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(71) Applicant: **Sidel S.p.a. Con Socio Unico**
**43100 Parma (IT)**

(72) Inventors:
- **Bast, Tim**
  **CH-6318 Zug (CH)**
- **Pace, Raffaele**
  **I-43100 Parma (IT)**

## (54) Apparatus and method for decorating the surface of irregularly shaped containers

(57) In an apparatus (1) for decorating an outer surface (2a) of an irregularly shaped container (2): a support structure (4) supports the container (2), the container (2) having a pre-defined axis of rotation (A); a decoration applicator (7) applies a decoration onto the outer surface (2a) of the container (2); an actuator (15) causes a rotation of the container (2) relative to the decoration applicator (7) around the axis of rotation (A). In particular, a sensor (8) detects an initial rotational orientation of the container (2) around the rotation axis (A), and a control unit (10), operatively coupled to the sensor (8) and to the actuator (15), causes a relative rotation around the axis of rotation (A) of the container (2) with respect to the decoration applicator (7) until a pre-determined rotational orientation is reached, before application of the decoration onto the outer surface (2a) of the container (2).

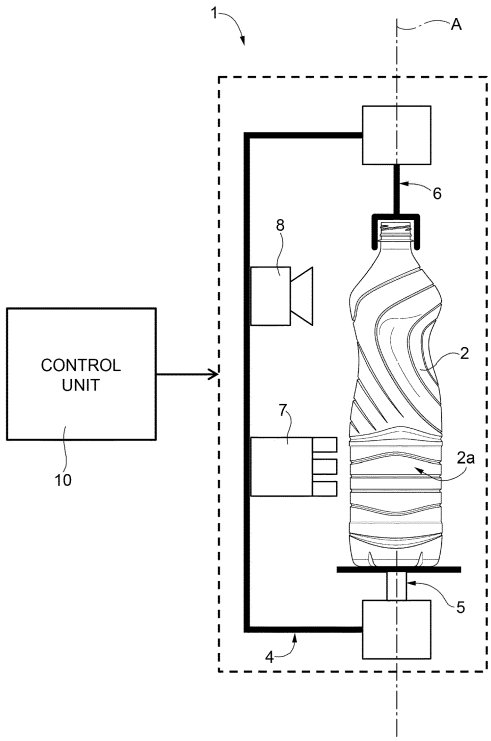


FIG. 1

EP 2 960 057 A1

## Description

### FIELD OF THE INVENTION

**[0001]** The present invention relates to the field of apparatus for decorating the surface of three-dimensional objects such as containers. More specifically, the invention relates to the field of apparatus for decorating the surface of containers having an irregular surface.

### BACKGROUND

**[0002]** Decorating the external surface of containers for storing consumables is important for rendering the containers distinguishable by the end user and for notifying the end user of the type of consumable stored in the container as well as of other information relating to its contents. Decorating the external surface of the container also plays a significant role in branding the containers. The decoration generally needs to be applied during the production of the container and usually no later than in connection with the filling of the container. The decoration should be durable enough such that its quality is not likely to deteriorate significantly when the filled container is stored and distributed to the end user.

**[0003]** Conventionally, containers have been decorated by applying adhesive labels to their outer surface. To ensure the durability of the label and its adhesive bond to the container surface, the label was applied to a decoration surface area that essentially followed the shape of a cylinder surface. That way, the label could be applied to the bottle while the bottle was rotated around its longitudinal axis and the label would be held to the external surface of the container by an adhesive distributed across the entire decoration surface area to avoid peel-off.

**[0004]** More recently, it has been suggested to decorate containers directly by inkjet printing of its external surfaces. For example, WO 2012/022746 A1 describes an apparatus suitable for printing a container with a vertical stack of inkjet print heads while the container is rotated around its longitudinal axis of rotation in front of the print heads.

**[0005]** Known apparatuses, such as the one disclosed in WO 2012/022746 A1, however require the decoration surface area of the container to be arranged on a complete cylindrical surface with respect to the longitudinal axis of rotation of the container. This requirement is a significant limitation for the kind of container that can be printed with the process and apparatus.

**[0006]** It is an object of the present invention to enhance the state of the art. It is another object of the present invention to overcome the disadvantages of the prior art processes and apparatus for decorating the surfaces of three dimensional objects such as containers.

### SUMMARY OF THE INVENTION

**[0007]** This object can be achieved by an apparatus and method for decorating the surface of an irregularly shaped container, as defined in the appended claims.

### DETAILED DESCRIPTION OF THE FIGURES

**[0008]** A preferred, non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

- Figure 1 is a schematic diagram of an apparatus for decorating the surface of an irregularly shaped container, according to an embodiment of the present solution;
- Figure 2 is a schematic block diagram of a control unit in the apparatus of Figure 1;
- Figure 3 is a flow chart of operations performed by the control unit of Figure 2;
- Figures 4-6 are schematic diagrams of an apparatus for decorating the surface of an irregularly shaped container, according to further embodiments of the present solution;
- Figure 7 is a schematic diagram of a machine for decorating containers, according to a further aspect of the present solution.

### DETAILED DESCRIPTION OF THE INVENTION

**[0009]** In one aspect, the present invention provides a method for decorating the surface of an irregularly shaped container.

**[0010]** The term "container" refers to a hollow body suitable for storing a product such as a consumable, preferably a liquid consumable such as a beverages, cosmetics, body care consumables, medical consumables, household consumables, and the like. Yet more preferably the container is suitable for storing a liquid beverage such as water, soft drinks, juices, teas, coffees, dairy products, beers, wines, spirits, and the like. The container may have a standing surface defined by at least three contact points for supporting the container on a horizontal surface. The container may have an axis of rotation which is perpendicular to the standing surface of the container. The container may have an opening for accessing the interior storage volume of the container, preferably an opening with a circular cross-section such that a screw cap or other types of closures can be releasably applied easily. The container may have an axis of rotation that is perpendicular to the cross-section of the opening. The cross-section of the opening of the container may be parallel to the standing surface of the container.

**[0011]** The container has a decoration surface area

which is the part of its outer surface that is intended to be decorated with the apparatus of the present invention. The decoration surface area is generally large enough such that the decoration after being applied to the decoration surface area is distinguishable by the end user of the container. The decoration surface area may be contiguous or be comprised of several discontinuous parts such as a first decoration surface area positioned at a lower body portion of the container and a second decoration surface area at an upper body portion, or shoulder, of the container. Other configurations of a plurality of discontinuous parts jointly making up the decoration surface area are within the scope of this invention.

**[0012]** The term "irregularly shaped container" refers to a container with an axis of rotation, from which all points of the decoration surface area do not have an essentially constant distance, and/or for which the container is not rotationally invariant. For example, bottle with a triangular or square cross-section or any other at least partially non-circular cross-section is an irregularly shaped container. The irregularly shaped container may have irregularly shaped features such as ribs or ridges positioned on an otherwise cylindrically shaped decoration surface area.

**[0013]** When decorating the decoration surface area of an irregularly shaped container it is essential to know the rotational orientation of the container with respect to the decoration applicator such that either container can be rotated to a pre-determined rotational orientation prior to applying the decoration or that the application of the decoration can be adjusted to the current orientation of the container. Without such knowledge, the decoration will be applied to the decoration surface area with a random phase or offset with respect to the rotational orientation of the container. It is to be noted that the decoration in general is not rotationally invariant either, such as by containing letters and other graphical elements.

**[0014]** The irregularly shaped container has a pre-defined axis of rotation. The pre-defined axis of rotation may be an axis that is perpendicular to the opening surface of the container. The pre-defined axis of rotation may be the axis that is perpendicular to the opening surface of the container and crosses the opening surface through its center. The opening surface of the container may be circular and be positioned at the top of a cylindrically shaped container end. The cylindrically shaped container end allows the application of an essentially cylindrical closure such as a screw top, a sports cap, or a crown. The pre-defined axis of rotation may be an axis that is perpendicular to the standing surface of the container. The pre-defined axis may the axis perpendicular to the standing surface of the container that crosses the standing surface through its center. The opening surface may be parallel to the standing surface of the container. The pre-defined axis may cross the standing surface and the opening surface through their respective centers.

**[0015]** The method of the present invention comprises the step of supporting the container with a support. A support is any means that is useful for preventing acceleration of the container due to gravitational forces during the application of the decoration. The support may be adapted for supporting the container at least three points, preferably three points that form part of the standing surface of the container. The support may be adapted for supporting the container at the standing line which is the set of points of the container base which form part of the standing surface. For example, the container may have a circular standing ring comprised in its base and the support is supporting the container at least a portion of the standing ring. The container may have a neck ring and the support may be a gripper supporting the bottle at the neck ring. The support may be supporting the container at the standing surface as well as gripping the neck of the container. The support may comprise means for exerting a force onto the container which increases the friction against the support. For example, a top force may be applied to the container top in order to increase the friction against a support supporting the container at the standing surface.

