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(54) METHOD FOR ADJUSTING AN AUTOMATIC KNITTING MACHINE FOR PLATING KNITTING, AND CORRESPONDING SYSTEM

(57) Method and system for adjusting an automatic knitting machine for plating knitting comprising a plurality of movable needles (2) and yarn feeding means (3) with two guides (5a, 5b) for feeding two different yarns (4a, 4b) to a same operating needle (22). A digital camera captures image frames of an area including at least a portion of straight sections (6a, 6b) of the two yarns (4a, 4b) between the guides (5a, 5b) and the operating needle (22). An automatic image recognition is performed in the image frames to recognize the portions of the straight sections (6a, 6b), and directions of these straight sections (6a, 6b) are automatically derived. A relative position of the guides (5a, 5b) is adjusted in function of these directions.

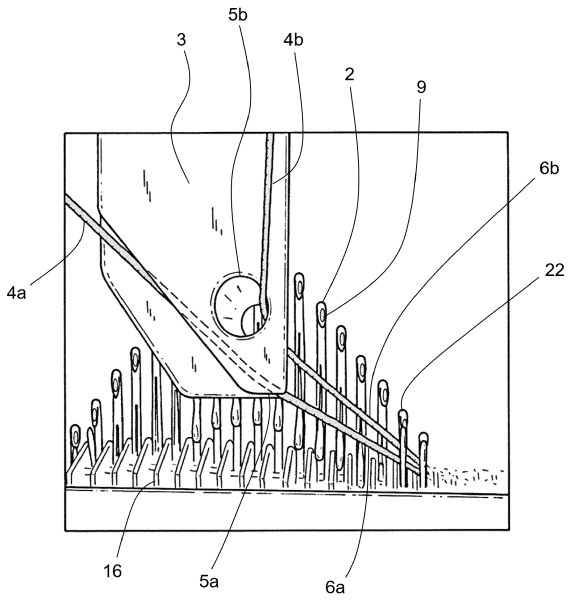

FIG. 4

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Description

Field of the invention

[0001] The invention is comprised in the field of automatic knitting machines for plating knitting.

[0002] The invention more specifically relates to a method for adjusting an automatic knitting machine for plating knitting, said automatic knitting machine (1) being of the type comprising:

> a plurality of movable needles;
> at least one yarn feeding means which feed a first yarn and a second yarn to a same operating needle, said operating needle being one of said movable needles which is catching both said first yarn and said second yarn at a certain instant, said yarn feeding means comprising a first guide for the first yarn and a second guide for the second yarn, said first yarn extending from said first guide to said operating needle along a first straight section in a first direction, and said second yarn extending from said second guide to said operating needle along a second straight section in a second direction different from said first direction,
> and an actuating device for automatically moving said needles according to a preestablished pattern for manufacturing a plated knitted fabric from said first and second yarns fed by said yarn feeding means.

[0003] The terms "plaiting" / "plaited" are also used in the textile industry with the same meaning as the terms "plating" / "plated" used in the present document.

[0004] A plated knitted fabric is a fabric with loops composed of two (or more) yarns of different type or colour, in which one of the yarns is prominent on a side of the fabric and another other yarn is prominent on the opposite side. In an automatic knitting machine for plating knitting, this is obtained by separately supplying each yarn through its own guide to a same needle, so that the two (or more) yarns are separately supplied to the needle in different positions. Depending on its position inside the hook of the needle, each yarn will come out on one side or the other of the knitted fabric.

Prior art

[0005] Defects on a plated knitted fabric occur when a yarn is on the wrong side of the fabric. The main cause is a wrong position of the guides which provide the yarns to the needle. The right position of the guides is not easy to establish, since it depends on several factors including the mechanical features of each yarn and the ranges of work tensions of said yarns. In practice, the method generally used for adjusting the position of the guides, in an automatic knitting machine for plating knitting, is a trial-and-error method based on the experience of a specialized worker. The worker starts the machine to produce a first section of fabric, stops the machine, visually inspects the section of fabric produced and, if he/she find any defect in plating, corrects the relative position of the yarn guides. Since this correction is based on empirical knowledge of the worker, several iterations of trial and error are usually necessary to achieve a good fit. When the process is finished, the fabric that has been produced is waste and must be discarded. On the other hand, it must be considered that a typical circular knitting machine for plating knitting, for example, can have up to 92 feeding means for feeding two (or more) yarns, each of them equipped with two (or more) yarn guides whose relative position must be adjusted with this method of trial and error. The adjustment procedure to ensure a quality plating is therefore slow and tedious, produces a considerable amount of waste fabric and, moreover, requires the intervention of an experienced worker.

[0006] WO2022158251A1 discloses a method for automatically adjusting a linear type knitting machine specifically adapted to make a fabric with inverse plating, in which the position of the two yarns is inverted in predetermined positions to obtain a pattern on both sides of the fabric. In this case, the specific purpose of the method is to accurately control the position of the inversion in the plated fabric. As in the previously mentioned state of the art, this is also a trial-and-error method based on inspecting the fabric that has been produced, but it is focused on controlling the position of the inversion in the plated fabric and it is automatically executed by a system based on artificial intelligence that uses a camera to inspect the plated fabric being produced. The system inspects with a camera the plated fabric being produced, determines the position of the inversion in the plated fabric and, if it is different from an expected position, adjusts a set of parameters that includes, among many other parameters, the relative positions of the yarn guides.

Description of the invention

[0007] The purpose of this invention is to provide a method for adjusting an automatic knitting machine for plating knitting of the type indicated above in the chapter "Field of the invention", which allows to make the adjustments in a more easy and more reliable manner and producing less waste or produces no waste at all.

[0008] This is achieved by means of a method for adjusting an automatic knitting machine for plating knitting of this type, characterised in that a digital camera is arranged to capture image frames of an area comprising at least one between at least a portion of the first straight section of the fist yarn and at least a portion of the second straight section of the second yarn;
and in that said method comprises the following steps:

> [a] obtaining from said digital camera image frames containing at least one between at least a portion of said first straight section and at least a portion of said

second straight section;

[b] performing an automatic image recognition in at least one of said image frames to recognise at least one between said portion of the first straight section and said portion of the second straight section;

[c] automatically deriving, from said automatic image recognition performed in step [b], at least one between the first direction of the first straight section and the second direction of the second straight section;

[d] adjusting at least one between a relative position of the first guide with respect to the operating needle and a relative position of the second guide with respect to said operating needle, respectively in function of said first direction or said second direction automatically derived in step [c].

Most commonly, automatic knitting machines for plating knitting are adapted to produce a plated fabric with two different yarns. In this case, each yarn feeding means have two guides that feed two different yarns (the first yarn and the second yarn) to a same operating needle. The invention is not limited to this configuration for two yarns. It also applies to automatic knitting machines for plating knitting adapted to produce a plated fabric with more than two different yarns (typically three yarns), in which each yarn feeding means have more than two guides which feed more than two yarns to a same operating needle. For instance, if there are three yarns and three guides, the area from which the digital camera takes image frames also contains a third straight section of the third yard, which is automatically recognised in step [b], a third direction of the third straight section is automatically derived in step [c], and in step [d] also a relative position of the third guide can be adjusted in function of said third direction.

[0009] In some knitting machines it can be feasible to install one digital camera for each feeding means. However, this would greatly burden space and would complicate access to the parts of the machine that must be accessible (the needles, the feeding means themselves, etc.). For this reason, in preferred embodiments there is a single digital camera, or a reduced number of digital cameras, which are moved from one feeding means to another to apply the method. For instance, the digital camera can easily be moved along a rail provided with this aim.

[0010] The first and second directions are preferably defined by means of the angle between each of these directions and a reference direction. The reference direction can be a fixed direction as, for instance, the horizontal direction. I can also be a direction related to a part of the knitting machine, preferably a direction related to the operating needle or a group of needles comprising the operating needle. For instance, as will be discussed later, it can be the direction of a local path followed by a group of needles including the operating needle.

[0011] The yarn feeding means can be a single piece in which the first guide and the second guide are formed, or they can be two independent devices each one respectively supporting the first guide and the second guide.

[0012] As will be seen below in the detailed description of the embodiments, the method according to the invention can be easily implemented by simply installing a digital camera in front of the area where the yarn feeding means feed the two or more yarns to the operating needle. Installing a camera in this position is generally not a problem. The camera can be attached to the knitting machine or an external frame. The main advantage of the invention is that it allows an automatic system or a worker, who is not necessarily a worker with experience in adjusting knitting machines for plating knitting, to make the adjustments by simply focusing on simple parameters which are automatically provided by the method. Indeed, in order to ensure a correct plating, it is enough to know the direction of the first straight section (first direction) and/or the direction of the second straight section (second direction), which are directly obtained thanks to the digital camera and the automatic recognition, and to correct these directions by adjusting the relative positions of the first guide and/or the second guide. The use of a digital camera and an automatic recognition software is very effective in this case because a straight yarn is particularly easy to capture in an image and can be automatically recognised and characterised with a very high reliability.

