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(54) REFLECTIVE JEWELRY ARTICLE

(57) The invention relates to a reflective ring or bracelet (10; 20) comprising at least one continuous reflective freeform surface (12; 22) configured to reflect light rays to a projection surface (30). The at least one continuous reflective freeform surface (12; 22) comprises a predetermined 3D pattern for projecting a predetermined image on the projection surface (30). The invention also relates to a method of manufacturing the reflective ring or bracelet (10; 20), comprising: i) providing a black and white image of the image to be displayed on the projecting surface (30), ii) using a computer algorithm to calculate the shape of the predetermined 3D pattern of said at least one continuous reflective freeform surface (12; 22), iii) generating a 3D surface in industry standard CAD format based on the predetermined 3D pattern, iv) providing a blank ring or bracelet, and v) reproducing the 3D surface on the blank ring or bracelet.

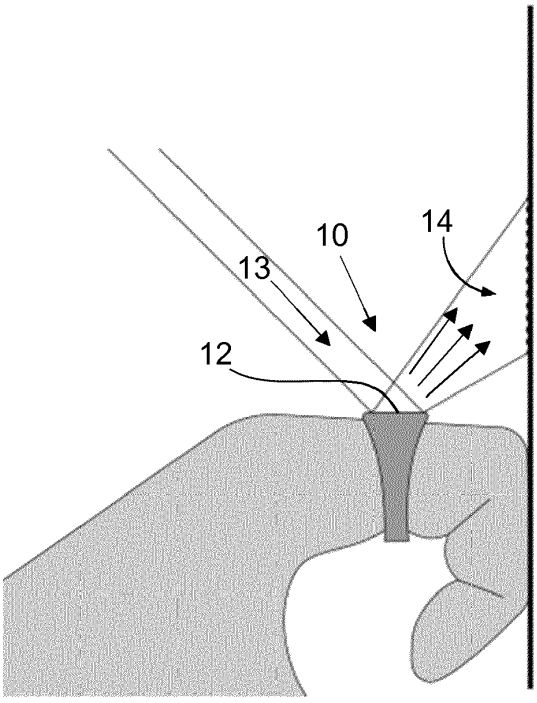

Fig. 2

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Description

Field of the invention

[0001] The present invention relates to a reflective jewelry article, in particular to a reflective ring, bracelet, or pendant.

Description of related art

[0002] Jewelry articles, such as pendants, configured to project an image on a projection wall already exist. One particularly example is illustrated in Figure 1. This pendant comprises a magnifying lens encapsulating texts which are projected on the wall when the pendant is illuminated. The projected texts are however blurry and dark and requires the use of a flashlight. Moreover, the texts are directly visible inside the pendant and thus fails to produce a surprising effect.

[0003] An aim of the invention is therefore to provide a jewelry article, in particular a ring, bracelet or pendant, configured to project crisp and bright images with high contrast, with any sort of light source.

[0004] Another aim of the invention is to provide a jewelry article comprising a 3D pattern barely visible to the naked eye on the jewelry article and which reflects an image on a projection surface which does not resemble to the 3D pattern of the jewelry article, thus providing a surprising effect.

Brief summary of the invention

[0005] These aims are achieved by a reflective jewelry article, in particular a ring or bracelet, comprising at least one continuous reflective freeform surface configured to reflect light rays to a projection surface. The at least one continuous reflective freeform surface is a computer-generated produced surface comprising a predetermined 3D pattern for displaying a predetermined image on the projection surface.

[0006] In an embodiment, the at least one continuous reflective freeform surface is a computer-generated machined surface or stamped surface.

[0007] In an embodiment, the surface normal of any point of the predetermined 3D pattern of said at least one continuous surface forms an angle, with respect to a reference surface, of at least 45°.

[0008] In an advantageous embodiment, the predetermined 3D pattern of the at least one continuous reflective freeform surface has a globally convex curvature extending from one edge to an opposite edge of the at least one reflective surface in order to enlarge the size of the predetermined image on the projection surface.

[0009] In an embodiment, the ring or bracelet comprises at least a first and a second distinctive continuous reflective freeform surface having different predetermined 3D patterns for displaying at least two distinctive predetermined images on said projection surface.

[0010] In an embodiment, the at least first and second distinctive continuous reflective freeform surfaces are arranged to project the at least two distinctive predetermined images next to each other.

[0011] In an embodiment, each of these two distinctive predetermined images represents a portion of a global image formed by the projection of said distinctive images.

[0012] In an embodiment, the ring has a general annular shape. The outer surface of the ring comprises the at least one continuous reflective freeform surface.

[0013] In an embodiment, the outer or inner surface of the bracelet comprises the at least one continuous reflective freeform surface. The bracelet may be for example a cut-off bracelet or a curb chain.

[0014] The preterminal image projected on the projection surface may be a text, a logo, an illustration or a photograph.

[0015] In an embodiment, the 3D pattern of said at least one continuous reflective freeform surface has been generated based on a computer algorithm configured to process images that have zero brightness background such that the shape of the boundary of the projected image on the projection surface differs from the shape of the boundary of said predetermined 3D pattern.