**[0016]** The support of the present invention may be adapted to prevent unwanted rotation of the container around its rotational axis. Since it is important to know the orientation of the container during the decoration application, an unwanted and uncontrolled change of the orientation of the container should be avoided as soon as the container is supported by the support.

**[0017]** The method of the present invention further comprises the step of applying a decoration.

**[0018]** The term "decoration" refers to any material applied to the outer surface of the container with the objective of rendering the container distinguishable or to convey information to the user of the container such as the contents of the container or the brand of the content. The decoration can take the form of a label that can be applied directly to the bottle such as by printing. A large variety of suitable label geometries and materials is well known in the art. Applying the decoration to the bottle may be achieved by either applying ink to the surface of the container or by activating pigments in the container material for example by selective irradiation. Suitable devices for applying ink to the surface of a container and to activate pigments in container material are well known in the art.

**[0019]** The decoration applied to the irregularly shaped container by the method of the present invention is phased. The term "phased" means that the rotational orientation of the bottle around the pre-defined axis of rotation is defined with respect to the rotational orientation of the decoration. For example, a word included in the decoration is intended to be centered on the surface between two vertical edges of a container having a triangular cross-section and is not supposed to run over an edge. For example, a label is a phased decoration if the label is not surrounding the complete circumference of the container cross-section as is to be applied to a predefined position on the decoration surface of the irregularly shaped container.

**[0020]** In the method of the present invention the dec-

oration is applied with a decoration applicator. The term "decoration applicator" refer to any means that is capable of applying a decoration such as a labeling station for the application of a label, an ink print head for the application of ink to the container surface, or an irradiation source adapted to selective irradiate portion of the container surface. Suitable decoration applicators are well known in the art.

**[0021]** During the application of the decoration, the container is rotated around the axis of rotation relative to the position of the decoration applicator. The decoration applicator is generally not able to decorate the entire decoration surface of the irregularly shaped container without being moved relative to the container. The relative movement of the decoration applicator with respect to the container can be achieved for example by rotating the container around the pre-defined axis of rotation while the decoration applicator is stationary, or the decoration applicator is rotated around the pre-defined axis of rotation while orientation of the container is fixed, or by rotating the container as well as the decoration applicator around the axis of rotation. In addition to the rotational movement, the distance of the decoration applicator to the pre-defined axis of rotation may be varied during the application of the decoration. A variation of this distance can be achieved for example by radially moving the decoration applicator or the container with respect to the predefined axis of rotation of the container.

**[0022]** The rotation of the irregularly shaped container may for example be achieved by placing the container on a rotatable turntable as support. A turntable is a suitable means for supporting the container at a part of the container surface that does not include the decoration surface. The turntable may support the container at the standing surface which generally faces downwards and is not readily visible for the end user. A turntable is further suitable because it allows for the rotational movement of the container supported by it, preferably rotation around an axis that is perpendicular to the standing surface of the container. The turntable may have any suitable geometry and preferably has the geometry of the horizontally oriented disk having a circular circumference. The turntable may further be coupled with a gripper which holds the container and fixes the rotational orientation of the container with respect to the support. The gripper preferably holds the container at a part of the container surface which does not include any portion of the decoration surface so as to avoid interference with the decoration application process. Preferably, the gripper may hold the container by its neck. Alternative, the container may be pressed against the support surface by a means applying a force component perpendicular to the support surface and preferably the standing surface. The turntable may include an actuator such as a step motor optionally including a gear for actuating the rotation of the turntable. Other suitable actuators such as a cam and a cam follower are also known in the art. The rotation of the irregularly shaped container may alternatively be achieved by supporting the container with a rotatable gripper including an actuator for rotating the gripper such as a step motor optionally including a gear mechanism.

**[0023]** The rotation of the decoration applicator may be achieved by mounting the decoration application on a movable support which is movable along a path in a circumferential direction with respect to the pre-defined axis of rotation of the container. The support of the decoration applicator may include an actuator for actuating the movement in the circumferential direction such as a step motor optionally including a gear mechanism.

**[0024]** The support of the container as well as the support of the decoration applicator may include sensor means for determining the current rotational and translational position of the support and the decoration applicator. The sensor may be connected to a control unit for the apparatus of the present invention for transmitting the current position to the control unit.

**[0025]** In the method of the present invention, the step of applying the decoration to the container surface is preceded by the step of determining the initial orientation of the container with respect to the axis of rotation.

**[0026]** The determination of the initial orientation may be achieved optically such as by obtaining an image of the container in its current orientation and comparing the image to stored information for example information representing images of the container taken at pre-determined orientations. The obtained image maybe be one two-dimensional photographic image having a sufficient resolution for determining the orientation of the irregular shaped container. The required resolution depends for example on the specific geometry of the irregularly shaped container such as the degree of irregularity. The obtained image may comprise two two-dimensional photographic images having a sufficient resolution taken from different positions, either by two cameras or one movable camera. The obtained images may be a stereoscopic photographic image having sufficient resolution, for example taken by a stereoscopic camera. The obtained image may be three-dimensional photographic image, taken by a three-dimensional camera. A three-dimensional photographic image is a two-dimensional photographic image in which for a plurality of, preferably the majority of, more preferably essentially all pixels a depth value has been measured and stored in relation to the pixel information.

**[0027]** A suitable device for carrying out the step of determining the initial orientation may comprise a sensor for creating a two dimensional photographic image of the container in its initial orientation. Digital cameras for obtaining two dimensional photographic images are well known in the art. The device may further comprise a means for illuminating the container while the photographic image is obtained. The means for illuminating may be positioned at a certain spatial angle with respect to the camera in order to increase the distinctiveness of the photographic images taken at different orientation of the camera. For example, the illumination means may

be arranged at angles of 30°, 45°, 69°, or 90° from the sensor obtaining the photographic image.

**[0028]** A suitable device for carrying out the step of determining the initial orientation may further comprise storage means for storing a number of sensor signals related to the container at different known orientations and a processing means for comparing the sensor signal obtained for the initial orientation of the container with the stored signals and deriving a value representative for the initial orientation from the comparison. Suitable electronic storage and processing means are well known in the art. Suitable algorithms for comparing sensor signals are well known in the art for each kind of suitable sensor. The skilled artisan is capable of selecting and if needed adapting such algorithms for the present invention. The suitable algorithm may be provided in the form of a executable program code stored in a program storage means associated with the electronic processing means.

**[0029]** The suitable device for carrying out the step of determining the initial orientation may be connected directly or indirectly to the actuator for the rotatable support of the container. The suitable device for carrying out the step of determining the initial orientation may arranged such that it may control the actuation of the rotatable support and causes the support to rotate until the predetermined rotation of the container is achieved. The electronic processing means include a program storage means storing executable program code.

**[0030]** The determination of the initial orientation may be achieved holographically such as by obtaining a holographic recording of the container in its current orientation and comparing the recording to stored information for example information representing holographic recordings of the container taken at pre-determined orientations.

**[0031]** The determination of the initial orientation may be achieved acoustically such as by obtaining an ultrasound echo of the container in its current orientation and comparing the echo to stored information for example information representing echoes of the container taken at pre-determined orientations. The ultrasound echo which is obtained may be the echo of a single ultrasound wave or may be the interference of the echoes of two or more ultrasound wave created by one or more ultrasound sources.

**[0032]** In the method of the present invention, the step of applying the decoration to the container surface is preceded by the step of rotating the container around its axis of rotation relative to the decoration applicator until a predetermined orientation is reached. The rotation of the container around its axis of rotation relative to the decoration applicator can be achieved by rotating the container around its pre-defined axis of rotation, by rotating the decoration applicator around the pre-defined axis of rotation or by rotating the container as well as the decoration applicator around the predefined axis of rotation. The amount of rotation required to reach the pre-determined orientation is determined in dependence on the initial rotational orientation of the container such as by determining the difference in rotational angle between the predetermined orientation and the initial orientation.

**[0033]** The rotation of the container may be controlled by the control unit of the apparatus of the present invention which may be controlling the rotational movements of the container in dependence on the current orientation of the container.

**[0034]** In the method of the present invention, the step of applying the decoration to the container surface with a decoration applicator may comprise the step of applying ink drops from an ink jet print head onto the outer surface of the container while the container is rotated around the axis of rotation relative to the ink jet print head. Suitable ink jet print heads are well known in the art and are commercially available. The application of the decoration may further comprise a step of pre-treating the surface such that the surface is rendered capable of holding the ink after the ink is applied. For PET container, such a treatment could include a plasma treatment. Suitable devices for plasma treating the surface of PET containers are well known in the art. The step of applying the decoration may further be followed by a step of curing the applied decoration such as by curing the ink by exposing the decoration to a UV light source. Suitable curable inks are well known in the art.

**[0035]** In the method of the present invention, the step of applying the decoration to the container surface with a decoration applicator may alternatively comprise a step of activating an activatable pigment with a laser whereby the activatable pigment is comprised in the container material. Suitable activatable pigments as well as suitable activation devices such as lasers are well known in the art.