[0013] The method is more robust when the directions of both the first straight section and the second straight section are obtained and used to adjust the relative positions of the first and second guides. In preferred embodiments the digital camera is arranged to capture image frames of an area comprising both at least a portion of the first straight section and at least a portion of the second straight section; and:

in step [a], the image frames obtained from said digital camera contain both at least a portion of said first straight section and at least a portion of said second straight section;

in step [b], both at least a portion of the first straight section and at least a portion of the second straight section are recognised by the automatic image recognition;

in step [c], both the first direction and the second direction are automatically derived;

in step [d], the adjustment of at least one between a relative position of the first guide with respect to the operating needle and a relative position of the second guide with respect to said operating needle is carried out in function of both said first direction and said second direction automatically derived in step [c].

[0014] In preferred embodiments, the adjustment in step [d] is carried out in function of at least one, preferably

both, between a comparison of the first direction with a predefined target direction for the first direction and a comparison of the second direction with a predefined target direction for the second direction. These predefined target directions can be derived from a database or from a formula in function of parameters including, for instance, the type of yarn, the tension of the yarn, the type of needles, etc. A reliable database or formula can be obtained for a particular knitting machine from previous tests. When this is achieved, there is no need to inspect the fabric and therefore the method can be carried out with the knitting machine stopped, or by running the knitting machine during a very short time, so that no waste or very little waste is produced. The predefined target directions for the first and second directions can also be the first and second directions derived by carrying out steps [a] to [c] of the method when the automatic knitting machine is well adjusted, and the first and second directions are known to be the optimum for obtaining a proper plating.

[0015] In some embodiments the adjustment in step [d] is carried out automatically.

[0016] In other embodiments, between steps [c] and [d], instructions on the adjustment are automatically generated and prompted at a screen, and in step [d], said adjustment is carried out manually by a worker.

[0017] In some embodiments, a hologram projector is arranged to project holograms in the area (the area from which the digital camera takes image frames), and between steps [c] and [d], said hologram projector projects in said area at least one between a hologram of a first straight line in a predefined target direction for said first direction and a hologram of a second straight line in a predefined target direction for said second direction. As discussed above, these predefined target directions can be obtained from a database or from a formula, or they can be the first and second directions derived from carrying out steps [a] to [c] of the method when the automatic knitting machine is known to be well adjusted for a proper plating. The function of these holograms is to be a visual reference for the worker when he/she is manually making the adjustments of step [d]. The worker can make adjustments on the relative position of the first guide and/or the second guide until the first straight section and/or the second straight section respectively matches the hologram of the first or the second straight line.

[0018] In preferred embodiments, the automatic knitting machine is configured so that, when it is working, the needles circulate one after the other along a path, the digital camera is arranged so that the area, of which the digital camera captures image frames, comprises a group of said needles, including the operating needle, circulating one after the other along a local path in said area; and:

step [b] comprises performing an automatic image recognition in at least one of said image frames to recognize at least a portion of said local path adjacent to said operating needle and upstream said operating needle (the term "upstream" is relative to the direction of movement of the needles);

step [c] comprises automatically deriving a slope of said portion of the local path, said slope defining a third direction;

and in step [c] at least one between the angle between the first direction and said third direction, and the angle between the second direction and said third direction is automatically derived from the automatic image recognition performed in step [b].

[0019] Making the adjustment in function of these angles is particularly effective: a proper plating without defects can be ensured with high reliability.

[0020] Preferably, the portion of the local path, as seen by the digital camera, is a straight line, so that the third direction is the direction of said straight line. For instance, as will be shown later in the detailed description of the embodiments, for a circular knitting machine the digital camera can be positioned so that it focuses on a group of needles which, as seen by said digital camera, circulate along a straight line. This makes the method even more robust, since a straight line can be automatically recognised and characterized with better reliability.

[0021] In some embodiments, the image frames are captured by said digital camera while said needles are circulating one after the other along the path, and in step [b] said automatic image recognition is carried out in a superposition of a plurality of said image frames which are consecutive in time, and a continuous line along the portion of the local path is formed in said superposition by a section of at least some of the needles circulating along said portion of the local path, and in step [b] the automatic recognition of the portion of the local path is made by automatically recognising said continuous line. In these embodiments, the knitting machine must be working while the image frames are captured. However, since there is no need to inspect the produced fabric, the time the knitted machine must be running can be very short. Optionally, the adjustment in step [d] can be done automatically. In this case, the method could be continuously applied while the knitting machine ins running.

[0022] Preferably, the continuous line is formed by spots in said image frames, each of said spots corresponding to a reflexion of light in said section of each needle. A continuous line generated in this manner by moving spots can be automatically recognised and characterised with even higher reliability.

[0023] I other embodiments, in step [b] the automatic image recognition is carried out in one of the image frames, and a pattern jointly defined by sections of at least some of the needles is automatically recognised and said portion of the local path is automatically identified as a line passing said sections.

[0024] Preferably, the pattern comprises a plurality of spots in the image frame, each of said spots corresponding to a reflexion of light in the section of each needle.

This provides a particularly fast and easy way for determining the pattern, since a set of spots is easily recognizable by software. This solution is particularly suitable for the needles of a knitting machine, because said needles are usually metallic, with a surface that reflects light well, and have various curved parts that can generate a spot of reflected light in the image frame. In addition, the method according to this solution can be easily transferred from one knitting machine to another with just a few adjustments, because even if the shape of the needles is not the same, the pattern of a group of spots created by equivalent parts of the needles can be very similar.

[0025] Preferably, said section of the needles is a free end of the needle. This is the section of the needle which is more accessible for capturing an image and which usually forms a hook, so that it creates a good contrast in the image frame.

[0026] Preferably, a controlled lighting is focused on the area of which the digital camera captures image frames, so that the images to be recognised does not depend on the ambient light present in the place where the machine is located.

[0027] Although the method according to the invention can be applied to a variety of automatic knitting machines, in preferred embodiments the automatic knitting machine is a circular knitting machine in which the needles are arranged in a rotating cylinder which make said needles to travel along a circumference which is coaxial with said rotating cylinder. The digital camera 7 is statically arranged, so that it does not rotate with said rotating cylinder, and the area, of which said digital camera captures image frames, includes a portion of said circumference.

[0028] The invention also comprises a corresponding system for adjusting an automatic knitting machine for plating knitting, comprising an automatic knitting machine for plating knitting with: a plurality of movable needles;

at least one yarn feeding means which feed a first yarn and a second yarn to a same operating needle, said operating needle being one of said movable needles which is catching both said first yarn and said second yarn at a certain instant, said yarn feeding means comprising a first guide for the first yarn and a second guide for the second yarn, said first yarn extending from said first guide to said operating needle along a first straight section in a first direction, and said second yarn extending from said second guide to said operating needle along a second straight section in a second direction different from said first direction,

and an actuating device for automatically moving said needles according to a preestablished pattern for manufacturing a plated knitted fabric from said first and second yarns fed by said yarn feeding means;

characterised in that it further comprises:

- a digital camera arranged to capture image frames of an area comprising at least one between at least a portion of said first straight section and at least a portion of said second straight section;
- a processor connected to said digital camera;
- a computer program comprising instructions which, when executed by said processor, cause said processor to carry out the following steps:

  [a] obtaining from said digital camera image frames containing at least one between at least a portion of said first straight section and at least a portion of said second straight section;

  [b] performing an automatic image recognition in at least one of said image frames to recognise at least one between said portion of the first straight section and said portion of the second straight section;

  [c] automatically deriving, from said automatic image recognition performed in step [b], at least one between said first direction of the first straight section and said second direction of the second straight section;

  [d] adjusting at least one between a relative position of said first guide with respect to said operating needle and a relative position of said second guide with respect to said operating needle, respectively in function of said first direction or said second direction automatically derived in step [c]; or providing instructions or guidance based on said first direction or said second direction for carrying out said adjustment.

[0029] The system optionally has the structural features according to the preferred embodiments discussed above for the method, and the computer program optionally comprises instructions to carry out the steps of the method according to said preferred embodiments.

[0030] The invention also comprises the computer program defined above in the description of the system.

[0031] The invention also comprises other features concerning details illustrated in the detailed description of embodiments of the invention and in the attached drawings.

