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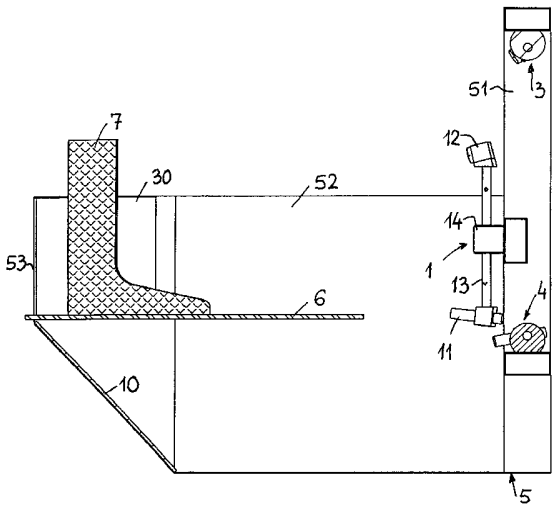
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(54) Title: APPARATUS FOR DETERMINING SIZE AND SHAPE OF A FOOT



(57) Abstract: The purpose of the present invention is to create a simple and in particular easily handling and maintaining apparatus for determining size and shape of a foot (7), which should enable to each user in situ acquiring reliable and precise data about the size and shape of his foot in a natural, relaxed and released state, especially a quick acquiring in a very short time period, so that during the regular use of such apparatus any possibility of displacing the foot is excluded. The apparatus according to the invention consists of a casing (5), in which a desired number of projectors (11, 21, 31, 41) is foreseen, each of them being addapted for ensuring a desired number of light planes (B1, ..., B17, ..., B33, ...), which are directed either towards the belonging mirror (10, 20, 30) in order to be reflected towards the surface of the foot (7), which is fixedly placed onto a fixed supporting plate (6), or also directly towards the surface of the said foot (7) forming thereby the required illumination, which may be recorded by means of the corresponding camera (12, 22, 32, 42), whereupon e.g. by means of triangulation the shape and the size of the foot (7) may be determined.

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APPARATUS FOR DETERMINING SIZE AND SHAPE OF A FOOT

The invention refers an apparatus for determining size and shape of a foot. The term "the size of a foot" denotes dimensions of the foot along all three directions of a space, i.e. the length, the width and the height of a particular point of the foot, relatively to the reference point on the base plate, and furthermore, the term "shape" means a contour of the foot in each desired cross-section in the space.

The purpose of the present invention is to create a simple apparatus, preferably designed without any moving parts and therefore simple for using and maintaining, especially for wide range of users applicable for determining of size and shape of a foot, which should enable every time in situ, for example in a footwear store or a sports equipment store, to acquire sufficiently accurate and reliable data of the size and shape of the user's foot in its natural, released state, namely within a very short time of period, that at regular usage of the apparatus any possibility of the foot movement as a measured object and consequently generation of inaccurate measurements due to conscious or subconscious reactions to the external irritation, due to the so called humane factor, is prevented.

In the past, measuring of the size and the shape of human feet was performed mainly for the purposes of forming artificial limbs, thus for substitution of amputated limbs, as well as by manufacturing orthopedic footwear, which should compensate the shape and size deviations of one foot relatively to the regular size and shape of the remaining foot. One of such apparatus, including the orthopedic manufacturing procedure, is described in US 6,006,412. The apparatus determines the foot shape and size in various planes by means of scanning, thus by using progressively lighting of the foot surface along a desired direction on one plane, and then repeating this step either in various directions in the same plane, and/or also in different planes, if desired. Determination of the size and the shape of the foot, which is enabled by such apparatus, is based on executing multiple progressive repetitions of the mentioned

scanning procedure, where the duration of each repetition is at least several seconds. Scanner movement along any other direction or any other plane for the purposes of scanning also takes some time. Thus, it is evidently, that even if the leg, to which the measured foot belongs, is somehow fixed, there always exists a possibility, that the foot is moved during the measuring cycle for several millimeters or even for several centimeters. In such a manner, the results can be only more or less approximate and in no way exact. Accordingly, the leg or at least the foot of the user must be firmly fixed for a relatively long time, for example for at least several minutes, which is quite unfeasible by determining the size and shape of a foot at a wide range of people, for example for the clients in a footwear store. Analysis of the above reference of the described procedure of determining the foot size and shape and subsequent orthopedic production on the basis of preparation of mould positive and negative is, in our opinion, irrelevant for the purpose of evaluation of the present invention.

Before that, determining the size and the shape of a foot was possible by using an apparatus, which is described in US 5,128,880. It is a relatively simple apparatus, which might be generally used by a wide range of users and could be also located in a footwear store. Such an apparatus consists of a top measuring equipment or reference surface, onto which each measured foot is placed with the sole, which is oriented downwards. If the foot is kept in absolutely standing state for at least several seconds i.e. at least during the scanning time in one plane and one direction, there is a way to assure accurate information about the foot length and width, the contour and relief of the foot bottom side, i.e. sole. However, the experiences show that in many cases, there is very difficult to assure such fixation of the foot even during such very short time, because even the foot charging or discharging due to weight transmission or even due to reaction of certain groups of muscles with respect to any irritation in the cirumference, could lead to millimeter-range movements of the foot bones during the scanning process. In addition, if the apparatus could perform extremely fast scanning, the measured data would still describe only the size and the shape of the sole, i.e. only the bottom foot surface, which is sufficient for the selection of the appropriate shoe sole, but in no way for the proper selection of the shoe as a whole. For such shoe selection, there is need to find much more data about the foot, especially about the instep height, the heel region geometry, etc., which the above apparatus cannot enable.

Furthermore, an apparatus for three-dimensional measuring of the human foot is described in EP 1 010 393 A1, which is composed of the measuring unit, the signal-processing unit, including display unit and the unit for saving the coded data on the magnetic card. By using such apparatus, the user would, after the finished measurement, get the card with the data about his feet, after which he could buy the proper footwear considering the data stored in his card. The mentioned apparatus is designed as a scanner, which is composed of properly arranged transmitters and receivers of infrared rays. Each, from the transmitter-exiting ray, is reflected from the foot surface and received by the appropriate receiver, which send the appropriate signal into the signal-processing unit. The latter enables the review of the measured foot on the display unit, for example on monitor, or as suitable printing on paper and in addition it also provides the generation of adequate data and saving on the magnetic card. This apparatus could also be quite an inaccurate as a result of its measurement principle. And also the scanning procedure takes relatively long time, certainly too long, that the possibility of errors due to foot movement during the scanning could be eliminated.

Furthermore, the determining problem of, especially the foot size is being examined with an optical measuring apparatus, which is depicted in UK 2 141 226 A. By realizing that, especially at children, merely tension or tonus of the foot, when it is putted on certain surface, can cause excessive errors, the apparatus is designed so, that enables the foot measurement in the feet free, discharged state. This apparatus is consisted of a pedestal and a console. There is an aperture in mentioned pedestal which receives the foot and where two units, one for the foot length measuring and one for the foot width measuring, are installed. The console includes the display, where the foot position can be observed relatively to the reference line, as a result of detection of both previously mentioned units. When the foot is placed in the proper place relatively to the reference line, where the light rays intersect the foot, which is the base of determining of the foot length and width, the points measurement could be done very fast, practically in a moment. The measuring phase of this device is performed so fast, that it is possible to exclude any inaccuracy, as a consequence of foot movement during the measurement. But also in this case, similarly as in previously mentioned apparatus as described in US 5,128,880, the data acquired on the basis of only foot

length and width, are at least insufficient if not unsuitable for a correct choice of a shoe.

Another optical apparatus for determining or measuring three-dimensional shape of a foot is known from US 4,802,759, by which the measuring surface is illuminated through an aperture with defined pattern, which forms the light pattern on the measured surface, and after the light reflection from the later, the pattern is visible on the screen surface. By calculating coordinates of particular characteristic points, it is possible to determine the shape of the measured surface. By using such apparatus, it is possible to determine the shape of particular foot regions, but in general this apparatus does not solve the problem as defined before.

Furthermore, in GB 2 240 623 is described an optical apparatus for determining the object of three-dimensional shape, where this apparatus consists of a source of a light stripe and a camera, placed on a framework, which can be rotated around the measured object. In the case of determining the foot size and shape, such a principle would be unsuitable at least because of two reasons: the apparatus would be too big and too complicated due to rotation framework, and simultaneously, the measuring time would be very long because only one light stripe have to travel around the foot surface.

Still further, in US 5,848,188 and US 5,546,189 are described apparatuses for measuring the shape of a three-dimensional object based on the triangulation principle. There goes for highly complicated devices. One also consists of fast rotational mirror. The main intention of mentioned apparatuses is to assure high accuracy of results, but obviously they are intended for production process monitoring.

In addition, US 4,705,401 describes an apparatus for fast three-dimensional surface digitalization. The apparatus has a light source, which illuminates the object in multiple planes simultaneously such, that multiple lines are visible on the object, which determines its outline. Those units, which assure the simultaneous surface illumination in multiple planes, could be named as projectors. There is also a camera for acquiring the pictures of the illuminated lines on the object surface. Furthermore, there is also a part of apparatus, which controls the movement of measured object

relative to the light source i.e. projector. By measuring the foot size and shape with such apparatus, the foot would ordinarily be illuminated with multiple so-called light planes, and on the foot surface would get multiple lines of different curvatures, which would be acquired with the camera during foot movement in different positions, and the foot shape would be calculated on the basis of line curvatures in particular positions relatively to the light source. Such procedure is by all means in contradiction with the basic intention of the desired apparatus, which is that the measurement is fast and if it is possible without foot movement. By using this apparatus, the shape measurement would take relatively long time, and the foot should follow to the part of the apparatus, which is used for assuring its movement. In such a way, the foot would be exposed to the irritation on whose it would response. We can summarize, that this apparatus for measuring the size and for determining the shape of a foot in its natural standing is basically inconvenient.

According to the present invention an apparatus for measuring and determining of the human foot shape in general comprises at least one measuring module, which consists of at least one projector and at least one camera. As a measuring module it is meant one source of light planes, particularly laser rays that are directed toward the foot surface, with which it is possible to illuminate in each case selected foot surface, and also at least one camera, with which it is possible to acquire the mentioned surface illumination, and to determine the shape of the illuminated foot surface from the acquired pattern. In the introduction defined technical problem is in the present invention solved in such a way, that it is anticipated in each case required number of projectors, where each projector is arranged for assuring in each case suitable number of laser light planes, which are equally apart for certain angle and directed either toward to the in each case belonging mirror, by which they are redirected toward to the surface of in each case for a light at least semitransparent supporting plate, where the foot is immovable placed, or they are directed directly toward to the surface of the mentioned foot, such that they form in each case suitable illumination, which could be acquired using in each case related camera and then the foot size and shape is determined from the acquired images. Furthermore, such apparatus consists of a casing that forms on one side a supporting frame, which carries proper arrangement of the measuring modules, and on the other side a hull that on the distant side from the

supporting frame have entry aperture for placement of in each case measured foot on the mentioned at least partially light transparent supporting plate, which define device measuring field and is placed at mentioned entering aperture, and simultaneously, there are also in the mentioned hull mounted mirrors, whose arrangement is chosen in accordance with arrangement of the mentioned measuring modules and their components, namely projectors and its cameras. Each measuring module includes at least one projector and at least one camera, its placement in apparatus, namely on a supporting frame of casing is chosen in accordance with arrangement of with its in each case acting mirror with respect to the position of the mentioned supporting plate and the foot placed on it.