**[0036]** In the method for decorating the surface of an irregularly shaped container, the step of determining the initial orientation of the container with respect to the axis of rotation may comprise the step of generating a sensor output as a result of sensing the orientation of the container after said container has been supported with a support. Optical sensor are capable of generating an output result such as a digital image that changes in dependence on the rotational orientation of the container. Suitable sensors include two-dimension digital cameras, three-dimensional digital cameras, stereoscopic digital cameras, holographic digital cameras, and the like. Other sensors such as ultrasonic imaging sensors are also suitable for generating a sensor signal responsive to the rotational orientation of the container.

**[0037]** In the method for decorating the surface of an irregularly shaped container, the step of determining the initial orientation of the container with respect to the axis of rotation may comprise the step of comparing the sensor output with a plurality of stored sensor outputs corresponding to pre-determined container orientations. Since the container to be decorated can have different shapes and cross-sections, the sensor output generated with the actual container orientation is compared to a

plurality of stored sensor outputs which correspond to the sensor output at different predetermined container orientations. The number of sensor outputs for predetermined container orientations that is required for the method of the method of the present inventions depends on the required accuracy of the phasing of the decoration with respect to the container decoration surface area as well as to the degree of irregularity of the container. The predetermined orientations may be sampled equidistantly (for example one predetermined orientation at 5° intervals between 0° and 360°) or they may be sample at uneven intervals in order to have a higher resolution for certain container orientation.

**[0038]** In the method for decorating the surface of an irregularly shaped container, the step of determining the initial orientation of the container with respect to the axis of rotation may comprise the step of computing the orientation of the container using the result of the comparisons as input. The computation of the actual orientation may comprise the step of selecting that pre-determined orientation for which the comparison has with the actual orientation has yielded the best match. This method requires a relatively high number of stored sensor outputs at predetermined orientation in order to achieve a high level of accuracy. The computation may further comprise a step of interpolating between the sensor outputs of two adjacent pre-determined container orientation when the comparison with the actual signal is no matching well enough with any of the stored sensor signals.

**[0039]** The step of rotating the container around its axis of rotation relative to the decoration applicator until a predetermined orientation is reached can be executed in a two-step or multistep iterative process with increasing precision. In the first step the current orientation is determined with a first level of accuracy and in response to the sensor signal generated in the first step, the container is rotated to a first pre-determined position. The new current position is then determined in a second step again but with higher accuracy. In response to the second sensor signal, the container is then rotated to the second pre-determined position. The second step can be repeated until the desired level of precision in the rotational orientation of the container is reached. In each of the steps, the same sensor may be used for generating the sensor signal responsive to the current orientation of the container. Alternative, different sensors similar sensors with varying position, a moving sensor capable of generating sensor signals from different positions can be used for the different steps of this iterative process.

**[0040]** In another aspect the present invention provides an apparatus for decorating the surface of an irregularly shaped container.

**[0041]** The apparatus for decorating the surface of an irregularly shaped container comprises a support for supporting the container as described above.

**[0042]** The apparatus for decorating the surface of an irregularly shaped container comprises a decoration applicator for applying a decoration onto the outer surface of the container as described above. The decoration applicator may be rotatably connected to the support. This rotatable connection allows for rotation of the decoration applicator relative to the container support. This relative rotation can be achieved by rotatably mounting the decoration applicator to the apparatus or by rotatably mounting the support to the apparatus. Alternatively, both the decoration and the support may be rotatably mounted to the apparatus of the present invention. They may rotate about the same axis of rotation of or about different axis of rotation. Preferably, the decoration applicator is rotatable around the predetermined axis of rotation of the container to be decorated. Preferably, the support is rotatable in such a way that the container when supported by the support is rotatable around its predetermined axis of rotation.

**[0043]** The apparatus for decorating the surface of an irregularly shaped container comprises an actuator operatively connected to the support or the decoration applicator for rotating the container around its axis of rotation relative to the decoration applicator. Suitable actuators have been described above.

**[0044]** The apparatus for decorating the surface of an irregularly shaped container comprises a sensor for detecting the rotational orientation of the container.

**[0045]** A suitable sensor for detecting the rotational orientation of the container is a digital camera capable of recording a two-dimensional digital image of the container in its current position. The digital camera may operate within the optical range or may operate at a different wavelength such as infra-red, ultraviolet, microwave. A large number of suitable cameras and industrial sensors for recording digital images is commercially available.

**[0046]** Another suitable sensor for detecting the rotational orientation of the container is a stereoscopic digital camera having at least two separate optical systems and image sensors for simultaneously taking two images of the same object from different angles thus simulating the binocular vision of mammals. The stereoscopic camera for the present invention may include means for comparing the two images and to generate a resulting stereo image. Suitable algorithms for generating stereo images are well known in the art. Many different suitable stereoscopic digital cameras and industrial sensors are commercially available.

**[0047]** Another suitable sensor for detecting the rotational orientation of the container is a 3D digital camera capable of recoding a two-dimensional digital image together with depth information for at least some of the pixels or for at least some subsets of pixels. The 3D digital camera may use a time-of-flight measurement to determine the distance from the camera to a specific point of the object. Thus, the 3D camera is capable of measuring the depth information for a plurality of pixels or subsets of pixels simultaneously in one iteration. 3D cameras require the object to be illuminated with a dedicated light source that pulse with a high frequency of up to 100 MHz. Suitable 3D cameras and industrial sensors are commer-

cially available, for example the 3D chip commercially designated "pmd PhotonIC® 19k-S3" available from Pmdtechnologies GmbH in Siegen/Germany or the depth sensor commercially designated "Argos®3D - P100" available from Bluetechnix GmbH in Wien/Austria.

**[0048]** Another suitable sensor for detecting the rotational orientation of the container is an active laser scanner either working according to the time-of-flight or the triangulation principle. The object is illuminated by a modulated laser light source and the reflected light is analyzed using a camera. In the time-of-flight sensor the laser source and the camera are essentially collocated one facing the other, whereas in the triangulation sensor the light source, the object, and the camera form a triangle. With laser scanners only one distance of a point on the object can be measured and hence the light source, the object, and/or the camera need to be moved in case the distance of a further point of the object is to be measured. In the present invention, the number of points required and their positions depend on the complexity of the shape of the container and the desired accuracy. A large variety of suitable laser scanner working according to either principle are commercially available from various sources.

**[0049]** Another suitable sensor for detecting the rotational orientation of the container is a holographic digital camera recording holographic measurement data representing the three-dimensional shape of the imaged object. The holographic digital camera may use any one of the following techniques for analyzing the recorded data: off-axis configuration, phase-shifting holography, frequency-shifting holography, multiplexing of holograms, super-resolution in digital holography, optical sectioning in digital holography, combining of holograms and interferometric microscopy. Suitable holographic digital cameras are known in the art and commercially available.

**[0050]** The sensor of the apparatus of the present invention may be arranged so that a series of two or more sensor signals are created while the container is in rotary motion and the recorded series of sensor signals is compared to stored sensor signals or series of sensor signals for determining the current rotational orientation of the container.

**[0051]** The sensor in the apparatus of the present invention may be positioned such that the direction of view onto the container is perpendicular to the pre-determined axis of orientation of the container and such that the camera will generate a side view of the container. As an alternative, the camera may be arranged so that the direction of view forms an angle of less than 90° with the predetermined axis of orientation of the container. In this case, the image of the camera will have a perspective view onto the side surface of the container and may include some features at the shoulder of the container.

**[0052]** The apparatus for decorating the surface of an irregularly shaped container may comprise means for illuminating the container while the sensor is generating the sensor signal responsive to the actual orientation of the container to be decorated. Through the illumination, the conditions for creating the sensor signal can be standardized in comparison to relying on factory lighting for this purpose. The one or more means for illumination may be positioned at specific positions such that certain features on the surface of the irregularly shaped containers create shadows which are in turn reflected in the sensor signal. A large variety of suitable devices for illuminating the container are commercially available.

**[0053]** The apparatus for decorating the surface of an irregularly shaped container may comprise a control means operatively connected to the sensor and to the actuator causing the actuator to rotate the container around its axis of rotation relative to the decoration means until a predetermined rotational orientation is reached. The control means can be arranged such that an estimate of the current rotational orientation of the container is determined and that the actuator is controlled to rotate the container relative to the decoration applicator to the pre-determined position. The control means can be arranged to generate a further sensor signal after the rotation in order to verify the accuracy of the preceding rotation. The control means may be adapted to initiating a second and potentially further rotations of the container until the pre-determined rotational orientation is reached with the desired degree of accuracy.

**[0054]** The control means in the apparatus of the present invention may further be operatively connected to the decoration applicator to control the application of the decoration at a certain time. The control means may be adapted to both control the relative rotation of the irregularly shaped container and the application of the decoration.

**[0055]** The apparatus for decorating the surface of an irregularly shaped container may further comprise a storage means for storing sensor outputs for pre-determined container orientations. The storage may be operatively connected to the control means or the sensor means.

