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(54) Title: METHOD AND APPARATUS FOR ALIGNING A CUTTING TRAJECTORY

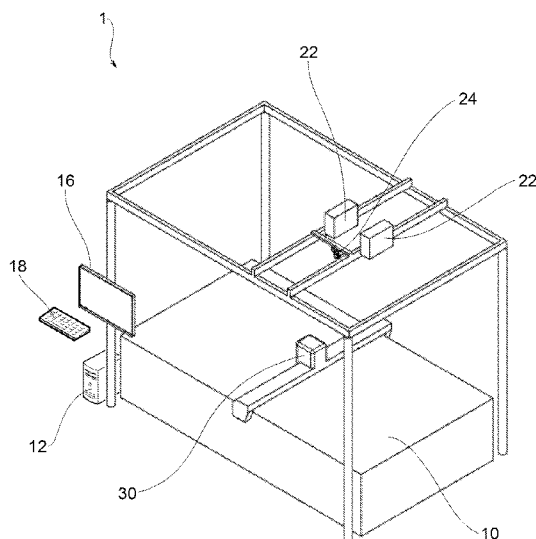


FIG.1

(57) Abstract: A method of aligning a cutting trajectory (2) of a flat element (3) with respect to a graphic pattern (4) on said flat element, comprises the steps of: positioning the flat element to be cut on a support table (10); projecting onto the flat element, by means of a projector device (22), the image of a reference figure (6) uniquely associated with coordinates of the cutting trajectory and/or coordinates relative to the graphic pattern; framing, by means of a camera (24), at least a portion of the flat element wherein there is present at least a part of the graphic pattern (4) and at least a part of said image of the reference figure (6); displaying on a monitor the image (8) framed by the camera and a virtual image of the graphic pattern (4') defined by the coordinates relative to the graphic pattern; moving the image of the reference figure (6) or the virtual image of the graphic pattern (4') until a portion of the said virtual image of the graphic pattern coincides with the corresponding real image of the graphic pattern taken by the camera.

DESCRIPTION**"METHOD AND APPARATUS FOR ALIGNING A CUTTING TRAJECTORY"**

[0001] The present invention relates in general to machines for cutting shapes of a flat element, such as a fabric, a leather, a sheet of glass, of wood, etc., and relates in particular to a method and an apparatus for aligning a cutting trajectory with respect to a graphic pattern present on said flat element.

[0002] In some applications, for example in the field of haute couture or in any case in the production of clothing or other high-end products, it is necessary to guarantee the maximum possible precision in cutting a shape of the flat element, for example a fabric, according to a cutting trajectory that a designer has identified with respect to one or more graphic elements present on the flat element, for example a drawing, a geometric pattern, etc.

[0003] In other words, starting from a flat element bearing graphic patterns, it is desired that the shape that is cut contains one or more graphic patterns positioned exactly where the designer had planned.

[0004] Usually, the cutting operation is carried out starting from a CAD working file which contains the coordinates of the cutting trajectory to be supplied to a cutting machine. These coordinates are selected also or

above all according to the position of the graphic patterns present on the flat element to be cut.

[0005] One of the difficulties encountered in trying to obtain the required precision in terms of positioning the shape to be cut with respect to the graphic patterns present in the flat element, especially in the case of cutting flat elements having a certain degree of dimensional deformability, such as fabrics or leathers, is linked to the fact that, although the support table on which the flat element is positioned to be cut, is generally provided with reference systems that help the operator in positioning the flat element on the support, it is never possible to ensure that the flat elements are positioned on the support table all in the same and precise position.

[0006] Indeed it happens that, with respect to the theoretical position chosen by the designer and described by the coordinates of the working file, once the flat element has been manipulated and put into the machine, the effective cutting trajectory is displaced even by several millimeters, if not even centimeters, with respect to such a theoretical position and therefore with respect to the graphic patterns with respect to which the cutting trajectory must have the desired coordinates.

[0007] Several alignment systems have already been proposed

which seek to correct this difference between the theoretical position and the actual position of the cutting trajectory, but none of them has been particularly effective, since it cannot guarantee a high
5 degree of precision.

[0008] The object of the present invention is to propose a method and an apparatus capable of meeting the aforementioned precision requirement in positioning the cutting trajectory with respect to graphic patterns
10 present on the element to be cut.

[0009] Said object is achieved with an alignment method according to claim 1 and with an apparatus according to claim 5. The dependent claims describe preferred embodiments of the invention.

15 [0010] The features and the advantages of the method and of the apparatus according to the invention shall be made readily apparent from the following description of preferred embodiments thereof, provided purely by way of a non-limiting example, with reference to the
20 accompanying figures, in which:

[0011] - figure 1 schematically illustrates an example of an alignment and cutting apparatus according to the invention;

[0012] - figure 2 shows the machine with a flat
25 element to be cut, positioned on the support table and

before the start of the alignment procedure;

[0013] - figure 2a is a view similar to the previous one, with the machine in the alignment step; and

[0014] - figures 3, 3a and 3b show as many steps of
5 the alignment procedure of the cutting trajectory with respect to a graphic pattern present on a flat element to be cut.

[0015] In said drawings, reference numeral 1 indicates as a whole an apparatus for aligning a cutting trajectory 2' of a flat element 3 with respect to an ideal cutting path 2 determined by the presence of one or more graphic patterns 4 on the flat element 3.
10

[0016] The apparatus 1 comprises a support table 10 suitable to receive the flat element 3 to be cut. The flat element 3 may be a fabric, a leather, a glass sheet, rubber, wood or other material.
15

[0017] The flat element 3 bears one or more graphic patterns 4, which may be decorative patterns or recurrent geometric patterns, for example lines, squares, etc.