[0032] The invention also comprises other features concerning details illustrated in the detailed description of embodiments of the invention and in the attached drawings.

Brief description of the drawings

[0033] The advantages and features of the invention can be seen from the following description in which, with a non-limiting character with respect to the scope of the main claim, preferred embodiments are described in ref-

erence to the drawings.

Fig. 1 is a schematic view of a system according to the invention. The automatic knitting machine is circular, of the kind with one set of vertical needles and one set of sinkers.

Fig. 2 is a view of the upper part of a needle, with the latch in open position.

Fig. 3 is a view of the same upper part of the needle, with the latch in closed position.

Fig. 4 is a view of the area of which the digital camera captures image frames, seen from the digital camera.

Fig. 5 is an image frame of the area of Fig. 4 taken by the digital camera.

Fig. 6 is a schematic view of treated image using for the automatic image recognition, according to a first embodiment.

Fig. 7 is a real picture of the treated image of Fig. 6.

Fig. 8 is a partial zoom of the image of Fig. 7.

Fig. 9 show the directions and the angles derived from Fig. 8.

Fig. 10 is a partial enlarged view of Fig. 4.

Fig. 11 is a schematic view of processed image used for the automatic image recognition, according to a second embodiment, and corresponding to the enlarged area shown in Fig. 10.

Fig. 12 show the directions and the angles derived from Fig. 11.

Fig. 13 is a block diagram of the main steps of the method according to the invention.

Detailed description of embodiments of the invention

[0034] Figs. 1-9 refer to a first embodiment of a system and a method according to the invention. Figs. 10-12 refer to a second embodiment, which only differs from the first embodiment in how some steps of the method are carried out. The automatic knitting machine 1 for plating knitting is the same for both embodiments. It is a circular knitting machine of the type having a set of vertical needles 2 and a set of sinkers 16 for manufacturing a plated knitted fabric 17.

[0035] Fig. 1 is a schematic view of the system, in which the automatic knitting machine 1 for plating knitting is represented in a schematic sectional view. The system comprises the automatic knitting machine 1, a digital camera 7, a controlled lighting 10 and a computer system including a processor 12 which is connected to the digital camera 7. A computer program, including a software for automatic image recognition, is executed by the processor 12.

[0036] The automatic knitting machine 1 comprises a plurality of yarn feeding means 3, a plurality of movable needles 2, each of said needles 2 being adapted to subsequently catch and free two yarns 4a, 4b provided by one of the yarn feeding means 3 when the needle 2 is moved, and an actuating device for automatically moving the needles 2 according to a preestablished pattern for manufacturing a plated knitted fabric from the two yarns 4a, 4a provided by the yarn feeding means 3.

[0037] Each yarn feeding means 3 feed a first yarn 4a and a second yarn 4b to a same operating needle 22. The term "operating needle" refers to one of the movable needles 2 which is catching both the first yarn 4a and the second yarn 4b at a certain instant. In the embodiments described here, as shown in Fig. 4, each yarn feeding means 3 is a one-piece arm comprising a first guide 5a for the first yarn 4a and a second guide 5b for the second yarn 4b. The first guide 5a is a hole in the arm, through which the first yarn 4a passes. The second guide 5b is a groove formed at a lower end of the arm, which guides the second yarn 4b. Other embodiments are possible in which the feeding means 3 is composed by two independent pieces, each respectively comprising the first guide 5a and the second guide 5b. As can be seen in Fig. 4, the first yarn 4a extends from the first guide 5a to the operating needle 22 along a first straight section 6a in a first direction D1. The second yarn 4b extends from the second guide 5b to the operating needle 22 along a second straight section 6b in a second direction D2, which is different from said first direction D1. Each yarn feeding means 3 receives the two yarns 4a, 4b from yarn spools 15a, 15b.

[0038] Both the method and the system have been tested with an automatic circular knitting machine for plating knitting, namely a model of CANMARTEX-JUMBER-CA brand having 1728 needles, a diameter of 30 inches, and an 18 gauge (number of needles per inch). The needles 2 are arranged in a rotating cylinder 11, so that they travel along a path which is a circumference coaxial with the rotating cylinder 11. The needles 2 interact with cams which are statically arranged in a dial around the rotating cylinder 11, and which make each needle 2 to move vertically up and down forming stitches with two yarns 4a, 4b while the cylinder 11 rotates continuously. The rotating cylinder 11, actuated by a motor, and the static cams are the actuating device referred to above for automatically moving the needles 2. Since the cams are static, each needle 2 travelling along the circumference has a unique position at each point of said circumference. The sinkers 16 are arranged between the needles 2 and move horizontally as the machine knits.

[0039] The needles 2 are all identical. They are latch

needles as schematically shown in Figs. 2 and 3. Each needle 2 has a free top end forming a hook 13 and a pivoting latch 14 which is pushed by the yarn 4a, 4b of the knit loop as the needle 2 moves up and down, so that the latch 14 subsequently closes and open the hook 13. The hook 13 is adapted to subsequently catch and free the two yarns 4a, 4b when the needle 2 is moved. Figs. 2 and 3 respectively show the needle 2 with the latch 14 in an open and a closed position. The operation of this type of circular knitting machine with needles and sinkers, as well as the movements of the latch needles to form the knit loops, are not described in greater detail here since they are well known to those skilled in the art.

[0040] The digital camera 7 is statically arranged, so that it does not rotate with the rotating cylinder 11. It is arranged to capture image frames of an area comprising a portion of the first straight section 6a, a portion the second straight section 6b and a group of needles 2, including the operating needle 22. Fig. 4 is a drawing of this area as seen in an image frame taken by the digital camera 7. Fig. 5 is the image frame of the area of Fig. 4 taken by the digital camera 7. The area is a portion of the circumference along which the needles 2 travel. Since this portion is a small sector of the circumference and the digital camera 7 is focused perpendicular to the axis of the circumference, in the digital frames taken by the digital camera 7 the needles appear to circulate one after the other along a local path 8, as schematically shown in Fig. 6, which is essentially a straight line in a third direction D3.

[0041] The lighting 10 is a lamp statically arranged so that the light it emits focuses on the area. The relative position of the lamp with respect to the digital camera 7 and the intensity of the light emitted by said lamp are adjusted so that a suitable reflexion of light on the needles 2 and also on the first straight section 6a and the second straight section 6a of the two yarns 4a, 4b is obtained, allowing to identify patterns in processed image frames 5 as will be discussed below. In the exemplary embodiment depicted in the figures, the digital camera 7 and the lighting 10 are fixed to a support, on an outer side with respect to a virtual cylinder that axially extends the rotating cylinder 11. The support can optionally be a circular lane along which the digital camera 7 can be moved from one area to another, each of these areas corresponding to a group of needles 2 fed by one of the yarn feeding means 3. In other possible embodiments, the digital camera 7 can also be a handheld portable camera, for instance a handheld scanner. The digital camera 7 and/or the lighting 10 can also be arranged in different positions. For instance, they can be arranged on an inner side with respect to said virtual cylinder.

[0042] The digital camera 7 used in the tests described below is a video digital camera model TIS-DMK-33UX264 commercialized by the German firm The Imaging Source Europe GmbH. It is equipped with a Sony IMX264 sensor and has a 2448x2048 pixels resolution and a 35 PFS (frames per second) (FPS) video capture. The sensor operates with a Global Shutter CMOS image capture method, allowing to collect all the data at the same time without a lag due to the shutter.

[0043] The method according to the invention comprises the following main steps, which are automatically carried out by the computer program executed by the processor 12:

[a] obtaining from the digital camera 7 image frames of the area described above in reference to Figs. 4 and 5, containing a portion of the first straight section 6a, a portion of the second straight section 6b, and a group of needles 2, including the operating needle 22;

[b] performing an automatic image recognition in at least one of said image frames to recognise the portion of the first straight section 6a, the portion of the second straight section 6b and a portion of the local path 8 of the needles 2 adjacent to the operating needle 22 and upstream said operating needle 22;

[c] automatically deriving, from the automatic image recognition performed in step [b], the first direction D1 of the first straight section 6a, the second direction D2 of the second straight section 6b and the third direction D3 of the straight line local path 8. The angle A1 between the first direction D1 and the third direction D3 and the angle between the second direction D2 and the third direction D3 are also automatically derived.

[0044] A final step [d] of the method, which can be carried out manually or automatically, consists in adjusting the relative position of the first guide 5a with respect to the operating needle 22 and/or the relative position of the second guide 5b with respect to said operating needle 22, respectively in function of the first direction D1 and/or the second direction D2 automatically derived in step [c]. The adjustment is preferably made in function of the angle A1 and/or the angle A2.