The preferred embodiment of this apparatus according to the present invention includes a supporting plate for placement of appropriate measured or inspected foot, which is at least essentially horizontally mounted in the casing, so that its longitudinal horizontal axis forms a longitudinal axis of apparatus, which is in each case at least essentially coincident with the longitudinal axis of the foot as a measured object, and that apparatus includes three mirrors. Those mirrors are arranged so, that the first mirror is placed near the entry aperture and is turned down with respect to the at least partially for light transparent supporting plate for a specific angle in vertical direction, which is chosen in dependence to the position of the in each case acting measuring module in the casing or on the framework. The second and the third mirror are arranged in vertical planes immediately at and above the mentioned supporting plate, so that they are inclined for a specific angle with respect to the mentioned longitudinal axis of the mentioned supporting plate, which is chosen with respect to the position of in each case acting measuring modules and that they are extending away from the mentioned entering aperture in the casing and apart from each other. The most preferred construction of this apparatus according to the present invention consists of four measuring modules, which are fixed on the supporting frame, where the first and the second measuring module are mounted above the plane of at least partially translucent supporting plate, and each on each side of the longitudinal axis of the mentioned plate, while the third measuring module is mounted above in respect to the first-mentioned modules logically at least approximately above the mentioned longitudinal axis of the supporting plate, and the fourth module is placed under the

mentioned supporting plate, logically at least approximately under the mentioned longitudinal axis of the supporting plate, on which the measured foot is placed. Furthermore, according to the present invention, the first measuring module consists of a projector, which is intended for directing in each case the proper number of equidistant light planes towards the belonging mirror, namely towards the mirror above the supporting plate, which is placed at the equiolateral with respect to the longitudinal axis of the mentioned plane, as the mentioned projector, and which is intended for redirecting of the mentioned rays to the belonging surface on the mentioned plate placed foot, as well as from the camera, which is arranged in such a way, that the surface of the foot, which is illuminated by the mentioned light planes, is placed within the viewing area of the camera. The second measuring module consists at the one hand of a projector, which is intended for generating a desired number of properly directed light planes, which are preferably arranged equidistant each to other, towards the belonging mirror, namely towards the mirror above the supporting plate, which is placed at the same side of the longitudinal axis of the mentioned plane, as this projector, and which is intended for reflecting the said rays towards the belonging surface on the mentioned foot oplaced on the plate, and on the other hand also of a camera, which is arranged in such a way, that with the mentioned light planes illuminated foot surface is placed within the viewing area of the camera. The third measuring module consists of a projector, which is intended for directing appropriate number of equidistant light planes directly towards the surface of the foot, which is oriented towards to this module, as well as of the camera, which is arranged in such a manner, that the surface of the foot, which is illuminated by the said light planes, is placed within the viewing area of the camera. The fourth measuring module consists of a projector, which is intended for directing appropriate number of equidistant light planes towards the corresponding mirror, namely towards the mirror under the supporting plate, which is intended for reflecting the said light planes towards the belonging surface on the foot as placed on the plate, as well as of appropriate camera, which is arranged in such a way, that the surface of the foot, which is illuminated by the said light planes, is placed within the viewing area of the camera. It can be especially preferable, if each measuring module is fixed on the supporting frame of the casing in that manner, that at least the projector and the belonging camera are possible to be fasten on a holding bar, which is by using an appropriate fastening means fixed

in a proper holder. In this way, after releasing the fastening means, the holding bar is movable along its axis and may also be rotated around it, and after strengthening the mentioned fastening means, the holding bar is fixedly positioned on the holder in each desired position.

Furthermore, in accordance with the present invention, the measuring modules may be designed in such a way, that the number of projectors corresponds to the number of cameras, or that the number of cameras is greater than the number of projectors. Besides, it is further preferable, if each projector is able to generate at least ten, preferably at least thirty, and particularly more than thirty-two light planes, where each plane is essentially designed as a straight band, and which are preferably equidistant spaced for a certain angle between each other.

The invention will be explained on the basis of the embodiment in relation with the appended drawing, where

Fig. 1 is a schematical perspective front view of the apparatus for determining the foot size and shape;

Fig. 2 is a schematical perspective back view of the apparatus for determining the foot size and shape;

Fig. 3 is a top view of the the apparatus according to Figs. 1 and 2;

Fig. 4 is a cross-section along the plane III-III according to Fig. 3;

Fig. 5 is a schematical perspective front view of the apparatus for determining the foot size and shape together with the schematically shown measured foot;

Fig. 6 is schematical a perspective back view again of the apparatus for determining the foot size and shape together with the schematically shown measured foot;

Fig. 7 is a top view of the apparatus according to Figs. 5 and 6;

Fig. 8 is a cross-section along the plane VII-VII according to Fig. 7;

Fig. 9 is a disposition sketch of the main elements of the apparatus according to the present invention;

Fig. 10 is a schematically presented optical situation during functioning, shown in a top view;

Fig. 11 is a schematically presented optical situation during functioning, in a side view;

Fig. 12 is a presentation of functioning of each used measuring module;

Fig. 13 is s schematical presentation of functioning of the measuring module, when the measured object is illuminated by several light planes,

Fig. 14 is a planar presentation, i.e. a snap-shot or a photo of the illuminated object, i.e. the foot, on the basis of data, acquired from one of measuring modules, when it is placed at a proper position, which in general is not in correlation with the measuring modules position, which are shown in other figures.

The apparatus for determining the foot size and shape basically consists of the casing 5, where the for light at least partially transparent supporting plate 6 is, and on which the measured object 7 is placed, and secondly, in the mentioned casing 5 the measuring modules 1, 2, 3, 4 with their belonging mirrors 10, 20, 30, 40 are fixed in the in each case desirous and proper way, which will be depicted in the continuation.

Each of measuring modules 1, 2, 3, 4 consists of at least one light emitter, in this case laser light emitter, namely the so called laser projector 11, 21, 31, 41, as well as from at least one receiver of laser rays, namely the so called camera 12, 22, 32, 42.

Casing 5 is designed from an extremely rigid supporting frame 51, which is adopted for fastening of measuring modules 1, 2, 3, 4 and related mirrors 10, 20, 30 as well as appropriate hull 52 that have entry aperture 53 for placement of the foot 7 as the measured object on the pre-mentioned supporting plate 6 in appropriate working region of the measuring modules 1, 2, 3, 4 with regard to the position of the mirrors 10, 20, 30.

The supporting plate is made of a light transparent material, especially at least for this type in each case selected light, emitted by projectors 11, 21, 31, 41 of the measuring modules 1, 2, 3, 4. The supporting plate is mounted in casing 5 preferentially in horizontal position. In general, it can be inclined for a specific angle with regard to the horizontal plane, which is for each user or for requirements of maximally accurate and comfortable execution of measurement in each case most appropriate. Supporting plate 6 can be generally mounted in casing 5 so that tilting around one or both axes of horizontal plane of apparatus according to the invention is possible, which can be carried out by using appropriate mechanisms (not shown in enclosed figures).

The design and realization of measuring modules 1, 2, 3, 4 will be described in detail only in case of one of the measuring modules, namely on basis of module 1 shown in figure 1. In this case, measuring module 1 comprising one projector 11 and just one camera 12 is for their appropriate positioning equipped with holding bar 13, which is clamped in holder 14, that is fastened on the pre-mentioned frame 51 of casing 5. Holder 14 is in the presented example equipped with fastening or stretching means 15, reasonably just by screws, and designed so that after releasing the pre-mentioned fastening means 15, holding bar 13 is movable in the direction of its longitudinal axis and the rotational about it, simultaneously it enables fixing of the pre-mentioned bar 13 in each case in a new selected position. Projector 11 and camera 12 of each measuring module 1 are in appropriate manner each apart fixed on the pre-mentioned holding bar 13. On one side, mounting of the projector 11 and camera 12 of in each case measuring module 1 is enabled in appropriate position in each case, especially in each case in their properly interacting position on the relating bar 13, and on the other side by moving holding bar 13, appropriate position of the complete measuring module 1, namely projector 11 and camera 12 can be established with regard to the anticipated measuring field, which can be in the presented example defined by size and position of the foot 7 as the measuring object, that is placed on the supporting plate 6.

Proper operating of the apparatus according to the invention can be established on the basis of the appropriate number and arrangement of measuring modules 1, 2, 3, 4 and to them related mirrors 10, 20, 30. During the measurement of the foot 7 by the apparatus according to the invention, longitudinal axis of the pre-mentioned foot 7 is at least coincident with the longitudinal axis 60 (Fig. 3) of the supporting plate 6. Because of that, supporting plate 6 with its longitudinal axis 60 of the foot 7 can be selected as the origin for the determination of arrangement of measuring modules 1, 2, 3, 4 and mirrors 10, 20, 30, where the pre-mentioned axis 60 stretches from the heel region of the foot to the finger region of it.

On this basis, all measuring modules 1, 2, 3, 4 in the presented example are arranged in front of the pre-mentioned supporting plate 6, where the first two measuring modules 1 and 2 are arranged over the supporting plate 6, in a manner that they are

horizontally separated in approximately equal distances each on each side of the pre-mentioned axis 60, and that their connecting axis is approximately orthogonal with regard to the pre-mentioned axis 60. The third module 3 is placed above the pre-mentioned modules 1 and 2, while the fourth module 4 is in this example below the first mentioned modules 1 and 2, under the plane of the supporting plate 6.