[0016] In an embodiment, the 3D pattern of said at least one continuous reflective freeform surface has been generated based on a computer algorithm configured to process images that have zero brightness background such that the projected image cannot be recognized by looking directly at said predetermined 3D pattern.

[0017] In an embodiment, the predefined 3D pattern is barely visible to the naked eye.

[0018] In an embodiment, the jewelry article is made of gold.

[0019] Another aspect of the invention relates to a method of manufacturing the reflective jewelry article as described above. The method comprises the steps of:

i) providing an image, preferably in black and white, of the image to be displayed on said projection surface;
ii) using a computer to execute an algorithm to calculate the shape of the predetermined 3D pattern of the at least one continuous reflective freeform surface;
iii) generating a 3D image of the predetermined 3D pattern in industry standard CAD format;
iv) providing a blank jewelry article, preferably a ring or bracelet, and
v) reproducing said predetermined 3D pattern on the blank jewelry article.

[0020] In an embodiment, the step of reproducing the predetermined 3D pattern on the blank jewelry article consists in machining a surface of the blank jewelry article to obtain the predetermined 3D pattern.

[0021] In an embodiment, the machining consists in displacing a cutting tool over a surface of the size of the

continuous reflective surface to be machined in at least two successive passes to remove successively at least a first and a second layer of material of the blank jewelry article to obtain the predetermined 3D pattern. The first pass removes the majority of the excess material while the second pass removes the remaining of the material with high precision.

[0022] In an embodiment, the distal end of the cutting tool is rounded with a radius smaller than the smallest radius of the predetermined 3D pattern.

[0023] In an embodiment, the distal end of the cutting tool is made of a single crystal diamond.

[0024] In an embodiment, the step of reproducing the predetermined 3D pattern on the blank jewelry article consists in: i) creating a die with a 3D mirror surface of the predetermined 3D pattern to be reproduced, and ii) die stamping the blank jewelry article to transfer the shape of the die to the surface of said blank jewelry.

Brief description of the drawings

[0025] The invention will be better understood with the aid of the description of several embodiments given by way of examples and illustrated by the figures, in which:

- Figure 1 shows a pendant according to the prior art;
- Figure 2 shows a schematic illustration of a ring according to an embodiment of the invention worn by a person for optimal positioning of the ring for accurate reproduction of the reflected image on a projection surface;
- Figure 3 shows a perspective view of a ring according to another embodiment;
- Figure 4 shows a perspective view of the ring of Figure 3 worn by a person when reflecting rays of light on a projection surface;
- Figure 5 shows a photography of a slightly different ring to the ring of Figure 3 according to another embodiment when reflecting rays of light on a projection surface;
- Figure 6 shows a perspective view of a ring according to another embodiment;
- Figure 7 shows a perspective view of a cut-off bracelet according to another embodiment;
- Figures 8a, 8b schematically shows a profile respectively of a continuous reflective freeform surface within the context of the invention and a non-continuous surface according to the prior art;
- Figure 8c is schematic close-up view of the continuous reflective freeform surface of Figure 8a;
- Figures 9a and 9b show a simulation of the projected image for a 3D pattern comprising a flat base surface with a projection distance of 30 mm and 50 mm respectively;
- Figures 10a and 10b show a simulation of the projected image for a 3D pattern comprising a convex base surface with a projection distance of 30 mm and 50 mm respectively;
- Figures 11a, 11b, 11c show reflection models for respectively a flat surface, a convex surface and a concave surface;
- Figures 12a, 12b show a simulation of the projected image on a projection surface of respectively the 3D pattern according to the invention and a 3D pattern from the prior art, and
- Figure 13 shows a schematic illustration of successive manufacturing steps for creating the 3D pattern on the surface of a blank ring or bracelet.

Detailed description of several embodiments of the invention

[0026] Figure 2 shows an exemplary embodiment of a reflective jewelry article in the form of a ring 10. The ring 10 comprises a surface 12 that is shaped with a specific so-called freeform surface defining a computer-generated 3D pattern which is barely visible to the naked eye.

[0027] The freeform surface of the reflective jewelry article is a continuous reflective freeform surface 12. The continuous reflective freeform surface 12, as shown in Figure 8a, must be understood within the context of the present invention as a surface with no vertical or near vertical walls as opposed, for example, to micro-facet and micro-patch arrays as shown in Figure 8b and described for example in patent US9188783B2.

[0028] More particularly, with reference to Figure 8c, the continuous reflective freeform surface 12 could be defined as a surface comprising a 3D pattern, wherein the surface normal of any point on the 3D pattern, i.e. the vector (identified as N on Figure 8c) perpendicular to any inclined portion of the surface anywhere on the 3D pattern, forms an angle α, with respect to a reference plane (dotted lines in Figure 8c), of at least 45°. The reference plane must be interpreted as the best fitting plane of the 3D pattern.

[0029] The method for producing the continuous reflective freeform surface 12 is well-described for example in EP2963463. It consists in general in computing a continuous surface whose normals are such that incoming light rays are reflected into a prescribed illumination pattern (more rays are focused to the bright areas of the image). The normal field ensures that the distance traveled by the light rays is minimized which ensures that the surface is as flat, as smooth and as stable as possible.