[0045] In the embodiment shown in Figs. 6-9, the image frames are captured by the digital camera 7 while the automatic knitting machine 1 is working and the needles 2 are circulating one after the other along the path. In step [b] the automatic image recognition is carried out in a superposition of a plurality of said image frames which are consecutive in time. This superposition can be the sum of a series of image frames taken by the digital camera 7 or, equivalently, it can also be an overexposed image taken by the digital camera 7. Since the needles 2 are circulating along the straight line local path 8, a continuous straight line 18 along the portion of the local path 8 is formed in said superposition. More concretely, in the embodiment shown in Figs. 6-9, the line 18 is formed by spots 9 in the image frames, each spot 9 corresponding to a reflexion of light in a free end of each needle 2. These spots 9 are shown in Figs. 4 and 5. They circulate along the straight line local path 8 and thus form the line 18 in the superposition, as shown in Figs. 6 and

7. In step [b], the automatic recognition of the portion of the local path 8 is made by automatically recognising the continuous line 18 in the superposition. The computer program analyses a partial enlarged view of the superposition as shown in Fig. 8, recognises the portion of the first straight section 6a (the lower line in Fig. 8), the portion of the second straight section 6b (the intermediate line in Fig. 8) and the portion of the straight line local path 8 (the upper line in Fig. 8), and derives from this recognition the three directions D1, D2, D3 and the two angles A1, A2 as shown in Fig. 9.

[0046] The two angles A1, A2 are automatically compared with predefined values. If a significant difference is found, the relative positions of the first guide 5a and the second guide 5b are adjusted. This can be done by adjusting the position of the arm comprising the two guides 5a, 5b, or by adjusting the position of the needles 2, so that the angles A1, A2 match with the predefined values. If the automatic knitting machine 1 comprises means to move the arm or the needles 2 in a controlled way, the adjustments in step [d] can be done automatically and can be controlled by the computer program. In most cases, however, the machine 1 does not have these means and the adjustments in step [d] are done manually by a worker. Instructions on the adjustments to be done can be automatically generated by the computer program and prompted at a screen, so that the worker can follow these instructions to make the adjustments in step [d]. These instructions can contain, for instance, a value of the vertical distance the arm must be moved along.

[0047] Another possibility (not shown in the figures) for assisting the worker in the adjustments consists in using a hologram projector arranged to project holograms in the area. Between steps [c] and [d], the computer program automatically makes the hologram projector to project in said area a hologram of a first straight line in a predefined target direction for the first direction D1 and a hologram of a second straight line in a predefined target direction for the second direction D2. These predefined target directions are preferably the first and second directions D1, D2 initially derived from carrying out steps [a] to [c] of the method when the automatic knitting machine is known to be well adjusted for a proper plating.

[0048] The embodiment shown in Figs. 10-12 can be carried out while the automatic knitting machine 1 is working or when it is stopped. It differs from the previously discussed embodiment in that, in step [b], the automatic image recognition is carried out in one of the image frames taken by the digital camera 7, in which a pattern jointly defined by sections of some of the needles 2 is automatically recognised. In the exemplary embodiment shown in the figures, the pattern is the plurality of spots 9 discussed above. The portion of the local path 8 is automatically identified as a straight line which better passes by these spots 9. The computer program analyses a processed image as shown in Fig. 11, recognises the portion of the first straight section 6a (the lower line in Fig. 12) and the portion of the second straight section 6b (the upper line in Fig. 11), and derives from this recognition the two directions D1 and D2. It also recognises the pattern formed by aligned spots 9, and derives from this recognition the third direction D3 as being the direction of a straight line passing by the spots 9. The two angles A1, A2 are then derived from the three directions D1, D2, D3, as shown in Fig. 12. The processed image of Fig. 11 is generated by oversaturated and transforming to monochrome an enlarged partial view of an image frame taken by the digital camera 7 as shown in Fig. 10.

Claims

1. - Method for adjusting an automatic knitting machine for plating knitting, said automatic knitting machine (1) comprising:

a plurality of movable needles (2);
at least one yarn feeding means (3) which feed a first yarn (4a) and a second yarn (4b) to a same operating needle (22), said operating needle (22) being one of said movable needles (2) which is catching both said first yarn (4a) and said second yarn (4b) at a certain instant, said yarn feeding means (3) comprising a first guide (5a) for the first yarn (4a) and a second guide (5b) for the second yarn (4b), said first yarn (4a) extending from said first guide (5a) to said operating needle (22) along a first straight section (6a) in a first direction (D1), and said second yarn (4b) extending from said second guide (5b) to said operating needle (22) along a second straight section (6b) in a second direction (D2) different from said first direction (D1),
and an actuating device for automatically moving said needles (2) according to a preestablished pattern for manufacturing a plated knitted fabric from said first and second yarns (4a, 4b) fed by said yarn feeding means (3);
characterised in that a digital camera (7) is arranged to capture image frames of an area comprising at least one between at least a portion of said first straight section (6a) and at least a portion of said second straight section (6b);
and **in that** said method comprises the following steps:

[a] obtaining from said digital camera (7) image frames containing at least one between at least a portion of said first straight section (6a) and at least a portion of said second straight section (6b);
[b] performing an automatic image recognition in at least one of said image frames to recognise at least one between said portion of the first straight section (6a) and said portion of the second straight section (6b);

[c] automatically deriving, from said automatic image recognition performed in step [b], at least one between said first direction (D1) of the first straight section (6a) and said second direction (D2) of the second straight section (6b);
[d] adjusting at least one between a relative position of said first guide (5a) with respect to said operating needle (22) and a relative position of said second guide (5b) with respect to said operating needle (22), respectively in function of said first direction (D1) or said second direction (D2) automatically derived in step [c].

2. - Method according to claim 1, wherein said digital camera (7) is arranged to capture image frames of an area comprising both at least a portion of said first straight section (6a) and at least a portion of said second straight section (6b); and in that:

in step [a], said image frames obtained from said digital camera (7) contain both at least a portion of said first straight section (6a) and at least a portion of said second straight section (6b);
in step [b], both at least a portion of the first straight section (6a) and at least a portion of the second straight section (6b) are recognised by the automatic image recognition;
in step [c], both the first direction (D1) and the second direction (D2) are automatically derived;
in step [d], the adjustment of at least one between a relative position of said first guide (5a) with respect to said operating needle (22) and a relative position of said second guide (5b) with respect to said operating needle (22) is carried out in function of both said first direction (D1) and said second direction (D2) automatically derived in step [c].

3. - Method according to any one of claims 1 to 2, wherein, in step [d], said adjustment of at least one between a relative position of said first guide (5a) with respect to said operating needle (22) and a relative position of said second guide (5b) with respect to said operating needle (22) is carried out automatically.

4. - Method according to any one of claims 1 to 3, wherein, between steps [c] and [d], instructions on said adjustment of at least one between a relative position of said first guide (5a) with respect to said operating needle (22) and a relative position of said second yarn guide (5b) with respect to said operating needle (22) are automatically generated and prompted at a screen, and in step [d], said adjustment is carried out manually.

5. - Method according to any one of claims 1 to 3, wherein a hologram projector is arranged to project holograms in said area, and wherein between steps [c] and [d], said hologram projector projects in said area at least one between a hologram of a first straight line in a predefined target direction for said first direction (D1) and a hologram of a second straight line in a predefined target direction for said second direction (D2).

6. - Method according to any one of claims 1 to 5, wherein said automatic knitting machine (1) is configured so that, when it is working, said needles (2) circulate one after the other along a path, said digital camera (7) is arranged so that said area, of which said digital camera (7) captures image frames, comprises a group of said needles (2), including said operating needle (22), circulating one after the other along a local path (8) in said area; and:

step [b] comprises performing an automatic image recognition in at least one of said image frames to recognize at least a portion of said local path (8) adjacent to said operating needle (22) and upstream said operating needle (22);
step [c] comprises automatically deriving a slope of said portion of the local path (8), said slope defining a third direction (D3);
and in step [c], at least one between the angle (A1) between said first direction (D1) and said third direction (D3) and the angle (A2) between said second direction (D2) and said third direction (D3) is automatically derived from the automatic image recognition performed in step [b].

7. - Method according to claim 6, wherein said portion of the local path (8), as seen by said digital camera (7), is a straight line, so that said third direction (D3) is the direction of said straight line.

