have typically had to be constructed so that the structures that remain between the radiation source 4 and the cephalometric imaging station 12, as the holder structures of the panoramic film cassette 5, or the like, have had to be moved aside when the device has been changed from panoramic imaging mode to cephalometric imaging mode. In particular, in applications using the same digital camera 5 this problem can simply be solved by producing such a panoramic imaging station 11 of the camera 5 that removal of the camera 5 is sufficient to leave a free path for the beam towards the camera 5 moved to its cephalometric imaging station 12.

**[0047]** Fig. 2 shows a structure of a camera housings 51 of a digital camera 5 according to the invention. In this embodiment of the invention, respective apertures 53, 53’ matching the form of one of the sensor module arrangements according to the invention have been arranged to the actual housing part of the camera 5, which is covered by an upholstery surface which is permeable to the radiation used for imaging. In addition, camera 5 comprises means 60 for positioning and mechanical fixing of the camera 5, to be later shown in more detail in connection with Fig. 6, and means 70 for electric connection of the camera, which means can be implemented so that there are separate connecting means in the camera, on one hand for different imaging modes, and on the other for electrical and mechanical connections of the camera to the imaging device.

**[0048]** Figs. 3A-3E show some of the sensor module arrangements according to the invention. In this context, by sensor module is meant any structure forming an essentially uniform sensor surface. The sensor module 20 may e.g. have the structure shown in Fig. 3A, of the sensor structure 21 formed by four CCD microchips, optical fibre 22, scintillating material 23, housing 24 of the sensor structure 21, cover 25 and a printed circuit board (PCB) 27, or the like, coupled to this structure by electric interface surfaces 26, but it may also consist of, e.g., a single monolithic CCD chip.

**[0049]** The sensor module arrangement according to the invention may be implemented in innumerable different ways out of which some have been shown in Figs. 3B-3E. These figures show the structure of camera 5 seen from the direction of the focus of the radiation source, when the radiation containing image information is directed via the apertures 53, 53’ of the camera housing 52, essentially corresponding to the form of the sensor module arrangement of camera 5, to the sensor modules 20, 20’, 20", 20"’ that have been placed on the opposite inner wall in relation to the apertures 53, 53’ of the camera housing. A right-angled set of coordinates x, y, z according to the definition used above has been added to the Figs. 3B-3E, where the direction of the axle z is the same as the direction of the movement of the camera, i.e. the scanning direction of the beam, when the camera is used for scanning slot imaging.

**[0050]** Fig. 3B shows the simplest embodiment, consisting of two modules 20, 20’, of the sensor module arrangement according to the invention. With a camera 5 consisting of this kind of a structure one is able to take a tomographic image using one module 20, and a larger transillumination image by using also the other sensor module 20’ positioned in overlapping relation to the first module 20. The stripe-forming effect encountered in tomographic imaging, where at any moment of time during the imaging scan the sensors are at different stages, can be controlled without problems in transillumination imaging. When the focus of the radiation source and the object to be imaged are held stationary and the scanning movement of the beam is implemented by collimators limiting the beam, the modules moving synchronized with the scanning movement form a true transillumination image, each of them at a certain stage of the scanning movement, i.e. e.g. when using the sensor arrangement according to Fig. 3B, when the modules pass the object from left to right, the upper part of the transillumination image will be completed later than the lower one. Even a long distance between the modules 20, 20' in the direction of scanning movement is not problematic from the point-of-view of the formation of the final integrated image but, naturally, e.g. due to the possibly uneven radiation output of the radiation source 4, or regarding the physical dimensions of the camera, this distance should, however, be left as short as will be reasonable, regarding the other solutions of the camera arrangement. And, as in all slot imaging applications of this type, it would also be preferred, in view of the object not to move, to be able to have as short imaging time as possible, i.e. to keep the distance in between the modules scanning direction as short as possible for this reason, too.

**[0051]** If the projections of modules 20, 20', on the plane formed by axles x, y at least partly cover the same area this will not cause any problems in the formation of a transillumination image, as the overlapping parts can be integrated by the image processing methods evident to those professed in the art, to appear as if they had been taken by one sensor. The partial images can be combined e.g. so that the image information corresponding to the part of the object that has possibly been imaged more than once, due to the overlapping of the sensor surfaces, is either removed from the information produced by all the modules except one, or, in particular, so that all of the information received is used in forming the image and the part having been imaged more than once is scaled to correspond the image information that would have been received from only one sensor module. On the other hand, overlapping is also useful regarding the fact that then there will certainly not be left any gaps between the partial images formed by the separate modules. In some special imaging modes it may even be appropriate to arrange two or more modules to image, even totally, the same area, i.e. to arrange the modules so that, according to the definition used above, the projections of the sensors cover the same areas on the plane formed by the axles x, y.

**[0052]** According to the invention, the camera 5 may also include three, four, or even more sensor modules to form e.g. an overlapping line according to Fig. 3C, a structure formed by sensor modules of different sizes according to Fig. 3D, or a structure formed by two columns according to Fig. 3E. Then, Figs. 3D and 3E illustrate the possibility that, according to the definition used above, when proceeding in the direction of the axle y, the border of the area covered by each successive projection on the plane formed by the axles x, z can be at a distance in different directions from the border of the area covered by the previous projection, compared with the previous projection and the one before it, and that these projections may cover, partly or even totally, the same area. This kind of covering the same area cannot, however, be present when proceeding in the direction of the axle y for any two successive projections.

**[0053]** Figs. 3B to 3E only show some simple basic structures that can be combined and extended in many different ways within the basic idea of the invention. Further, according to the invention, the sensor module arrangement can also be realized e.g. by arranging the modules 20, 20', 20", 20"', and, in particular, their surfaces 23 receiving the image information, on different planes, i.e. at different distances from the focus of the radiation source. This can be realized e.g. by using connecting surfaces 26 of different lengths. On the other hand, using connecting surfaces of different lengths, it is possible to create a structure where the sensor surfaces are at the same level but where the printed circuit boards 27, or the like, are at different levels. These types of arrangements allow more latitude for the implemention of the electronics arrangements of the camera. The marginal magnification error caused by the position of the sensor surfaces at different distances from the objects to be imaged can, if desired, be corrected e.g. by the image processing methods known as such.

**[0054]** In order to achieve as effective sensor surface as possible in transillumination imaging using the sensor module arrangement according to the invention, it would be preferred to leave the possible overlapping portion of the sensor surfaces, naturally even for cost reasons, as short as possible. In principle, the sensor module arrangement could be realized so that, according to the definition used above, the projections of the sensor surfaces on the plane formed by the axles x, y, would not overlap at all, i.e. that the distance between them would be zero. A so precise physical positioning of the modules is, however, technically more difficult to achieve than e.g. an arrangement where the modules are positioned at least a little overlapping and the possible extra overlapping will be taken into account in the imaging process, e.g. by using a suitable collimation of the beam. Furthermore, an overlapping of the size of at least one row of sensor pixels is preferred also because the combination of images is then more easily feasible, using means offered by many as such known electronic and/or image processing software solutions. Especially if the effective height of the sensor arrangement does not belong to the critical development criteria, the use of overlapping and its optimal magnitude can be considered in the light of any particular characteristics of the respective application.

**[0055]** Regarding the needs of dental imaging, it is preferred to arrange the module used for tomographic imaging as the lowest module of the sensor module arrangement, as in all other cases especially the imaging of the lower jaw onto the panoramic image is difficult to arrange. In these type of applications, it is also preferred to implement the sensor module arrangement according to the invention so that two identical modules, possibly in overlapping positions, are used, and the physical and electronic arrangements of the camera are implemented so that the modules can be easily removed and/or connected to the camera. Expressed more precisely, this means that it will be possible, in the first stage, to arrange in the camera housing only the module needed for tomographic imaging, and the physical space needed for the transillumination imaging module plus the necessary means for its positioning and functional connection to the camera. In this way, a panoramic camera is provided with a relatively inexpensive acquisition price, and to which, however, another module needed for cephalometric imaging can later be connected in a simple way. In addition to this, thus a damaged module can easily be replaced by a new one and if the damaged module happened to be one used only for cephalometric imaging, the camera can still be used for panoramic imaging purposes even during the time the acquisition of a new module takes. The price of this type of a panoramic camera can be made to match the price of a conventional panoramic camera, i.e. the camera will be significantly cheaper - due to its smaller sensor surface - than a panoramic camera consisting of one sensor module that could as such also be used for cephalometric imaging. In addition, even price of a camera according to this invention, extended suitable also for cephalometric imaging, consisting of two relatively small sensor modules will, however, remain clearly lower than that of a one module camera of comparable size. Even in a more general consideration, a sensor arrangement according to the invention can thus be realized so that, for whatever single module or several modules used only for transillumination imaging, only the physical space and the necessary means for connecting the module functionally to the camera are arranged to the camera housing, in which case the sensor arrangement can by simple connection measures be arranged to form a larger overlapping modular structure.

**[0056]** According to the invention, there are numerous ways to remove or discard the signal produced by other modules than that used for tomographic imaging from the image information used for creating the tomographic image. E.g. the electronics arrangements of the camera can be implemented so that the signal path to the transillumination imaging modules can be cut, or so that the image is formed, or the image data is transmitted from the camera to separate image processing means only from the signal received from the tomographic imaging sensor. The non-desired information can be sorted out and removed by using electronics arrangements, known as such, e.g. in the logic circuit of the camera, or later by image processing methods, known as such. In addition or besides to these arrangements, it is also possible to proceed so that the collimation arrangement limiting the beam of the imaging device is implemented so that, when the imaging device is used for tomographic imaging, the access of radiation to other sensor modules is blocked.

**[0057]** Further, taking into consideration certain preferred embodiments to be presented later, one possible solution is to arrange two sets of separate electric connection means for the camera, in which case the signal paths can be arranged so that one connecting element will be in connection only to the tomographic imaging sensor module and the other both to the tomographic imaging sensor module and at least to one transilluminaton imaging sensor module - or then at least to one of the connection means arranged for this type of module. Thus, when the first mentioned electric connector is used for attaching the camera to the tomographic imaging position, automatically, only the image information produced by the tomographic image sensor module is obtained via this connector, as desired.

**[0058]** The final formation of the image may be done in ways known as such, e.g. by connecting the imaging device to a computer, whereby the memory and the processing means of the computer can be utilized. The processing means can also be realized by e.g. a dedicated ASIC circuit (Application Specific Integrated Circuit), connected to memory means, e.g. RAM memory. Naturally, and as already partially described above, many measures of the image information processing can already be carried out in the camera, e.g. specifically in the ASIC circuit arranged to the camera. The formation of the final image information as such is well-known technology to those professed in the art, and a more detailed description of it is not necessary for the implementation of the invention. In principle, the camera may be made by arranging all means required for the image formation in the camera itself when it could be connected directly to the display device.

**[0059]** In the implementation of the invention, it is possible to utilize the CCD sensor technology known as such, having shown to be very useful in e.g. panoramic imaging. On the other hand, one interesting alternative also is the use of a newer technology based on CMOS sensors and direct detection of radiation, as with them certain advantages can be obtained as compared to the traditional semiconductor sensors. The CMOS sensor technology as such enables, due to its so-called parallel bus type data transfer system, a faster transfer of image information, and with sensors based on direct detection an even better resolution is achieved than with the traditional semiconductor sensors, when there are no scintillating and optical fibre structures reflecting light also to non-desired directions. The sensitivity of the sensors based on direct detection is better, too. The CMOS technology is the most commonly applied semiconductor technology and, because of this, the availability of CMOS circuits is good and their manufacturing costs are being reduced by the technical development.

**[0060]** One of the sensor technologies based on direct detection of radiation has been described in more detail e.g. in the Patent Application Publications WO 95/33332 and WO 97/20342. It is not possible to perform a charge transfer function (Time Delay Integration = TDI) with this type of a sensor, nor is there any simple way to construct such a function to it. However, this type of a sensor can be used in these imaging modes by forming the image so that an image of the object is produced every time the object to be imaged, or the sensor, has moved about one pixel forward, and by adding these images to each other so that they are, at the same time, overlapping a corresponding distance in relation with each other.