Other methods may be applied to shape the continuous reflective surface 12 to obtain the desired image projected on the projection surface 14.

[0030] A computer algorithm based on the above method is used to calculate the shape of a predetermined 3D pattern of the continuous reflective freeform surface 12 and a 3D image of the predetermined 3D pattern is generated in industry standard CAD. The predetermined 3D pattern for a given image is then reproduced on a surface of a blank jewelry article.

[0031] This continuous reflective freeform surface may advantageously be obtained through continuously displacing a cutting tool, during a machining operation, along and against an entire surface of the size of the continuous reflective freeform surface without the need of lifting the tool away from the surface during a pass over the entire surface. The continuous reflective freeform surface may also be advantageously obtained by die stamping a surface of a blank jewelry article with a die comprising a 3D mirror surface of a 3D pattern to be reproduced.

[0032] The continuous reflective freeform surface 12 reflects the incoming light rays 13 which are focused on a nearby flat projection surface 14 for displaying an image of 16 on the projection surface 14 as shown for example in Figures 4 and 5. The projected image 16 may be for example a text, a logo, a photography or any other visible pattern.

[0033] In an embodiment, as shown in Figure 13, the predetermined 3D pattern is directly machined on a surface of the jewelry article using a CNC machine with a sharp cutting tool 40 to remove the excess material with high precision. The cutting tool 40 is displaced along x, y, z cartesian coordinates to remove the excess material on the machined surface.

[0034] The cutting tool 40 may for example be controlled to remove successively a first and a second layer 42, 44 of the blank jewelry article through successive first and second passes over a surface of the size of the continuous reflective freeform surface in order to machine the predetermined 3D. The first layer 42 preferably comprises the majority of the excess material to be removed while the second layer 44 comprises a small amount of the remaining material to be removed with high precision to obtain the final predetermined 3D pattern. The distal end of the cutting tool 40 is rounded with a radius smaller than the smallest radius of the predetermined 3D pattern. Advantageously, the distal end of the cutting tool 40 is made of a single crystal diamond.

[0035] The predetermined 3D pattern of the continuous reflective freeform surface must comprise a mirror-like surface for effective reflection of the predetermined image on the projection surface. Depending on the precision of the machining, the surface of predetermined 3D pattern may need to be polished. The polishing step may be done by applying on the surface to be polished a polishing cloth wheel comprising a polishing compound.

[0036] In another embodiment, a die is created with a 3D mirror surface of the predetermined 3D pattern to be reproduced on a surface of the jewelry article. The jewelry article is then die stamped to transfer the shape of the die to the surface of the jewelry article. This embodiment is particularly well-adapted for mass production of jewelry articles.

[0037] Referring back to Figure 2, the light rays should hit the surface at an angle of around 45°. In general, the distance between the continuous reflective freeform surface 12 and the projection surface 14 should be around 2 to 10 times the width of the freeform surface 12. For a ring, a distance between 20 and 40mm, and preferably around 30mm is ideal.

[0038] In an embodiment and with reference to Figure 3, a ring 10 may comprise an annular portion 10a and a reflection portion 10b comprising two distinct continuous reflective freeform surfaces 12a, 12b comprising each a different predetermined 3D pattern which is invisible or barely visible to the naked eye. These two distinct continuous reflective freeform surfaces are configured to reflect incoming light rays to a projection surface in order to display distinctive images. The two 3D patterns on the two distinctive free-form surfaces 12a, 12b may for example reflect on the projecting surface 14 two adjacent images comprising each one or more letters to form a word as illustrated by Figures 4 and 5.

[0039] Figures 6 and 7 illustrate other exemplary embodiments of the invention where the continuous reflective freeform surface is realized on an annular ring 10 and bracelet 20 respectively. The bracelet may be for example a cut-off bracelet 20 or a curb chain (not illustrated). The continuous reflective freeform surface may be located on an outer surface 22a and/or on an inner surface 22b of the bracelet 20.

[0040] When the continuous reflective freeform surface is located on the inner surface 22b of the bracelet 22, the incoming light rays may be reflected by the freeform surface such that they are focused on a resting surface when the bracelet 20 is removed and lies on the resting surface such as a table. In this configuration, the inner surface 22 of the bracelet of slightly concave and the image is projected on the resting surface inside the bracelet 20.

[0041] According to the method for producing the freeform surface as briefly described above and extensively in EP2963463, the size of the projected image usually corresponds to the size of a free-form surface having a globally flat surface.

[0042] In an advantageous embodiment, the continuous reflective freeform surface may have a globally convex surface in order enlarged the dimensions of the projected predefined image to be visible further away. The globally convex surface has also the benefit to stabilize the projected predefined image which is therefore less prone to distortions when in real-life the relative position between the light source, the object comprising the continuous reflective freeform surface with the predetermined 3D pattern and the projection surface are not ex-

actly the positions of the predefined setup parameters used to calculate the 3D pattern from a predefined image such as a text, a logo or a photography, etc. to be projected a projection surface.