[0018] The flat element 3 must be cut so as to obtain one or more shapes 5, at least one of which containing a graphic pattern 4.
20

[0019] For example, in the case of clothing fabric, the flat element 3 must be cut according to predetermined shapes 5 which correspond to parts of the item of
25

clothing to be made.

[0020] As stated above, it is desired that at least one graphic pattern 4 be found in a very precise position with respect to the shape 5.

5 [0021] Knowing a reference system with respect to which the dimensional features of the flat element 3 to be cut with its graphic patterns 4, for example a Cartesian axis system, are uniquely defined, in the design step the desired trajectory 2' of the shapes to be cut is
10 selected. The trajectory 2' is defined by a set of points, each of which is described by spatial coordinates in the reference system.

[0022] These spatial coordinates of the cutting trajectory 2' are stored in a working file.

15 [0023] Having established in advance the exact position of the cutting trajectory 2' with respect to at least one graphic pattern 4, the working file also contains the position coordinates of the set of points that define the graphic pattern 4' with respect to the cutting trajectory
20 2'.

[0024] The working file is accessible from a processing unit 12 of the alignment apparatus 1.

[0025] As will be described below, the coordinates of the cutting trajectory 2' stored in the working file can be
25 modified with respect to an origin of the reference

system during the alignment procedure, until final coordinates 2 of the cutting trajectory are obtained. Therefore, the starting or theoretical coordinates of the cutting trajectory 2' are also defined as "initial
5 coordinates", to differentiate them from the "final" coordinates that are obtained at the end of the alignment procedure.

[0026] The alignment apparatus is provided with a user interface 14, comprising a display device 16, for example
10 a screen, and control means 18 by which an operator may locate the working file and display on the display device 16 an image of the flat element and the cutting trajectory;

[0027] The alignment apparatus 1 comprises, on the support
15 table 10, a frame 20 which supports at least one projector device 22 and at least one camera 24.

[0028] The projector device 22 is configured so as to project on the flat element 3 placed on the support table 10, an image of a reference figure 6 uniquely associated
20 with the coordinates of the cutting trajectory 2' or the coordinates of the graphic pattern 4'.

[0029] In one embodiment, the reference figure 6 is the same cutting trajectory 2' or the image of the reference graphic pattern 4', or both. For example, once the
25 working file has been located, the user interface is

configured to allow the operator to select the cutting trajectory 2' or the graphic pattern 4', or both, to be projected onto the flat element 3 by the projector device 22.

5 [0030] In one embodiment, the projector device 22 may be provided, for its functionality, with electric axes controlled by the processing unit 12 to be positioned, before the start of the alignment process, in a suitable position above the flat element 3. For example, the
10 processing unit 12 may control the electric axes to position the projector device on the basis of the coordinates of the cutting trajectory 2' present in the working file.

[0031] In one embodiment, the projector device 22 uses
15 laser technology to project, through a system of suitably oriented lenses, the image of the reference figure 6.

[0032] In one embodiment, the lens system is controlled by electric motors which allow the lenses of the lens system to be oriented so as to translate the image of the
20 reference figure 6 projected onto the flat element 3 without the need to move the projector device 22.

[0033] The camera 24 is controlled by the processing unit 12 so as to frame at least a portion of the flat element 3 wherein there is present at least a part of the graphic
25 pattern 4 and at least a part of the image of the

reference figure 6.

[0034] In one embodiment, the camera 24 may be moved, for example by means of its own electric axes to frame the working area in detail.

5 [0035] The image taken by the camera is sent to the processing unit 12 to be displayed on the screen 16.

[0036] As mentioned above, and as shown in figure 3, the image 7 of the working file, in particular the images of the cutting trajectory 2' and of the graphic pattern 4' 10 may also be displayed on the screen 16. These images deriving from the working file may be defined as "virtual" to distinguish them from the "real" images framed by the camera.

[0037] Figures 2 and 3 represent a first step of the 15 alignment method. The flat element 3 is located on the support table 10 and the projector device 22 and the camera 24 are positioned above the flat element 3. The operator locates the image 7 of the working file to be displayed on the screen. In this step, the camera 24 has 20 not yet been activated or in any case the image taken by the camera has not yet been displayed on the screen 16.

[0038] Figure 2a shows the machine during the alignment procedure. At least one projector device 22 projects the image of the reference figure 6 onto the flat element 3 25 and the camera 24 frames a portion of the flat element 3

which at least partially includes the graphic pattern 4 and the image of the reference figure 6.

[0039] Figure 3a shows the screen 16 on which the image 7 of the working file and the image 8 taken by the camera 24 are displayed simultaneously, for example on two side-by-side portions of the display area.

[0040] The image 8 framed by the camera includes the graphic pattern 4 and the reference figure 6. In the illustrated embodiment, the reference figure 6 consists of the image of the graphic pattern 4' and of the cutting trajectory 2'. In the example, the reference figure 6 is shown exaggeratedly misaligned with respect to the graphic pattern 4.

[0041] In one embodiment, the processing unit 12 is configured to allow the operator to select and move the virtual image of the graphic pattern 4' or the image of the reference figure 6 framed by the camera until at least one portion the virtual image of the graphic pattern 4' coincides with a corresponding portion of the real image of the graphic pattern 4 framed by the camera 24.