**[0056]** In the apparatus for decorating the surface of an irregularly shaped container, the support may comprise a rotatable turntable for supporting the container and a gripper connected to the turntable for fixing the orientation of the container relative to the turntable as described above.

**[0057]** In the apparatus for decorating the surface of an irregularly shaped container, the decoration applicator may comprise a labeling station for the application of labels to the surface of the irregularly shaped container. Suitable labeling stations are well known in the art and are commercially available.

**[0058]** In the apparatus for decorating the surface of an irregularly shaped container, the decoration applicator may comprise an inkjet print head for applying drops of ink to the outer surface of the container. Suitable inkjet print heads are known in the art and are commercially available for example from Xaar plc in Cambridge/UK. A large variety of suitable inks such as for example UV curable are also well know and commercially available.

**[0059]** In the apparatus for decorating the surface of

an irregularly shaped container, the container surface may comprise activatable pigments and the decoration applicator may in that case be a laser for activating the selected activated pigment. Suitable activatable pigments for being embedded into the container material are known in the art. The decoration applicator may comprise a suitable laser which operates either according to the mask marking or according to the beam deflection methods. Suitable laser systems are also well known in the art.

**[0060]** Reference is now made to Figure 1, which schematically shows an apparatus 1 for decorating at least a portion of an outer surface 2a of an irregularly shaped container 2, according to one embodiment of the present solution, the container 2 having a predefined axis of rotation A.

**[0061]** As previously discussed, the apparatus 1 comprises:

- a support structure 4, configured to support the container 2, during decoration operations (and possibly other operations on the same container 2);
- a base 5, e.g. including a rotatable turntable, coupled to the support structure 4 and supporting a bottom portion of the container 2; the base 5 may be rotatably coupled to the support structure 4 and driven by an actuator to cause a suitable rotation of the container 2 around rotation axis x;
- a gripper 6, coupled to the support structure 4 for holding the container 2 at an upper, or neck, portion thereof; the gripper 6 may be rotatably coupled to the support structure 4 and driven by a respective actuator to cause a rotation of the container 2 around rotation axis x;
- a decoration applicator 7, coupled to the support structure 4, and operable to apply a decoration onto the outer surface of the container (in any suitable manner, previously discussed in details, e.g. via inkjet printing); also the decoration applicator 7 may be rotatably coupled to the support structure 4 and may be driven by a respective actuator to cause a suitable rotation of the container 2 around its rotation axis x;
- a sensor arrangement 8, which may be coupled to the support structure 4, and is configured to provide an indication of an initial rotational orientation of the container 2 with respect to the axis of rotation A (again, in any suitable manner, previously discussed in detail, e.g. detecting one or more images of the container 2);
- a control unit 10, operatively coupled to the sensor 8, to acquire sensor signals therefrom, and to one or more of the above discussed actuators, in order to control a relative rotation around the axis of rotation A of the container 2 with respect to the decoration applicator 7; the control unit 10 may also be operatively coupled to the same decoration applicator 7, in order to control execution of the decoration operations.

**[0062]** In particular, during a preliminary or set-up operation, the control unit 10 is configured to determine an initial rotational orientation of the container 2 with respect to the axis of rotation A, based on the sensor signals provided by the sensor arrangement 8.

**[0063]** The control unit 10 is moreover configured to cause, through the controlled actuator, the relative rotation around the axis of rotation A of the container 2 with respect to the decoration applicator 7, until a predetermined desired rotational orientation is reached, starting from which the decoration operations of the decoration applicator 7 may be correctly performed.

**[0064]** As previously discussed, this relative rotation may be controlled by the control unit 10 through a respective, or combined, rotation of one or more of the base 5, the gripper 6 or the decoration applicator 7, with respect to the axis of rotation A.

**[0065]** In more details, and with reference to Figure 2, control unit 10 of the apparatus 1 for decorating the container 2, includes:

- a first interface 12, configured to provide a wired or wireless coupling to the sensor arrangement 8, in order to receive sensor signals, or sensor outputs, which are indicative of the initial orientation of the container 2 with respect to its axis of rotation A;
- a second interface 14, configured to provide a wired or wireless coupling to the actuator arrangement, here denoted with 15, configured to cause the relative rotation of the container 2 with respect to the decoration applicator 7;
- a processing stage 16, coupled to the first and second interfaces 12,14, and configured to implement a suitable algorithm (which will be discussed in detail in the following) to determine the initial rotation of the container 2 based on the sensor signals from the sensor arrangement 8, and to generate driving signals for the actuator arrangement 15, to cause the relative rotation of the container 2 with respect to the decoration applicator 7, until the pre-determined rotational orientation is reached; as previously discussed, the algorithm may envisage iterative repetition of the above operations, in order to improve the accuracy on the final rotational orientation around rotation axis A of the container 2 with respect to the decoration applicator 7.

**[0066]** According to an aspect of the present solution, control unit 10 may also include a memory 18, coupled to the processing stage 16, and storing stored sensor signals or outputs, indicative of predetermined known rotational orientations of the container 2 around rotation axis A. For example, in case the sensor arrangement 8 includes a digital camera, the stored sensor signals may include digital images of the container 2, taken at different known predetermined orientations (for example at regu-

lar, or uneven, angular intervals around rotation axis A).

**[0067]** The algorithm executed by processing stage 16 of control unit 10 is now discussed with reference to Figure 3. In particular, control unit 10 may be configured to execute suitable software instructions, which may be stored in memory 18, or in a further non volatile memory or other kind of storing means coupled thereto.

**[0068]** At a first step 20, control unit 10 acquires the sensor signals from the sensor arrangement 8, which are indicative of the initial orientation of the container 2. For example, control unit 10 acquires one or more digital images taken by one or more digital cameras in the sensor arrangement 8.

**[0069]** Then, at step 21, processing stage 16 of control unit 10 retrieves from memory 18 stored sensor signals, corresponding to a first predetermined known rotational orientation of the container 2 around rotation axis A.

**[0070]** At step 22, processing stage 16 then execute a suitable comparison of the acquired sensor signals to the stored sensor signals, in order to verify a suitable matching between the same signals (any suitable processing technique may be used for the purpose, and any suitable matching determined). For example, a comparison of the acquired and stored images may be performed, and a correspondence between the pixels of the images may be used to determine the level of matching between the digital images.

**[0071]** In case matching is not verified at step 23, the algorithm returns to step 21, in order to retrieve further stored sensor signals, corresponding to a further predetermined known rotational orientation of the container 2 around rotation axis A, and to step 22, in order to verify the possible matching between the acquired and the further stored sensor signals.

**[0072]** In case matching is instead verified at step 23, processing stage 16 of control unit 10 determines, at step 24, that the initial orientation of the container 2 corresponds to the currently checked predetermined known rotational orientation of the container 2 around rotation axis A.

**[0073]** Then, at step 25, processing stage 16, based on the determined initial orientation, determines the relative rotation that is to be applied around rotation axis A between the container 2 and the decoration applicator 7, in order to establish a desired starting position for the application of the decoration. Accordingly, processing stage 16 generates suitable driving signals for the actuator arrangement 15, to cause the determined relative rotation.

**[0074]** Afterwards, decoration operations may be performed, in a known manner, here not discussed in detail.

**[0075]** As previously underlined, an aspect of the present solution may envisage one or more iterative repetitions of the previously discussed algorithm, as shown at step 26, in order to gradually increase accuracy of the determination of the initial orientation of the container 2 around axis A, until a desired level of accuracy is reached (and decoration operations may be performed).

**[0076]** In particular, at each new iteration, sensor outputs are again acquired from the sensor arrangement 8 (after the relative rotation performed in the previous iteration), and their matching checked against the stored sensor outputs, or any kind of interpolations thereof.

**[0077]** A possible modification of the apparatus 1 for decorating a portion of an outer surface 2a of an irregularly shaped container 2 is schematically shown in Figure 4.

**[0078]** In this embodiment, the base 5 and gripper 6 of the apparatus 6 are coupled to the support structure 4 via movable braces 30, which allow for a vertical movement thereof, in a direction parallel to the axis of rotation A.

**[0079]** This allows, for example, to exert a force onto the container 2, which increases the friction against the support structure 4.

**[0080]** In the embodiment schematically shown in Figure 5, the sensor arrangement 8 includes a camera, which is arranged so that its direction of view forms an angle of less than 90° with the axis of rotation A of the container 2 (the direction of view is thus not orthogonal to the axis of rotation A).

**[0081]** In the embodiment schematically shown in Figure 6, the sensor arrangement 8 instead includes two different cameras, here denoted with 8a, 8b, which are arranged with respect to the container 2, so as to provide two digital images taken from different positions and different directions of view (e.g. in order to implement a stereo imaging system).