In the presented example, for an efficient operating of the apparatus according to the invention three planar mirrors 10, 20, 30 are required. The first mirror 10 is placed under the plane of the supporting plate 6, in a manner that it is positioned inclined with respect to the plane of the supporting plate 6, so that in region of the entry aperture 53 of casing 5 it starts descending from the level of the supporting plate 6 to the basis in direction toward the measuring modules 1, 2, 3, 4 placed on frame 51. Remaining mirrors 20 and 30 are symmetrically arranged in vertical planes with regard to the pre-mentioned longitudinal axis 60 of the plate 6, they are placed near the entry aperture 53 of casing 6 in specific separation, they extend inclined apart from the pre-mentioned entering aperture 53 toward modules 1, 2, 3, 4 placed on the frame 51 of casing 5. The separation between mirrors 20 and 30 in region of the entry aperture 53 enables realization of a sufficiently large entering aperture 53, for an untroubled passing of the foot 7 through it, while placing the foot on the supporting plate 6, or while withdrawing it from the supporting plate 6. Starting from the extremely stiff construction of the frame 51, fixing of the pre-mentioned measuring modules 1, 2, 3, 4 and mirrors 10, 20, 30 is carried out in a manner that prevents deformations, whose consequences could be deflections of the pre-mentioned optical elements from their initial position and thus inaccuracy of measured results.

As mentioned, in each case measuring module 1, 2, 3, 4 generally comprises at least one projector 11, 21, 31, 41 and at least one camera 12, 22, 32, 42. Each of projectors 11, 21, 31, 41 is designed so that by using appropriate grating forms great number in each case equally separated, essentially plane light planes B1,..., B17, ..., B33 (Fig. 13), especially from laser rays formed light planes. For this purpose, an appropriate projector can be applied, as is in the presented example, by using a currently selling projector under trade mark Lasiris® of manufacturer Stocker Yale, Inc., that forms illumination region from thirty-three equally separated light planes B1 to B33, which

in each case for a specific projector 11, 21, 31, 41 directly or indirectly across the in each case related redirecting mirror 10, 20, 30 illuminate the surface of the foot 7, and on it form a pattern with respect to the relief of the surface of more or less deformed light curves, which is for better understanding depicted in Fig. 14.

In the case when a specific projector 11, 21, 31, 41 and with it acting camera 12, 22, 32, 42 are placed in the same plane, and the surface of the foot 7 is illuminated with multiple light planes B1 to B33, multiple straight lines are visible on the foot surface. These lines become curved after the camera is placed out of the projector plane, because of the bulged surface of the foot 7. The surface of the measured foot 7 can be uniformly determined from the shape of these curved illumination lines, by knowing deflection angle of the cameras 12, 22, 32, 42.

In each case acting camera 12, 22, 32, 42 is directed toward the surface of the foot 7 as measured object, illuminated in each case by the related projector 11, 21, 31, 41 in a manner that the image of the illuminated region on the surface of the foot 7 can be acquired by cameras 12, 22, 32, 42 and the data about the layout of the illuminated lines can be saved. An expert will understand that both steps, namely the illumination of the surface of the foot 7 by using one of projectors 11, 21, 31, 41 and the recording of the image of the layout of the curved illuminated lines on the surface of the foot 7 by in every case related camera 12, 22, 32, 42 is feasible in extremely short time of range of several hundredths or even several thousandths of a second. In addition, it is also possible to ensure very compressed sequent operation of all available modules 1, 2, 3, 4, namely their projectors 11, 21, 31, 41 and related cameras 12, 22, 32, 42 in extremely short time periods, which is several tenths of a second, preferentially not more than 0.5 second. Under the term 'sequent operation' it is considered that firstly illumination of the related region on the surface of the foot 7 is carried out by using projector 11 of the first module 1, followed by the recording of the surface with related camera 12 and finally the illumination with the projector is stopped. Then follows illumination of the related region on the surface of the foot 7 using projector 21 of the second module 2 and after that recording of the surface by related camera 22. After stopping illumination by this second projector 21, follows illumination of the related region on the surface of the foot 7 by projector 31 of the third module 3, after that

recording of the surface by related camera 32 and finally after stopping illumination with the third projector 31 follows illumination of the related region on the surface of the foot 7 by projector 41 of the fourth module 4 and after that recording of the surface by related camera 42. In general, activating sequence of specific modules 1, 2, 3, 4 is irrelevant, but it is important that in each case after illumination of the surface of the foot 7 using specific projector 11, 21, 31, 41 follows the recording of the surface by the appropriate camera 12, 22, 32, 42 in other words with that camera which is appropriately arranged for recording in that time illuminated surface region on the foot 7 as measured object.

When measuring the size and the shape of the foot 7, sizes of the measuring fields are in advance determined for each case, and by assuring appropriate positions of projectors 11, 21, 31, 41 and cameras 12, 22, 32, 42 of modules 1, 2, 3, 4 in each case, so that at one side desired number of available light planes B1, ..., B17, ..., B33, preferentially most of them, from in each case desired direction, namely in each case from direction of projector 11, 21, 31, 41, hit the surface of the foot 7, and on the other side, recording of the layout of the curved illumination lines formed by light planes B1, ..., B17, ..., B33 is ensured by viewing angle of the in each case related camera 12, 22, 32, 42.

By known positions of the projectors 11, 21, 31, 41 and cameras 12, 22, 32, 42, namely their space coordinates, as well as intermediate angles of light planes B1, ..., B17, ..., B33, the distances from the individual points on the surface of the foot 7 to the related projector 11, 21, 31, 41 or camera 12, 22, 32, 42 and thus also to the supporting plate 6, can be quickly determined and with a high accuracy on the basis of the layout of the curved illumination lines recorded by the in each case acting camera and by using appropriate software. Coordinates of the individual points on the surface of the foot 7 can be determined on the basis of known principles, preferentially by means of triangulation.

When the user puts the foot 7 through the entry aperture 53 of the hull 52 of the casing 5 on the supporting plate 6 (Figs. 5 to 8), the longitudinal axis of the foot 7 must at least approximately coincident with longitudinal axis 60 of the above mentioned

supporting plate 6. Measuring modules 1, 2, 3, 4 are arranged in front of the foot 7 as shown in Fig. 9, while the mirrors 10, 20, 30 are arranged behind and below the foot in the pre-described manner, which is also shown in Fig. 9. Starting from the pre-mentioned arrangement, illumination of the left side of the foot 7 (Fig. 10) is possible across redirecting mirror 30 by projector 11 of the first module 1, before or after that right side of the foot 7 can be illuminated by projector 21 of the second module 2. Before or after that the front side of the foot 7, namely the finger and instep region and front part of the ankle of the foot 7 can be illuminated from the top by projector 31 of the module 3 (Fig. 11), and even before or after that lower part, namely the sole of the foot including the heel region and the ankle from the back side can be illuminated from the bellow by projector 41 of the module 4. In this manner all relevant regions of the foot 7 can be sequentially illuminated by using four projectors 11, 21, 31, 41 with appropriately spaced light planes B1, ..., B17, ..., B33. As mentioned, after the illumination of the in each case specific region on the foot 7, the recording of the illuminated region follows by in each case related camera 12, 22, 32, 42.

An expert from this field should understand that operational sequences of the measuring modules 1, 2, 3, 4 can be completely automatized, so that after the placement of the foot 7 on the supporting plate 6, the user triggers the working of the apparatus by pressing a starting button (not shown in figures), after that all illuminations and recordings are carried out almost in a moment.

With regard to the design of the apparatus according to the invention, measuring accuracy of the size of the foot in individual planes and geometry of the surface of the foot can be achieved more than 0.5 mm, which is actually more than it is required in practice, especially if we take into account that anomalies on the skin of the foot 7, namely wrinkles, pores or similar features could easily achieve the pre-mentioned size and that the texture of the sock is in most cases ticker than this amount. At the same time we can take into account the fact that measurement is carried out so fast or that the time required for the realization of the sequence of the illuminations and recordings with individual modules is so short that it lasts in the worst case at most a few tenths of a second, especially less than is the common reaction time of a person, which means that during the measurement the person could neither consciously nor

subconsciously respond to the impulses detected by their body for any reasons what so ever.

It should also be emphasized, that the described example represents just one of the possible cases, which in no way whatsoever determines the extent of the invention as such. Although the design and arrangement of individual components of the measuring modules 1, 2, 3, 4 in the discussed case at least in the essence correspond to the design and arrangement of the same elements as at the preferential construction, in general or at least in specific cases of application different design and arrangement is preferential. Also a number of in each case available light planes B1, ..., B17, ..., B33 can generally differ from the number defined in the discussed example of construction. Additionally, in the apparatus according to the invention a different number of projectors 11, 21, 31, 41 and cameras 12, 22, 32, 42 can generally be used too, so that the sequence of steps of illumination of the surface regions of the foot 7 by in each case selected projector 11, 21, 31, 41 and sequent steps of recording the so illuminated surface regions of the foot 7 by in each case appropriate camera 12, 22, 32, 42 can be a bit different from the ones stated in the discussed example of construction of the apparatus according to the invention. In general it is at least in specific cases possible to use only one camera to sequentially record surface regions of the foot 7, that are illuminated by different projectors 11, 21, 31, 41 in sequent time periods with intermediate interruptions or without them, or with several cameras 12, 22, 32, 42 to sequentially record specific surface region of the foot 7, which is in sequent time periods with intermediate interruptions or without them illuminated by the specific projector 11, 21, 31, 41.

PATENT CLAIMS

1. Apparatus for measuring and determining size and shape of a human foot, comprising at least one projector (11, 21, 31, 41), namely at least one source of light rays (B1, ..., B17, ..., B33, ...), especially laser beams, directed towards the surface of the foot surface, which enables illumination of the foot surface, as well as at least one camera (12, 22, 32, 42), by means of which recording of the said illuminated surface is possible in order to determine the shape of the illuminated surface of the foot (7) on the basis of such recorded pattern, characterized in that the apparatus comprises a desired number of projectors (11, 21, 31, 41), each of them being adapted for generating a desired number of light planes (B1, ..., B17, ..., B33, ...), which are formed by laser beams in appropriate arrangement and are preferably spaced each to another and inclined at appropriate angle and which are moreover directed either towards the belonging mirror (10, 20, 30) in order to be deflected towards the surface of a fixed and at least partially translucide supporting plate (6) adapted for fixedly placing the foot (7), or may also be directed directly towards the surface of the foot (7) in order to ensure a desired illumination, which can be then recorded by means of appropriate camera (12, 22, 32, 42), so that the shape and size of the foot (7) can be determined on the basis of such generated images.

2. Apparatus according to Claim 1, comprising a desired number of properly arranged measuring modules (1, 2, 3, 4), where each of them includes at least one projector (11, 21, 31, 41) and at least one camera (12, 22, 32, 42), and the number of cameras (12, 22, 32, 42) is greater or equal as the number of projectors (11, 21, 31, 41).

3. Apparatus according to Claims 1 or 2, comprising a casing (5) which is formed on the one hand by a supporting frame (51) with the measuring modules (1, 2, 3, 4) arranged and oriented corresponding to the position of the measured foot (7), and on the other hand by appropriate hull (52), which on the one side placed away from the supporting frame comprises an aperture (53), which is intended for placement of each measured foot (7) onto at least partially translucent transparent, preferrably translucent and most preferrably transparent supportintg plate (6), which determines the measuring

area of the apparatus and is placed adjacenbt to the said aperture (53), and at the same time within the said (52) also appropriate mirrors (10, 20, 30) are placed, the arrangement of which is chosen in accordance with the arrangement of the said measuring modules (1, 2, 3, 4) and their assembly parts, namely projectors (11, 21, 31, 41) and cameras (12, 22, 32, 42).