[0043] The above distortion phenomenon is well-illustrated by computer-generated simulations shown in figures 9a and 9b when incoming lights rays are reflected on a rectangular-shaped continuous reflective freeform surface having no curvature along its longitudinal direction. Figure 9a shows the word "LOVE" projected on a projection surface when the predefined distance between the continuous reflective freeform surface and the projection surface is 30mm which corresponds to one of the preset parameters used to calculate the 3D pattern of the freeform surface from the predefined image to be projected a projection surface. When the distance between the freeform surface and the projection surface does not correspond to the predefined distance of the preset parameters the projected image appears to be distorted as shown in figure 9b where the continuous reflective free-form surface is situated 20mm further away from the predefined distance.

[0044] On the other hand, as shown in computer-generated simulations of figures 10a, 10b, when incoming lights rays are reflected on a rectangular-shaped continuous reflective freeform surface having a convex curvature along its longitudinal direction, not only is the projected image enlarged by 200%, but it is also more stable, i.e. less prone to distortions when the distance of the continuous reflective freeform surface and the projection surface deviates from the predefined distance of the predefined set-up parameters.

[0045] In some cases, it might be desired to have a globally concave free-form surface as it can be less impacted by environmental damages such as scratches. To achieve this, the incoming light rays between the globally concave surface and the projection surface is flipped as schematically illustrated by figure 11c.

[0046] The 3D pattern of the continuous reflective freeform surface 12 is generated based on a computer algorithm configured to process images that have zero brightness background (complete black background). Accordingly, this continuous reflective freeform surface creates brighter images by focusing all the light to a small area which provides the following advantages: i) the edges of the 3D pattern do not reflect incoming light rays such that the shape of the boundary of the reflected image 16 on the projection surface 14 differs from the shape of the boundary of the 3D pattern as shown in 12a, and ii) the projected image cannot be recognized just by looking at the 3D structure which makes the effect more surprising.

Claims

1. Reflective jewelry article, in particular a ring or bracelet (10; 20), comprising at least one continuous reflective freeform surface (12; 22) configured to reflect light rays to a projection surface (30), wherein said at least one continuous reflective surface (12; 22) comprises a predetermined 3D pattern for projecting a predetermined image on said projection surface (30).

2. The reflective jewelry article according to claim 1, wherein said at least one continuous reflective freeform surface (12; 22) is a computer-generated machined surface or stamped surface.

3. The reflective jewelry article according to claim 1 or 2, wherein the surface normal of any point of the predetermined 3D pattern of said at least one continuous surface (12; 22) forms an angle (a), with respect to a reference plane, of at least 45°.

4. The reflective jewelry article according to any preceding claim, wherein said at least one continuous reflective freeform surface (12; 22) is globally convex, the curvature of the reflective freeform surface extending from one edge to an opposite edge of said surface in order to enlarge the size of the predetermined image on said projection surface (30).

5. The reflective jewelry article according to any preceding claim, wherein said ring or bracelet comprises at least a first and a second distinctive continuous reflective surface (12a, 12b) having two different predetermined 3D patterns for projecting at least two distinctive predetermined images on said projection surface (30).

6. The reflective jewelry article according to the preceding claim, wherein said at least first and second distinctive continuous reflective surfaces (12a, 12b) are arranged to project said at least two distinctive predetermined images next to each other, each of said two distinctive predetermined images representing a portion of a global image formed by the projection of said distinctive images.

7. The reflective jewelry article according to any preceding claim, wherein said ring has a general annular shape, the outer surface of the ring (10) comprising said at least one continuous reflective freeform surface (12).

8. The reflective jewelry article according to any of claims 1 to 5, wherein the outer surface and/or the inner surface (22a, 22b) of the bracelet (20) comprises said at least one continuous reflective freeform surface (22).

9. The reflective jewelry article according to any preceding claim, wherein the 3D pattern of said at least one continuous reflective freeform surface (12; 22) has been generated based on a computer algorithm

configured to process images that have zero brightness background such that the shape of the boundary of the projected image (16) on the projection surface (14) differs from the shape of the boundary of said predetermined 3D pattern and the projected image (16) cannot be recognized by looking directly at said predetermined 3D pattern.

10. Method of manufacturing the reflective jewelry article according to any preceding claim, comprising:

providing an image, preferably in black and white, of the image to be displayed on said projection surface (30),
using a computer algorithm to calculate the shape of the predetermined 3D pattern of said at least one continuous reflective freeform surface (12; 22),
generating a 3D image of the predetermined 3D pattern in industry standard CAD format,
providing a blank jewelry article, preferably a ring or bracelet, and
reproducing said predetermined 3D pattern on the blank jewelry article.

11. The method according to the preceding claim, wherein the step of reproducing the predetermined 3D pattern on the blank jewelry article consists in machining a surface of the blank jewelry article to obtain said predetermined 3D pattern.

12. The method according to the preceding claim, wherein said machining consists in displacing a cutting tool (40) over a surface of the size of said continuous reflective surface to be machined in at least two successive passes to remove successively at least a first and a second layer (42, 44) of material of the blank jewelry article to obtain said predetermined 3D pattern, and wherein the first pass removes the majority of the excess material while the last pass removes the remaining of the excess material with high precision.

