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(54) **Method and means for producing a metal strip, method of producing the means, and a metal strip and article comprising the same**

(57) Work roll for rolling a metal strip, comprising an essentially circular cylindrical working surface, whereby in area having a uniform curvature, the working surface is provided with a non-uniform surface finish. The work roll can be obtained by locally modifying the working surface to obtain the non-uniform surface finish. The work roll can be used in a final roll stand of an apparatus for rolling a metal strip. The metal strip product that is rolled with the work roll has a customised non-uniform surface finish, which can be a desired image such as a logo.

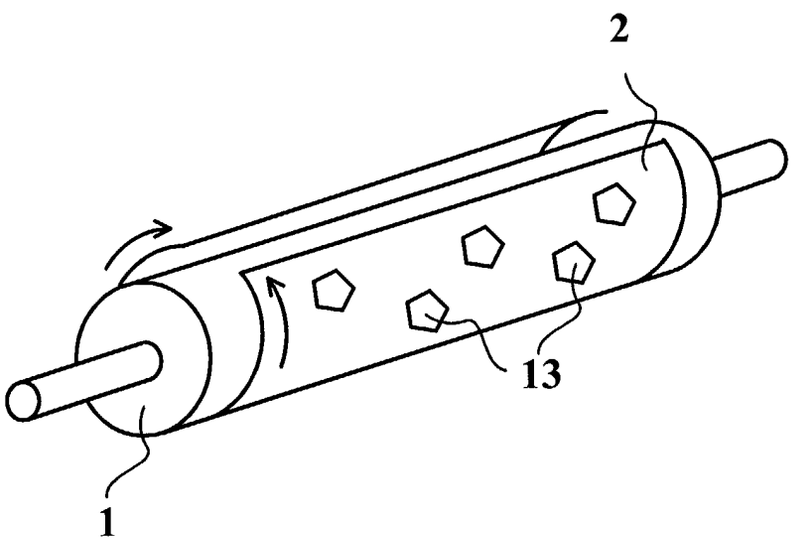

Fig. 1a

EP 1 362 653 A1

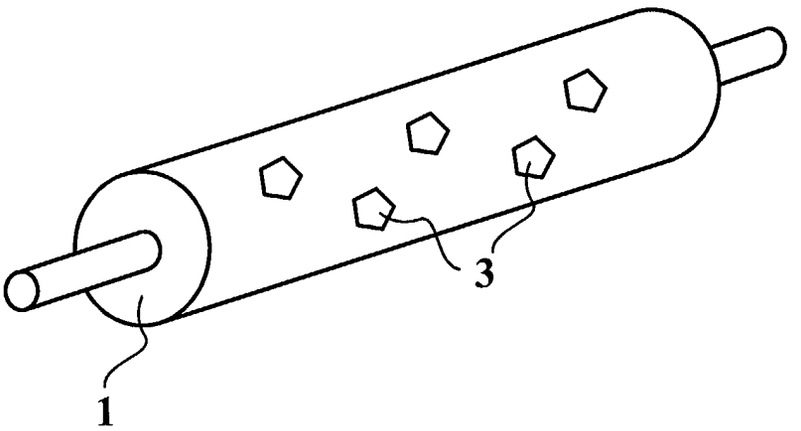

Fig. 1b

Description

[0001] The invention relates to means and a method for producing a metal strip.

[0002] The production of a metal strip normally comprises mechanical rolling, whereby the metal strip is rolled between a pair of work rolls.

[0003] Work rolls are generally known in the art. A work roll is normally incorporated in a roll stand, optionally supported by one or more back-up rolls. When in use for rolling a metal strip, a mechanical interaction is brought about between the working surface of the work roll and the metal strip for deforming the metal strip. Rolling of metal strip normally occurs in a rolling mill comprising one rolling stand or a sequence of rolling stands.

[0004] In the art of rolling steel strip, the last rolling operation in such sequence is known as temper rolling, skin pass rolling or double reduction rolling. The reason for this last rolling step is usually to strengthen the steel strip and to impart the required surface finish.