[0042] The displacement of the virtual image of the graphic pattern 4' or of the reference figure 6 is shown in figure 3b.

[0043] For example, if for the reference figure 6 the

virtual image of the graphic pattern 4' is used, the operator can select and move the image of the projected reference figure 6, framed by the camera and displayed on the screen, or select and move the virtual image of the graphic pattern 4' resulting from the working file and displayed on the screen. In both cases, the effect produced is that of a translation of the virtual image of the graphic pattern 4' up to its superimposition on the real image of the graphic pattern 4 framed by the camera

10 24.

[0044] If the operator acts on the reference figure 6 framed by the camera, he can enlarge the image up to a desired level of detail to obtain a very high alignment accuracy.

15 [0045] If the operator acts on the virtual image of the graphic pattern 4' deriving from the working file, he can have the advantage, if a larger portion of the flat element project defined by the working file is displayed, of also checking how the cutting trajectory 2' connected to the image of the selected graphic pattern 4' moves, with respect for example to other elements 9 of the project.

20

[0046] More in detail, the displacement of the image of the reference figure 6 is obtained by selecting, through the user interface 14, the virtual image of the graphic

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pattern 4' or the image of the reference figure 6, moving this virtual image of the graphic pattern or of the reference figure, and updating the coordinates of the reference figure 6 accordingly.

5 [0047] On the basis of the updated coordinates of the reference figure, the electric motors of the lens system are controlled so that they update their orientation.

[0048] It should be noted that, in the case in which the projector device 22 projects the image of the graphic
10 pattern 4' as a reference figure, the operator can verify the alignment both on the screen and on the flat element placed on the support table of the apparatus.

[0049] In the case of display and selection of the image of the cutting trajectory 2', a displacement of this image
15 corresponds to a same displacement of the virtual image of the graphic pattern 4', which can be either projected and displayed on the flat element, or displayed on the screen superimposed on the real image of the graphic pattern framed by the camera.

20 [0050] In one embodiment, while the operator moves the virtual image of the graphic pattern and/or the cutting trajectory to be aligned, the processing unit 12 calculates the coordinates to be supplied to the electric motors of the lens system to also display on the flat
25 element the displacement of the reference figure 6.

[0051] When the reference figure 6 coincides with the image of the graphic pattern 4', the operator can then verify, both on the display device and by directly observing the flat element, when the reference figure (or, for example, a portion thereof enlarged by the camera) is superimposed exactly on the real image of the graphic pattern 4.

[0052] In an embodiment variant, when the reference figure 6 coincides with the image of the graphic pattern 4', the operator could directly control the electric motors of the lens system, for example with a joystick, so as to move the reference figure 6 until it exactly overlaps the graphic pattern 4 present on the flat element.

[0053] When the virtual image of the graphic pattern is superimposed onto the real image, the final coordinates of the cutting trajectory are saved in the working file.

[0054] In one embodiment, the alignment apparatus is made on the cutting machine itself. The latter therefore comprises, in addition to the devices of the alignment apparatus described above, a cutting head 30 movable on the flat element 3 to carry out the cutting of shapes following the cutting trajectories memorized at the end of the alignment procedure.

[0055] In one embodiment, the alignment apparatus 1 comprises a cutting support on which the flat element is positioned before the alignment procedure and which is

adapted to be traversed by the blade of a cutting head
30.

[0056] In an embodiment variant, the flat element is positioned on a rigid support suitable for transport, for example made of paper or similar materials. At the end of
5 the alignment procedure, the rigid support with the flat element integral therewith is removed from the support table and positioned on a separate cutting machine, which comprises a cutting head movable on the flat element
10 according to the cutting trajectory obtained from the alignment procedure. For example, the cutting head may be moved by electric axes controlled by an axis control unit in which the final coordinates of the cutting trajectory have been transferred.

15 [0057] It is apparent that the alignment method and apparatus described above allow the requirement of precision needed to be met. In particular, it is possible to obtain a high degree of precision due to the fact that the alignment procedure is carried out between the
20 virtual image of the graphic pattern and the real image of the graphic pattern, with the flat element positioned on the support table, therefore in the situation of real deformation of the flat element.

[0058] Moreover, the alignment procedure is carried out
25 just before the cutting operation, therefore without

further elements able to alter the positioning of the flat element and therefore the ratio between the cutting trajectory and the graphic pattern.

[0059] Finally, it should be noted that, unlike other known alignment systems, which adapt the shape of the shapes to the deformation of the flat element, altering the coordinates of the cutting trajectory, in the proposed alignment method it is not necessary to perform such a deformation, but only a translation of the cutting trajectory.

[0060] A man skilled in the art may make several changes, adjustments, adaptations and replacements of elements with other functionally equivalent ones to the embodiments of the method and apparatus according to the invention in order to meet incidental needs, without departing from the scope of the following claims. Each of the features described as belonging to a possible embodiment can be obtained independently of the other embodiments described.

CLAIMS

1. A method of aligning a cutting trajectory (2) of a flat element (3) with respect to a graphic pattern (4) on said flat element, comprising the steps of:

5 - providing a working file wherein are stored the initial spatial coordinates of the trajectory defining the cutting trajectory (2') with respect to a reference system and the graphic pattern coordinates (4') defining the position of said graphic pattern with respect to the
10 cutting trajectory;

 - positioning the flat element to be cut on a support table (10);

 - projecting onto the flat element, by means of a projector device (22), the image of a reference figure
15 (6) uniquely associated with the coordinates of the cutting trajectory and/or the coordinates relative to the graphic pattern;

 - framing, by means of a camera (24), at least a portion of the flat element wherein there is present at
20 least a part of the graphic pattern (4) and at least a part of said image of the reference figure (6);

 - displaying on a monitor the image (8) framed by the camera and a virtual image of the graphic pattern (4') defined by the coordinates relative to the graphic
25 pattern;

- moving the image of the reference figure (6) or the virtual image of the graphic pattern (4') until a portion of the said virtual image of the graphic pattern coincides with the corresponding real image of the graphic pattern taken by the camera.