**[0061]** Fig. 4 shows one preferred embodiment of the invention for a collimator arrangement for limiting the beam, which in the situation shown in the figure has been arranged to be ready for use in cephalometric imaging. In cephalometric imaging the beam received from the radiation source 4 is first limited by a primary collimator 31 (collimator opening 31A) placed in the vicinity of the radiation source 4, and before the object to be imaged 33 by another collimator 32 placed to a sufficient distance from the focus, which will limit the beam to essentially match the form of the areas 53, 53' the camera housing, which are permeable to radiation. The scanning movement of the beam is realized by the movement of the collimators and the camera is moved synchronized with this movement. If the sizes of the active surfaces 23, 23' of the sensor modules 21 and of the areas 53, 53' permeable to radiation, especially their overlapping, are arranged to be larger than the effective sensor surface 23, 23' required in the respective imaging, with a suitable limitation of the beam it will be possible to prevent the unnecessary direction of radiation through the object to be imaged 33 twice, to the area of the sensor surface not to be utilized in image formation, and the image information of the area left outside the beam can be removed before the partial images are combined.

**[0062]** Panoramic imaging can be realized in a manner known as such by the structure according to Fig. 4 by positioning the aperture 31B, intended for panoramic imaging, of the primary collimator 31 in the essential vicinity of the radiation source 4 to limit the beam to match the conventional beam used in panoramic imaging, i.e. to essentially match the aperture 53 of the camera housing.

**[0063]** The Figs. 5A and 5B show one of the preferred ways to attach the camera 5 according to the invention to the imaging device. In the solution according the figures, the camera 5 can be considered as positioned e.g. to its cephalometric imaging station 12 in Fig. 5A and to its panoramic imaging station 11 in Fig. 5B. In Figs. 5A and 5B arrow 41 indicates the entry direction of the x-rays to the camera 5, i.e. the camera 5 and the connection arrangements 42A, 42B of the imaging device have been arranged to be of different structure, so that the camera 5 can, on one hand, only be mounted from one direction to the cephalometric imaging station 12, and from the other direction to the panoramic imaging station 11 (compare with Fig. 1). When the said directions have been arranged horizontally according to Figs. 5A and 5B, moving the camera 5 between the imaging stations 40A, 40B is easy and fast, and at the same time, the danger of dropping the camera 5 unintentionally has been minimized. When positioning oneself to the area between the panoramic imaging station 11 and the cephalometric imaging station 11, 12, the camera is easily removable from one imaging station and attachable to the other imaging station by using a simple horizontal movement. In this way, that critical time for the risk of damaging the camera 5 when it is not safely mounted and secured to the imaging device, is reduced.

**[0064]** Technically, the imaging device according to the invention is, naturally, also possible to realize so that the scanning movement of the beam is made in some other direction than horizontally. Especially, the panoramic and cephalometric imaging devices according to the invention can be made so that the scanning movement of the cephalometric imaging is arranged to be done in vertical direction, whereby the sensor module arrangement can be implemented in a somewhat shorter form.

**[0065]** Fig. 6 shows a connection arrangement 60', 70' enabling one preferred embodiment of the invention shown in Fig. 5 to fix the camera 5 according to Fig. 2 to the imaging device. The structure shown in Fig. 6 may be considered to correspond the panoramic imaging station 11 according to Fig. 5B, when e.g. the respective connecting arrangement (60, 70) forming a structural mirror image may be arranged to the cephalometric imaging station 12. The connection arrangement 42B according to Fig. 6 consists means 60' for positioning and mechanical mounting of the camera 5 and means associated with the electrical couplilng 70' of the camera. The camera 5 is brought to the imaging station 11 in the direction of the guiding rails 61, 62 that ensure the correct positioning, from the opposite side of their end plate 63. When the guiding rails 61, 62 have penetrated fully into the matching guiding grooves in the camera 5, the fixing of the camera 5 can be secured by turning the locking means 64 to its locking position over the camera housing 51. Additionally, the connection arrangement according to Fig. 6 can also be made so that the electric connecting means 71, 72 are moved to contact the matching elements in the camera not until the camera has been mechanically locked, e.g. with a perpendicular movement in relation to the direction of the positioning movement of the camera, which is realized by a pressing element appearing from below of the locking means 64. Thus, the sensitive electric means can be protected from mechanical stresses by this kind of compulsory operating sequence of positioning - securing the mechanical connection - electric coupling. In particular, this kind of an arrangement enables the realisation of the electric coupling and its switching off without any gliding movements of the connecting means.

**[0066]** The connecting arrangement 42B according to Fig. 6 does not cause mechanical stresses to the means 70 involved with the electric coupling of the camera 5 and the imaging device even when the camera is connected to its operational station. The mechanical stresses on the electric connectors are problematic, especially if the duration of them is long, as the connection elements may bend with time, or otherwise be damaged to the extent that the electric contact starts to fail, or even becomes cut off permanently.

**[0067]** As already partly described above, in the solution according to Fig. 6 specifically horizontal rails have been used to reduce the possibility that the expensive camera would slip to the floor unintentionally during its removal and/or mounting. On the other hand, intention in using more than one guide rail, as well as in separating the positioning and the actual locking means to elements of their own, is to ensure the correct positioning of the camera, regarding which in slot imaging, in particular in the direction of the width of the narrow beam, one must especially precise. The solution according to Fig. 6 of separating the actual mechanical connection from the electric coupling also reduces e.g. the imminent danger of shortcuts by unintentional crashes to the camera that could lead to a consequence of damaging the camera, or the imaging device as a whole, or even to fatal danger in the form of an electric shock.

**[0068]** The connecting arrangements 42A, 42B of the separate imaging stations 11, 12 can be realized as structurally different so that the camera 5 can be attached to one imaging station 11 only by using a connection arrangement 60, 70 only compatible with it, and to another imaging station 12 by using another connection arrangement. Thus it can be ensured that the camera 5 will always be connected correctly to each imaging station 11, 12. At the same time, the operational life time of the electric connectors will be increased when the number of times of coupling per connector structure is reduced to half, and even if, despite of the above, one connection arrangement would be damaged, the camera could still be used at least in one of the imaging stations during the time the acquisition of a new camera, or in practice, most likely new connecting means, will last.

**[0069]** As a summary, it can be said that, according to the embodiment of the invention shown in Figs. 2, 5, and 6, there are structurally different connection arrangements for the tomographic and for the transillumination imaging stations, whereby, respectively, there are two structurally different connection arrangements in the camera, and these connection arrangements consist of separate mechanical connection structures and electric connector elements arranged as independently functioning elements, one for connection for tomographic imaging on one hand and the other for transilluminaton imaging connection on the other. The electric coupling means arranged to the imaging devices are connected to means for moving them in order to move them into contact with the coupling means located in the camera, and when the mechanical connection means are arranged to consist of separate positioning and locking means for the mechanical connection, the camera according to this embodiment of the invention can be attached to the imaging device by one connection arrangement consisting of two separate connection structures only to a certain kind of connection arrangement of the imaging station, and only using a compulsory operating sequence of positioning - securing the mechanical connection - electric coupling.

**[0070]** Although the invention has been described above mainly by using panoramic and cephalometric imaging applications as examples, it can naturally also be used in connection with any other corresponding imaging applications. For example, according to the invention, any radiation that can be detected by semiconductor sensors can be used.

**[0071]** The invention is especially useful in the imaging applications of medical technology where x-ray or gamma ray radiation is typically used, or in biotechnological applications where beta radiation is typically used. Further, the invention can be applied to industrial testing and quality control methods utilizing transillumination.

**[0072]** For those professed in the art, it is evident that, especially with developing technology, the basic idea of the invention is realizable in many ways, and the embodiments will not be limited by the above examples, but they can vary within the scope of protection defined in the attached claims.

## Claims

**1.** A digital camera to be used in tomographic imaging, or in both tomographic and transillumination imaging, in particular in dental imaging, whereby the area to be imaged is scanned by a beam generated by a radiation source (4) to produce image information, the camera comprising

information receiving means for obtaining said image information, wherein said information receiving means are positioned or movable on a desired image-forming surface, the area covered by said information receiving means being essentially smaller than the projection of the object to be imaged on the image-forming surface, said information receiving means comprising a first sensor module (20) receiving image information produced at least in tomographic imaging,

wherein at least one additional sensor module accommodating space is provided in said camera (5) for accommodating at least one additional sensor module (20', 20", 20"') to exclusively receive image information produced in transillumination imaging,

the camera (5) further comprising an electronic arrangement to connect said at least one additional sensor module (20', 20", 20"') within said at least one additional sensor module accommodating space functionally to the camera,

**characterized in that**

said at least one additional sensor module accommodating space is provided such that, when said at least one additional sensor module (20', 20", 20"') is connected functionally to the camera (5) within said at least one additional sensor module accommodating space, said at least one additional sensor module (20', 20", 20"') forms together with said first sensor module (20) a sensor module assembly wherein said first sensor module (20) and said at least one additional sensor module (20', 20", 20"') are arranged in relation to each other such that the modules, or their projections, are overlapping in relation to each other on the image-forming surface so that,

when considering the sensor surfaces of said sensor modules (20, 20', 20", 20"'), or their projections, on a plane formed by axles y, z of a right-angled set of coordinates x, y, z, in which the z coordinate is the direction of movement of the camera (5), i.e. the scanning direction, each of said sensor surfaces or their projections covers a different area on said plane,

when proceeding in the direction of the axle y in said right-angled set of coordinates x, y, z, the projection of each subsequent sensor surface on the plane formed by the axles x, z, will cover a different area from the previous projection, and

the projection of each subsequent sensor surface on the plane formed by the axles x, y, will meet that of the previous projection.

2. A camera according to claim 1, **characterized in that** the camera (5) includes means to form an image information signal and/or an image from the image information received exclusively from the first sensor module (20).

3. A camera according to claim 1 or claim 2, **characterized in that** the camera (5) includes means for combining the image information produced by the first module (20) with image information produced by said at least one additional sensor module (20', 20", 20"'), in particular means for reading the image information produced by the sensor modules (20, 20', 20", 20"') in an overlapping position which include said first sensor module (20) and said at least one additional sensor module (20', 20", 20"'), and for forming a transillumination image corresponding to the area covered by the sensor modules (20, 20', 20", 20"') together.

4. A camera according to any of the claims 1 to 3, **characterized in that** the projections on the plane formed by the axles x, y coincide with each other to cover, partly or totally, the same area.

5. A camera according to any of the claims 1 to 4, **characterized in that** the borders of the areas covered by the projections on the plane formed by the axles x, z are at a distance from each other.

6. A camera according to any of the claims 1 to 5, **characterized in that** the areas covered by the projections on the plane x, z are always located in the same direction of the axle z in relation to the area covered by the previous projection.

7. A camera according to any of the claims 1 to 6, **characterized in that** the sensor module assembly consists of three or more sensor modules (20, 20', 20", 20"') so that at least one projection on the plane formed by the axles x, z, at least partially covers the same area as one of the other projections.

8. A camera according to claim 7, **characterized in that** the sensor surfaces, or their projections, form a two column assembly on the plane formed by the axles y, z.

9. A camera according to any of the claims 1 to 6, **characterized in that** the sensor module assembly consists of two sensor modules (20, 20').

10. A camera according to any of the claims 1 to 9, **characterized in that** the sensor surfaces of the sensor modules (20, 20', 20", 20"') are essentially of the same size or identical, or that the sensor modules (20, 20', 20", 20"') themselves are essentially similar or identical.

11. A camera according to any of the claims 1 to 10, **characterized in that** the sensor surfaces of the sensor modules (20, 20', 20", 20"') are positioned to be located on the image-forming surface, or in the essential vicinity of the image-forming surface.

12. A camera according to any of the claims 1 to 11, **characterized in that** the first sensor module (20) to be used in tomographic imaging is the utmost sensor module of the sensor module assembly, especially the lowest sensor module of the sensor module assembly.

13. A camera according to any of the claims 1 to 12, **characterized in that** the camera (5) includes a connection means

(60, 70) to enable mechanical and electric connection and detachment of a display device, an imaging device and/or an image processing device, such as a computer.

**14.** A camera according to claim 13, **characterized in that** said connection means (60, 70) includes a connector to transmit the main power, the image data and/or any corresponding variables along one signal path from and to the first sensor module (20), and another electric connector that is adapted to transmit corresponding variables via another, branching signal path from and to the first sensor module (20), and from and to the at least one additional sensor module (20', 20'', 20''').

**15.** A camera according to claim 14, **characterized in that** said branching signal path includes means, such as an electronic logic circuit, for combining the partial images produced by the sensor modules (20, 20', 20'', 20''') to one uniform transillumination image.

**16.** A camera according to any of the claims 13 to 15, **characterized in that** said connection means includes separate mechanical (60) and electric connection means (70), wherein said electric connection means (70) is preferably placed on a different side of the camera housing surrounding the sensor module assembly than said mechanical connection means (60).