8. - Method according to any one of claims 6 or 7, wherein the image frames are captured by said digital camera (7) while said needles (2) are circulating one after the other along the path, and in step [b] said automatic image recognition is carried out in a superposition of a plurality of said image frames which are consecutive in time, wherein a continuous line (18) along said portion of the local path (8) is formed in said superposition by a section of at least some of said needles (2) circulating along said portion of the local path (8), and in step [b] the automatic recognition of said portion of the local path (8) is made by automatically recognising said continuous line (18).

9. - Method according to claim 8, wherein said continuous line (18) is formed by spots (9) in said image frames, each of said spots (9) corresponding to a

reflexion of light in said section of each needle (2).

10. - Method according to any of claims 6 or 7, wherein in step [b] said automatic image recognition is carried out in one of said image frames, and a pattern jointly defined by sections of at least some of the needles (2) is automatically recognised and said portion of the local path (8) is automatically identified as a line passing by said sections.

11. - Method according to claim 10, wherein said pattern comprises a plurality of spots (9) in said image frame, each of said spots (9) corresponding to a reflexion of light in said section of each needle (2).

12. - Method according to any one of claims 10 or 11, wherein said section of the needles (2) is a free end of the needle (2).

13. - Method according to any one of claims 1 to 12, wherein a controlled lighting (10) is focused on said area of which said digital camera (7) captures image frames.

14. - Method according to any one of claims 1 to 13, wherein said automatic knitting machine (1) is a circular knitting machine in which said needles (2) are arranged in a rotating cylinder (11) which make said needles (2) to travel along a circumference which is coaxial with said rotating cylinder (11), and wherein said digital camera (7) is statically arranged, so that it does not rotate with said rotating cylinder (11), and said area, of which said digital camera (7) captures image frames, include a portion of said circumference.

15. System for adjusting an automatic knitting machine for plating knitting, comprising an automatic knitting machine (1) for plating knitting with:

a plurality of movable needles (2);
at least one yarn feeding means (3) which feed a first yarn (4a) and a second yarn (4b) to a same operating needle (22), said operating needle (22) being one of said movable needles (2) which is catching both said first yarn (4a) and said second yarn (4b) at a certain instant, said yarn feeding means (3) comprising a first guide (5a) for the first yarn (4a) and a second guide (5b) for the second yarn (4b), said first yarn (4a) extending from said first guide (5a) to said operating needle (22) along a first straight section (6a) in a first direction, and said second yarn (4b) extending from said second guide (5b) to said operating needle (22) along a second straight section (6b) in a second direction different from said first direction,
and an actuating device for automatically moving said needles (2) according to a preestablished pattern for manufacturing a plated knitted fabric from said first and second yarns (4a, 4b) fed by said yarn feeding means (3);
characterised in that it further comprises:

- a digital camera (7) arranged to capture image frames of an area comprising at least one between at least a portion of said first straight section (6a) and at least a portion of said second straight section (6b);
- a processor (12) connected to said digital camera (7);
- a computer program comprising instructions which, when executed by said processor (12), cause said processor (12) to carry out the following steps:

[a] obtaining from said digital camera (7) image frames containing at least one between at least a portion of said first straight section (6a) and at least a portion of said second straight section (6b);
[b] performing an automatic image recognition in at least one of said image frames to recognise at least one between said portion of the first straight section (6a) and said portion of the second straight section (6b);
[c] automatically deriving, from said automatic image recognition performed in step [b], at least one between said first direction (D1) of the first straight section (6a) and said second direction (D2) of the second straight section (6b);
[d] adjusting at least one between a relative position of said first guide (5a) with respect to said operating needle (22) and a relative position of said second guide (5b) with respect to said operating needle (22), respectively in function of said first direction (D1) and said second direction (D2) automatically derived in step [c]; or providing instructions or guidance based on said first direction (D1) or said second direction (D2) for carrying out said adjustment.