2. Method according to claim 1, wherein said reference figure (6) is the virtual image of the graphic pattern (4') and/or the image of the cutting trajectory (2').

3. Method according to claim 1 or 2, wherein the step of moving the image of the reference figure comprises the substeps of:

- selecting, by means of a user interface, the virtual image of the graphic pattern or the image of the reference figure;

- moving said virtual image of the graphic pattern or of the reference figure;

- updating the coordinates of the reference figure accordingly;

- controlling motorized means of the projector device responsible for the spatial positioning of the image of the reference figure on the flat element based the updated coordinates of the reference figure.

4. Method according to any one of the preceding claims, wherein, when the virtual image of the graphic pattern is superimposed onto the real image of the graphic pattern,

the final coordinates of the cutting trajectory are saved in the working file.

5. Apparatus for aligning a cutting trajectory (2) of a flat element (3) with respect to a graphic pattern (4)

present on said flat element, comprising:

- a processing unit (12);
- storage means accessible from the processing unit and suitable for storing a working file wherein are stored the initial spatial coordinates of the trajectory that defines the cutting trajectory with respect to a reference system and the coordinates relative to the graphic pattern that defines the position of said graphic pattern with respect to the cutting trajectory;
- a user interface (14), comprising a display device (16) and control means (18) by which an operator may access the working file and display an image of the flat element and the cutting trajectory on the display device;
- a support table (10) suitable to receive the flat element;
- above the support table, a framework (20) supporting at least one projector device (22) and at least one camera (24) operatively connected to the processing unit, where the projector device is configured so as to project an image onto the flat element placed on the support table, and where the camera is suitable for

framing at least a portion of the flat element,
wherein the processing unit is configured to implement
the alignment method according to any one of claims 1-4.

6. Apparatus according to the preceding claim, wherein
5 the projector device is equipped with electrical axes
controlled by the processing unit to be positioned in a
suitable position above the flat element.

7. Apparatus according to claim 5 or 6, wherein the
projector device uses laser technology to project an
10 image through a lens system.

8. Apparatus according to the preceding claim, wherein
the lens system is controlled by electric motors
operatively connected to the processing unit and suitable
for orienting the lenses of the lens system to translate
15 the image of the reference figure projected onto the flat
element.

9. Apparatus according to any one of claims 5-8,
comprising, on the support table, a rigid support
suitable to receive the flat element and to be integrally
20 bound thereto.

10. Software product directly loadable into the memory
of a processor and including portions of code suitable to
implement the alignment method according to any one of
claims 1-4.

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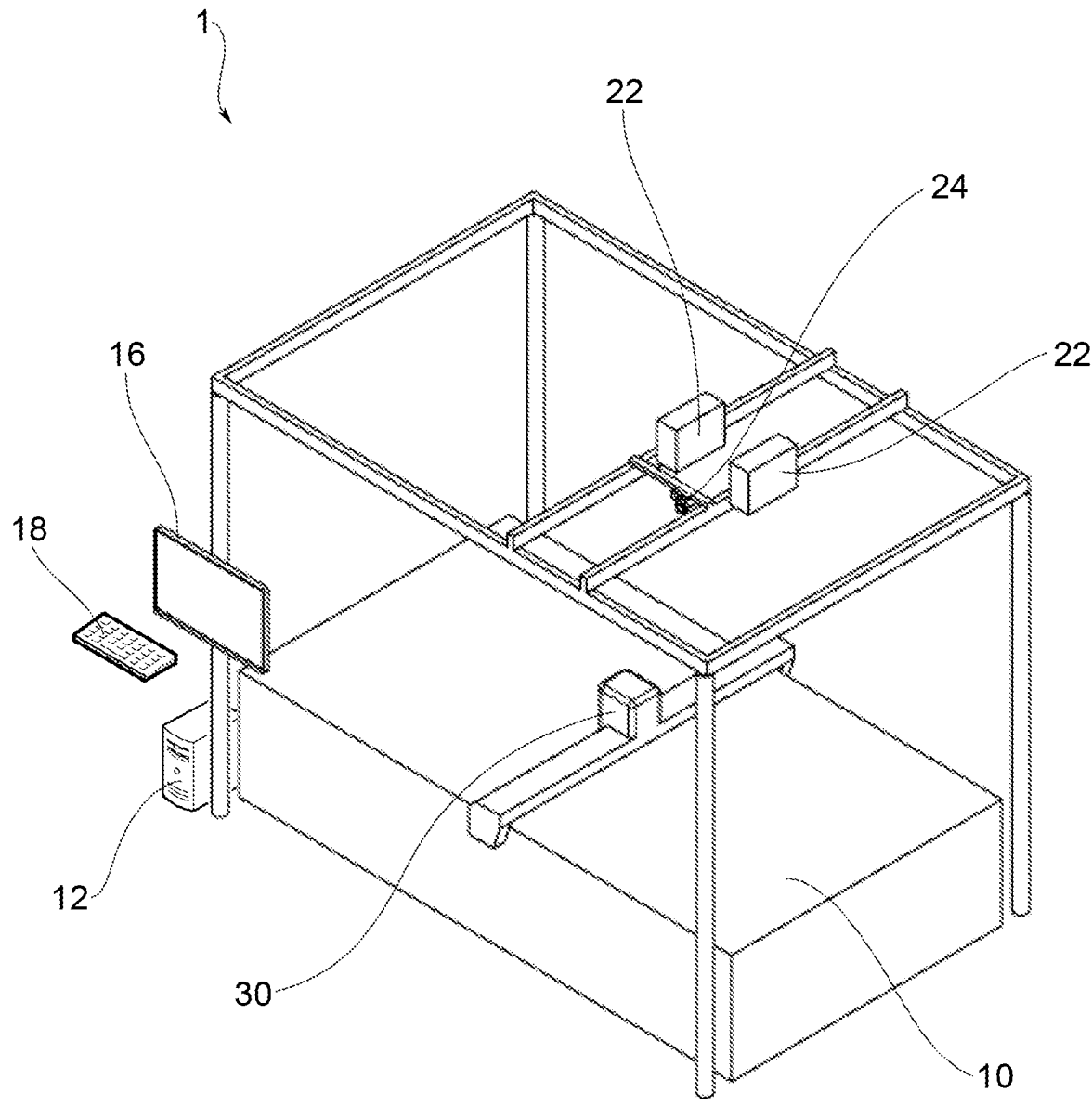