**[0082]** It is a further aspect of the present invention to provide a machine for decorating the surfaces of a series of irregularly shaped containers in a process, preferably a continuous process. The machine of the present invention comprises a rotatable wheel supporting a plurality of apparatus for decorating the surface of an irregularly shaped container, an actuator for rotating the rotatable wheel, means for supplying one container to one of the apparatus for decorating the surface of an irregularly shaped container, means for removing one container from one of the apparatus for decorating the surface of an irregularly shaped container. The means for supplying and removing one container from the apparatus of the present invention can have the form of a rotary infeed and outfeed wheel or the form of a transfer star wheel.

**[0083]** As schematically shown in Figure 7, the machine, here denoted with 40, may comprise: an input transfer wheel 42, configured to receive containers 2, e. g. from a forming machine, upstream in the container processing flow; a rotatable wheel 44, couple to the input transfer wheel 42 to receive the containers 2, and carrying a number of apparatuses 1 for decorating the outer surfaces of the same containers 2, each one configured to support a respective container 2 with the corresponding support structure 4 and to decorate the outer surface thereof with the corresponding decoration applicator 7; and an output transfer wheel 46, coupled to the rotatable wheel 44 to receive therefrom the decorated containers

2 and operable to transfer the same decorated containers 2 towards a further machine, downstream in the container processing flow, e.g. a filling or capping machine.

**[0084]** The advantages of the disclosed invention are clear from the foregoing description.

**[0085]** In particular, it is underlined that it allows to effectively decorate the outer surface of an irregularly shaped container, irrespectively of the initial orientation of the same container with respect to a decoration applicator.

**[0086]** Accordingly, limitations of known solutions for decorating containers may be overcome.

**[0087]** Clearly, changes may be made to what is described and illustrated herein without, however, departing from the scope of the present invention, as defined in the accompanying claims.

**[0088]** For example, in the apparatus 1, different means may be provided to cause the relative rotation between the container 2 and the decoration applicator 7 around the axis of rotation A, as well as different sensors may be used to provide an indication of the initial orientation of the container 2.

## Claims

1. An apparatus (1) for decorating an outer surface (2a) of an irregularly shaped container (2), comprising:

   - a support structure (4) for supporting the container (2), the container (2) having a pre-defined axis of rotation (A),
   - a decoration applicator (7) for applying a decoration onto the outer surface (2a) of the container (2),
   - an actuator (15) operable to cause a rotation of the container (2) relative to the decoration applicator (7) around the axis of rotation (A), **characterized by** further comprising:
   - a sensor (8) for detecting an initial rotational orientation of the container (2) around the rotation axis (A), and
   - a control unit (10), operatively coupled to the sensor (8) and to the actuator (15), and configured to cause a relative rotation around the axis of rotation (A) of the container (2) with respect to the decoration applicator (7) until a pre-determined rotational orientation is reached, before application of the decoration onto the outer surface (2a) of the container (2).

2. The apparatus according to claim 1, wherein the control unit (10) includes a processing stage (16), configured to determine the initial rotational orientation of the container (2) based on sensor signals acquired from the sensor (8), and to provide control signals to the actuator (15) to cause the relative rotation around the axis of rotation (A) of the container (2) with respect to the decoration applicator (7), based on the determined initial rotational orientation.

3. The apparatus according to claim 2, wherein the control unit (10) further comprises a memory (18), configured to store sensor outputs for respective pre-determined container orientations around the axis of rotation (A); and wherein the processing stage (16) is coupled to the memory (18) and is configured to jointly process the sensor signals acquired from the sensor (8) and the stored sensor outputs, to determine the initial rotational orientation of the container (2).

4. The apparatus according to claim 3, wherein the processing stage (16) is configured to execute a comparison between the sensor signals acquired from the sensor (8) and the stored sensor outputs, in order to identify a matching between the acquired sensor signals and the stored sensor outputs for a pre-determined container orientation; and to determine the initial rotational orientation of the container (2) based on the pre-determined container orientation corresponding to the matching stored sensor outputs.

5. The apparatus according to any of the preceding claims, wherein the sensor (8) for detecting the initial rotational orientation of the container (2) is an imaging sensor, configured to provide sensor signals related to at least one acquired imagine of the container (2).

6. The apparatus according to claim 5, wherein the sensor (8) includes a stereoscopic camera or a 3D video camera.

7. The apparatus according to any of the preceding claims, wherein the decoration applicator (7) is rotatably coupled to the support structure (4).

8. The apparatus according to any of the preceding claims, wherein the support structure (4) comprises a base (5) for supporting the container (2); and wherein the actuator (15) is coupled to at least one of the base (5) and the decoration applicator (7) for causing the rotation of the container (2) relative to the decoration applicator (7) around the axis of rotation (A).

9. The apparatus according to claim 8, wherein the support structure (4) comprises a gripper (6), operable to fix the orientation of the container (2) relative to the base (5); wherein the actuator (15) is coupled to at least one of the base (5), the decoration applicator (7) and the gripper (6), for causing the rotation of the container (2) relative to the decoration applicator (7) around its axis of rotation (A).

**10.** The apparatus according to any of the preceding claims, wherein the control unit (10) is further coupled to the decoration applicator (7), and is configured to control the decoration applicator (7) to apply the decoration onto the outer surface (2a) of the container (2), after the predetermined rotational orientation of the container (2) around its axis of rotation (A) relative to the decoration applicator (7) has been set.

**11.** The apparatus according to any of the preceding claims, wherein the container (2) is a beverage container.

**12.** The apparatus according to any of the preceding claims, wherein the decoration applicator (7) comprises an inkjet print head for applying drops of ink to the outer surface (2a) of the container (2).

**13.** The apparatus according to any of claims 1-11, wherein the outer surface (2a) of the container (2) includes activatable pigments, and the decoration applicator (7) is a laser for activating the selected activated pigments.

**14.** A rotary machine (40) for decorating a respective outer surface (2a) of irregularly shaped containers (2), comprising:

- a rotatable wheel (44) supporting a plurality of apparatuses (1) for decorating the respective outer surface (2a) of the irregularly shaped containers (2), according to any of the preceding claims;
- input means (42) for supplying containers (2) to the apparatuses (1) for decorating the outer surface (2a) thereof; and
- output means (46) for removing the containers (2) from the apparatuses (1).

**15.** A method for decorating an outer surface (2a) of an irregularly shaped container (2), the container (2) having a pre-defined axis of rotation (A), the method comprising the steps of:

- supporting the container (2) with a support structure (4),
- applying a decoration to the outer surface (2a) of the container (2) with a decoration applicator (7),

**characterized in that** the step of applying the decoration to the outer surface (2a) of the container (2) is preceded by the steps of:

- determining an initial rotational orientation of the container (2) with respect to the axis of rotation (A);
- causing a relative rotation around the axis of rotation (A) of the container (2) with respect to the decoration applicator (7), based on the determined initial rotational orientation, until a predetermined rotational orientation is reached.

**16.** The method according to claim 15, wherein the step of determining the initial rotational orientation of the container (2) with respect to the axis of rotation (A) comprises the steps of:

- generating a sensor output, as a result of sensing the orientation of the container (2), after said container (2) has been supported with the support structure (4);
- processing the sensor output to determine the initial rotational orientation.

**17.** The method according to claim 16, wherein the step of processing comprises the steps of:

- executing a comparison between the sensor output and a plurality of stored sensor outputs corresponding to pre-determined container orientations around the axis of rotation (A);
- computing the initial rotational orientation of the container (2) based on the result of the comparison.

**18.** The method according to claim 17, wherein the step of computing comprises the steps of:

- identifying a matching between the sensor output and the stored sensor output for a pre-determined container orientation; and
- determining the initial rotational orientation of the container (2) based on the pre-determined container orientation corresponding to the matching stored sensor output.

**19.** The method according to any of claims 15-18, wherein the step of supporting the container (2) with a support structure (4) comprises the step of placing the container (2) onto a rotatable base (5) and fixing the orientation of the container (2) relative to the base (5) with a gripper (6) coupled to the support structure (4).

**20.** The method according to any of claims 15-19, wherein the step of applying the decoration to the outer surface (2a) of the container (2) with a decoration applicator (7) comprises the step of applying ink drops from an ink jet print head onto the outer surface (2a) of the container (2) while the container (2) is rotated around the axis of rotation (A) relative to the ink jet print head.

**21.** The method according to any of claims 15-19, wherein the outer surface (2a) of the container (2) comprises an activatable pigment and wherein the step

of applying the decoration to the outer surface (2a) of the container (2) with a decoration applicator (7) comprises a step of activating the activatable pigment with a laser.