**17.** A camera according to any of the claims 13 to 16, **characterized in that** the mechanical connecting means (60) comprise means for positioning the camera (5) to its correct position before locking of its mechanical fixing.

**18.** A camera according to any of the claims 13 to 17, **characterized in that** the electric connection means (70) is implemented so that the mechanical connection of the camera (5) to another device does not directly bring about an electric coupling with the electric connection means (70) of the other device.

**19.** A camera according to any of the claims 13 to 18, **characterized in that** the connection means (60, 70) includes two sets of structurally different connecting means for connecting the camera (5) mechanically for tomographic imaging on one hand, and for transillumination imaging on the other.

**20.** A camera according to claim 19, **characterized in that** said two sets are located on different physical surfaces of the camera housing, specifically on opposite sides of the camera (5).

**21.** A camera according to any of the claims 13 to 20, **characterized in that** the connection means (60, 70) is a compulsory-phased system so that the camera (5) can be connected to an imaging device only by following the sequence: positioning of the camera, locking of the mechanical connection, and electric coupling.

**22.** An imaging device to be used for tomographic imaging, or both for tomographic and transillumination imaging, especially for use in the dental panoramic and other x-ray imaging, the device comprising
a radiation source (4), a collimator structure (31, 32) for limiting the beam received from the radiation source (4),
at least one connection arrangement (42A, 42B) whereto a digital camera (5) according to any of claims 1 to 21 is mounted, in which camera said sensor modules (20, 20', 20'', 20''') of said camera (5), or the projections of said sensor modules (20, 20', 20'', 20'''), in particular their point projections imaged via a focus of the radiation source (4), are overlapping in relation to each other,
means for positioning the object to be imaged at a tomographic imaging station (11), and on the other hand at a possible transillumination imaging station (12), and
means for effecting controlled movements of the radiation source (4), the collimator structure (31, 32), the camera (5) and/or the object to be imaged during the imaging scan, so that the information receiving means of the camera (5) are situated or can be moved along the desired image-forming surface, wherein the area covered by the information receiving means is essentially smaller than the projection of the object to be imaged on the image-forming surface.

**23.** An imaging device according to claim 22, **characterized in that** the collimator structure (31, 32) of the imaging device is arranged to enable the limitation of the beam exclusively to the first sensor module (20) to be used in said tomographic imaging.

**24.** An imaging device according to claim 22 or 23, **characterized in that** the imaging device comprises means for taking a transillumination image by carrying out the scanning movement of the beam by keeping the focus of the radiation source (4) stationary and by moving the collimation arrangement (31, 32) limiting the beam in a synchronized way with the movements of the camera (5).

**25.** An imaging device according to any of the claims 22 to 24, **characterized in that** the tomographic imaging station (11) of the imaging device is arranged essentially nearer to the focus of the radiation source (4) than the transillumination imaging station (12), and that the collimator structure (31, 32) of the imaging device comprises a first collimator structure (31) located in the essential vicinity of the radiation source (4), and another collimator structure (32) at a considerable distance from the focus of the radiation source (4), near to the transillumination imaging station (12), whereby, as seen from the direction of the focus of the radiation source (4), the first collimator structure (31) is positioned to a position preceding the tomographic imaging station (11), and the other collimator structure (32) to a position preceding the transillumination imaging station (12).

**26.** An imaging device according to any of the claims 22 to 25, **characterized in that** the collimator structure (31, 32) of the imaging device is arranged to enable the limitation of the beam to essentially match the form and size of the sensor module assembly used for transillumination imaging, preferably by arranging said second collimator structure (32) to limit the beam to essentially match the overlapping assembly of the sensor surfaces of the sensor modules (20, 20', 20", 20"') of the camera (5).

**27.** An imaging device according to any of the claims 22 to 26, **characterized in that** at least two structurally different connecting arrangements (42A, 42B) are arranged in connection with the imaging stations (11, 12) of the imaging device, for connecting the camera (5) in a removable way to its respective imaging stations (11, 12).

**28.** An imaging device according to any of the claims 22 to 27, **characterized in that** at least one of the connection arrangements (42A, 42B) of the imaging device comprises separate electric (70') and mechanical connection means (60').

**29.** An imaging device according to claim 28, **characterized in that** at least one of the connection means (60', 70') of the imaging device comprises contacting means (70') for the electric coupling, which are movable to a physical contact with their matching elements in the camera (5) only after locking of the mechanical connection has been completed.

**30.** An imaging device according to any of the claims 28 to 29, **characterized in that** the mechanical connection means (60') of at least one of the connecting arrangements (42A, 42B) of the imaging device comprise separate positioning means and means for locking the mechanical connection.

**31.** An imaging device according to any of the claims 22 to 30, **characterized in that** at least one of the connection arrangements (42A, 42B) of the imaging device, together with its corresponding elements in the camera (5), is arranged so that the mounting of the camera (5) takes place in a compulsory sequence of: positioning of the camera, locking of the mechanical connection, and electric coupling.

**32.** A method for digital imaging to be used, in particular, in dental x-ray imaging, in which method
an area to be imaged is scanned by a beam of a radiation source (4), limited by a collimator structure (31, 32), and the radiation, containing image information, is detected by a camera (5) according to any one of claims 1 to 21, in which camera said sensor modules (20, 20', 20", 20"') of said camera (5), or the projections of said sensor modules (20, 20', 20", 20"'), in particular their point projections imaged via a focus of the radiation source (4), are overlapping in relation to each other,
wherein only the image information detected by said first sensor module (20) is used for the formation of a tomographic image, and the image information of said first sensor module (20) and the at least one additional sensor module (20', 20", 20"') are used for the formation of a transillumination image.

**33.** A method according to claim 32, **characterized in that** image information signals and/or an image are formed exclusively from the image information detected by said first sensor module (20).

**34.** A method according to claim 33, **characterized in that** the image information produced by the at least one additional sensor module (20', 20", 20"') is removed from the image to be formed using image processing methods known as such, or from the signal produced by the sensor module assembly itself using electronic arrangements that control its operation.

**35.** A method according to any of the claims 32 to 34, **characterized in that** the transillumination image signal and/or the transillumination image is formed from the image information produced by the sensor module assembly, containing both the image information produced by said first sensor module (20) and the image information produced by said at least one additional sensor module (20', 20", 20"') by combining the image information produced by these modules (20, 20', 20", 20"').

**36.** A method according to claim 35, **characterized in that** the transillumination image is formed by reading the image information produced at different stages of the scanning movement from two sensor modules (20, 20', 20", 20"'), and by combining these partial images to one integrated image, in which combining process the image information corresponding the possibly more often than once produced part of the object is either removed from the information produced by any other than a single module, or specifically, where all image information imaged several times is used for image formation by scaling this part to correspond the image information that would have been obtained from a single sensor module.

**37.** A method according to claim 35 or 36, **characterized in that** in transillumination imaging the beam is limited before the object so that the area covered by its projection on the image-forming surface, as seen from the focus of the radiation source (4), is for the most as big as the corresponding projection of the sensor surfaces of the sensor modules (20, 20', 20", 20"') on this plane, whereby the image information of the area of the sensor surfaces possibly left outside of the projection of the beam is removed from the image information before combining the partial images.

**38.** A method according to any of the claims 32 to 37, **characterized in that** a connection arrangement (42A, 42B) is provided for the camera (5), with one electric connector to transmit at least the main power and image data along one signal path to and from the first sensor module (20), and another electric connector that is adapted to transmit at least the main power and image data via another branching signal path both to and from the first sensor module (20) and to and from at least one additional sensor module (20', 20", 20"'), whereby the image information received from only the first sensor module (20) is read by connecting the camera (5) to the imaging device via said first electric connector.

**39.** A method according to any of the claims 32 to 38, **characterized in that** in the tomographic imaging, the beam is limited to essentially match said first sensor module (20), and respectively, in transillumination imaging to essentially match said overlapping sensor module assembly (20, 20', 20", 20"').

**40.** A method according to any of the claims 32 to 39, **characterized in that** in transillumination, the imaging scan of the beam is realized by keeping the focus of the radiation source (4) and the object to be imaged stationary, and by moving the collimator structure (31, 32) limiting the beam and the sensor module assembly in a synchronized way.

**Patentansprüche**

**1.** Digitalkamera, die in einer tomographischen Bildgebung oder in sowohl einer tomographischen Bildgebung als auch einer Durchleuchtungsbildgebung, insbesondere in einer Dentalbildgebung, zu verwenden ist, wobei der abzubildende Bereich durch einen von einer Strahlungsquelle (4) erzeugten Strahl gescannt wird, um Bildinformation zu erzeugen, wobei die Kamera Folgendes aufweist:

Informationsempfangseinrichtungen zum Erhalten der Bildinformation, wobei die Informationsempfangseinrichtungen an einer gewünschten Bilderzeugungsfläche positioniert oder bewegbar sind, wobei die Fläche, die durch die Informationsempfangseinrichtungen abgedeckt ist, wesentlich kleiner als die Projektion des Objekts ist, das auf der Bilderzeugungsfläche abzubilden ist,
wobei die Informationsempfangseinrichtungen ein erstes Sensormodul (20) aufweisen, das Bildinformation empfängt, die wenigstens in einer tomographischen Bildgebung erzeugt wird,
wobei wenigstens ein Aufnahmeraum für ein zusätzliches Sensormodul in der Kamera (5) zum Aufnehmen wenigstens eines zusätzlichen Sensormoduls (20', 20", 20"') vorgesehen ist, um ausschließlich Bildinformation zu empfangen, die in einer Durchleuchtungsbildgebung erzeugt wird,
wobei die Kamera (5) des Weiteren eine elektronische Anordnung aufweist, um das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') innerhalb des wenigstens einen Aufnahmeraums für ein zusätzliches Sensormodul funktional mit der Kamera zu verbinden,

**dadurch gekennzeichnet, dass**

der wenigstens eine Aufnahmeraum für ein zusätzliches Sensormodul derart vorgesehen ist, dass, wenn wenigstens ein zusätzliches Sensormodul (20', 20", 20"') funktional mit der Kamera (5) innerhalb des wenigstens einen Aufnahmeraums für ein zusätzliches Sensormodul verbunden ist, das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') zusammen mit dem ersten Sensormodul (20) eine Sensormodulbaugruppe bildet, wobei das erste Sensormodul (20) und das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') in Bezug zueinander derart angeordnet sind, dass die Module oder ihre Projektionen in Bezug zueinander auf der Bilderzeugungsfläche überlappen, so dass,
wenn die Sensorflächen der Sensormodule (20, 20', 20", 20"') oder ihre Projektionen auf einer Ebene betrachtet werden, die durch Achsen y, z eines rechtwinkligen Koordinatensatzes x, y, z gebildet werden, in dem die z-Koordinate die Bewegungsrichtung der Kamera (5), d.h. die Scannrichtung, ist, jede der Sensorflächen oder deren Projektionen eine unterschiedliche Fläche auf der Ebene abdeckt,
wenn man in der Richtung der Achse y in dem rechtwinkligen Koordinatensatz x, y, z vorangeht, die Projektion jeder nachfolgenden Sensorfläche auf die Ebene, die durch die Achsen x, z gebildet ist, eine unterschiedliche Fläche von der vorherigen Projektion abdeckt, und
die Projektion von jeder nachfolgenden Sensorfläche auf die Ebene, die durch die Achsen x, y gebildet ist, mit der der vorhergehenden Projektion zusammentrifft.

**2.** Kamera nach Anspruch 1, **dadurch gekennzeichnet, dass** die Kamera (5) eine Einrichtung zum Bilden eines Bildinformationssignals und/oder eines Bilds aus der Bildinformation hat, die ausschließlich von dem ersten Sensormodul (20) empfangen wird.

**3.** Kamera nach Anspruch 1 oder Anspruch 2, **dadurch gekennzeichnet, dass** die Kamera (5) eine Einrichtung hat zum Kombinieren der Bildinformation, die durch das erste Sensormodul (20) erzeugt wird, mit Bildinformation, die durch das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') erzeugt wird, insbesondere eine Einrichtung zum Lesen der Bildinformation, die durch die Sensormodule (20, 20', 20", 20"') in einer überlappenden Position, die das erste Sensormodul (20) und das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') umfassen, erzeugt wird, und zum Ausbilden eines Durchleuchtungsbilds entsprechend des Bereichs, der durch die Sensormodule (20, 20', 20", 20"') gemeinsam abgedeckt wird.