FIG.1

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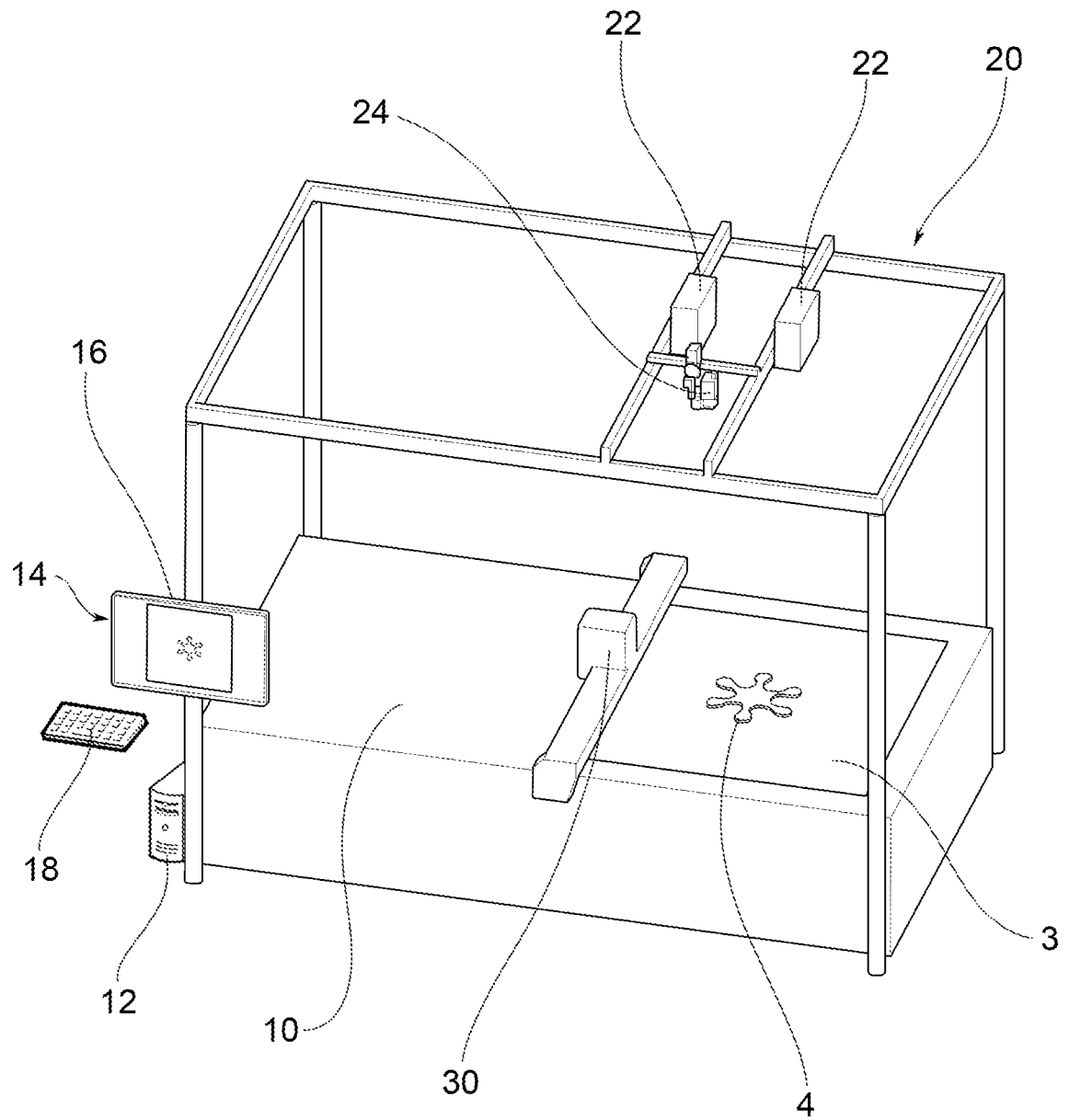