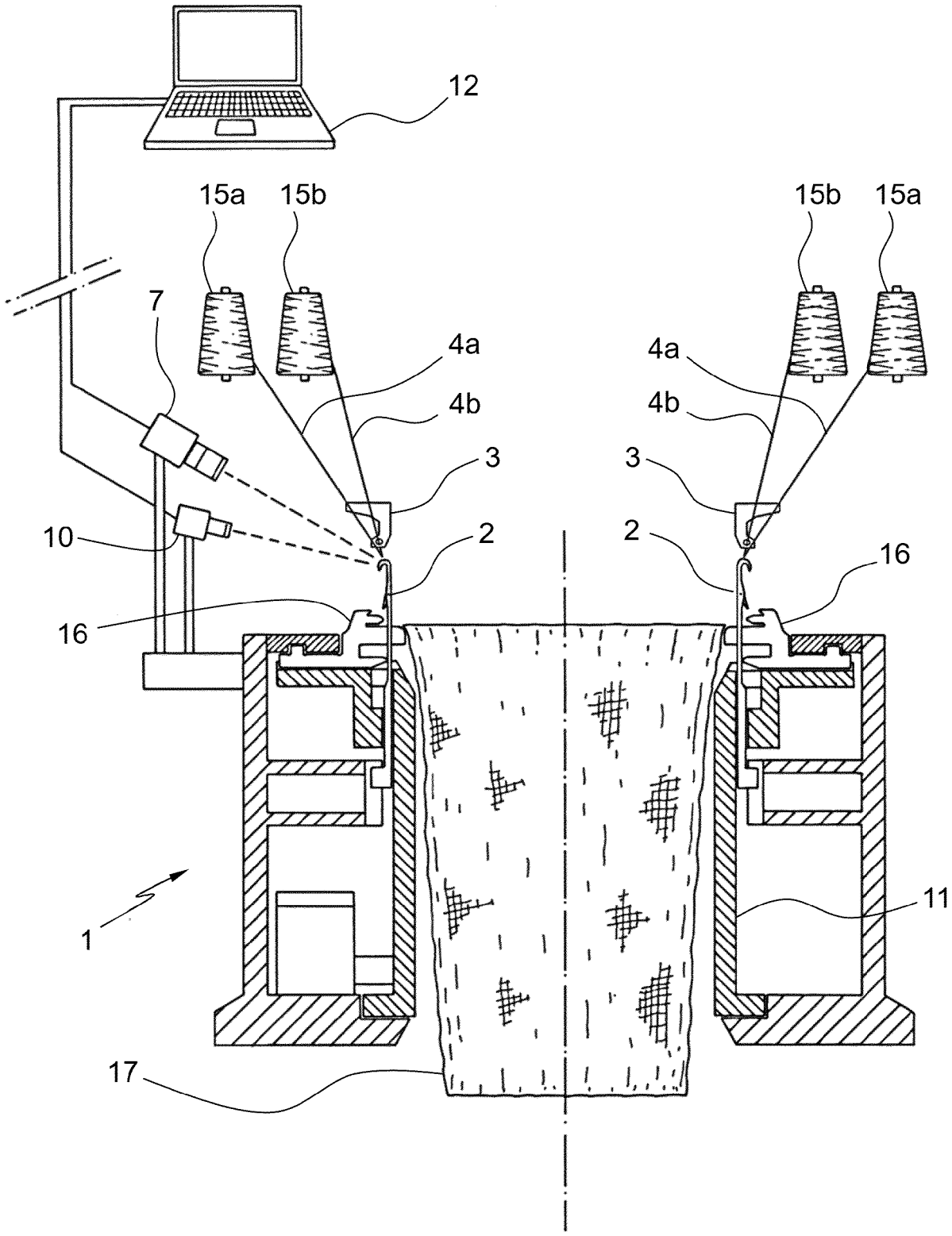

FIG. 1

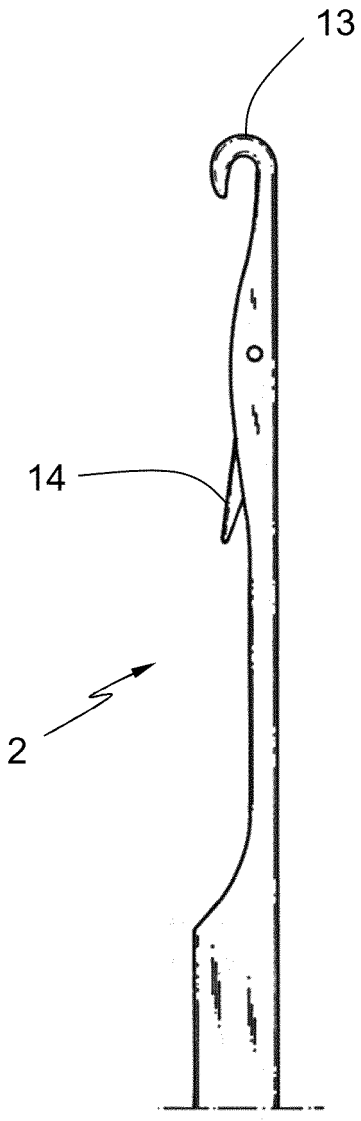

FIG. 2

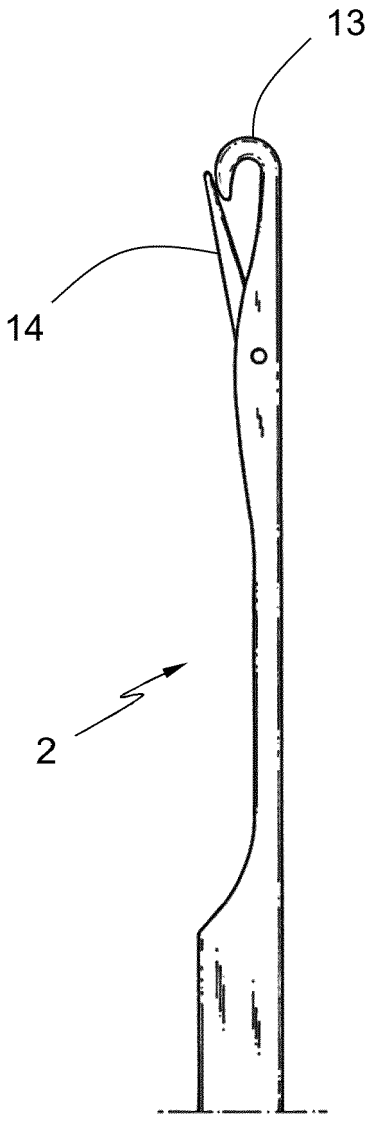

FIG. 3

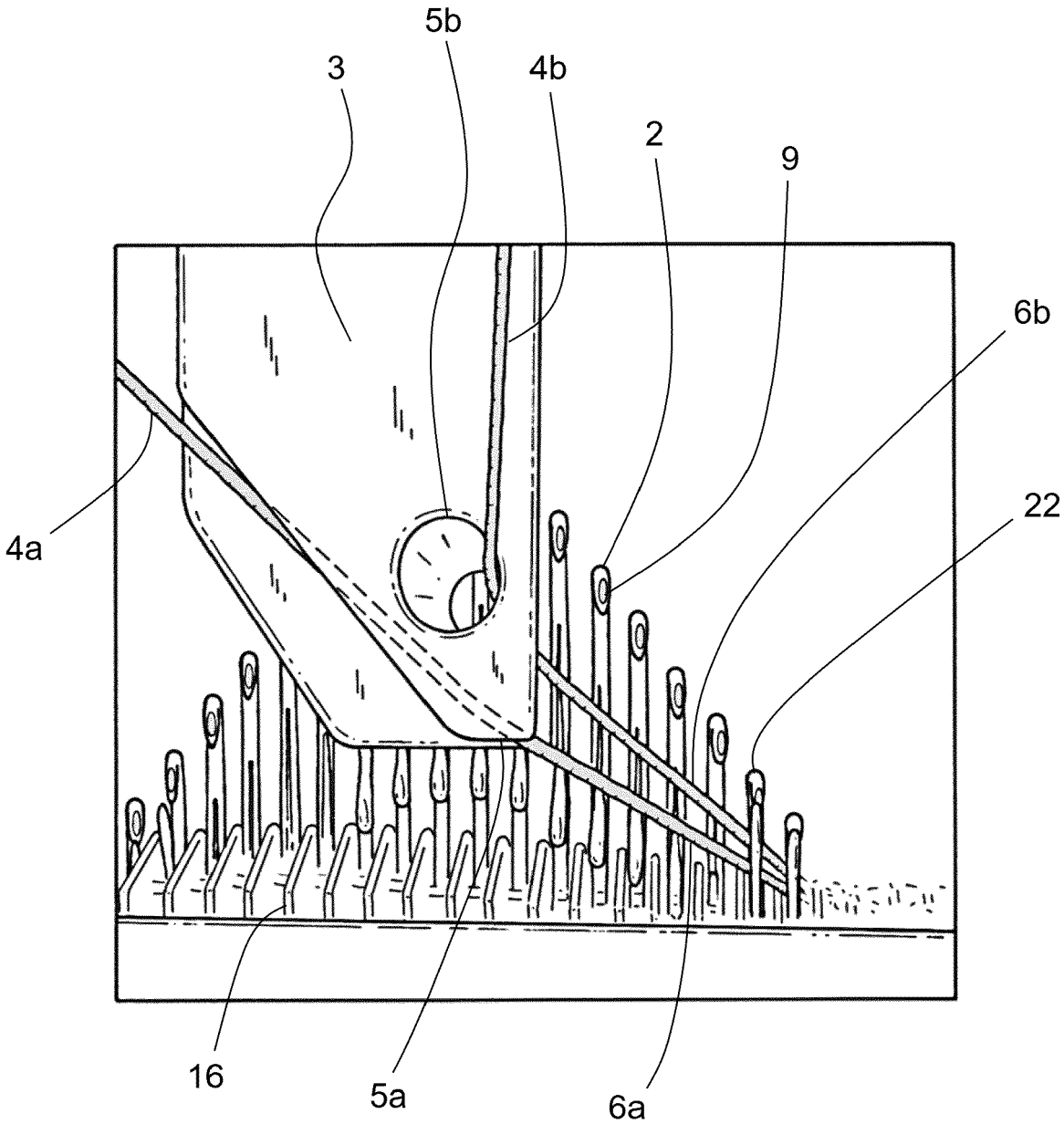

FIG. 4

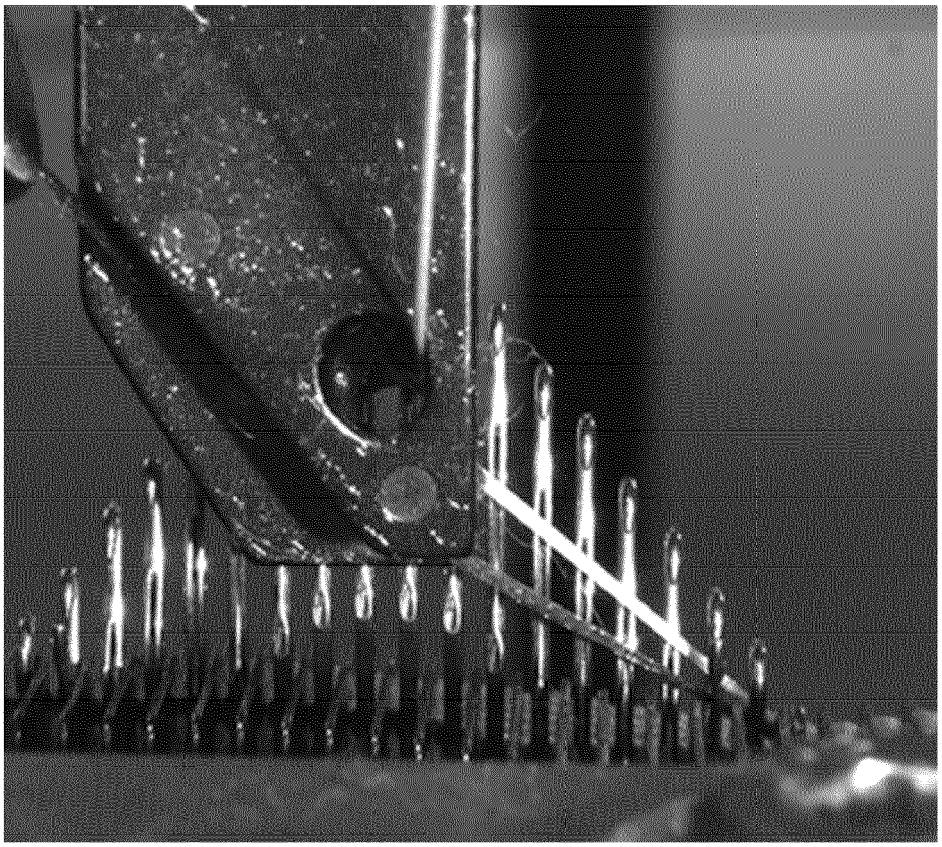

FIG. 5

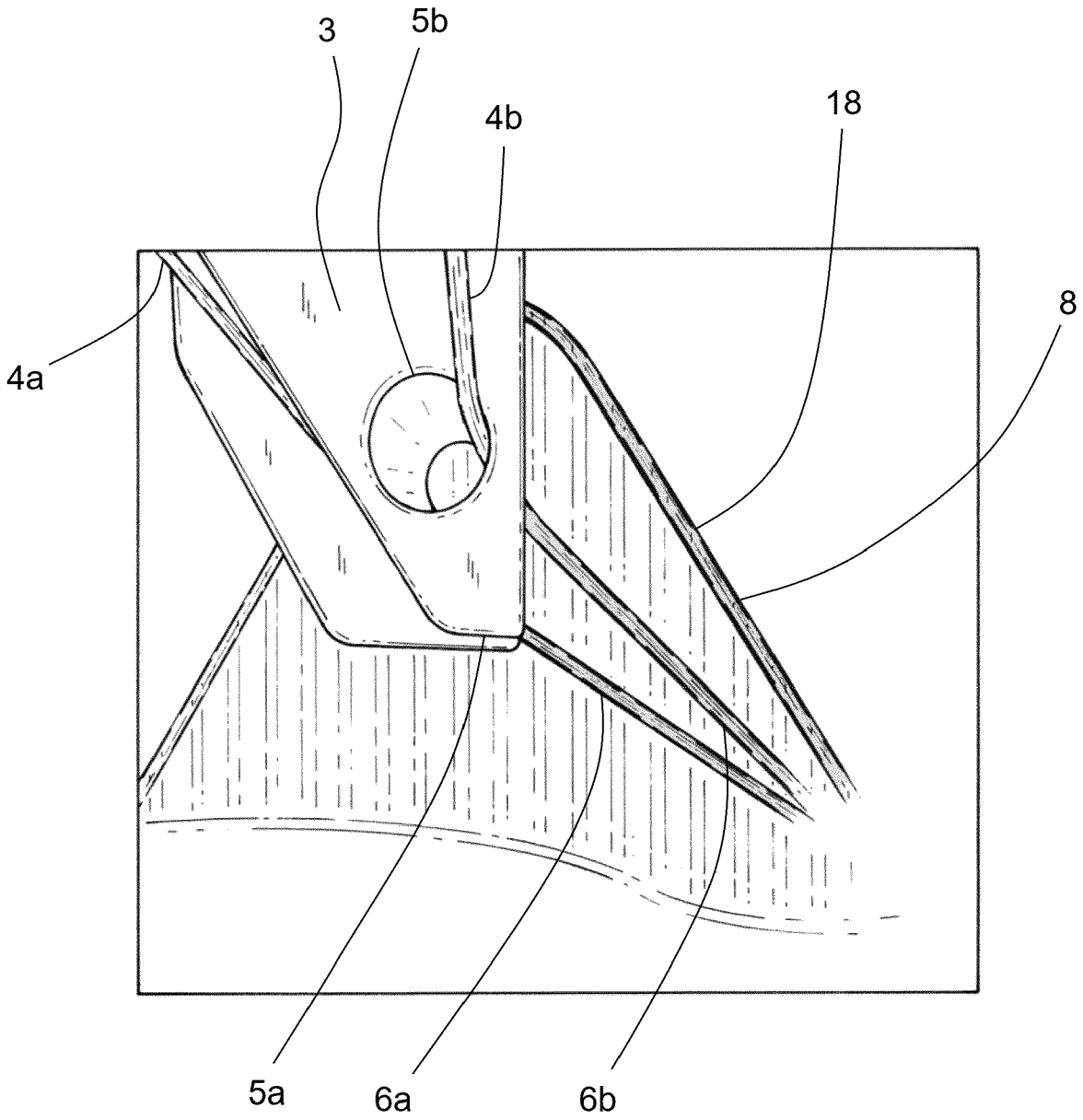

FIG. 6

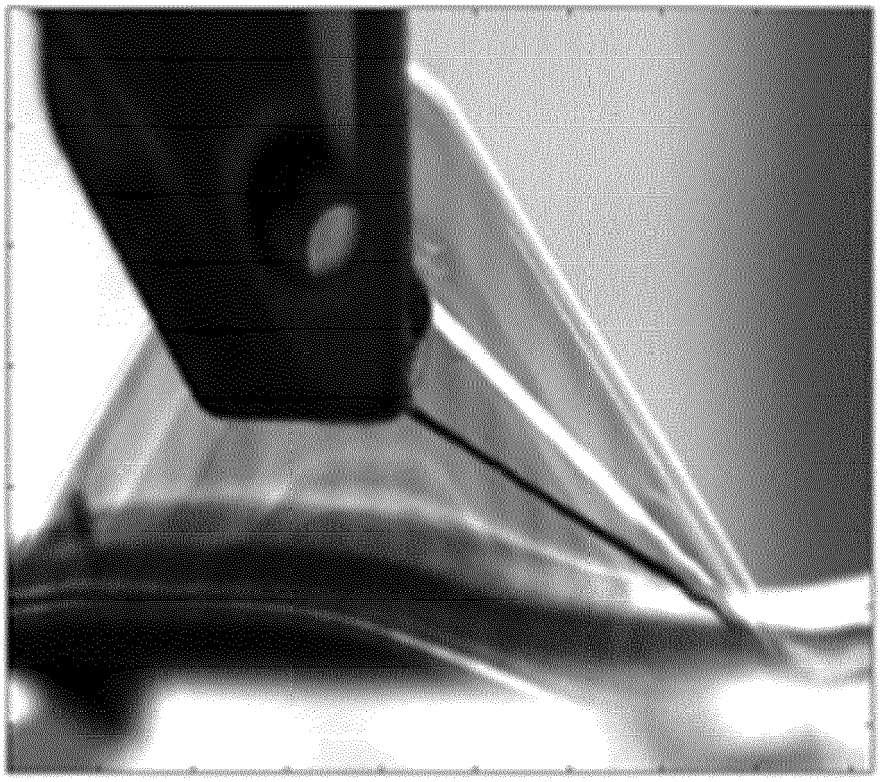

FIG. 7

FIG. 8

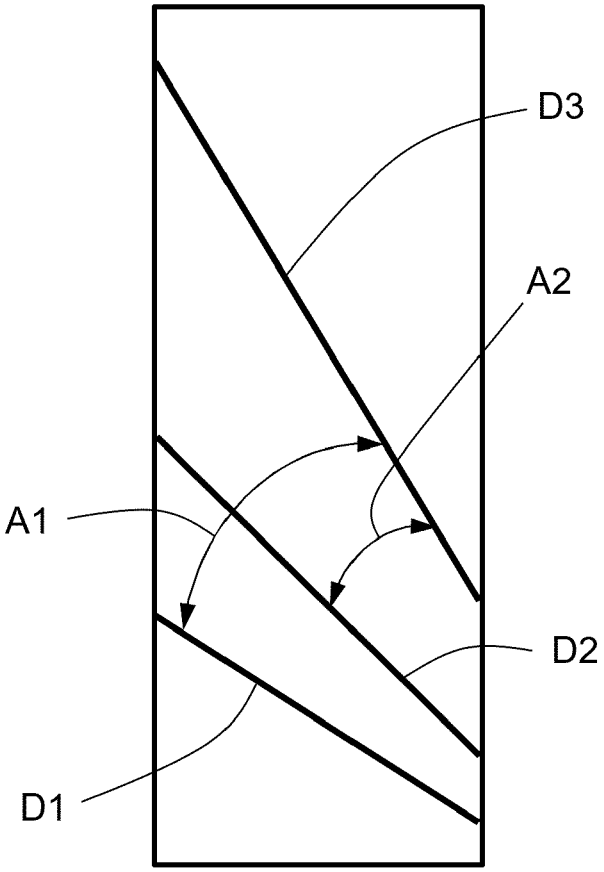

FIG. 9

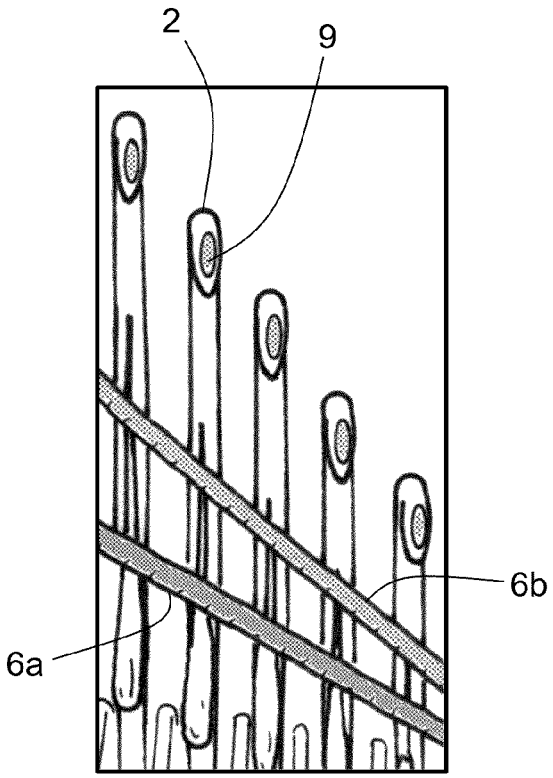

FIG. 10

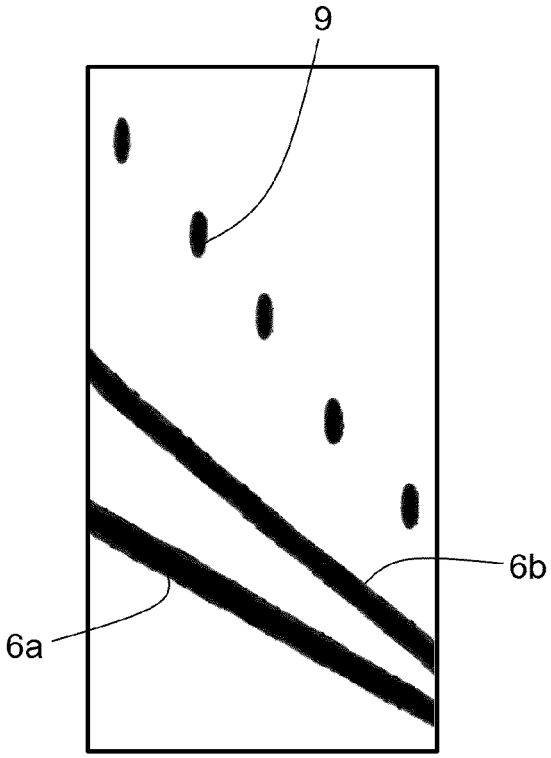

FIG. 11

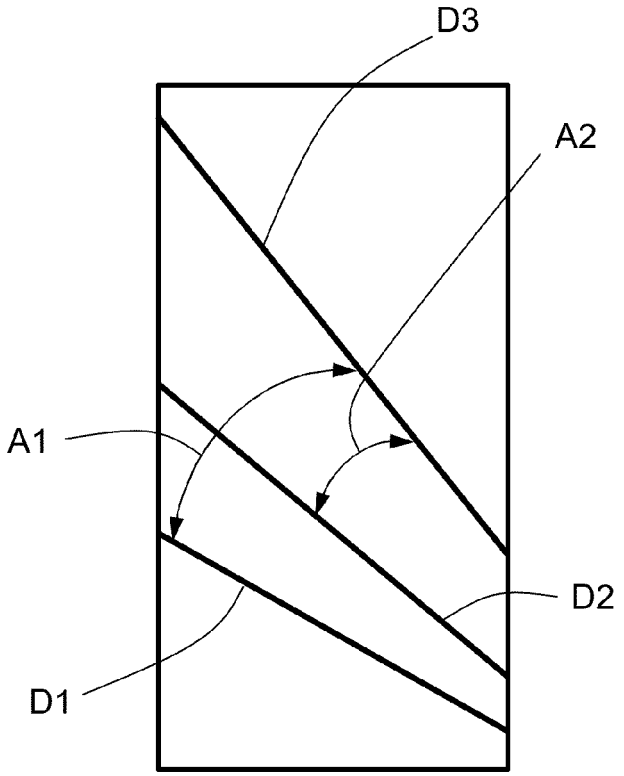

FIG. 12