**4.** Kamera nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die Projektionen auf die Ebene, die durch die Achsen x, y gebildet ist, miteinander zusammenfallen, um teilweise oder vollständig den gleichen Bereich abzudecken.

**5.** Kamera nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Grenzen der Bereiche, die durch Projektionen auf die Ebene, die durch die Achsen x, z gebildet ist, abgedeckt werden, voneinander beabstandet sind.

**6.** Kamera nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die Bereiche, die durch die Projektionen auf die Ebene x, z abgedeckt werden, immer in derselben Richtung der Achse z in Bezug auf den Bereich angeordnet sind, der durch die vorherige Projektion abgedeckt wird.

**7.** Kamera nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die Sensormodulbaugruppe aus drei oder mehr Sensormodulen (20, 20', 20", 20"') besteht, so dass wenigstens eine Projektion auf die Ebene, die durch die Achsen x, z gebildet ist, wenigstens teilweise den gleichen Bereich wie eine der anderen Projektionen abdeckt.

**8.** Kamera nach Anspruch 7, **dadurch gekennzeichnet, dass** die Sensorflächen oder deren Projektionen eine Anordnung mit zwei Säulen auf der Ebene bildet, die durch die Achsen y, z gebildet ist.

**9.** Kamera nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die Sensormodulbaugruppe aus zwei Sensormodulen (20, 20') besteht.

**10.** Kamera nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** die Sensorflächen der Sensormodule (20, 20', 20", 20"') im Wesentlichen dieselbe Größe haben oder identisch sind, oder dass die Sensormodule (20, 20', 20", 20"') selbst im Wesentlichen ähnlich oder identisch sind.

**11.** Kamera nach einem der Ansprüche 1 bis 10, **dadurch gekennzeichnet, dass** die Sensorflächen der Sensormodule (20, 20', 20", 20"') angeordnet sind, um in der Bilderzeugungsfläche oder im Wesentlichen in der Nähe der Bilderzeugungsfläche angeordnet zu sein.

**12.** Kamera nach einem der Ansprüche 1 bis 11, **dadurch gekennzeichnet, dass** das erste Sensormodul (20), das in einer tomographischen Bildgebung zu verwenden ist, das äußerste Sensormodul der Sensormodulbaugruppe ist, insbesondere das unterste Sensormodul der Sensormodulbaugruppe.

**13.** Kamera nach einem der Ansprüche 1 bis 12, **dadurch gekennzeichnet, dass** die Kamera (5) eine Verbindungseinrichtung (60, 70) hat, um eine mechanische und elektrische Verbindung und Abnahme einer Displayvorrichtung, einer Bildgebungsvorrichtung und/oder einer Bildverarbeitungsvorrichtung wie einem Computer zu ermöglichen.

**14.** Kamera nach Anspruch 13, **dadurch gekennzeichnet, dass** die Verbindungseinrichtung (60, 70) einen Verbinder hat, um die Versorgungsenergie, die Bilddaten und/oder entsprechende Größen entlang eines Signalwegs von und zu dem ersten Sensormodul (20) zu übertragen, und einen weiteren elektrischen Verbinder hat, der angepasst ist, um entsprechende Größen über einen weiteren abzweigenden Signalweg von und zu dem ersten Sensormodul (20) und von und zu dem wenigstens einen zusätzlichen Sensormodul (20', 20", 20"') zu übertragen.

**15.** Kamera nach Anspruch 14, **dadurch gekennzeichnet, dass** der abzweigende Signalweg eine Einrichtung, wie einen elektronischen Logikkreis, zum Kombinieren der Teilbilder, die durch die Sensormodule (20, 20', 20", 20"') erzeugt werden, zu einem einheitlichen Durchleuchtungsbild hat.

**16.** Kamera nach einem der Ansprüche 13 bis 15 **dadurch gekennzeichnet, dass** die Verbindungseinrichtung eine separate mechanische (60) und elektrische Verbindungseinrichtung (70) hat, wobei die elektrische Verbindungseinrichtung (70) bevorzugt an einer anderen Seite des Kameragehäuses, das die Sensormodulbaugruppe umgibt, als die mechanische Verbindungseinrichtung (60) angeordnet ist.

**17.** Kamera nach einem der Ansprüche 13 bis 16, **dadurch gekennzeichnet, dass** die mechanische Verbindungseinrichtung (60) eine Einrichtung aufweist zum Positionieren der Kamera (5) in ihrer korrekten Position vor Verriegelung ihrer mechanischen Fixierung.

**18.** Kamera nach einem der Ansprüche 13 bis 17, **dadurch gekennzeichnet, dass** die elektrische Verbindungseinrichtung (70) so realisiert ist, dass die mechanische Verbindung der Kamera (5) mit einer anderen Vorrichtung nicht direkt eine elektrische Kopplung mit der elektrischen Verbindungseinrichtung (70) der anderen Vorrichtung herbeiführt.

**19.** Kamera nach einem der Ansprüche 13 bis 18, **dadurch gekennzeichnet, dass** die Verbindungseinrichtung (60, 70) zwei Sätze von strukturell unterschiedlichen Verbindseinrichtungen zum mechanischen Verbinden der Kamera (5) für eine tomographische Bildgebung einerseits und für eine Durchleuchtungsbildgebung andererseits hat.

**20.** Kamera nach Anspruch 19, **dadurch gekennzeichnet, dass** die zwei Sätze an verschiedenen physikalischen Flächen des Kameragehäuses angeordnet sind, im Speziellen an entgegengesetzten Seiten der Kamera (5).

**21.** Kamera nach einem der Ansprüche 13 bis 20, **dadurch gekennzeichnet, dass** die Verbindungseinrichtung (60, 70) ein zwangsabgestimmtes System ist, so dass die Kamera (5) mit einer Bildgebungsvorrichtung nur durch Befolgen der Reihenfolge verbunden werden kann: Positionieren der Kamera, Verriegeln der mechanischen Verbindung und elektrisches Koppeln.

**22.** Bildgebungsvorrichtung, die für eine tomographische Bildgebung oder sowohl für eine tomographische Bildgebung als auch eine Durchleuchtungsbildgebung zu verwenden ist, insbesondere zur Verwendung in der dentalen Panoramabildgebung und einer anderen Röntgenbildgebung, wobei die Vorrichtung Folgendes aufweist:

eine Strahlungsquelle (4), einen Kollimatoraufbau (31, 32) zum Begrenzen des von der Strahlungsquelle (4) empfangenen Strahls,
wenigstens eine Verbindungsanordnung (42A, 42B), an der eine Digitalkamera (5) nach einem der Ansprüche 1 bis 21 montiert ist, wobei in der Kamera die Sensormodule (20, 20', 20", 20"') der Kamera (5) oder die Projektionen der Sensormodule (20, 20', 20", 20"'), insbesondere deren Punktprojektionen, die über einen Fokus der Strahlungsquelle (4) abgebildet werden, sich in Bezug zueinander überlappen,
eine Einrichtung zum Positionieren des abzubildenden Objekts an einer tomographischen Bildgebungsstation (11) und andererseits an einer möglichen Durchleuchtungsbildgebungsstation (12), und
eine Einrichtung zum Bewirken von gesteuerten Bewegungen der Strahlungsquelle (4), des Kollimatoraufbaus (31, 32), der Kamera (5) und/oder des abzubildenden Objekts während des Bildgebungsscans, so dass die

Informationsempfangseinrichtungen der Kamera (5) entlang der gewünschten Bilderzeugungsfläche angeordnet sind oder bewegt werden können, wobei der Bereich, der durch die Informationsempfangseinrichtung abgedeckt wird, wesentlich kleiner als die Projektion des Objekts ist, das an der Bilderzeugungsfläche abzubilden ist.

**23.** Bildgebungsvorrichtung nach Anspruch 22, **dadurch gekennzeichnet, dass** der Kollimatoraufbau (31, 32) der Bildgebungsvorrichtung angeordnet ist, um die Begrenzung des Strahls exklusiv auf das erste Sensormodul (20) zu ermöglichen, das in der tomographischen Bildgebung zu verwenden ist.

**24.** Bildgebungsvorrichtung nach Anspruch 22 oder 23, **dadurch gekennzeichnet, dass** die Bildgebungsvorrichtung eine Einrichtung hat zum Aufnehmen eines Durchleuchtungsbilds durch Ausführen der Scanbewegung des Strahls durch Halten des Fokus der Strahlungsquelle (4) stationär und durch Bewegen der Kollimationsanordnung (31, 32), die den Strahl in einer synchronisierten Weise mit den Bewegungen der Kamera (5) begrenzt.

**25.** Bildgebungsvorrichtung nach einem der Ansprüche 22 bis 24, **dadurch gekennzeichnet, dass** die tomographische Bildgebungsstation (11) der Bildgebungsvorrichtung im Wesentlichen näher zu dem Fokus der Strahlungsquelle (4) angeordnet ist als die Durchleuchtungsbildgebungsstation (12), und dass der Kollimatoraufbau (31, 32) der Bildgebungsvorrichtung einen ersten Kollimatoraufbau (31), der im Wesentlichen in der Nähe der Strahlungsquelle (4) angeordnet ist und einen weiteren Kollimatoraufbau (32) in einem beträchtlichen Abstand von dem Fokus der Strahlungsquelle (4) nahe der Durchleuchtungsbildgebungsstation (12) hat, wobei, von der Richtung des Fokus der Strahlungsquelle (4) gesehen, der erste Kollimatoraufbau (31) an einer Position positioniert ist, die der tomographischen Bildgebungsstation (11) vorausgeht, und der andere Kollimatoraufbau (32) an einer Position positioniert ist, die der Durchleuchtungsbildgebungsstation (12) vorausgeht.

**26.** Bildgebungsvorrichtung nach einem der Ansprüche 22 bis 25, **dadurch gekennzeichnet, dass** der Kollimatoraufbau (31, 32) der Bildgebungsvorrichtung angeordnet ist, um die Begrenzung des Strahls zu ermöglichen, um im Wesentlichen mit der Form und der Größe der Sensormodulbaugruppe zusammenzupassen, die für eine Durchleuchtungsbildgebung verwendet wird, bevorzugt durch Anordnen des zweiten Kollimatoraufbaus (32), um den Strahl zu begrenzen, um im Wesentlichen mit der überlappenden Baugruppe der Sensorflächen der Sensormodule (20, 20', 20", 20"') der Kamera (5) zusammenzupassen.

**27.** Bildgebungsvorrichtung nach einem der Ansprüche 22 bis 26, **dadurch gekennzeichnet, dass** wenigstens zwei strukturell verschiedene Verbindungsanordnungen (42A, 42B) in Verbindung mit den Bildgebungsstationen (11, 12) der Bildgebungsvorrichtung zur Verbindung der Kamera (5) in einer entfernbaren Weise an ihren jeweiligen Bildgebungsstationen (11, 12) angeordnet sind.

**28.** Bildgebungsvorrichtung nach einem der Ansprüche 22 bis 27, **dadurch gekennzeichnet, dass** wenigstens eine der Verbindungsanordnungen (42A, 42B) der Bildgebungsvorrichtung eine separate elektrische (70') und mechanische Verbindungseinrichtung (60') aufweist.

**29.** Bildgebungsvorrichtung nach Anspruch 28, **dadurch gekennzeichnet, dass** wenigstens eine der Verbindungseinrichtungen (60', 70') der Bildgebungsvorrichtung Kontakteinrichtungen (70') für die elektrische Kopplung aufweist, die für einen physikalischen Kontakt mit ihren zusammenpassenden Elementen in der Kamera (5) nur bewegt werden können, nachdem eine Verriegelung der mechanischen Verbindung beendet worden ist.

**30.** Bildgebungsvorrichtung nach einem der Ansprüche 28 bis 29, **dadurch gekennzeichnet, dass** die mechanische Verbindungseinrichtung (60') von wenigstens einer der Verbindungsanordnungen (42A, 42B) der Bildgebungsvorrichtung eine separate Positionierungseinrichtung und eine Einrichtung zum Verriegeln der mechanischen Verbindung aufweist.

**31.** Bildgebungsvorrichtung nach einem der Ansprüche 22 bis 30, **dadurch gekennzeichnet, dass** wenigstens eine der Verbindungsanordnungen (42A, 42B) der Bildgebungsvorrichtung zusammen mit ihren entsprechenden Elementen in der Kamera (5) so angeordnet ist, dass die Montage der Kamera (5) in einer Zwangsreihenfolge von Positionieren der Kamera, Verriegeln der mechanischen Verbindung und elektrisches Koppeln stattfindet.