4. Apparatus according to one of Claims 1 to 3, comprising at least one measuring module (1, 2, 3, 4), which generally consists of at least one projector (11, 21, 31, 41) as well as of at least one camera (12, 22, 32, 42), where its placement within the apparatus, namely on the supporting frame (51) of the casing (5), is determined in accordance with the arrangement of each corresponding mirror (10, 20, 30) and with respect to the position of the at least partially translucent supporting plate (6) and the foot (7) placed thereon.

5. Apparatus according to any of the previous claims, characterized in that the supporting plate (6), which is intended for placement of each measured or inspected foot (7), is at least essentially horizontally mounted in casing (5) in at least essentially horizontal position in such a manner, that its longitudinal axis (60) forms a longitudinal axis of the apparatus, which is in each case at least essentially coincident with longitudinal axis of the foot (7) as the measured object, and that the apparatus includes three mirrors (10, 20, 30), which are arranged in such a way, that the first mirror (10) is placed adjacent to the aperture (53) and is turned downwards in vertical direction with respect to the supporting plate (6) at a specific angle, which is determined with respect to the position of the corresponding measuring module (1, 2, 3, 4) as mounted within the casing (5), namely with respect to the position of projectors (11, 21, 31, 41) and cameras (12, 22, 32, 42), which are available on the supporting frame (51), and that second and third mirrors (20, 30) are arranged in vertical planes above the supporting plate (6) and adjacent to it, and are moreover inclined with respect to the said longitudinal axis (60) of the supporting plate at a specific angle, which is determined with respect to the position of available projectors (11, 21, 31, 41) and cameras (12, 22, 32, 42) of the corresponding measuring modules (1, 2, 3, 4), and are furthermore extending away from the said aperture (53) of the casing (5).

6. Apparatus according to Claim 5, comprising four measuring modules (1, 2, 3, 4), each of them consists of a desired number of projectors (11, 21, 31, 41) and cameras (12, 22, 32, 42), which are fixed onto the supporting frame (51), where the first two measuring modules (1, 2) are mounted above the plane of at least partially translucent supporting plate (6), each of them on the one side of the longitudinal axis (60) of the said plate (6), while the third measuring module (3) is mounted above the said measuring modules (1, 2), namely at least approximately above the said longitudinal axis (60) of the supporting plate (6), while the fourth module is arranged below the said supporting plate (6), namely at least approximately below the pre-mentioned longitudinal axis (60) of the supporting plate (6) intended for placing the foot (7).

7. Apparatus according to Claims 5 and 6, characterized in that the first measuring module (1) consists of the projector (11), which is intended for directing of a desired number of light planes (B1, ..., B17, ..., B33, ...) towards the above the plane of the supporting plate (6) placed mirror (30), which serves for reflecting the said light planes (B1, ..., B17, ..., B33, ...) onto corresponding surface of the foot (7), which is placed onto the said supporting plate (6), as well as of the camera (12), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

8. Apparatus according to Claims 5 and 6, characterized in that the first measuring module (1) consists of the projector (11), which is intended for directing of a desired appropriate number of equidistant light planes (B1, ..., B17, ..., B33, ...) towards to the belonging mirror (30), which is arranged above the plane of the supporting plate (6) placed mirror (30) and serves for reflecting the said light planes (B1, ..., B17, ..., B33, ...) onto the corresponding surface of the foot (7), which is placed on the said supporting plate (6), as well as of the camera (12), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

9. Apparatus according to Claims 5 and 6, characterized in that the second measuring module (2) consists of the projector (21), which is intended for directing of

a desired number of light planes (B1, ..., B17, ..., B33, ...) towards the corresponding mirror (20), which is placed above the plane of the supporting plate (6) and used for reflecting the said light planes (B1, ..., B17, ..., B33, ...) onto corresponding surface of the foot (7), which is placed on the said supporting plate (6), as well as of the camera (22), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

10. Apparatus according to Claims 5 and 6, characterized in that the second measuring module (2) consists of the projector (21), which is intended for directing of a desired number of equidistant inclined light planes (B1, ..., B17, ..., B33, ...) towards the corresponding mirror (20), which is placed above the plane of the supporting plate (6) and used for reflecting the said light planes (B1, ..., B17, ..., B33, ...) onto corresponding surface of the foot (7), which is placed on the said supporting plate (6), as well as of the camera (22), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

11. Apparatus according to Claims 5 and 6, characterized in that the third measuring module (3) consists of the projector (31), which is intended for directing of a desired number of light planes (B1, ..., B17, ..., B33, ...) directly towards the belonging facing area on the surface of the foot (7), as well as of the camera (32), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

12. Apparatus according to Claims 5 and 6, characterized in that the third measuring module (3) consists of the projector (31), which is intended for directing of a desired number of equidistant light planes (B1, ..., B17, ..., B33, ...) directly towards the belonging facing area on the surface of the foot (7), as well as of the camera (32), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

13. Apparatus according to Claims 5 and 6, characterized in that the fourth measuring module (4) consists of the projector (41), which is intended for directing of a desired number of light planes (B1, ..., B17, ..., B33, ...) towards the corresponding mirror (10), which is arranged below the plane of the supporting plate (6) and serves for reflecting the said light planes (B1, ..., B17, ..., B33, ...) onto corresponding surface of the foot (7), which is placed on the said supporting plate (6), as well as from the camera (12), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

14. Apparatus according to Claims 5 and 6, characterized in that the fourth measuring module (4) consists of the projector (41), which is intended for directing of a desired number of equidistant light planes (B1, ..., B17, ..., B33, ...) towards the corresponding mirror (10), which is arranged below the plane of the supporting plate (6) and serves for reflecting the said light planes (B1, ..., B17, ..., B33, ...) onto corresponding surface of the foot (7), which is placed on the said supporting plate (6), as well as from the camera (12), which is arranged in such a way, that the surface of the foot (7), which is illuminated by the said light planes (B1, ..., B17, ..., B33, ...), is lying within the viewing area thereof.

15. Apparatus according to any of previous claims, characterized in that each measuring module (1, 2, 3, 4) is fixed on the supporting frame (51) of the casing (5) in such a manner, that at least the projector (11, 21, 31, 41) and each corresponding camera (12, 22, 32, 42) or more even more corresponding cameras (12, 22, 32, 42) may be fastened onto a bar (13), which is by means of appropriate fastening means (15) fixed on the appropriate holder (14).

16. Apparatus according to the Claim 15, characterized that after releasing the fastening means (15) of the bar (13) in the holder (14), the said bar (13) can be moved in its longitudinal direction and rotated around its longitudinal axis, while upon strengthening the said fastening means (14), the bar (13) is fixed in each desired position on the holder (14).

17. Apparatus according to any of Claims 1 to 15, characterized in that the number of projectors (11, 21, 31, 41) of measuring modules (1, 2, 3, 4) is equal to the number of cameras (12, 22, 32, 42).

18. Apparatus according to any of Claims 1 to 15, characterized in that the number of projectors (11, 21, 31, 41) of measuring modules (1, 2, 3, 4) is greater than the number of cameras (12, 22, 32, 42).

19. Apparatus according to any of the preceeding Claims, characterized in that, each projector (11, 21, 31, 41) enables generating more than ten light planes (B1, ..., B17, ..., B33, ...), which are formed by means of laser rays.

20. Apparatus according to any of the preceeding Claims, characterized in that each projector (11, 21, 31, 41) enables generating more than ten light planes (B1, ..., B17, ..., B33, ...), which are formed by means of laser rays and inclined each to another at equal angles.

21. Apparatus according to any of the preceeding Claims, characterized in that, each projector (11, 21, 31, 41) enables generating more than at least thirty, preferrably at least thirty-two, light planes (B1, ..., B17, ..., B33, ...), which are formed by means of laser rays.

22. Apparatus according to any of the preceeding Claims, characterized in that each projector (11, 21, 31, 41) enables generating more than at least thirty, preferrably at least thirty-two, light planes (B1, ..., B17, ..., B33, ...), which are formed by means of laser rays and inclined each to another at equal angles.