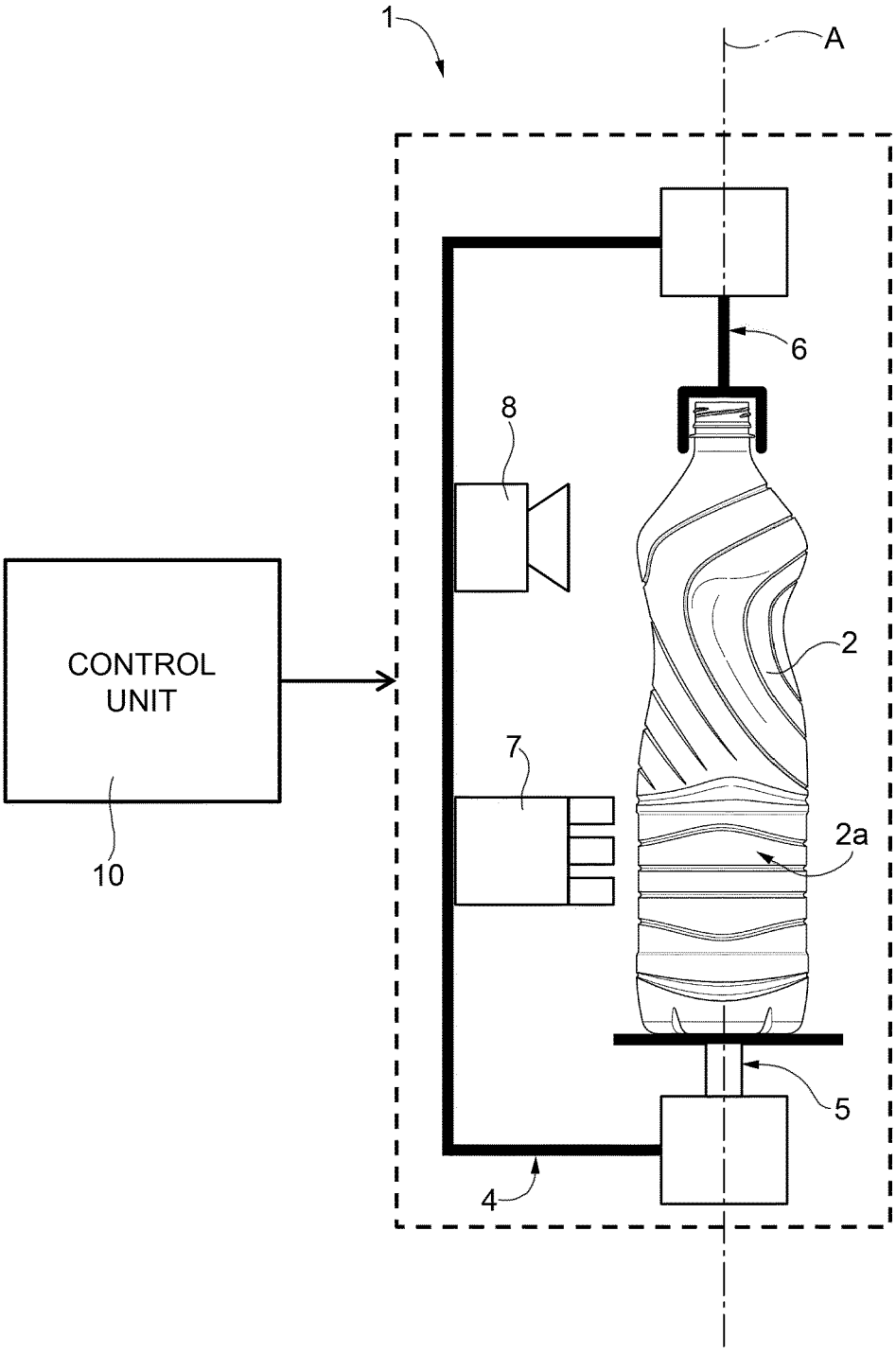


FIG. 1

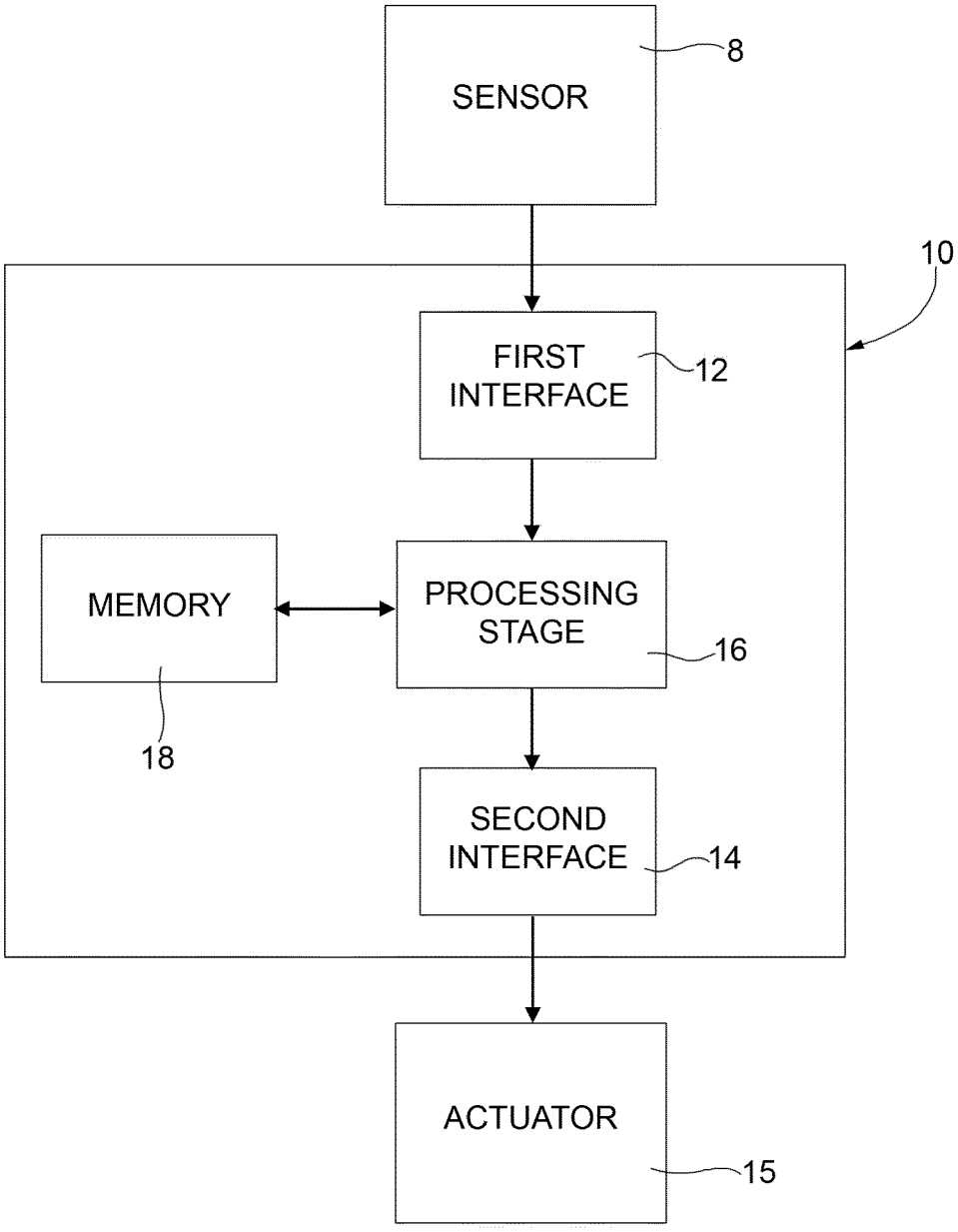
SENSOR
8
10
FIRST INTERFACE
12
MEMORY
PROCESSING STAGE
16
18
SECOND INTERFACE
14
ACTUATOR
15