**32.** Verfahren für eine digitale Bildgebung, das insbesondere in der dentalen Röntgenbildgebung zu verwenden ist, wobei in dem Verfahren
ein abzubildender Bereich durch einen Strahl einer Strahlungsquelle (4) gescannt wird, der durch einen Kollimator-

aufbau (31, 32) begrenzt ist, und
die Strahlung, die Bildinformation enthält, durch eine Kamera (5) nach einem der Ansprüche 1 bis 21 erfasst wird, wobei in der Kamera sich die Sensormodule (20, 20', 20", 20"') der Kamera (5) oder die Projektionen der Sensormodule (20, 20', 20", 20"'), insbesondere deren Punktprojektionen, die über einen Fokus der Strahlungsquelle (4) abgebildet werden, in Bezug zueinander überlappen,
wobei nur die Bildinformation, die von dem ersten Sensormodul (20) erfasst wird, für die Erzeugung eines tomographischen Bilds verwendet wird, und die Bildinformation des ersten Sensormoduls (20) und des wenigstens einen zusätzlichen Sensormoduls (20', 20", 20"') für die Erzeugung eines Durchleuchtungsbilds verwendet werden.

**33.** Verfahren nach Anspruch 32, **dadurch gekennzeichnet, dass** Bildinformationssignale und/oder ein Bild ausschließlich aus der Bildinformation erzeugt werden/wird, die durch das erste Sensormodul (20) erfasst wird.

**34.** Verfahren nach Anspruch 33, **dadurch gekennzeichnet, dass** die Bildinformation, die durch das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') erzeugt wird, von dem zu erzeugenden Bild unter Verwendung von bekannten Bildverarbeitungsverfahren oder von dem Signal, das durch die Sensormodulbaugruppe selbst erzeugt wird, unter Verwendung von elektronischen Anordnungen, die deren Betrieb steuern, entfernt wird.

**35.** Verfahren nach einem der Ansprüche 32 bis 34, **dadurch gekennzeichnet, dass** das Durchleuchtungsbildsignal und /oder das Durchleuchtungsbild aus der Bildinformation erzeugt wird, die durch die Sensormodulbaugruppe erzeugt wird, und die sowohl die Bildinformation, die durch das erste Sensormodul (20) erzeugt wird, als auch die Bildinformation enthält, die durch das wenigstens eine zusätzliche Sensormodul (20', 20", 20"') erzeugt wird, durch Kombinieren der Bildinformation, die durch diese Module (20, 20', 20", 20"') erzeugt wird.

**36.** Verfahren nach Anspruch 35, **dadurch gekennzeichnet, dass** das Durchleuchtungsbild erzeugt wird durch Lesen der Bildinformation, die in verschiedenen Stufen der Scanbewegung von zwei Sensormodulen (20, 20', 20", 20"') erzeugt wird, und durch Kombinieren dieser Teilbilder zu einem integrierten Bild, wobei in dem Kombinierungsprozess die Bildinformation, die dem möglicherweise mehr als einmal erzeugten Teil des Objekts entspricht, entweder von der Information entfernt wird, die durch irgendein anderes als ein einzelnes Modul erzeugt wird, oder, insbesondere wo die gesamte Bildinformation, die mehrere Male abgebildet ist, zur Bilderzeugung verwendet wird, es wird dieser Teil skaliert, um der Bildinformation zu entsprechen, die von einem einzelnen Sensormodul erhalten worden wäre.

**37.** Verfahren nach Anspruch 35 oder 36, **dadurch gekennzeichnet, dass** in der Durchleuchtungsbildgebung der Strahl vor dem Objekt begrenzt wird, so dass der Bereich, der durch seine Projektion auf der Bilderzeugungsfläche abgedeckt wird, aus Sicht von dem Fokus der Strahlungsquelle (4), wenigstens so groß wie die entsprechende Projektion der Sensorflächen der Sensormodule (20, 20', 20", 20"') auf diese Ebene ist, wobei die Bildinformation des Bereichs der Sensorflächen, die möglicherweise außerhalb der Projektion des Strahls verblieben ist, von der Bildinformation entfernt wird, bevor die Teilbilder kombiniert werden.

**38.** Verfahren nach einem der Ansprüche 32 bis 37, **dadurch gekennzeichnet, dass** eine Verbindungsanordnung (42A, 42B) für die Kamera (5) vorgesehen ist mit einem elektrischen Verbinder, um wenigstens die Versorgungsenergie und Bilddaten entlang eines Signalwegs zu und von dem ersten Sensormodul (20) zu übertragen, und einem weiteren elektrischen Verbinder, der angepasst ist, um wenigstens die Versorgungsenergie und Bilddaten über einen weiteren abzweigenden Signalweg als auch zu und von dem ersten Sensormodul (20) und zu und von wenigstens einem zusätzlichen Sensormodul (20', 20", 20"') zu übertragen, wobei die Bildinformation, die von nur dem ersten Sensormodul (20) empfangen wird, durch Verbinden der Kamera (5) mit der Bildgebungsvorrichtung über den ersten elektrischen Verbinder gelesen wird.

**39.** Verfahren nach einem der Ansprüche 32 bis 38, , **dadurch gekennzeichnet, dass** der Strahl in der tomographischen Bildgebung begrenzt ist, um im Wesentlichen mit dem ersten Sensormodul (20) zusammenzupassen, und in der Durchleuchtungsbildgebung begrenzt ist, um im Wesentlichen mit der überlappenden Sensormodulbaugruppe (20, 20', 20", 20"') zusammenzupassen.

**40.** Verfahren nach einem der Ansprüche 32 bis 39, **dadurch gekennzeichnet, dass** in einer Durchleuchtung der Bildgebungsscan des Strahls durch Halten des Fokus der Strahlungsquelle (4) und des abzubildenden Objekts stationär und durch Bewegen des Kollimatoraufbaus (31, 32), der den Strahl begrenzt, und der Sensormodulbaugruppe in einer synchronisierten Weise realisiert wird.

## Revendications

1. Caméra numérique à utiliser en imagerie tomographique, ou à la fois en imagerie tomographique et par transillumination, en particulier en imagerie dentaire, moyennant quoi un faisceau généré par une source (4) de rayonnement balaye la zone à imager pour produire une information d'image, la caméra comprenant :

   un moyen de réception d'information pour obtenir ladite information d'image, où ledit moyen de réception d'information est positionné ou mobile sur une surface désirée de formation d'image, la zone couverte par ledit moyen de réception d'information étant essentiellement plus petite que la projection de l'objet à imager sur la surface de formation d'image,
   ledit moyen de réception d'information comprenant un premier module capteur (20) recevant une information d'image produite au moins en imagerie tomographique,
   où au moins un espace d'accueil de module capteur supplémentaire est pourvu dans ladite caméra (5) pour accueillir au moins un module capteur (20', 20", 20"') supplémentaire pour recevoir exclusivement une information d'image produite en imagerie par transillumination,
   la caméra (5) comprenant en outre un agencement électronique pour relier de manière fonctionnelle ledit au moins un module capteur (20', 20", 20"') supplémentaire dans ledit au moins un espace d'accueil de module capteur supplémentaire à la caméra,
   **caractérisée en ce que**
   ledit au moins un espace d'accueil de module capteur supplémentaire est pourvu de sorte que, lorsque ledit au moins un module capteur (20', 20", 20"') supplémentaire est relié de manière fonctionnelle à la caméra (5) dans ledit au moins un espace d'accueil de module capteur supplémentaire, ledit au moins un module capteur (20', 20", 20"') supplémentaire forme avec ledit premier module capteur (20) un assemblage de modules capteurs où ledit premier module capteur (20) et ledit au moins un module capteur (20', 20 ", 20"') supplémentaire sont agencés l'un par rapport à l'autre de sorte que les modules, ou leur projections se chevauchent l'un par rapport à l'autre sur la surface de formation d'image de manière à ce que,
   lorsqu'on considère les surfaces de capteur desdits modules capteurs (20, 20', 20", 20"'), ou leurs projections, sur un plan formé par des axes y, z d'un ensemble à angle droit de coordonnées x, y, z, où la coordonnée z est la direction de mouvement de la caméra (5), c'est-à-dire la direction de balayage, chacune desdites surfaces de capteurs ou leurs projections couvre une zone différente sur ledit plan,
   en poursuivant dans la direction de l'axe y dans ledit ensemble à angle droit de coordonnées x, y, z, la projection de chaque surface de capteur subséquente sur le plan formé par les axes x, z, va couvrir une zone différente par rapport à la projection précédente, et
   la projection de chaque surface de capteur subséquente sur le plan formé par les axes x, y, va coïncider avec celle de la projection précédente.

2. Caméra selon la revendication 1, **caractérisée en ce que** la caméra (5) comporte un moyen pour former un signal d'information d'image et/ou une image d'après l'information d'image reçue exclusivement du premier module capteur (20).

3. Caméra selon la revendication 1 ou la revendication 2, **caractérisée en ce que** la caméra (5) comporte un moyen pour combiner l'information d'image produite par le premier module (20) avec une information d'image produite par ledit au moins un module capteur (20', 20", 20"') supplémentaire, en particulier, un moyen pour lire l'information d'image produite par les modules capteurs (20, 20', 20", 20"'), dans une position de chevauchement qui comporte ledit premier module capteur (20) et ledit au moins un module capteur (20', 20", 20"') supplémentaire, et pour former une image par transillumination correspondant à la zone couverte par tous les modules capteurs (20, 20', 20", 20"') en même temps.

4. Caméra selon l'une quelconque des revendications 1 à 3, **caractérisée en ce que** les projections sur le plan formé par les axes x, y coïncident entre elles pour couvrir partiellement ou totalement, la même zone.

5. Caméra selon l'une quelconque des revendications 1 à 4, **caractérisée en ce que** les frontières des zones couvertes par les projections sur le plan formé par les axes x, z sont distantes entre elles.

6. Caméra selon l'une quelconque des revendications 1 à 5, **caractérisée en ce que** les zones couvertes par les projections sur le plan x, z sont toujours situées dans la même direction de l'axe z par rapport à la zone couverte par la projection précédente.

7. Caméra selon l'une quelconque des revendications 1 à 6, **caractérisée en ce que** l'assemblage de modules capteurs se compose de trois modules capteurs (20, 20', 20", 20"') ou plus de manière à ce qu'au moins une projection, sur le plan formé par les axes x, z, couvre au moins partiellement la même zone que l'une des autres projections.

8. Caméra de la revendication 7, **caractérisée en ce que** les surfaces des capteurs, ou leurs projections, forment un assemblage à deux colonnes sur le plan formé par les axes y, z.

9. Caméra selon l'une quelconque des revendications 1 à 6, **caractérisée en ce que** l'assemblage de modules capteurs se compose de deux modules capteurs (20, 20').

10. Caméra selon l'une quelconque des revendications 1 à 9, **caractérisée en ce que** les surfaces des capteurs des modules capteurs (20, 20', 20", 20"') ont essentiellement la même dimension ou une dimension identique, ou **en ce que** les modules capteurs (20, 20', 20", 20"') eux-mêmes sont essentiellement similaires ou identiques.

11. Caméra selon l'une quelconque des revendications 1 à 10, **caractérisée en ce que** les surfaces des capteurs des modules capteurs (20, 20', 20" , 20"') sont positionnées de manière à ce qu'elles soient situées sur la surface de formation d'image, ou essentiellement au voisinage de la surface de formation d'image.

12. Caméra selon l'une quelconque des revendications 1 à 11, **caractérisée en ce que** le premier module capteur (20) à utiliser en imagerie tomographique est le plus grand module capteur de l'assemblage de modules capteurs, particulièrement le module capteur le plus bas de l'assemblage de module capteurs.

13. Caméra selon l'une quelconque des revendications 1 à 12, **caractérisée en ce que** la caméra (5) comporte un moyen (60, 70) de connexions pour permettre la connexion et le débranchement électriques et mécaniques d'un dispositif d'affichage, d'un dispositif d'imagerie et/ou d'un dispositif de traitement d'image tel qu'un ordinateur.

14. Caméra selon la revendication 13, **caractérisée en ce que** ledit moyen (60, 70) de connexions comporte un connecteur pour transmettre l'alimentation principale, les données d'image et/ou toutes variables correspondantes le long d'un chemin de signal du et au premier module capteur (20), et un autre connecteur électrique qui est adapté pour transmettre des variables correspondantes à travers un autre un chemin de signal de branchement du et au premier module capteur (20), et du et à au moins un module capteur (20', 20", 20"') supplémentaire.