FIG.2

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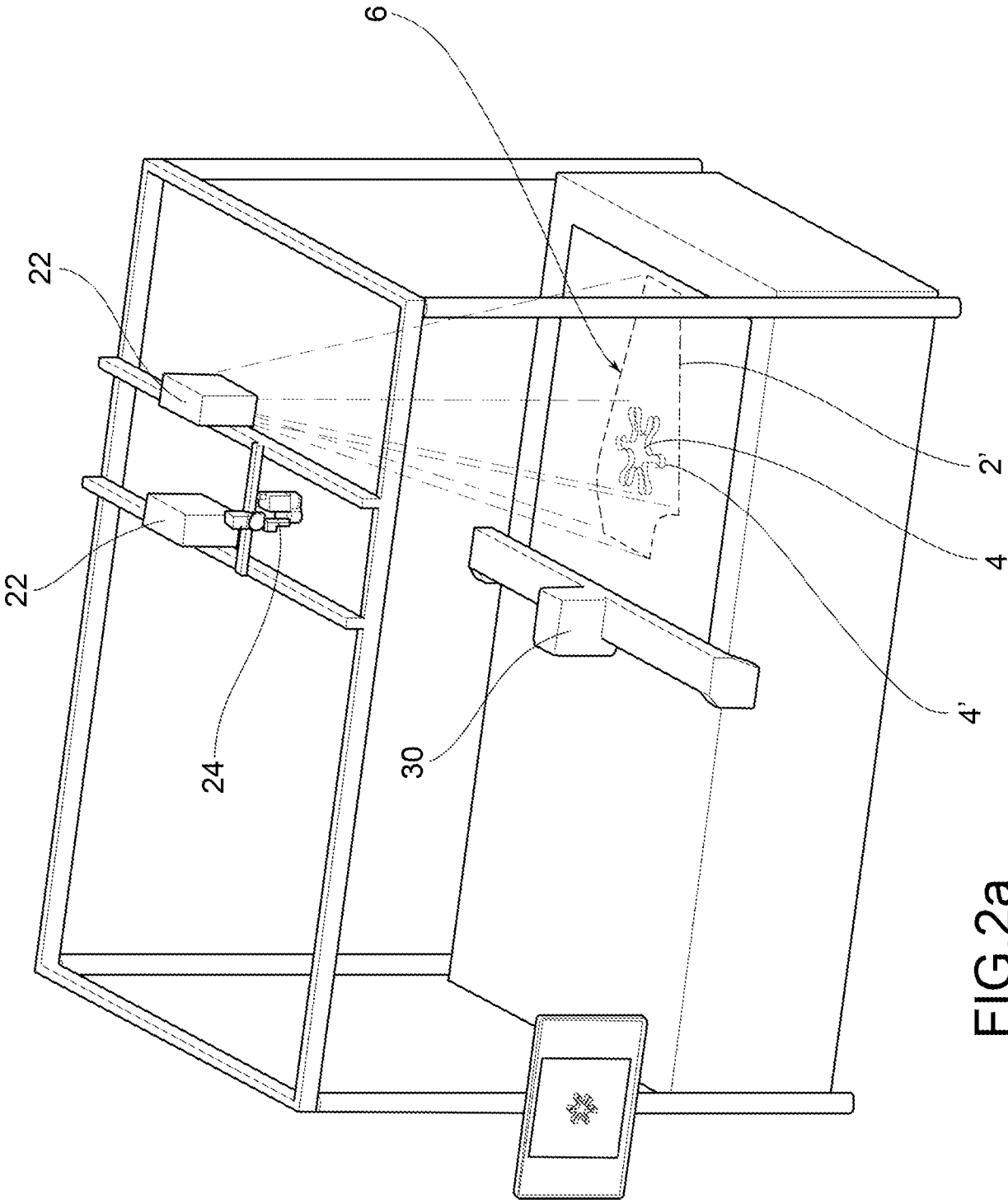