FIG. 2

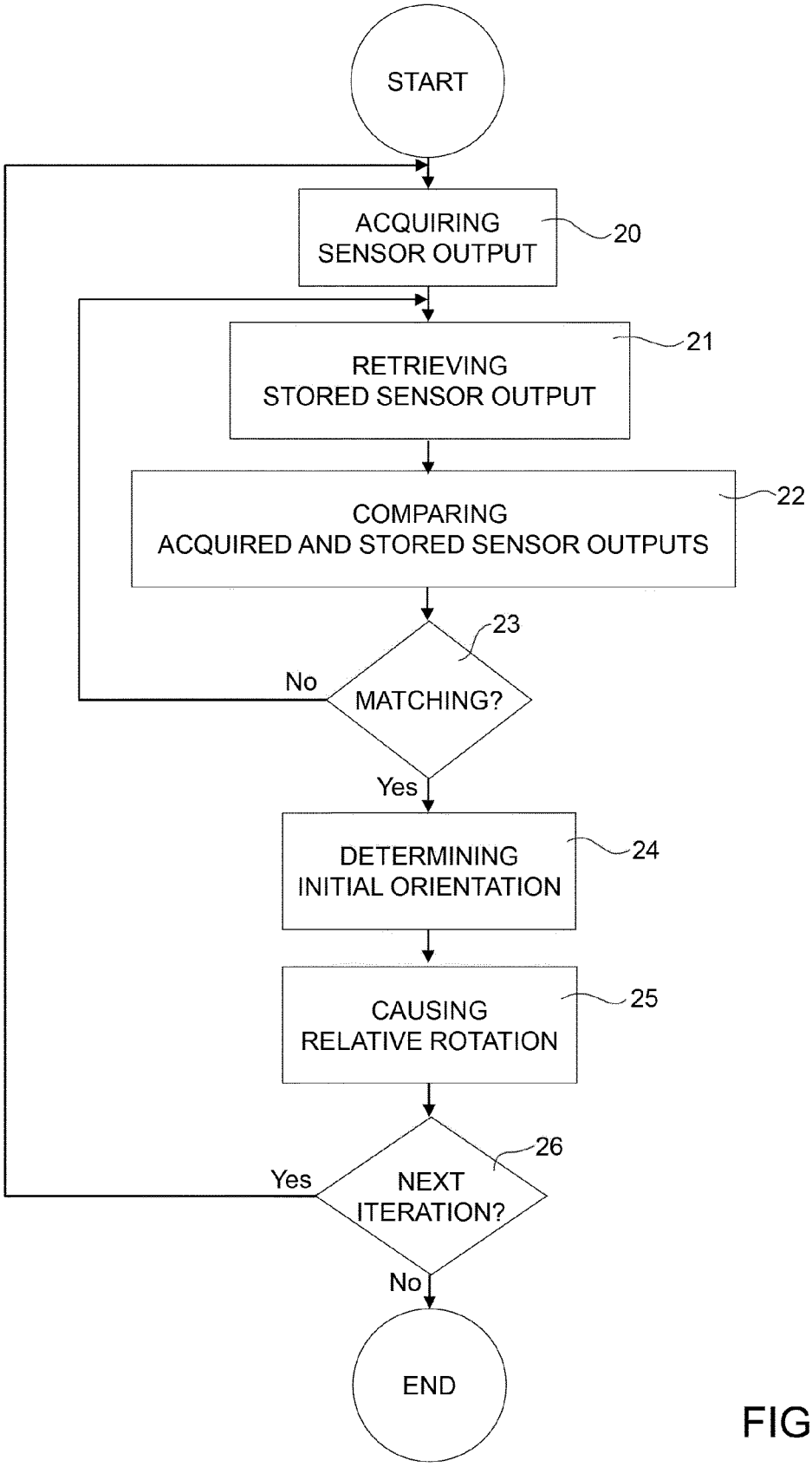
START
ACQUIRING SENSOR OUTPUT
20
RETRIEVING STORED SENSOR OUTPUT
21
COMPARING ACQUIRED AND STORED SENSOR OUTPUTS
22
23
MATCHING?
No
Yes
DETERMINING INITIAL ORIENTATION
24
CAUSING RELATIVE ROTATION
25
26
NEXT ITERATION?
Yes
No
END