15. Caméra selon la revendication 14, **caractérisée en ce que** ledit chemin de signal de branchement comporte un moyen, tel qu'un circuit logique électronique, pour combiner les images partielles produites par les modules capteurs (20, 20', 20", 20"') à une image par transillumination uniforme.

16. Caméra selon l'une quelconque des revendications 13 à 15, **caractérisée en ce que** ledit moyen de connexions comporte des moyens de connexion électrique (70) et mécanique (60) séparés, où ledit moyen de connexion électrique (70) est placé de préférence sur un côté différent du boîtier de la caméra entourant l'assemblage de modules capteurs que ledit moyen de connexion mécanique (60).

17. Caméra selon l'une quelconque des revendications 13 à 16, **caractérisée en ce que** le moyen de connexion mécanique (60) comprend un moyen pour positionner la caméra (5) à sa position correcte avant le verrouillage de sa fixation mécanique.

18. Caméra selon l'une quelconque des revendications 13 à 17, **caractérisée en ce que** le moyen de connexion électrique (70) est mis en ouvre de manière à ce que la connexion mécanique de la caméra (5) à un autre dispositif ne provoque pas directement un couplage électrique avec le moyen de connexion électrique (70) de l'autre dispositif.

19. Caméra selon l'une quelconque des revendications 13 à 18, **caractérisée en ce que** le moyen (60, 70) de connexions comporte deux ensembles de moyens de connexion structurellement différents pour connecter mécaniquement la caméra (5) pour l'imagerie tomographique d'une part, et pour l'imagerie par transillumination d'autre part.

20. Caméra selon la revendication 19, **caractérisée en ce que** lesdits deux ensembles sont situés sur des surfaces physiques différentes du boîtier de la caméra, spécifiquement sur des côtés opposés de la caméra (5).

21. Caméra selon l'une quelconque des revendications 13 à 20, **caractérisée en ce que** le moyen (60, 70) de connexions

est un système à phasage obligatoire de manière à ce que la caméra (5) puisse être connectée à un dispositif d'imagerie seulement par le suivi de la séquence : positionnement de la caméra, verrouillage de la connexion mécanique, et couplage électrique.

**22.** Dispositif d'imagerie à utiliser en imagerie tomographique, ou à la fois en imagerie tomographique et par transillumination, particulièrement à utiliser en imagerie panoramique dentaire ou autre imagerie aux rayons X, le dispositif comprenant :

une source (4) de rayonnement, une structure (31, 32) de collimateur pour limiter le faisceau reçu de la source (4) de rayonnement,
au moins un agencement (42A, 42B) de connexions auquel une caméra (5) numérique selon l'une quelconque des revendications 1 à 21 est montée, caméra dans laquelle lesdits modules capteurs (20, 20', 20", 20"') de ladite caméra (5), ou les projections desdits modules capteurs (20, 20', 20", 20"'), en particulier leurs projections ponctuelles imagées par le biais d'une focalisation de la source de rayonnement (4), se chevauchent l'un en relation avec l'autre,
un moyen pour positionner l'objet à imager au niveau d'une station (11) d'imagerie tomographique, et d'autre part au niveau d'une station (12) éventuelle d'imagerie par transillumination, et
un moyen pour effectuer des mouvements commandés de la source (4) de rayonnement, de la structure (31, 32) de collimateur, de la caméra (5) et/ou de l'objet devant être imagé pendant le balayage d'imagerie, de manière à ce que le moyen de réception d'information de la caméra (5) soit situé ou puisse être déplacé le long de la surface désirée de formation d'image, où la zone couverte par le moyen de réception d'information est essentiellement plus petite que la projection de l'objet devant être imagé sur la surface de formation d'image.

**23.** Dispositif d'imagerie selon la revendication 22, **caractérisé en ce que** la structure (31, 32) de collimateur du dispositif d'imagerie est agencée pour permettre la limitation du faisceau exclusivement au premier module capteur (20) à utiliser dans ladite imagerie tomographique.

**24.** Dispositif d'imagerie selon la revendication 22 ou 23, **caractérisé en ce que** le dispositif d'imagerie comprend un moyen pour prendre une image par transillumination en effectuant le mouvement de balayage du faisceau en gardant le foyer de la source (4) de rayonnement immobile et en déplaçant l'agencement (31, 32) de collimation limitant le faisceau de manière synchronisée avec les mouvements de la caméra (5).

**25.** Dispositif d'imagerie selon l'une quelconque des revendications 22 à 24, **caractérisé en ce que** la station (11) d'imagerie tomographique du dispositif d'imagerie est agencée essentiellement de manière plus proche du foyer de la source (4) de rayonnement que la station (12) d'imagerie par transillumination, et **en ce que** la structure (31 , 32) de collimateur du dispositif d'imagerie comprend une première structure (31) de collimateur située essentiellement au voisinage de la source (4) de rayonnement, et une autre structure (32) de collimateur éloignée d'une distance considérable du foyer de la source (4) de rayonnement, près de la station (12) d'imagerie par transillumination, moyennant quoi, en regardant de la direction du foyer de la source (4) de rayonnement, la première structure (31) de collimateur est positionnée à une position qui précède la station (11) d'imagerie tomographique, et l'autre structure (32) de collimateur positionnée à une position qui précède la station (12) d'imagerie par transillumination.

**26.** Dispositif d'imagerie selon l'une quelconque des revendications 22 à 25, **caractérisé en ce que** la structure (31, 32) de collimateur du dispositif d'imagerie est agencée pour permettre la limitation du faisceau pour qu'il corresponde essentiellement à la forme et à la dimension de l'assemblage de modules capteurs utilisé pour l'imagerie par transillumination, de préférence en agençant ladite deuxième structure (32) de collimateur pour limiter le faisceau pour qu'il corresponde essentiellement à l'assemblage en chevauchement des surfaces des capteurs des modules capteurs (20, 20', 20", 20"') de la caméra (5).

**27.** Dispositif d'imagerie selon l'une quelconque des revendications 22 à 26, **caractérisé en ce qu'**au moins deux agencements (42A, 42B) de connexions structurellement différents sont agencés par rapport aux stations (11, 12) d'imagerie du dispositif d'imagerie, pour connecter la caméra (5) de manière amovible à ses stations d'imagerie (11, 12) respectives.

**28.** Dispositif d'imagerie selon l'une quelconque des revendications 22 à 27, **caractérisé en ce qu'**au moins l'un des agencements (42A, 42B) de connexions du dispositif d'imagerie comprend des moyens de connexion électrique (70') et mécanique (60') séparés.

**29.** Dispositif d'imagerie selon la revendication 28, **caractérisé en ce qu'**au moins l'un des moyens (60', 70') de connexion du dispositif d'imagerie comprend des moyens (70') de contact pour le couplage électrique, qui sont mobiles jusqu'à un contact physique avec leurs éléments correspondants dans la caméra (5) seulement après que le verrouillage de la connexion mécanique a été terminé.

**30.** Dispositif d'imagerie selon l'une quelconque des revendications 28 à 29, **caractérisé en ce que** le moyen de connexion mécanique (60') d'au moins l'un des agencements (42A, 42B) de connexion du dispositif d'imagerie comprend des moyens de positionnement séparés et des moyens pour verrouiller la connexion mécanique.

**31.** Dispositif d'imagerie selon l'une quelconque des revendications 22 à 30, **caractérisé en ce qu'**au moins l'un des agencements (42A, 42B) de connexion du dispositif d'imagerie, avec ses éléments correspondants dans la caméra (5), est agencé de manière à ce que le montage de la caméra (5) a lieu dans une séquence obligatoire de : positionnement de la caméra, verrouillage de la connexion mécanique et couplage électrique.

**32.** Procédé d'imagerie numérique à utiliser, en particulier, en imagerie dentaire à rayons X, procédé dans lequel :

une zone devant être imagée est balayée par un faisceau d'une source (4) de rayonnement, limité par une structure (31, 32) de collimateur, et

le rayonnement, contenant une information d'image, est détecté par une caméra (5) selon l'une quelconque des revendications 1 à 21, caméra dans laquelle lesdits modules capteurs (20, 20', 20", 20"') de ladite caméra (5), ou les projections desdits modules capteurs (20, 20', 20", 20"'), en particulier leurs projections ponctuelles imagées par le biais d'une focalisation de la source de rayonnement (4), se chevauchent l'un en relation avec l'autre,

où seulement l'information d'image détectée par ledit module capteur (20) est utilisée pour la formation d'une image tomographique, et l'information d'image dudit premier module capteur (20) et de l'au moins un module capteur (20', 20", 20"') supplémentaire sont utilisés pour la formation d'une image par transillumination.

**33.** Procédé selon la revendication 32, **caractérisé en ce que** des signaux d'information d'image et/ou une image sont formés exclusivement à partir de l'information d'image détectée par ledit premier module capteur (20).

**34.** Procédé selon la revendication 33, **caractérisé en ce que** l'information d'image produite par l'au moins un module capteur (20', 20", 20"') supplémentaire est retirée de l'image devant être formée en utilisant des procédés de traitement d'image connus en soi, ou du signal produit par l'assemblage de modules capteurs lui-même en utilisant des agencements électroniques qui commandent son fonctionnement.

**35.** Procédé selon l'une quelconque des revendications 32 à 34, **caractérisé en ce que** le signal d'image par transillumination et/ou l'image par transillumination est formé à partir de l'information d'image produite par l'assemblage de modules capteurs, contenant à la fois l'information d'image produite par ledit premier module capteur (20) et l'information d'image produite par ledit au moins un module capteur (20', 20", 20"') supplémentaire en combinant l'information d'image produite par ces modules (20, 20', 20", 20"').

**36.** Procédé selon la revendication 35, **caractérisé en ce que** l'image par transillumination est formée en lisant l'information d'image produite au niveau de différents stades du mouvement de balayage à partir de deux modules capteurs (20, 20', 20", 20"'), et en combinant ces images partielles à une image intégrée, processus de combinaison dans lequel l'information d'image correspondant si possible plus souvent qu'une partie produite une seule fois de l'objet est soit retirée de l'information produite par tout autre module qu'un seul module, ou spécifiquement, lorsque toute information d'image imagée plusieurs fois est utilisée en vue d'une formation d'image par mise à l'échelle de cette partie pour qu'elle corresponde à l'information d'image qui aurait été obtenue à partir d'un seul module capteur.

**37.** Procédé selon la revendication 35 ou 36, **caractérisé en ce qu'**en imagerie par transillumination le faisceau est limité avant l'objet de manière à ce que la zone couverte par sa projection sur la surface de formation d'image, en regardant à partir du foyer de la source (4) de rayonnement, est en grande partie aussi grande que la projection correspondante des surfaces des capteurs des modules capteurs (20, 20', 20", 20"') sur ce plan, moyennant quoi l'information d'image de la zone des surfaces des capteurs laissée éventuellement à l'extérieur de la projection du faisceau est retirée de l'information d'image avant de combiner les images partielles.

**38.** Procédé selon l'une quelconque des revendications 32 à 37, **caractérisé en ce qu'**un agencement (42A, 42B) de connexions est pourvu pour la caméra (5), avec un connecteur électrique pour transmettre au moins l'alimentation principale et des données d'image le long d'un chemin de signal à et à partir du premier module capteur (20), et un autre connecteur électrique qui est adapté pour transmettre au moins l'alimentation principale et des données d'image à travers un autre chemin de signal de branchement à la fois vers et à partir du premier module capteur (20) et vers et à partir d'au moins un module capteur (20', 20'', 20''') supplémentaire, moyennant quoi l'information d'image reçue du premier module capteur (20) seulement est lue en connectant la caméra (5) au dispositif d'imagerie à travers ledit premier connecteur électrique.

**39.** Procédé selon l'une quelconque des revendications 32 à 38, **caractérisé en ce qu'**en imagerie tomographique, le faisceau est limité pour correspondre essentiellement audit premier module capteur (20), et, respectivement, en imagerie par transillumination pour correspondre essentiellement audit assemblage de modules capteurs (20, 20', 20'', 20''') en chevauchement.

**40.** Procédé selon l'une quelconque des revendications 32 à 39, **caractérisé en ce qu'**en transillumination, le balayage d'imagerie du faisceau est réalisé en gardant le foyer de la source de rayonnement (4) et l'objet devant être imagé immobiles, et en déplaçant la structure (31, 32) de collimateur limitant le faisceau et l'assemblage de modules capteurs de manière synchronisée.