FIG.2a

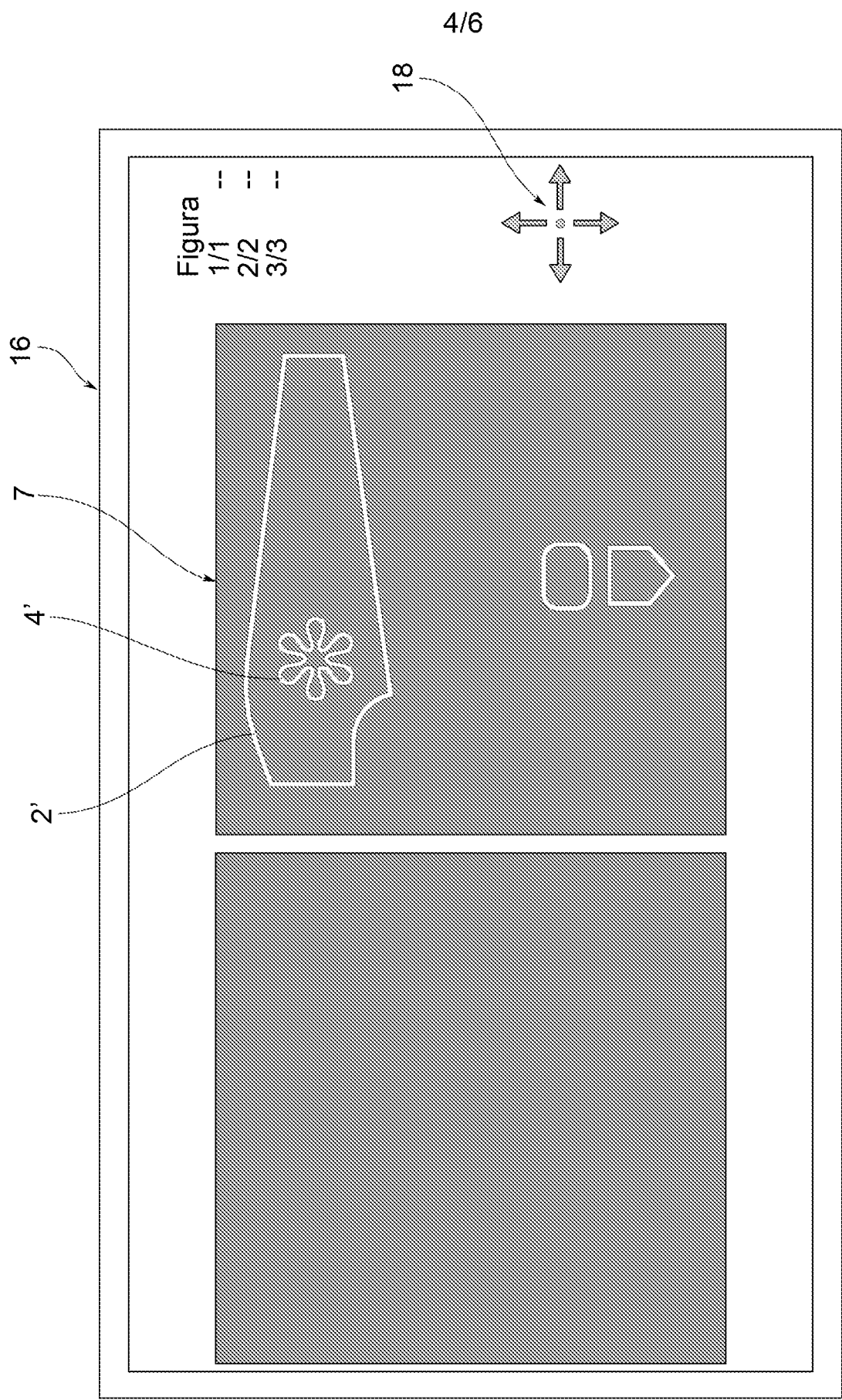
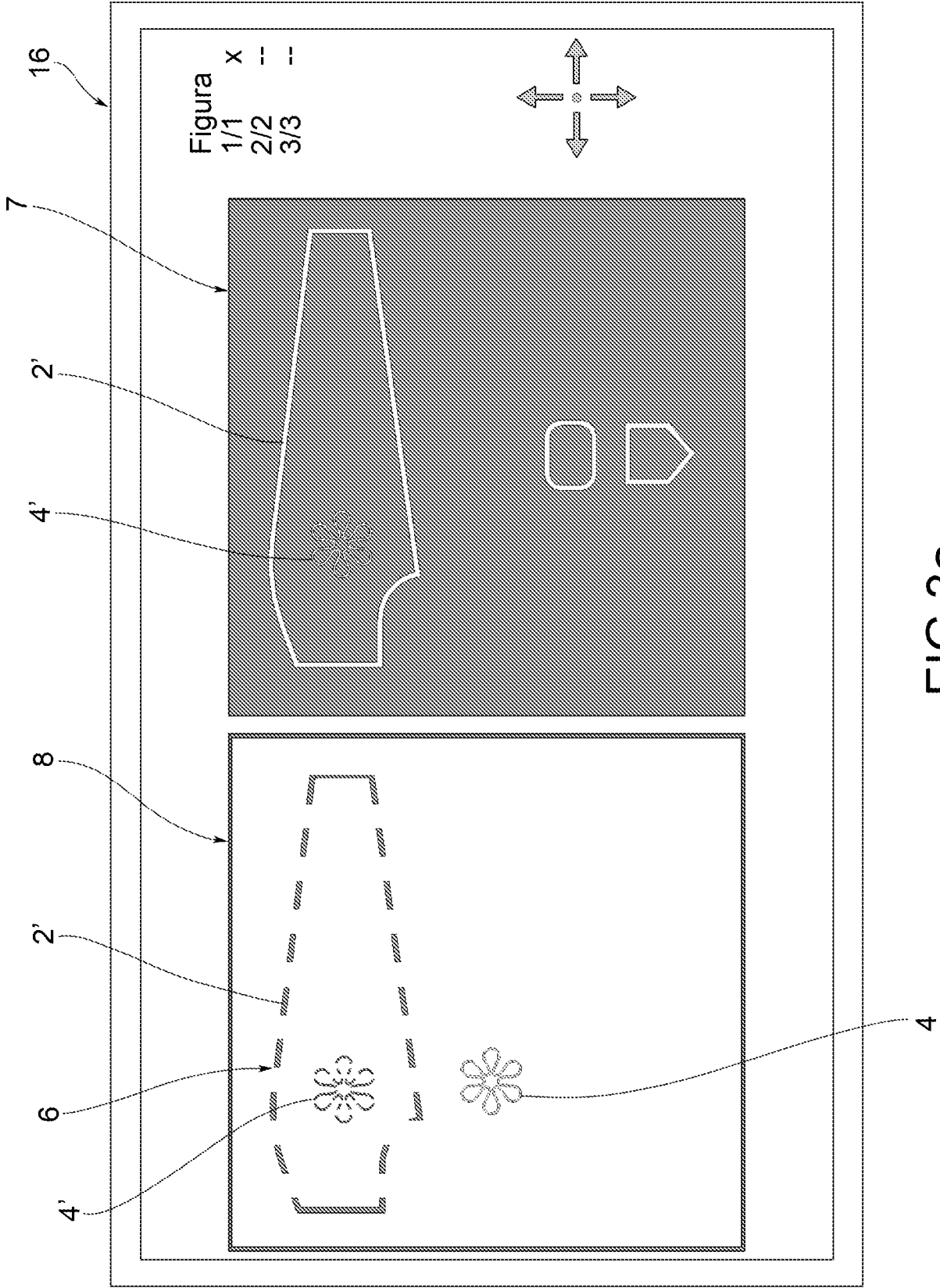
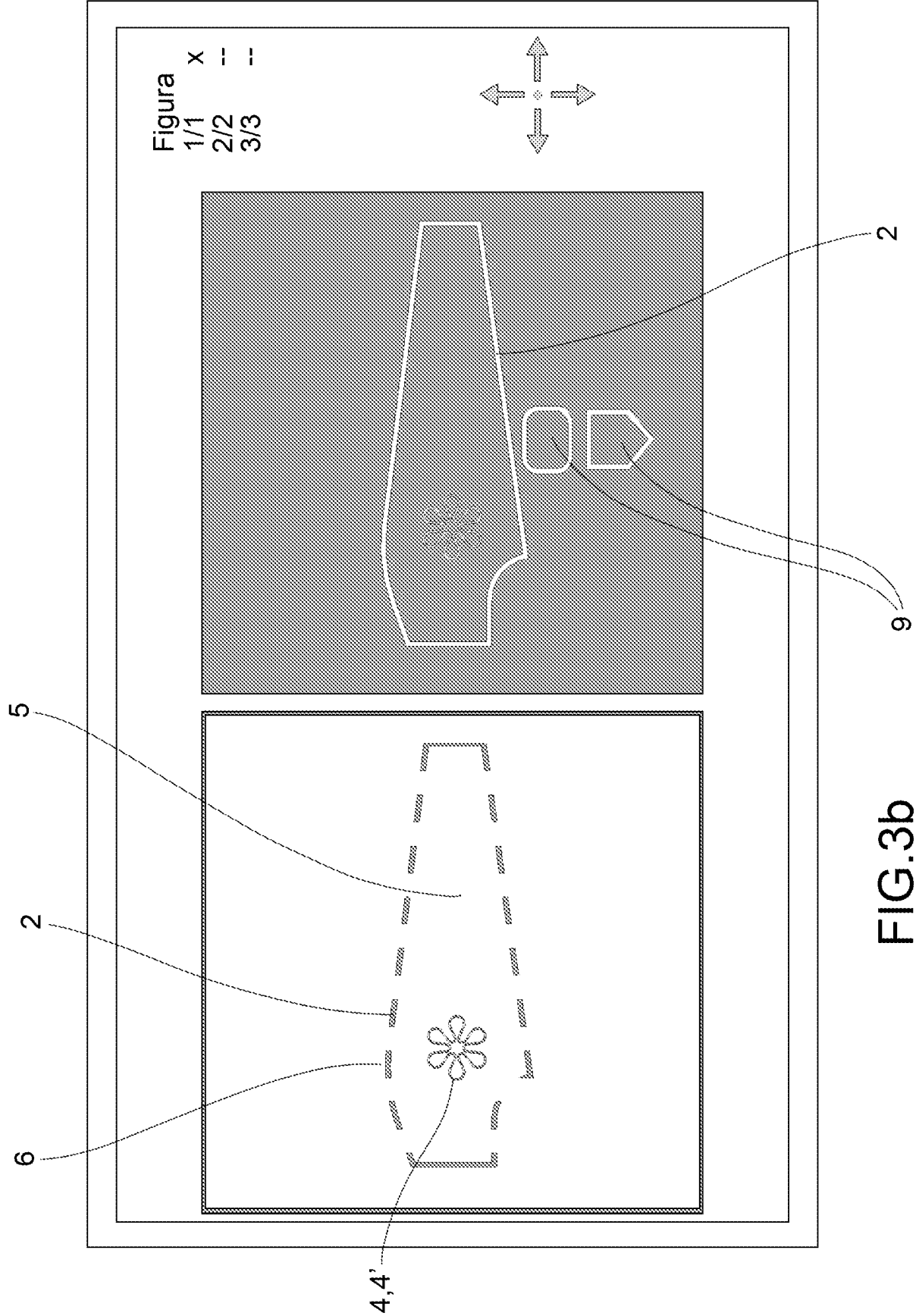


FIG.3





INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. B26D5/00 G05B19/00
ADD.

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G05B

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 practicable, 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 2002/002416 A1 (HERMAN JR JAMES S [US]) 3 January 2002 (2002-01-03) paragraph [0018] - paragraph [0022] paragraph [0027] paragraph [0032] paragraph [0036] - paragraph [0042] figure 1	1-10
A	----- US 2013/177215 A1 (CAMPBELL ROBERT L [US] ET AL) 11 July 2013 (2013-07-11) the whole document	1-10
A	----- US 5 172 326 A (CAMPBELL JR ROBERT L [US] ET AL) 15 December 1992 (1992-12-15) the whole document	1-10
	----- -/-	



Further documents are listed in the continuation of Box C.



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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016/031110 A1 (MIDDLETON GARYLAND KIRK [US] ET AL) 4 February 2016 (2016-02-04) the whole document	1-10
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2019/056064

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