13. The method according to the preceding claim, wherein the distal end of the cutting tool (40) is rounded with a radius smaller than the smallest radius of said predetermined 3D pattern.

14. The method according to the preceding claim, wherein said distal end of the cutting tool (40) is made of a single crystal diamond.

15. The method according to claim 10, wherein the step of reproducing the predetermined 3D pattern on the blank jewelry article consists in:

creating a die with a 3D mirror surface of said predetermined 3D pattern to be reproduced, and die stamping the blank jewelry article to transfer the shape of the die to the surface of said blank jewelry.

Fig. 1

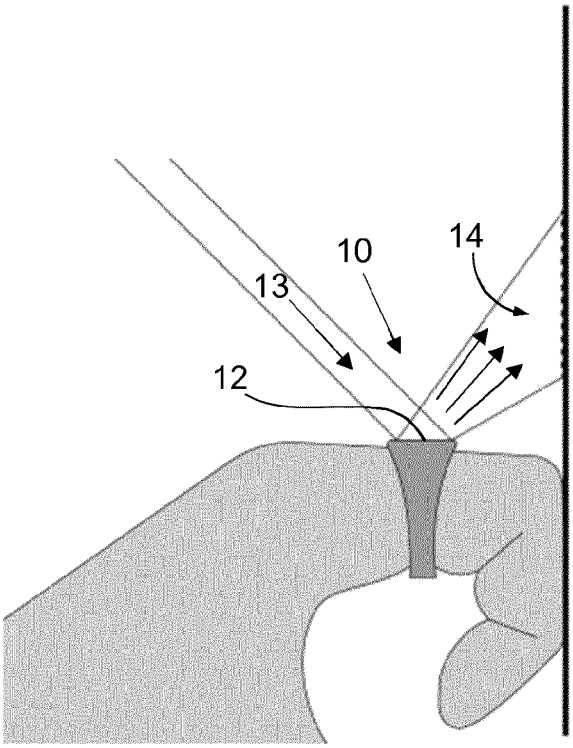

Fig. 2

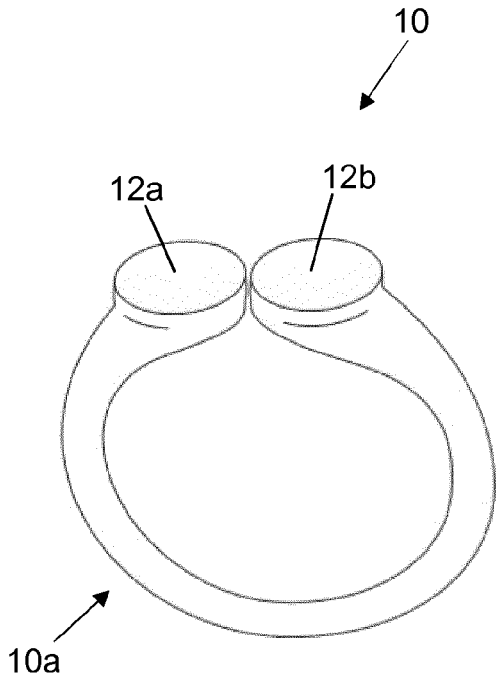

Fig. 3

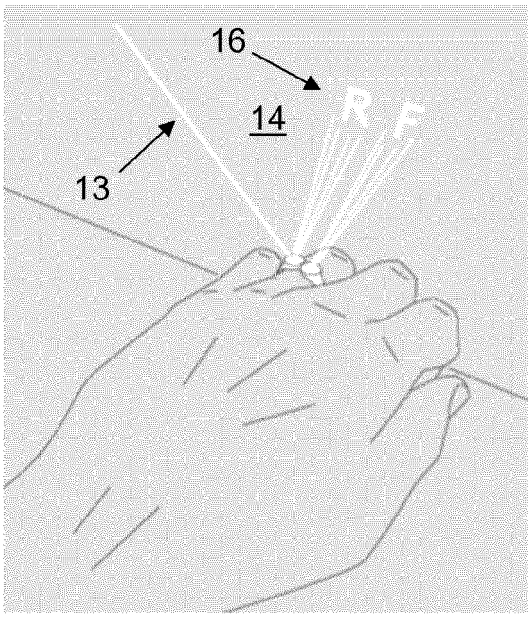

Fig. 4

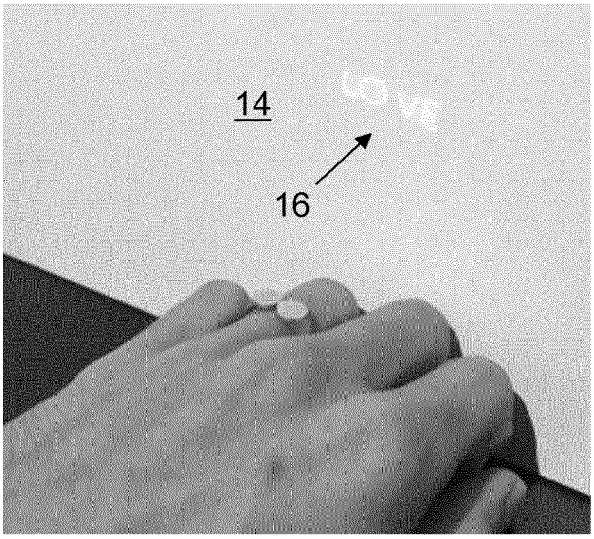

Fig. 5

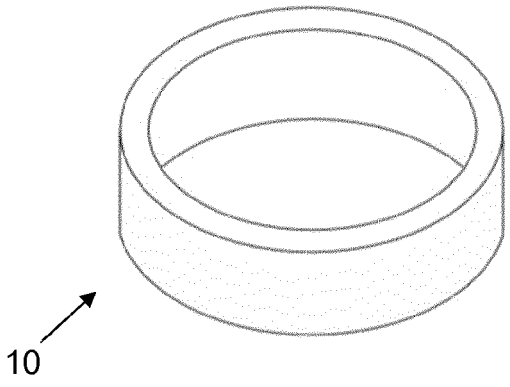

Fig. 6

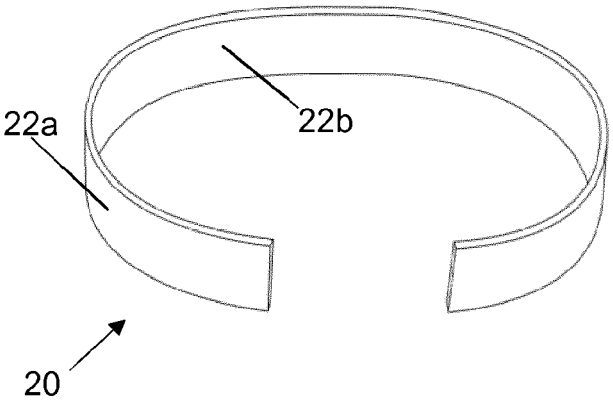

Fig. 7

Continuous surface:

Fig. 8a

Non-continuous surface:

Fig. 8b

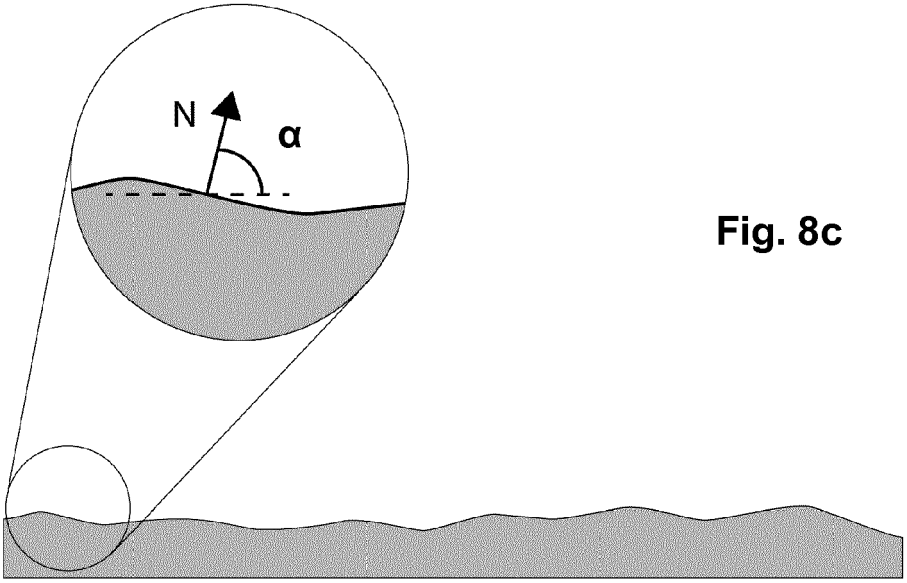

Fig. 8c

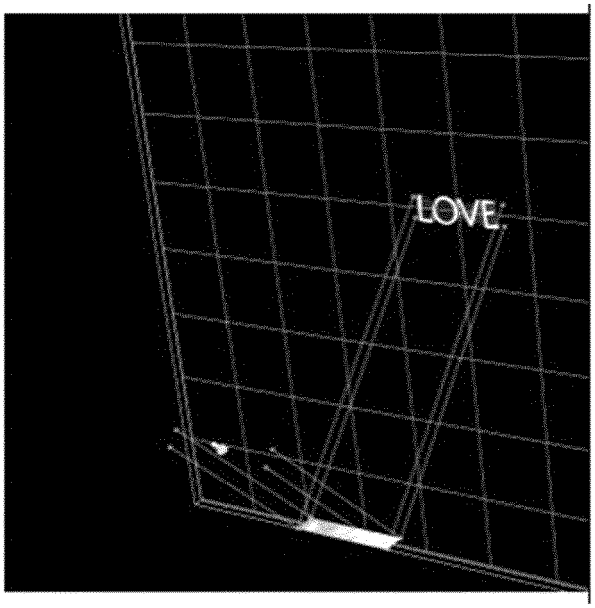

Fig. 9a

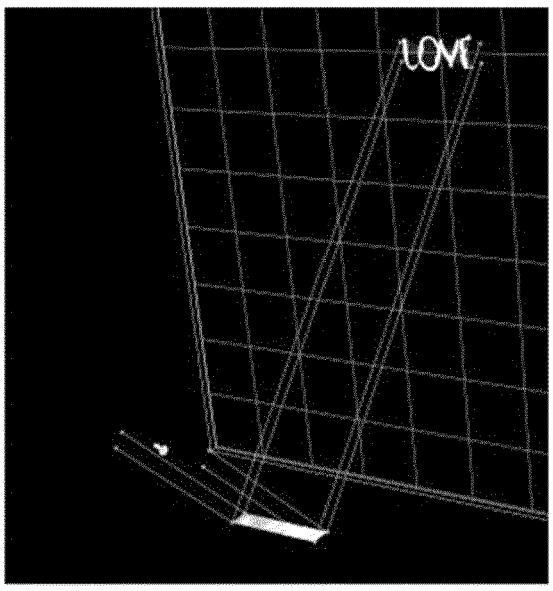

Fig. 9b

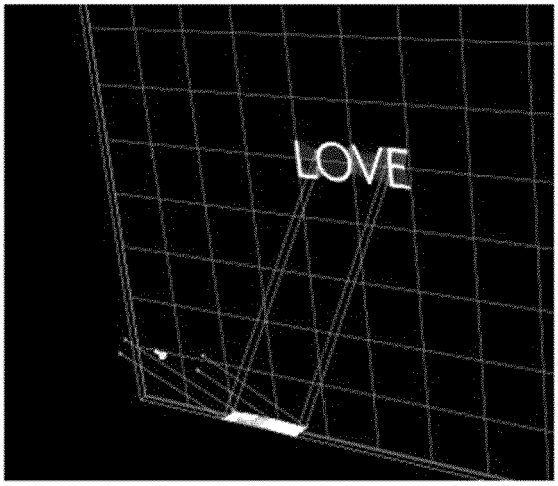

Fig. 10a

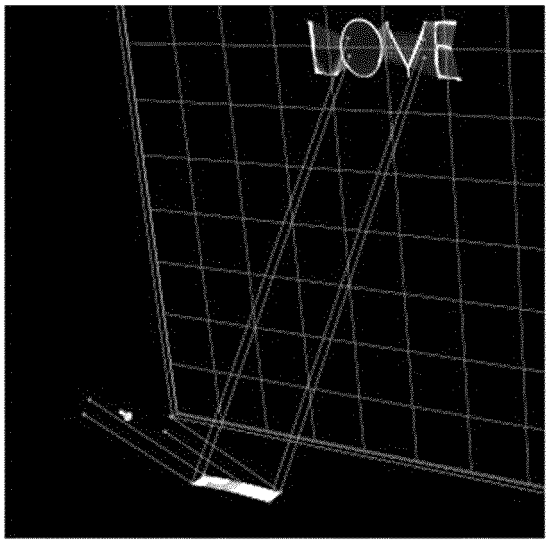

Fig. 10b

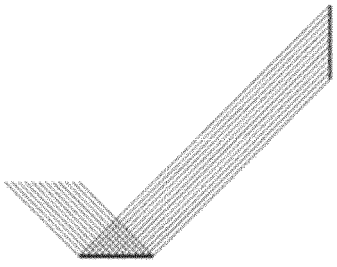

Fig. 11a

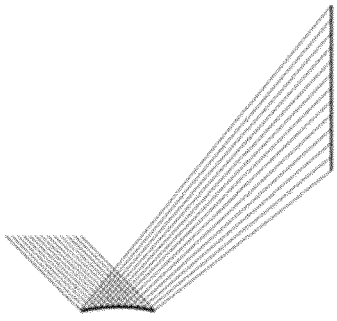