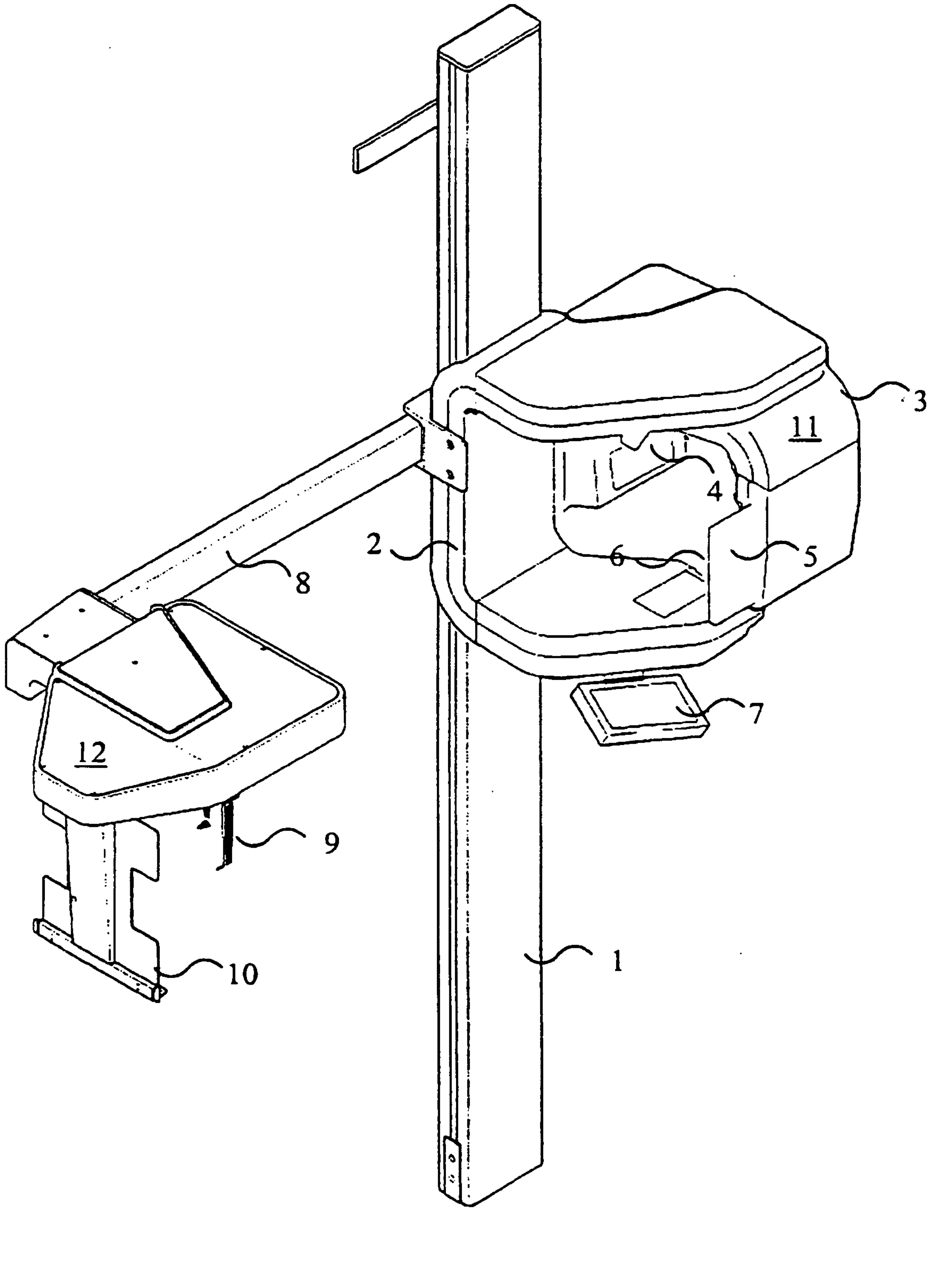



FIG. 1

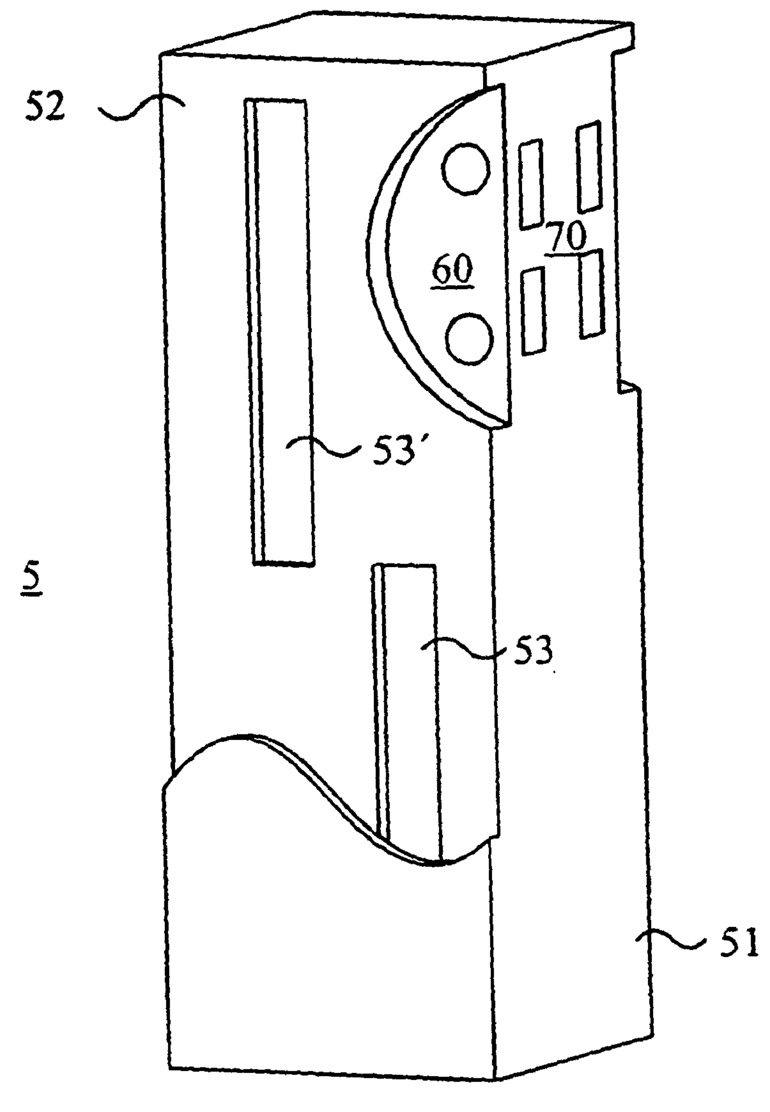



FIG. 2

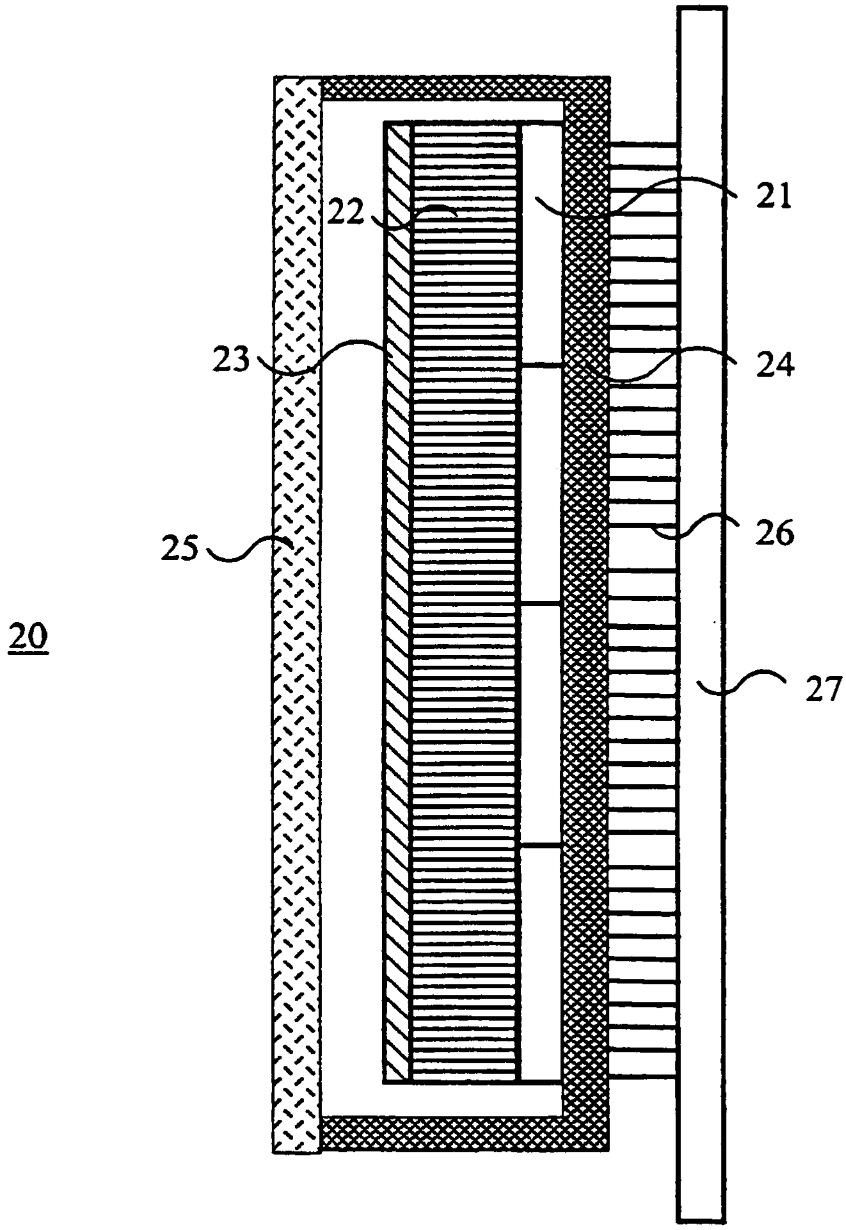



FIG. 3A

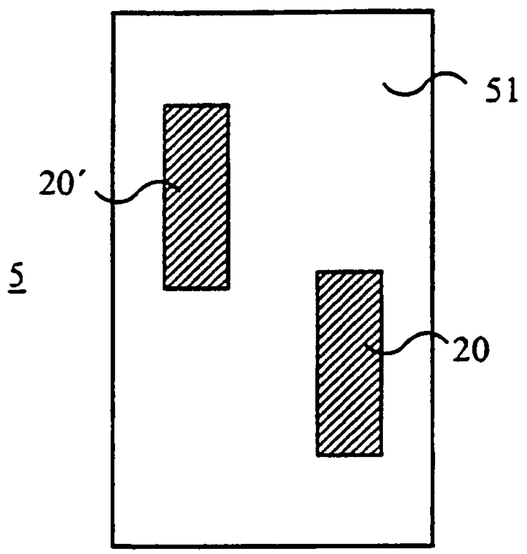



FIG. 3B

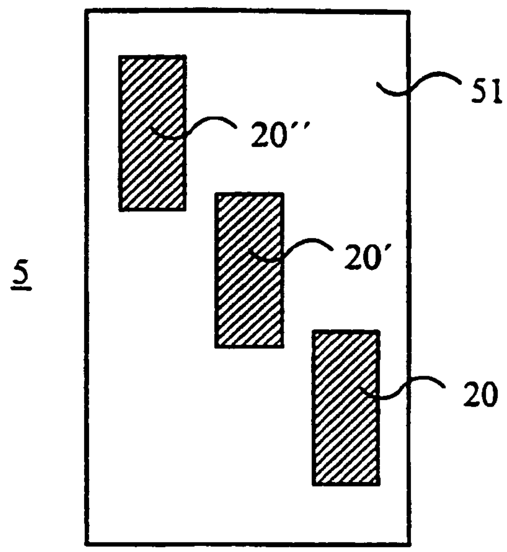
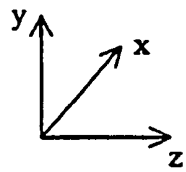