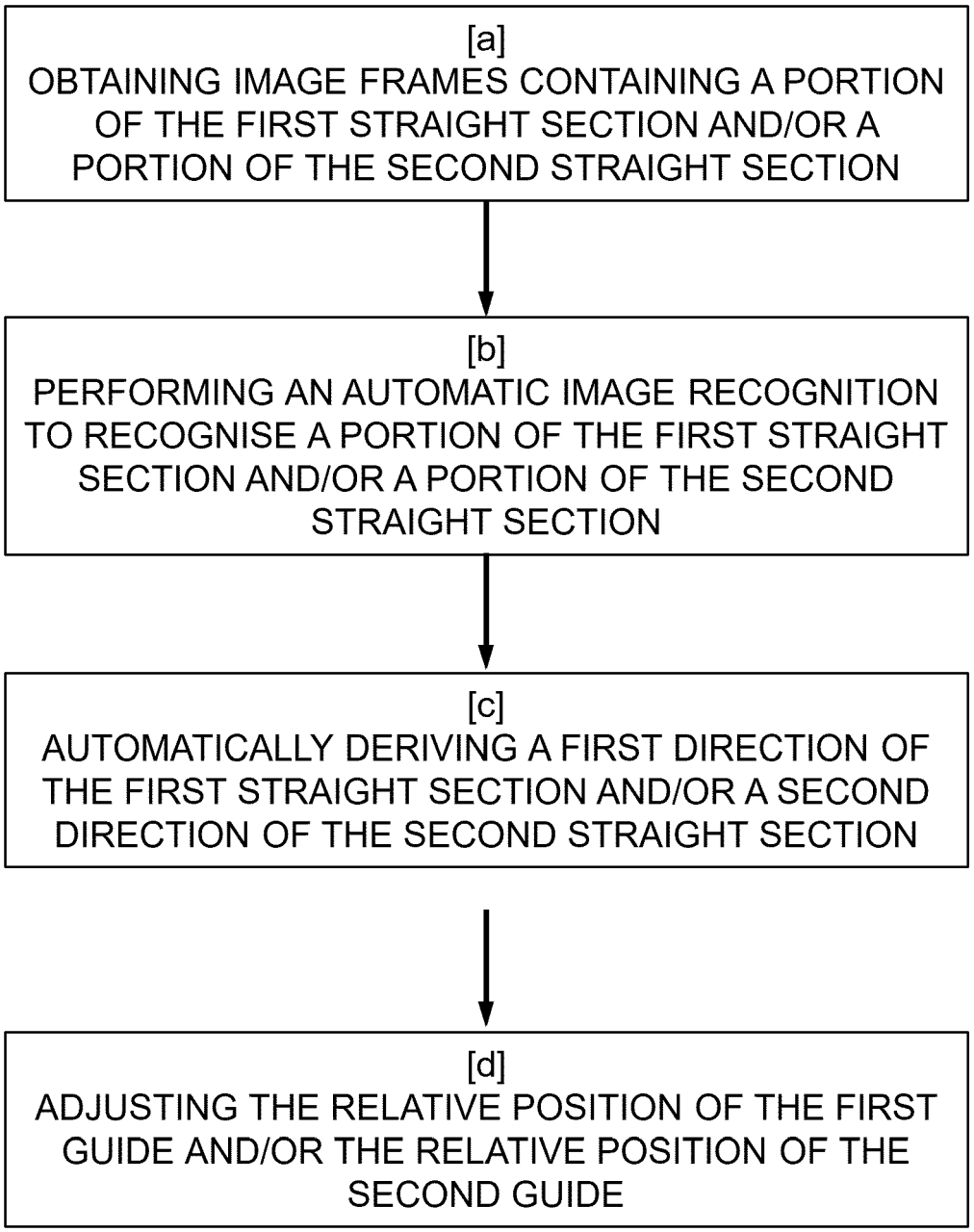
[a]
OBTAINING IMAGE FRAMES CONTAINING A PORTION OF THE FIRST STRAIGHT SECTION AND/OR A PORTION OF THE SECOND STRAIGHT SECTION
[b]
PERFORMING AN AUTOMATIC IMAGE RECOGNITION TO RECOGNISE A PORTION OF THE FIRST STRAIGHT SECTION AND/OR A PORTION OF THE SECOND STRAIGHT SECTION
[c]
AUTOMATICALLY DERIVING A FIRST DIRECTION OF THE FIRST STRAIGHT SECTION AND/OR A SECOND DIRECTION OF THE SECOND STRAIGHT SECTION
[d]
ADJUSTING THE RELATIVE POSITION OF THE FIRST GUIDE AND/OR THE RELATIVE POSITION OF THE SECOND GUIDE

FIG. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 23 38 2564

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A,D	WO 2022/158251 A1 (SHIMA SEIKI MFG [JP]) 28 July 2022 (2022-07-28) * paragraphs [0001] - [0004], [0008] - [0016]; figure 2 *	1-15	
A	EP 4 083 287 A1 (PAI LUNG MACHINERY MILL CO LTD [TW]) 2 November 2022 (2022-11-02) * paragraph [0008]; figure 2 *	1-15	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 December 2023	Wendl, Helen

CATEGORY OF CITED DOCUMENTS

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07-12-2023

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