Fig. 11b

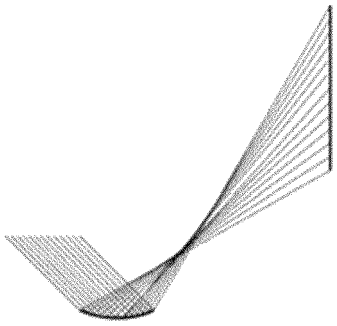

Fig. 11c

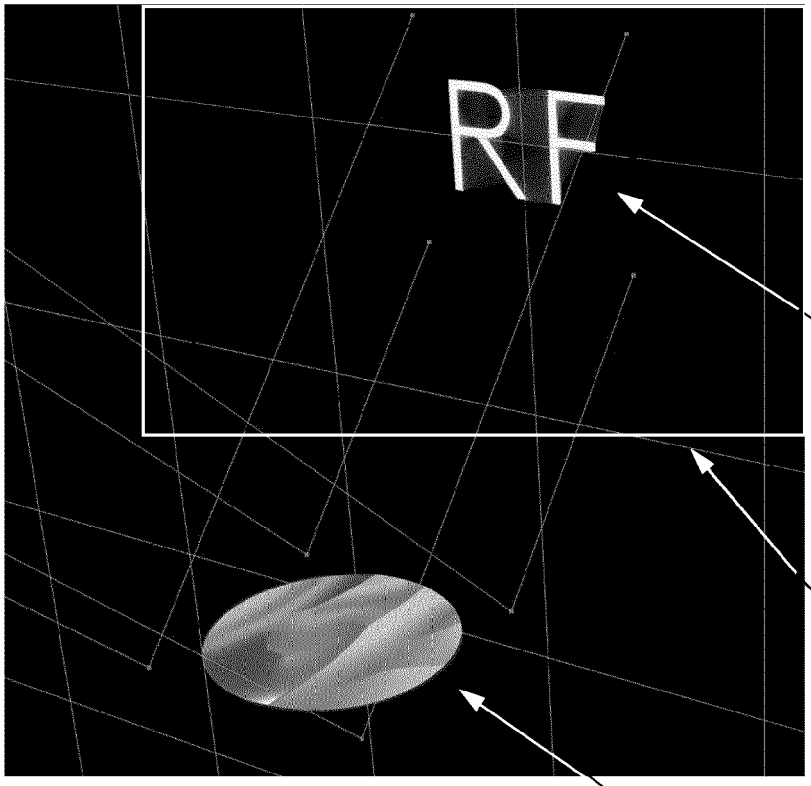

Fig. 12a

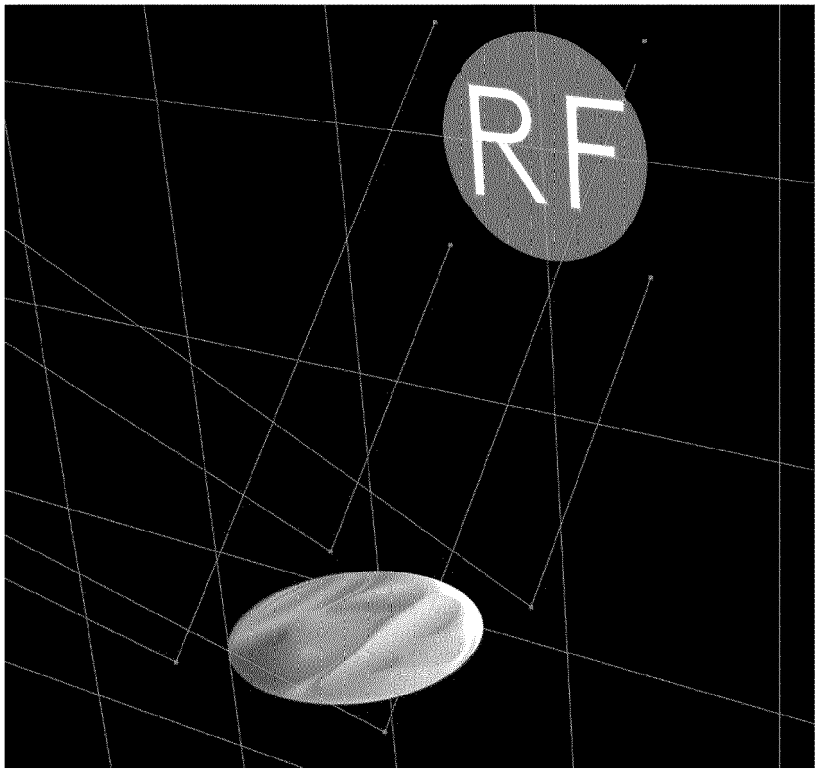

Fig. 12b

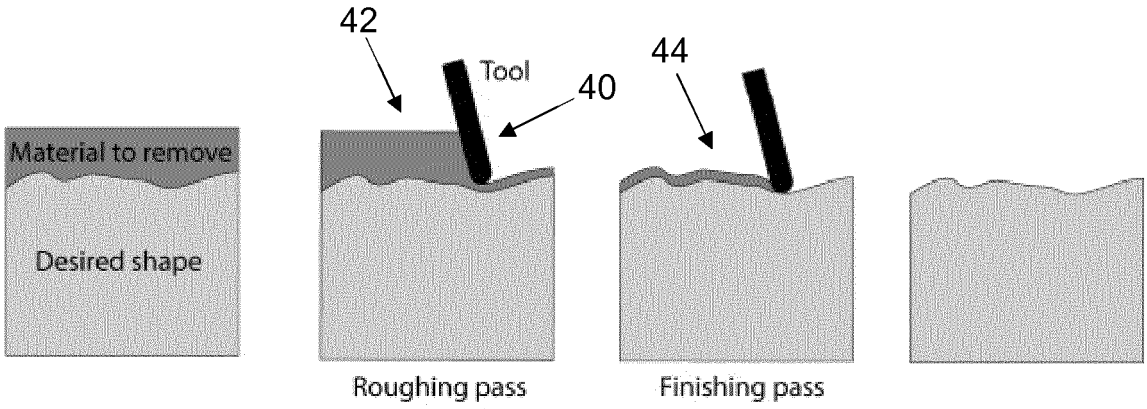
42
Tool
40
44
Material to remove
Desired shape
Roughing pass
Finishing pass

Fig. 13

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 17 1771

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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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
The Hague	20 September 2019	da Silva, José

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EUROPEAN SEARCH REPORT

Application Number
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