FIG. 3C



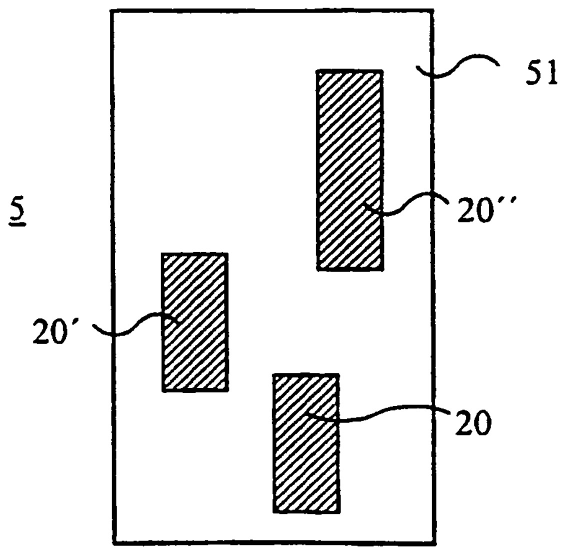




FIG. 3D

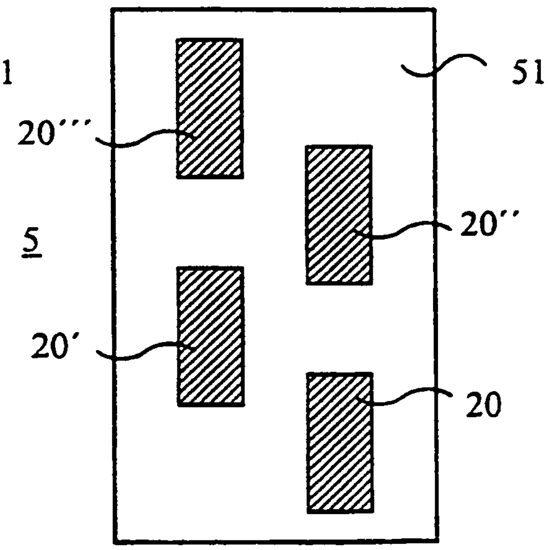



FIG. 3E

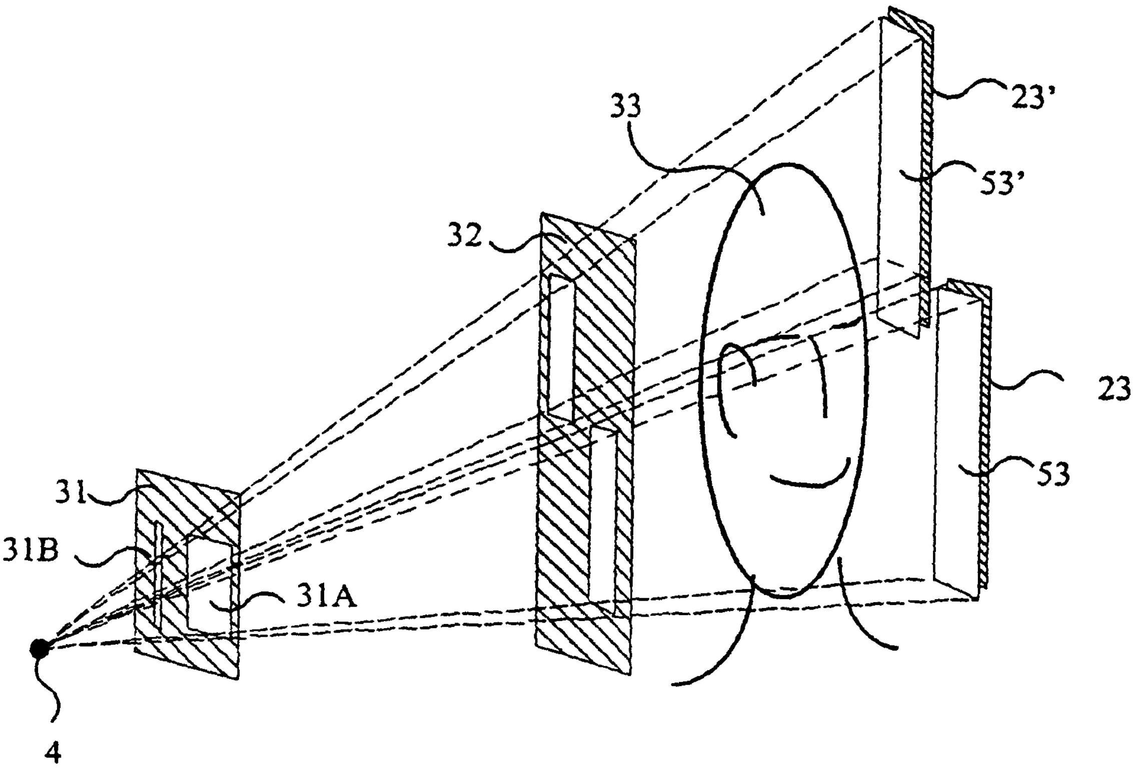



FIG. 4

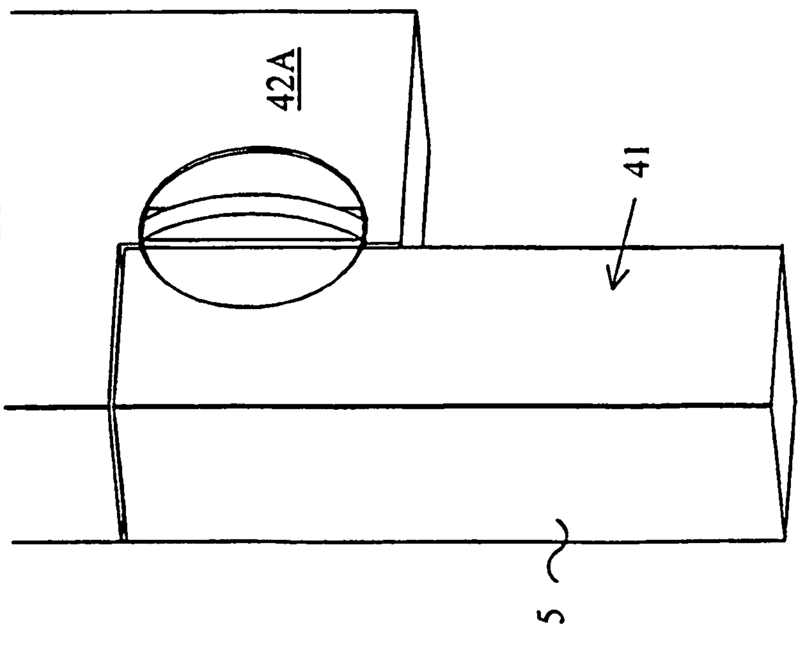



FIG. 5A

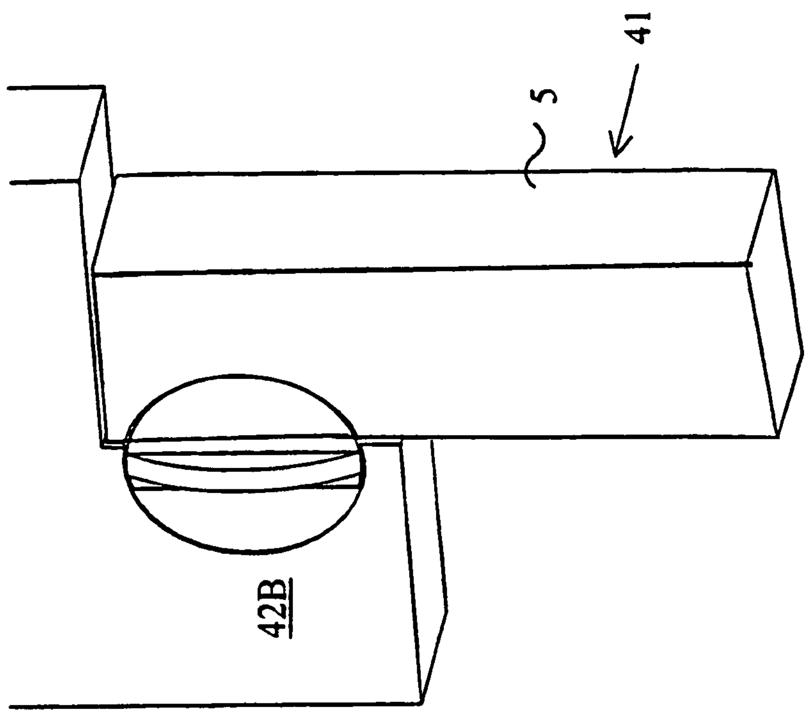



FIG. 5B

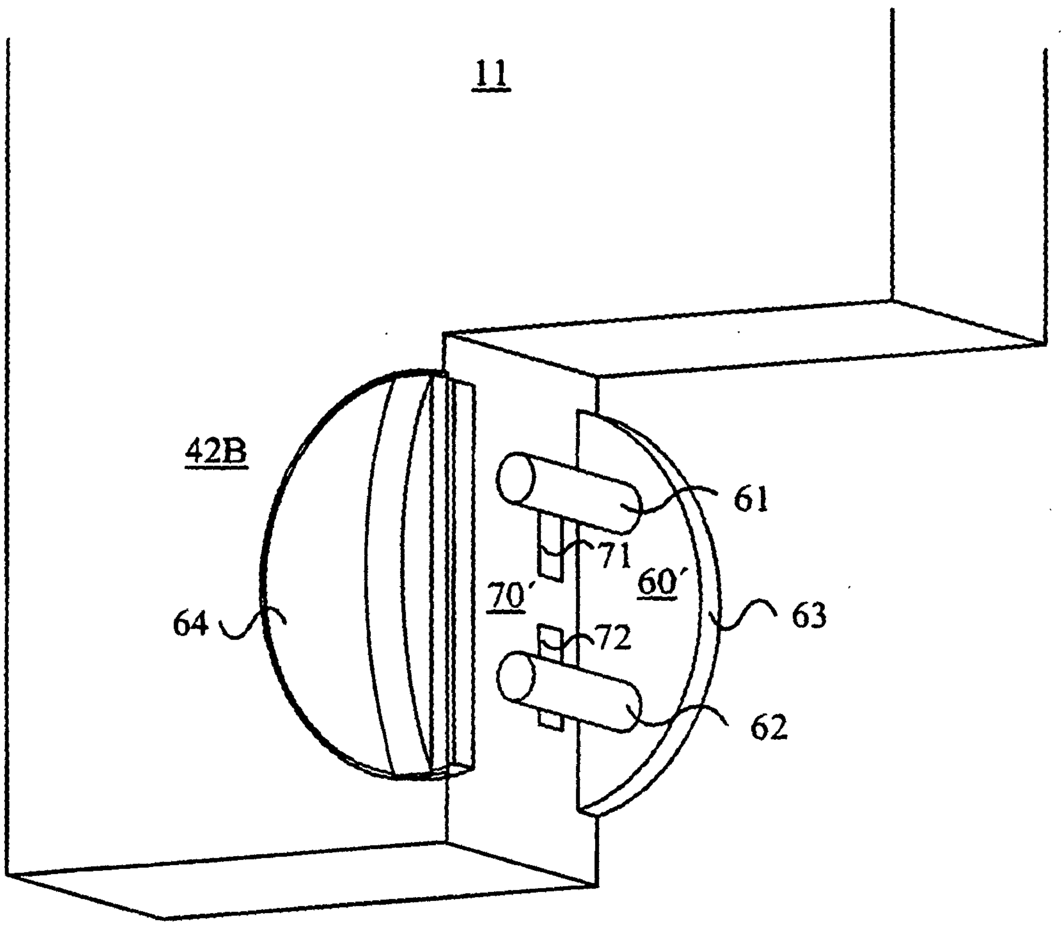



FIG. 6

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- **McDavid, W.D. et al.** Direct digital extraoral radiology of the head and neck with a solid-state linear radiographic detector. *Oral Surg Med Oral Pathol,* 1992, vol. 74, 811-7 **[0009]**

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|---|---|---|---|
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| [标]发明人 | NYHOLM KUSTAA | | |
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| 其他公开文献 | EP1263322A1 | | |
| 外部链接 | Espacenet | | |


**摘要(译)**

本发明涉及数字照相机，成像装置和牙科数字成像方法。一个传感器用于断层摄影成像，并且至少一个传感器用于透射成像。传感器布置成彼此重叠。与使用一个大面积传感器的相比，这种布置提供了多次使用和相对便宜的相机。另外，可以为不同的成像模式布置至少两个单独的电连接结构。此外，其连接布置可以以这样的方式布置，使得相机的机械连接结构与电连接结构分离。


$$V_P = ( L_{FP} / L_{OP} ) \times V_O \quad ,$$