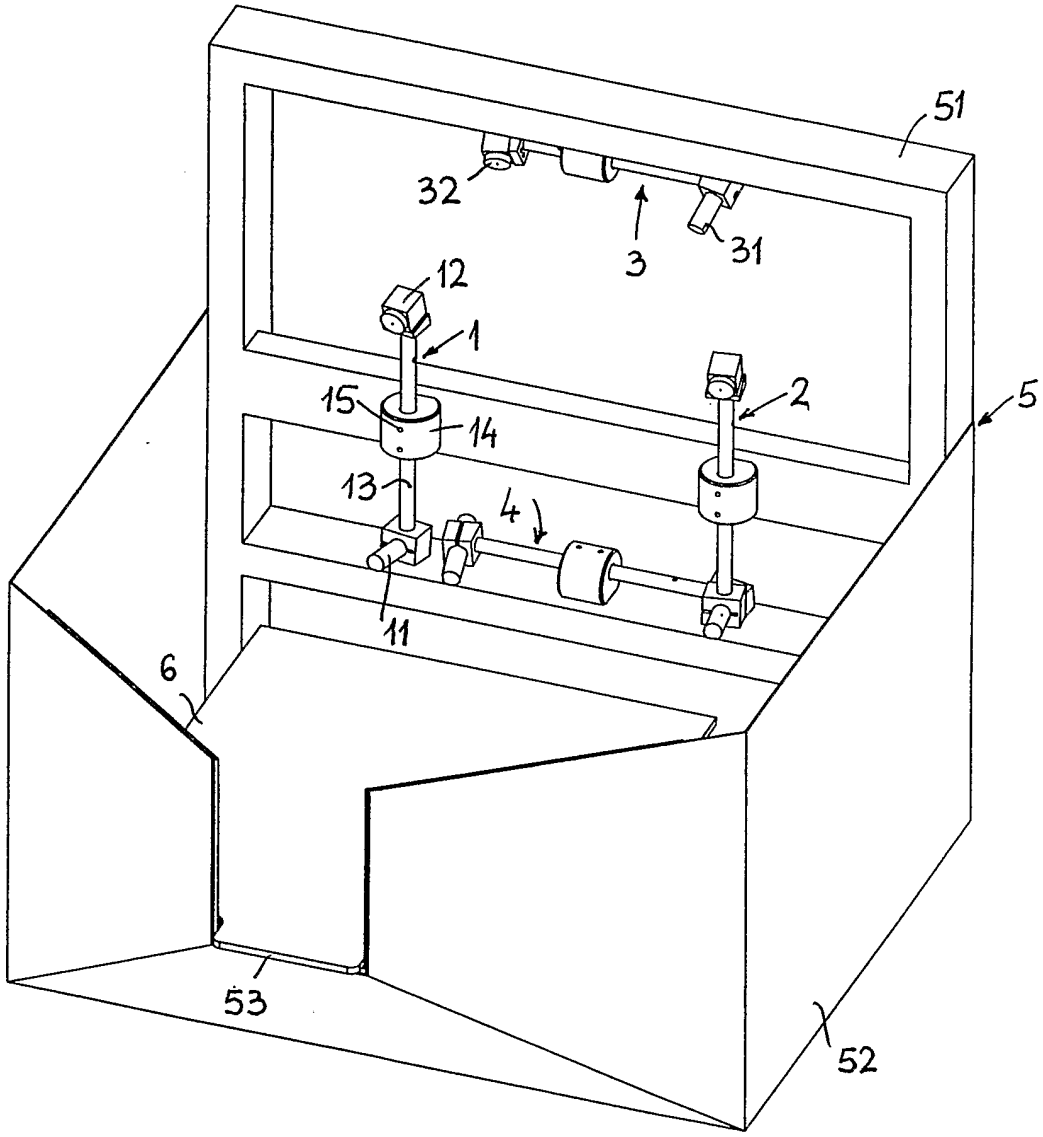


Fig. 1

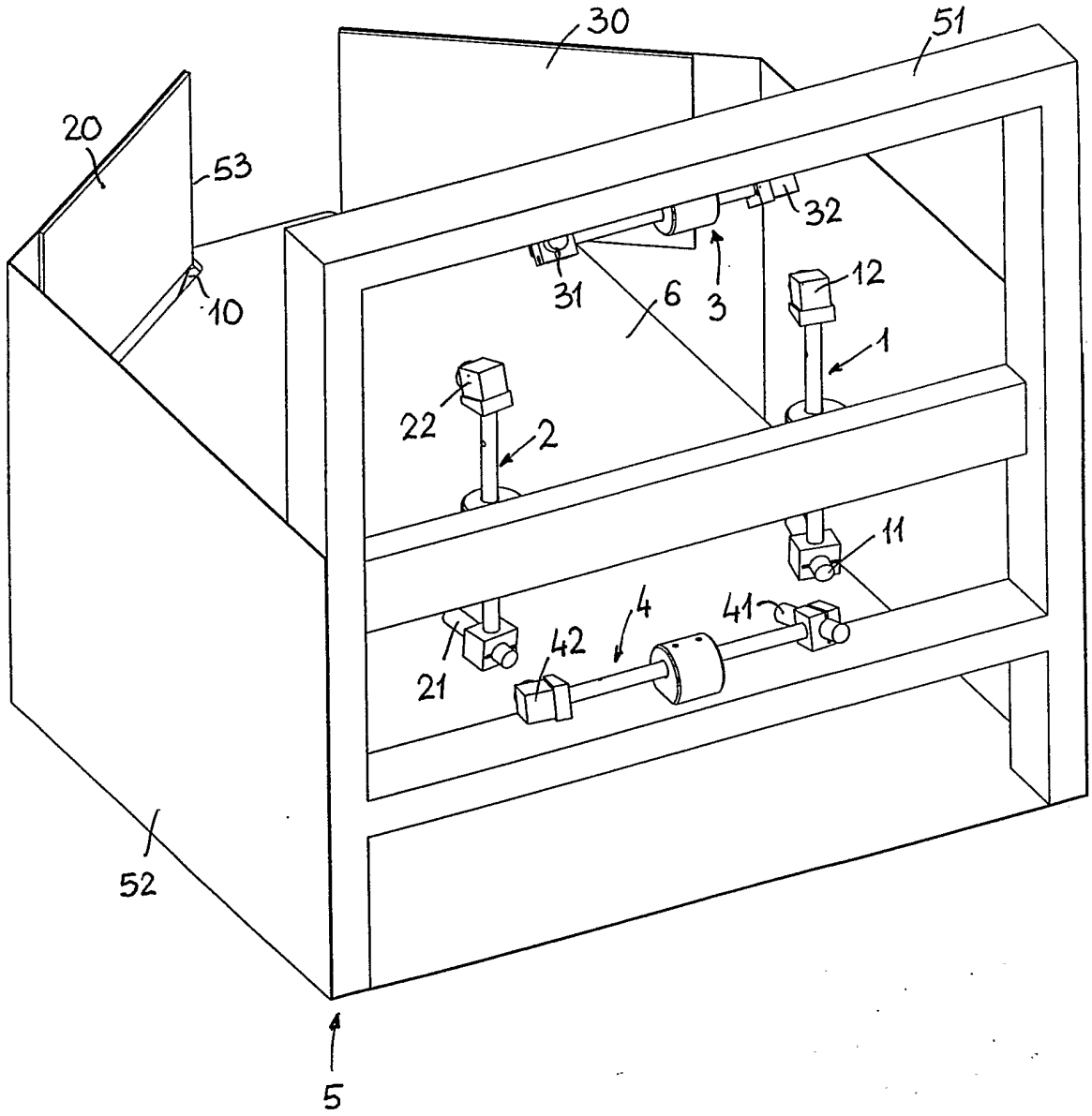


Fig. 2

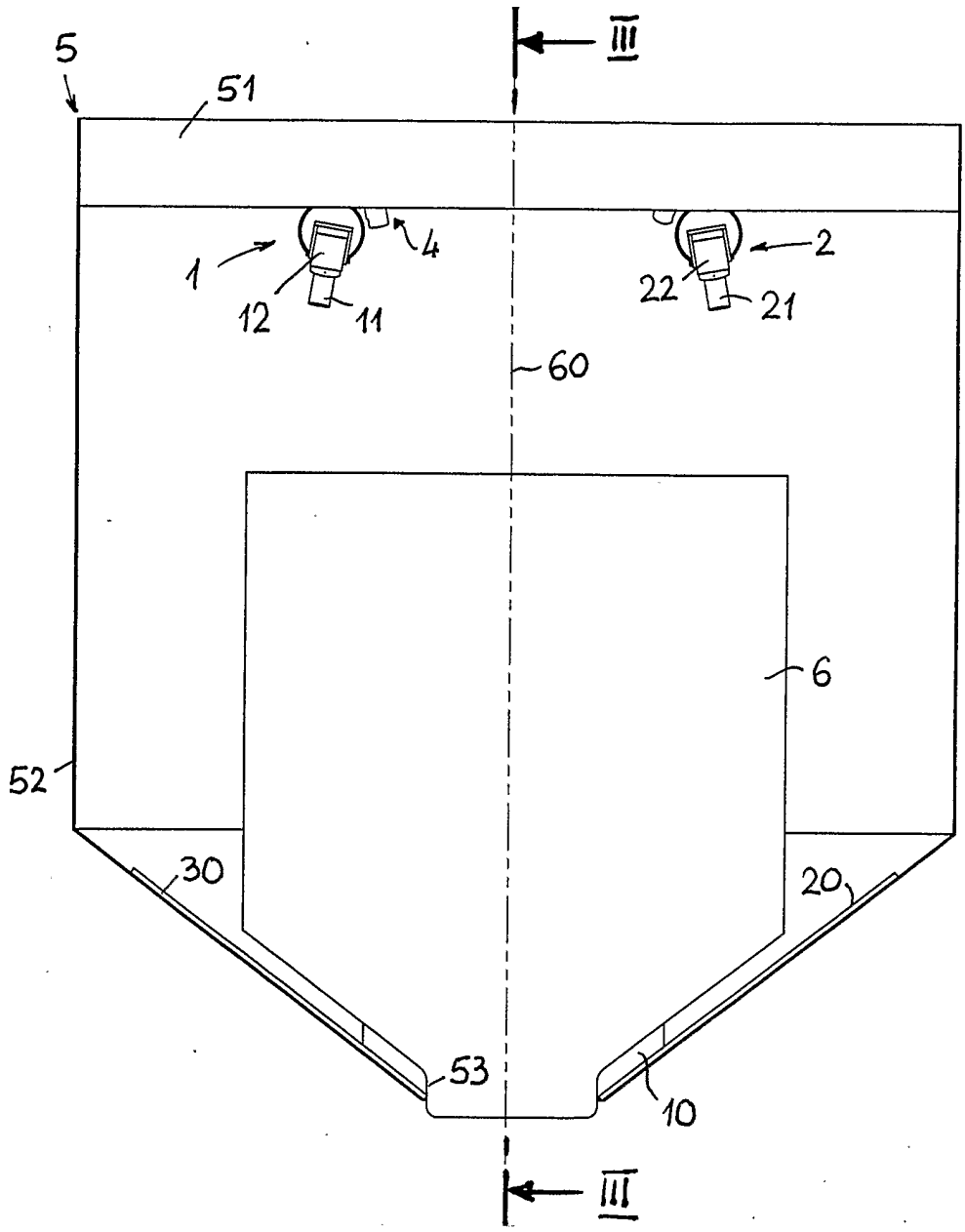


Fig. 3

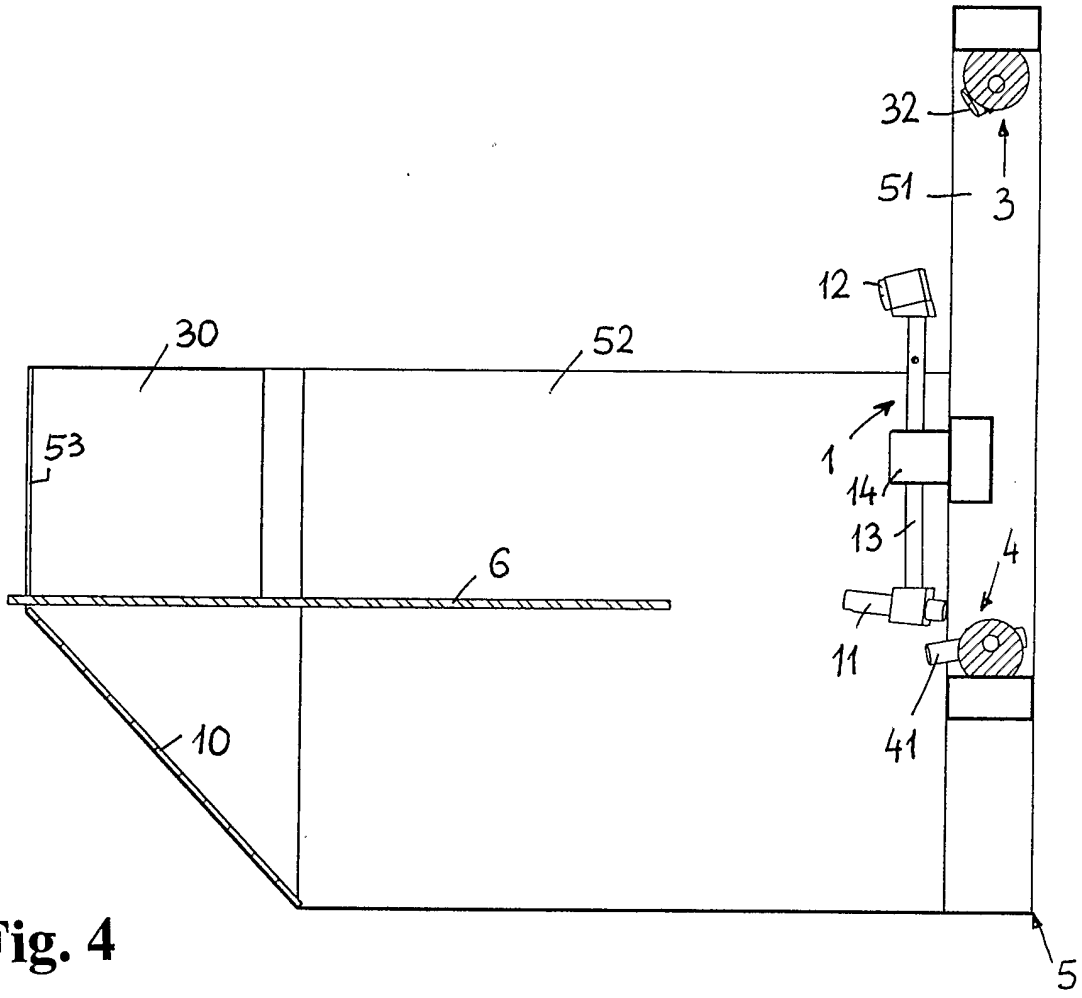


Fig. 4

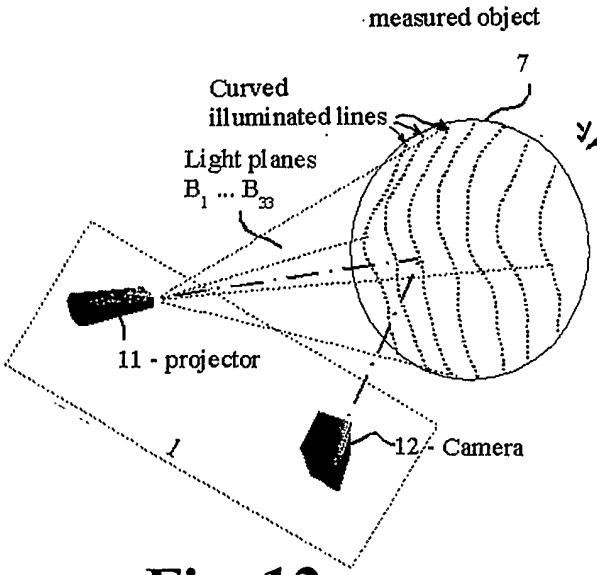


Fig. 12

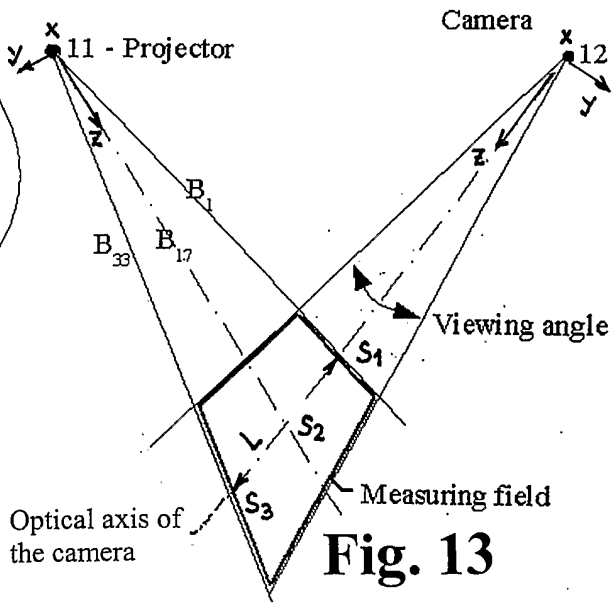


Fig. 13

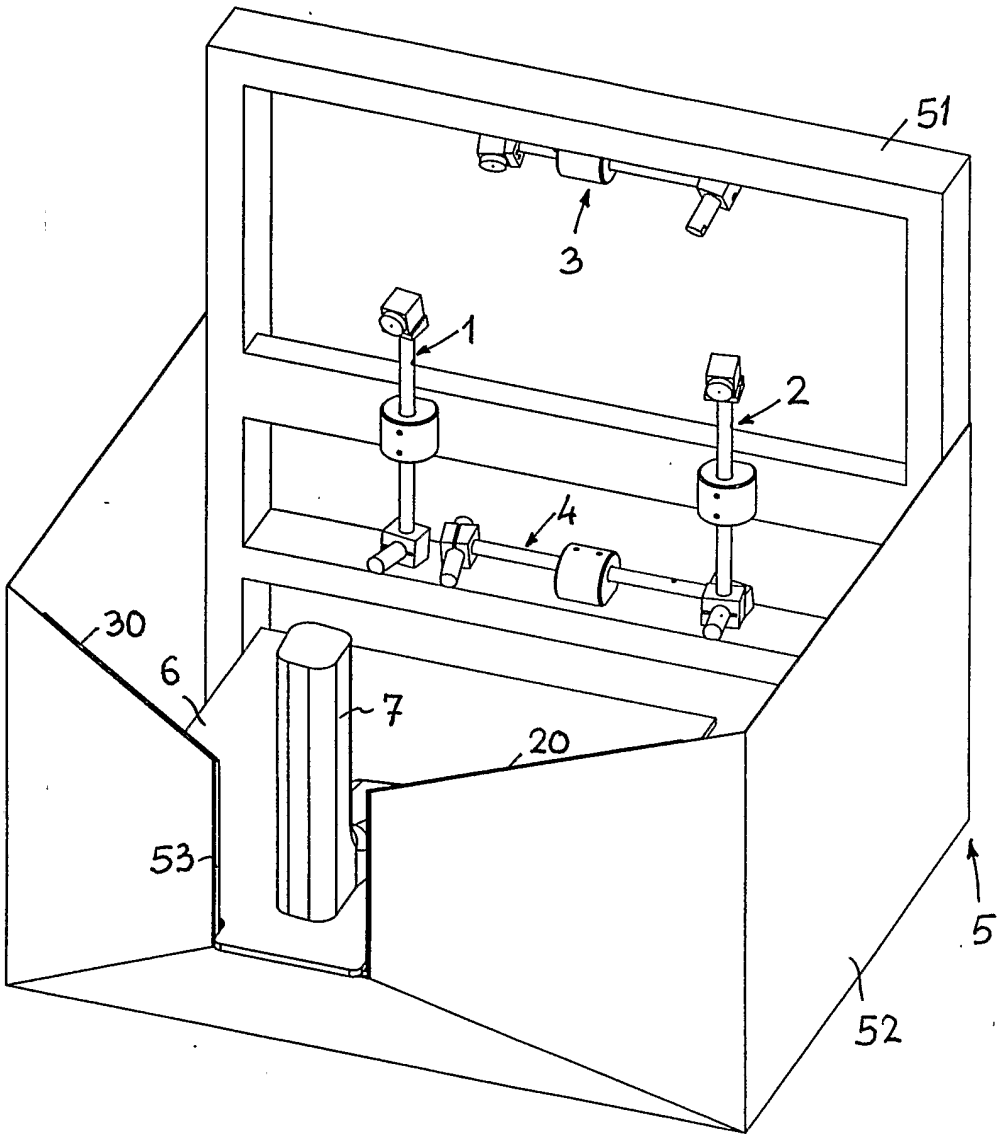


Fig. 5

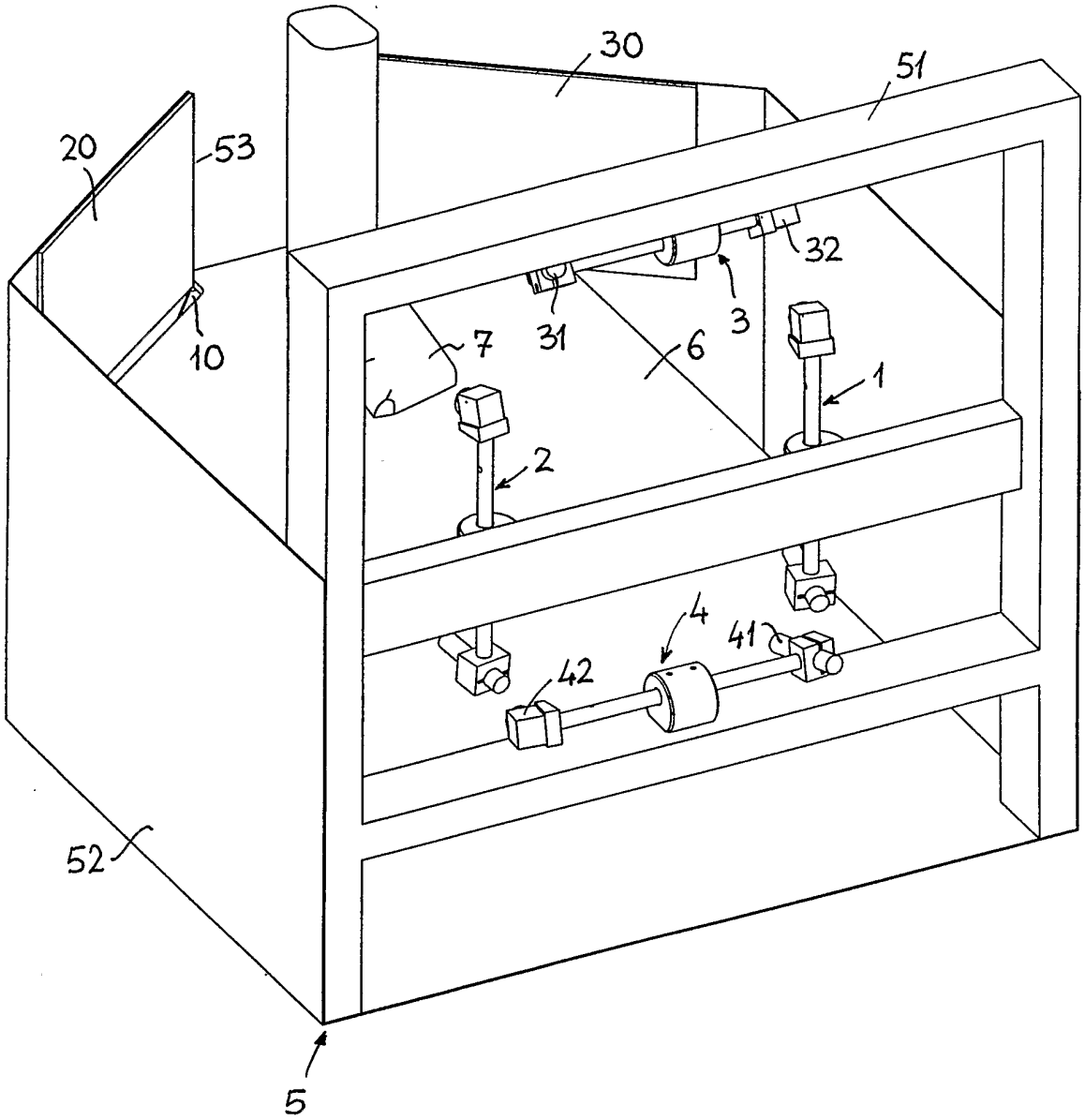


Fig. 6

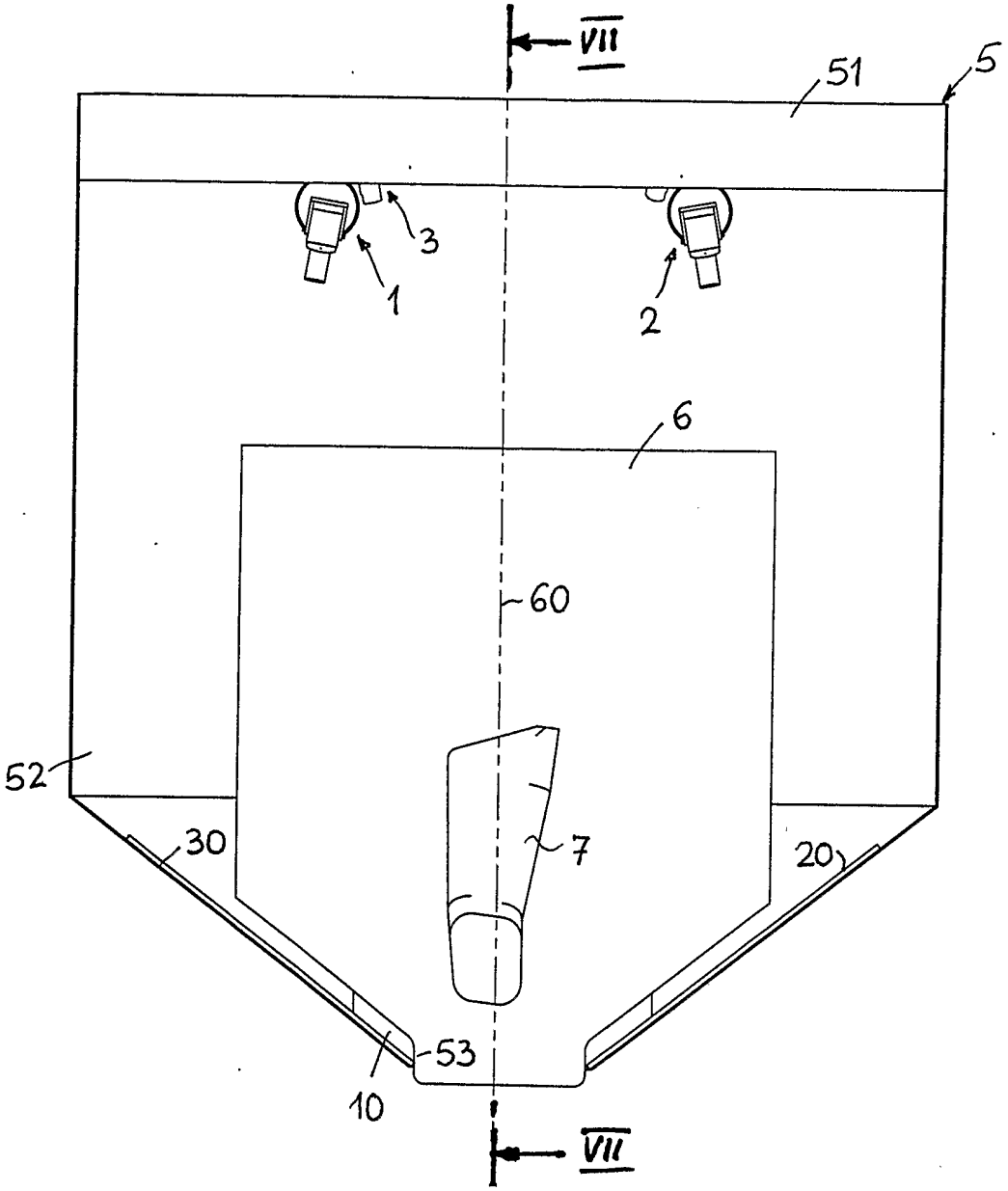