FIG. 3

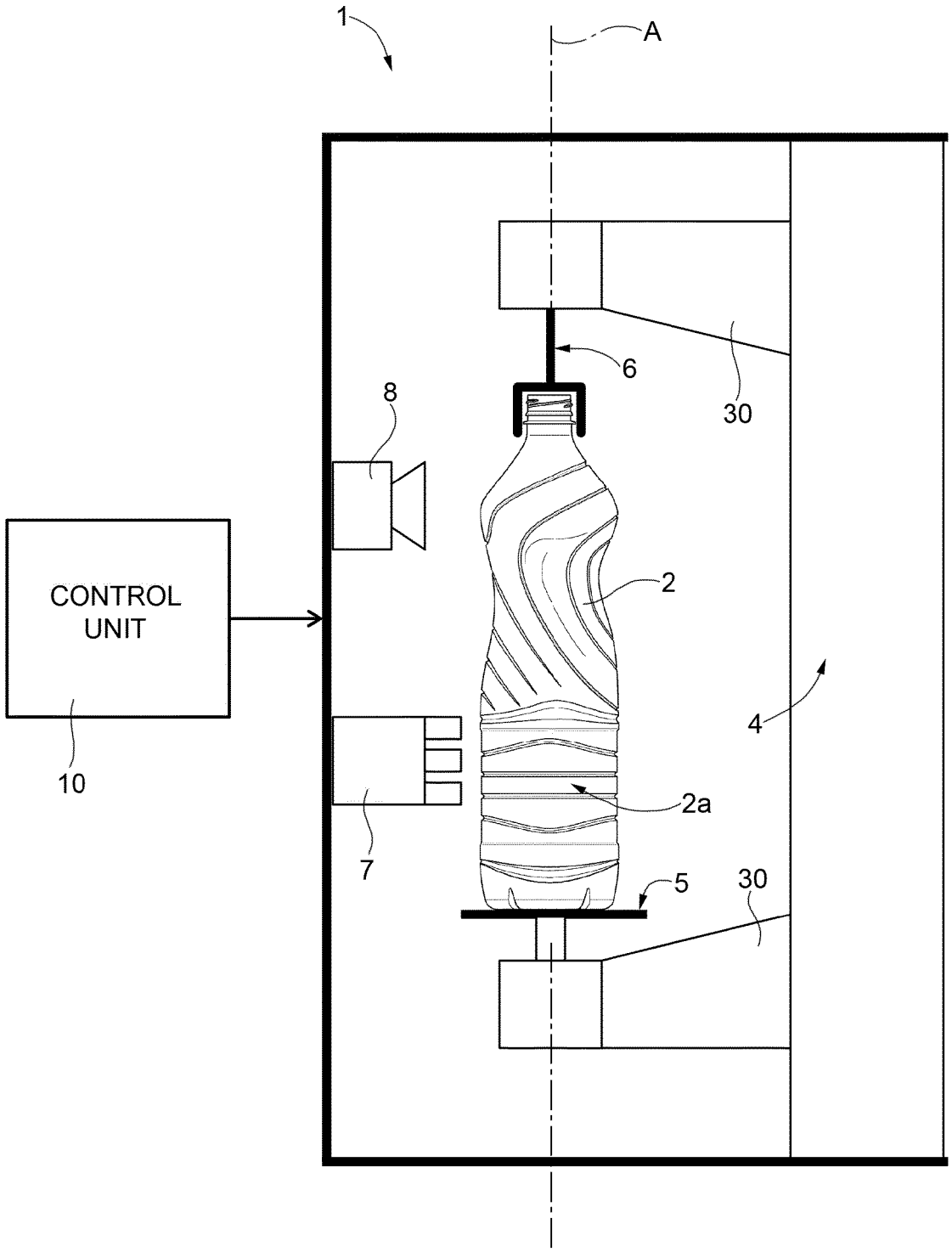


FIG. 4

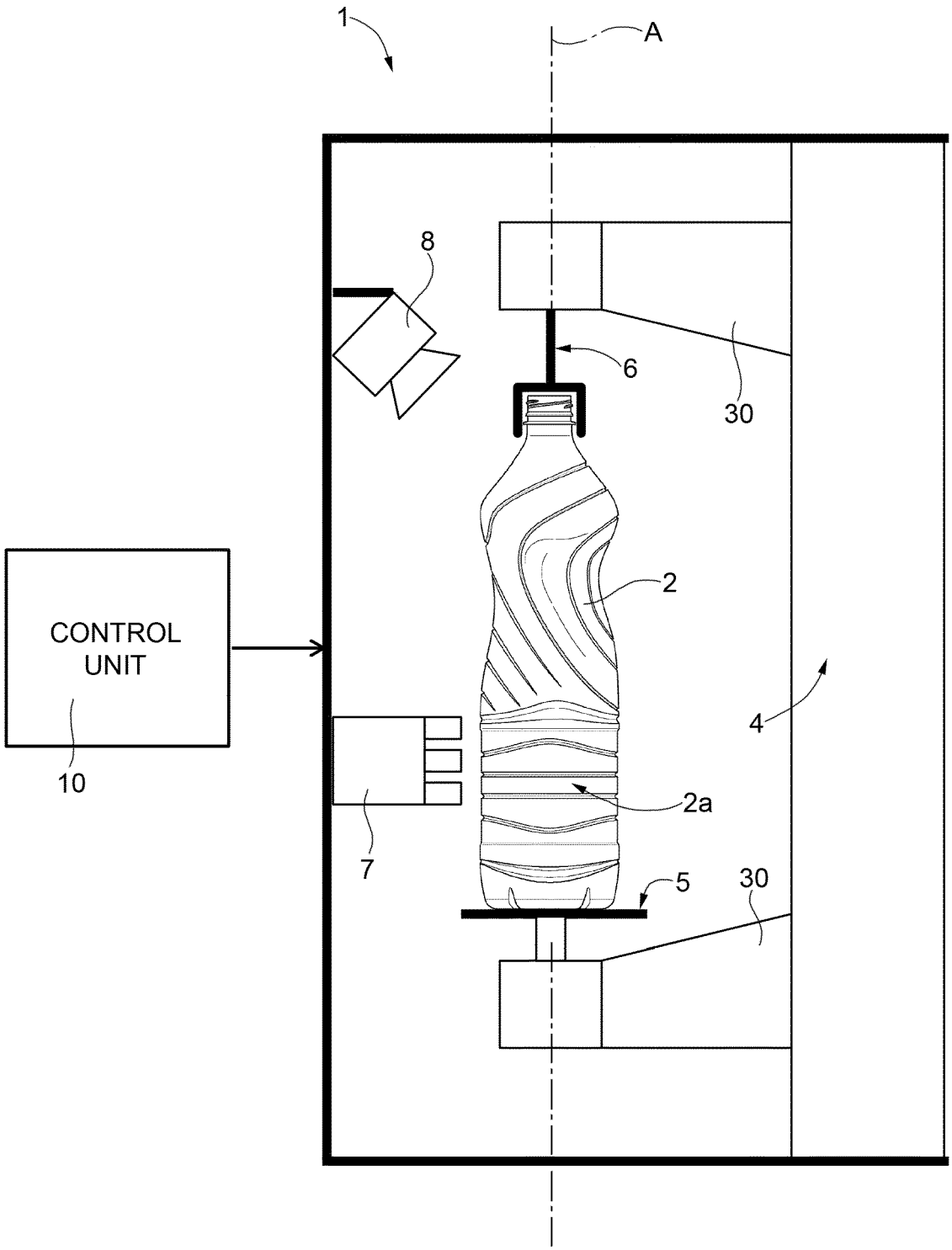


FIG. 5

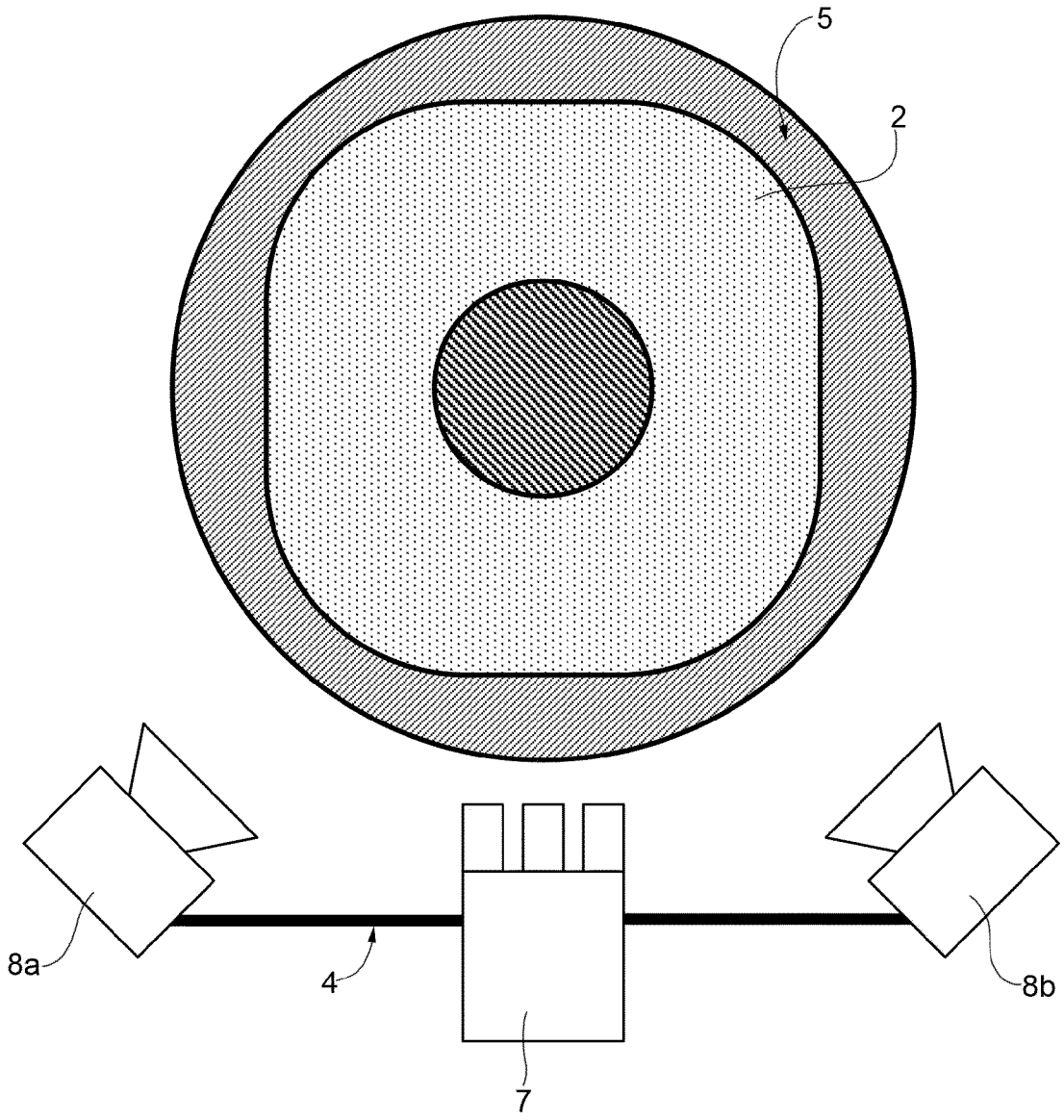


FIG. 6

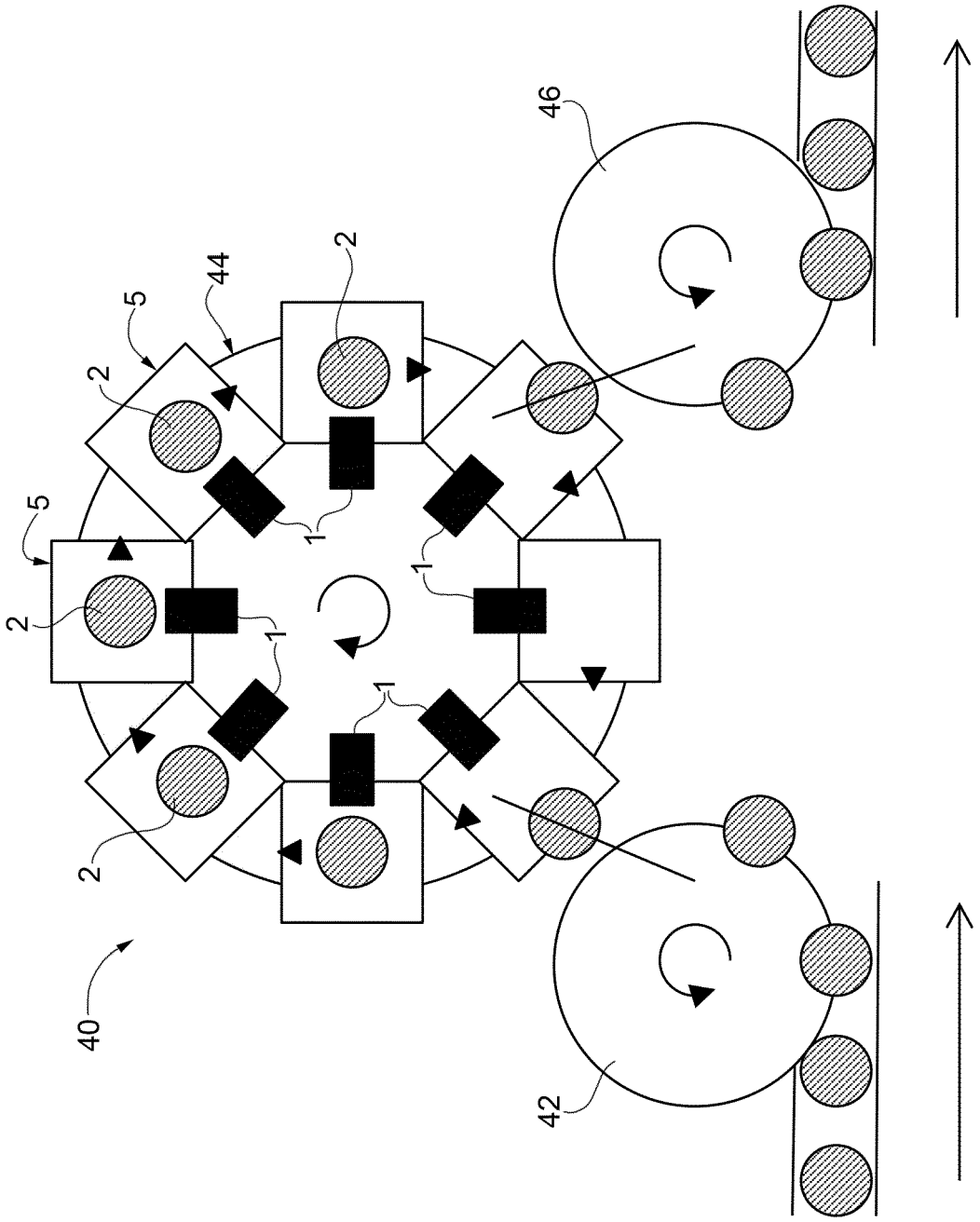


FIG. 7

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Application Number
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