Fig. 7

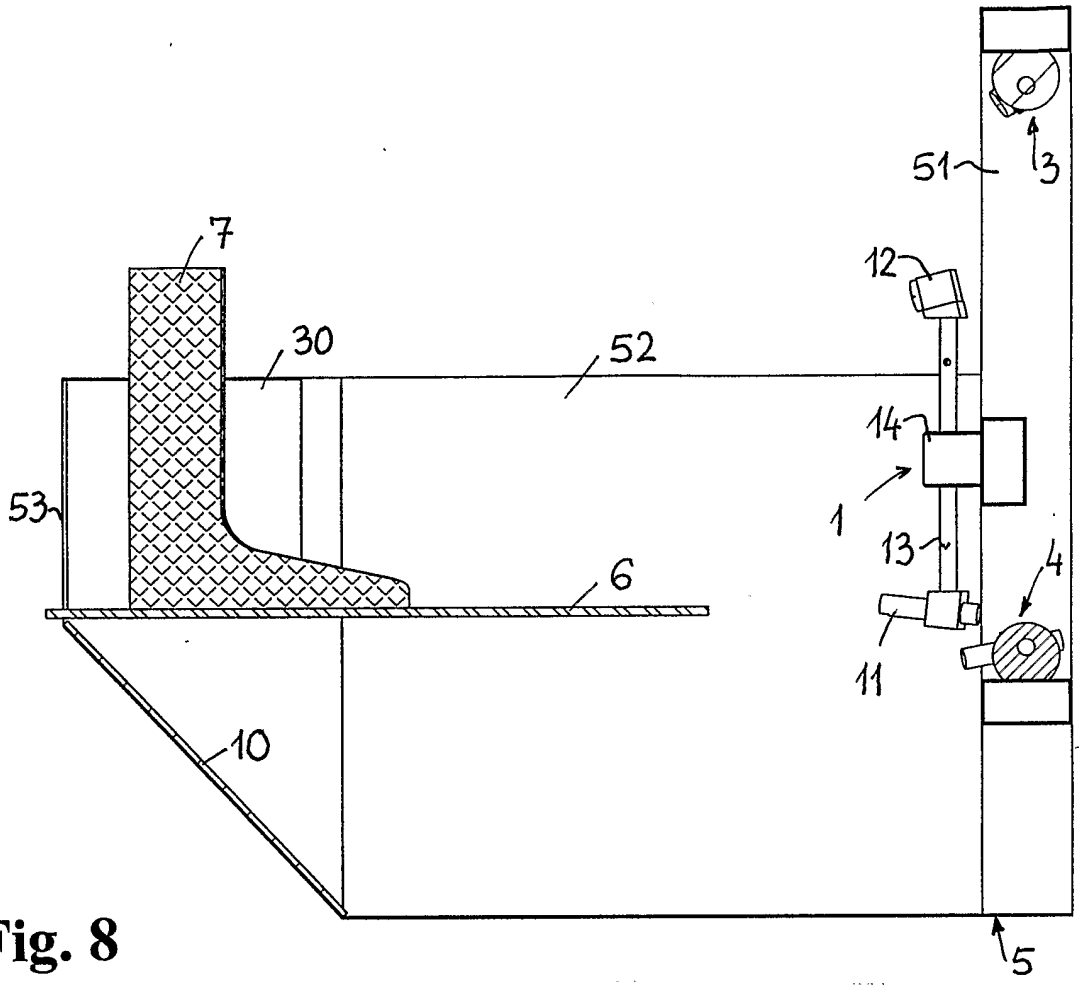


Fig. 8

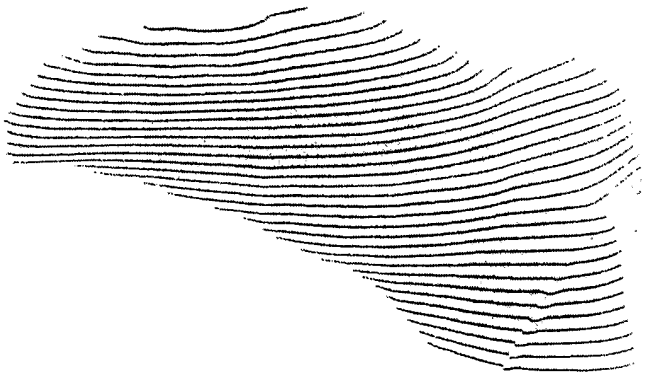


Fig. 14

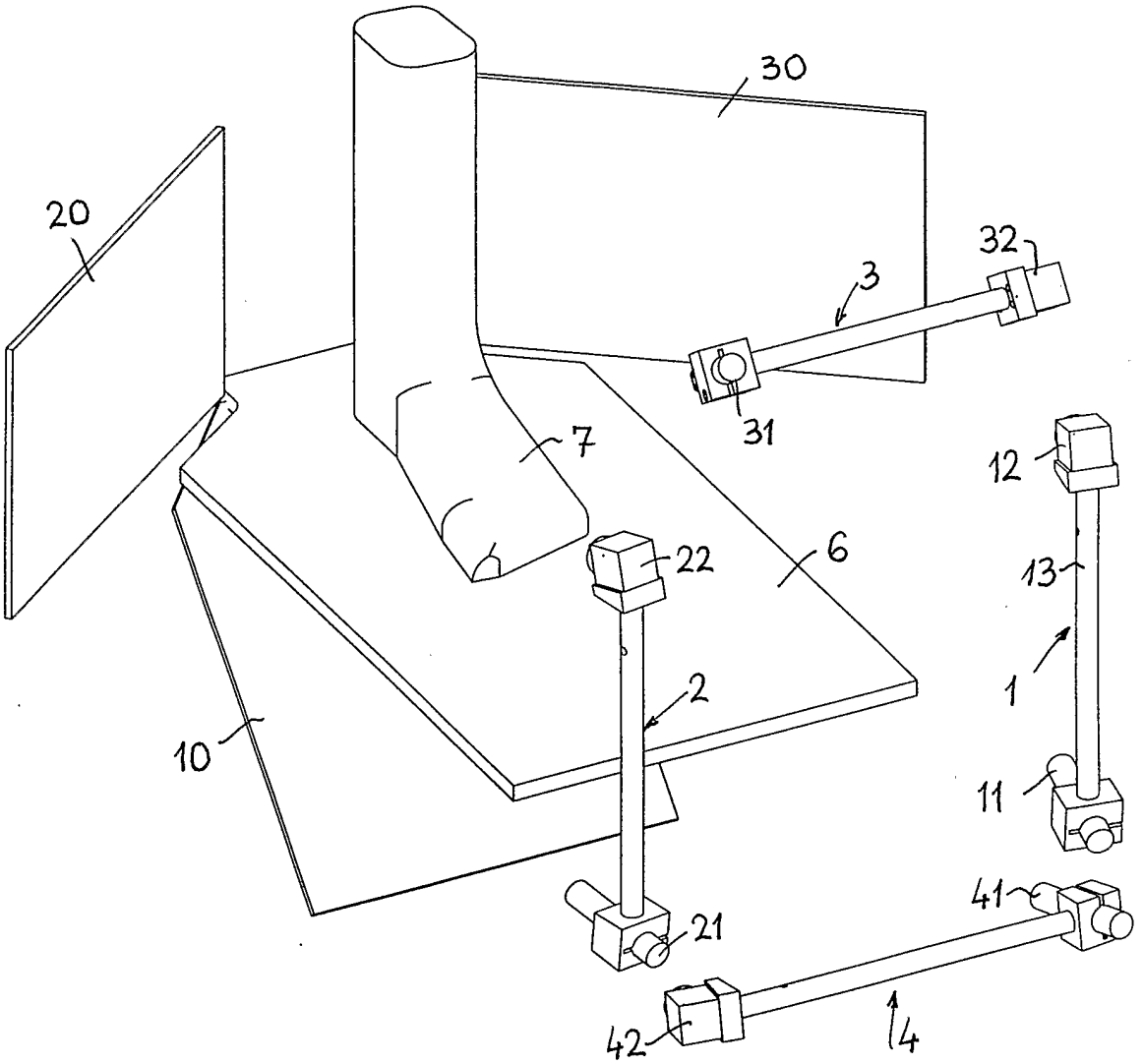


Fig. 9

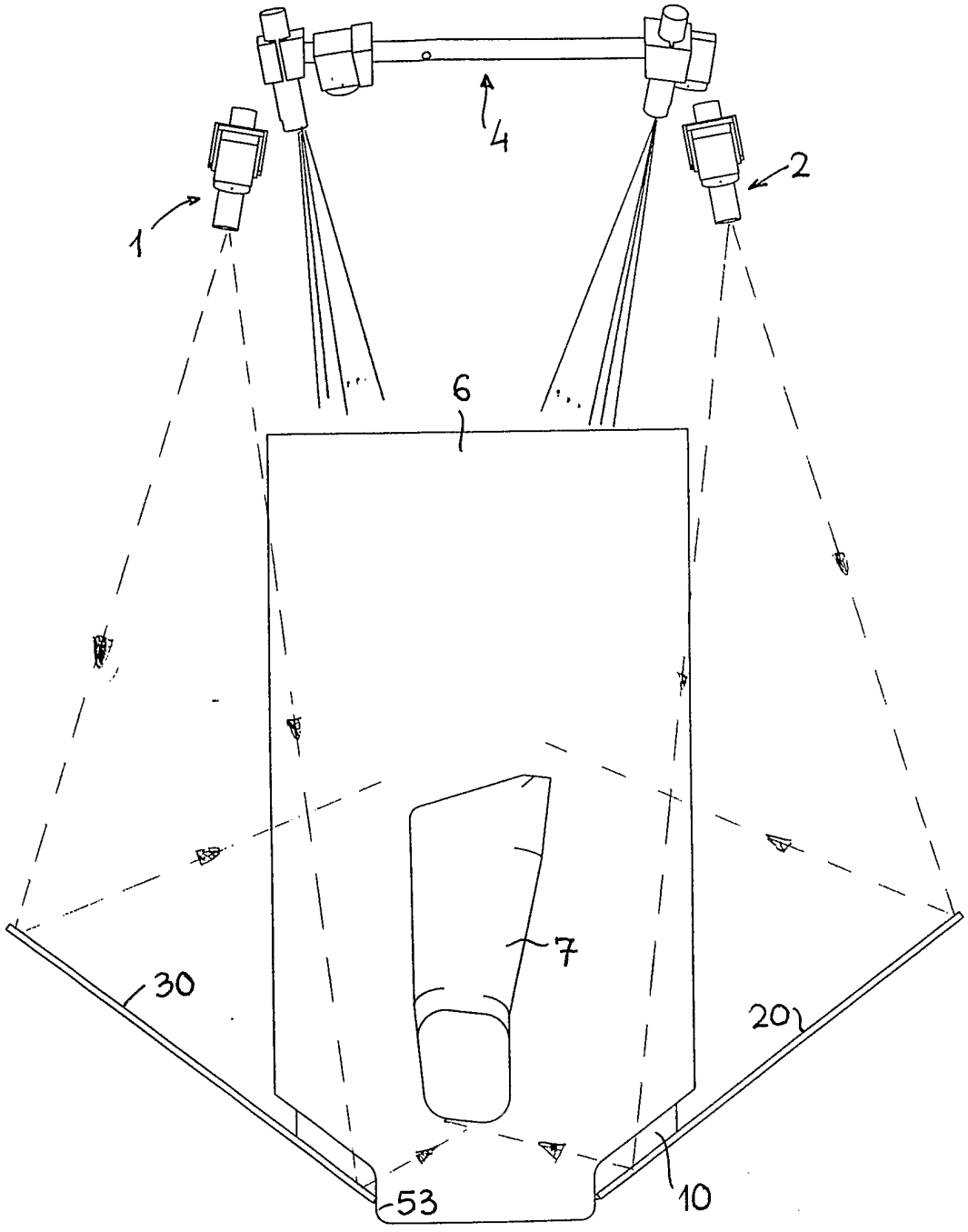


Fig. 10

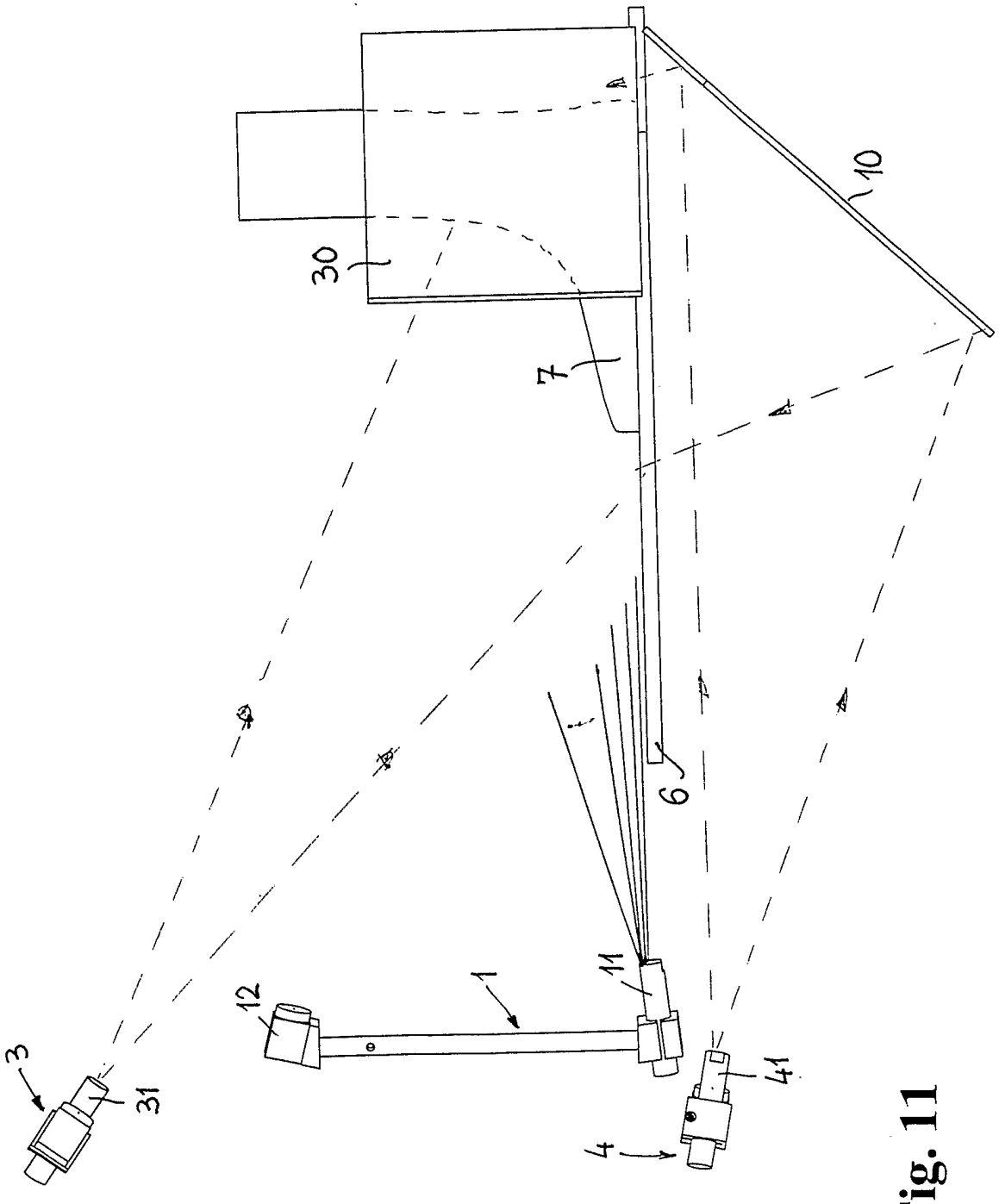


Fig. 11

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SI 03/00038

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B5/107

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B A43D G01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 753 931 A (BORCHERS ROBERT E ET AL) 19 May 1998 (1998-05-19) column 1, line 64 -column 2, line 5 column 3, line 1 -column 4, line 52 figures 1-3	1,2,4, 17-22
X	US 5 457 325 A (HUBERTY STEPHANE) 10 October 1995 (1995-10-10) column 2, line 36 -column 2, line 54 column 3, line 25 -column 4, line 11 figures 1-4	1,2, 15-22
A	US 5 025 476 A (GOULD NATHANIEL ET AL) 18 June 1991 (1991-06-18) figures 1,2	1-4,17
A	DE 196 34 254 A (VOLKSWAGENWERK AG) 6 March 1997 (1997-03-06)	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 March 2004	16/03/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lommel, A

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/SI 03/00038

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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