[0005] The working surface of a work roll is normally provided with a uniform surface finish having a surface roughness and texture-peak density of certain values, depending on the desired type of surface finish that is intended to be given to the metal strip under production. Typical surface finishes for the work roll's working surface include:

Finish type	Roughness value Ra (μm)
Bright	max. 0.10
Super Bright	max. 0.08
Matte A	1.35 - 1.55
Silver Glow	3.20 - 3.60
Stone	0.40 - 0.60
Fine Stone	0.20 - 0.40

[0006] It is an object of the invention to provide a method and means for producing a metal strip having a customised appearance.

[0007] It is another object of the invention to provide a method and means for producing a decorated metal strip.

[0008] According to the invention, there is provided a method for producing a metal strip, comprising rolling the metal strip with at least one work roll having an essentially circular cylindrical working surface, that, in an area having a uniform curvature, has been provided with a non-uniform surface finish.

[0009] The non-uniform surface finish of the work roll is herewith transferred to a corresponding imprint in the metal sheet concerned. The resulting surface finish of the metal strip that has been rolled this way, has a deliberate non-uniform appearance of the metal strip surface instead of the normally applied uniform one. The resulting metal strip therefore has a customised appearance. The non-uniform appearance of the metal strip surface enables the definition of a deliberate pattern on the surface of the metal strip for decorating it. Images can for instance be rolled onto the metal strip by making use of apparent contrasts in various types of surface finishes.

[0010] The method is very effective in producing large amounts of customised metal strip, because the desired pattern is applied only once to a intermediate surface, being the working surface of the work roll, and then transferred to the metal strip multiple times using the same work roll. Thus, in contrast to direct treatment of the surface of the metal strip, a very large surface area of customised metal strip can be produced by merely providing a corresponding customised surface finish to the relatively small area of the working surface of the work roll.

[0011] At the same time as imprinting the non-uniform surface finish onto the metal strip, the thickness gauge of the metal strip may be reduced by mechanical working of the metal strip.

[0012] Optionally, the method according to the invention comprises a subsequent step of providing it with a coating layer, such as a metallic tin or chromium layer, and/or an organic or polymeric coating layer. The non-uniform surface roughness is found to be visible even after providing such a coating layer.

[0013] The invention involves at least one special technical feature that is present in each of the following aspects of the invention, which are a work roll, a method for producing the work roll, an apparatus incorporating the work roll, a metal strip product and metal article including the metal strip product.

[0014] Each one of various embodiments of the work roll according to the second aspect of the invention as described below, may be used in the method according to the previous aspect of the invention.

[0015] The work roll according to the second aspect of the invention comprises an essentially circular cylindrical working surface which, in an area having a uniform curvature, is provided with a non-uniform surface finish.

[0016] An advantage of this work roll is that it allows for combining known modification of the physical properties of the metal strip, with customising and/or decorating the metal strip. Thus, a separate decorating step is not necessary.

[0017] It is remarked that work rolls and methods for so-called embossing are known. Embossing is a process wherein a raised image is introduced into the metal strip as a relief, by passing the metal strip though a pair of work rolls comprising at least one embossing work roll. In the present invention, in contrast, the image is provided in an essentially flat part of the metal strip, through contrast in reflectivity as opposed to relief, at least in part caused by surface roughness characteristics of different areas of the metal strip surface.

[0018] In an embodiment of the work roll, the non-uniform surface finish forms a desired image for imprinting

onto the metal strip when rolled by the work roll. Typical possible images comprise a brand-name or a logo, or an abstract image.

[0019] In another embodiment, the non-uniform surface finish forms a random pattern. A metal strip that is rolled using such a work roll is herewith provided with a corresponding random pattern, which renders such a metal strip particularly useful for subjecting to later forming operations.

[0020] The random pattern can comprise larger relatively rough areas on a relatively bright background, whereby the larger relatively rough areas can be surrounded by a number of smaller rough areas. Herewith an appealing decoration is achieved reminiscent of tiger-stripe print.

[0021] The surface finish may be non-uniform in any parameter leading to a visual effect, including roughness, reflectivity or gloss. Non-uniformity may be introduced in terms of roughness-peak density, roughness-peak shape, average roughness, width of a distribution of roughness values, or the like. Specular gloss can be expressed in terms of gloss units in accordance with ISO 2813.

[0022] In a preferred embodiment, the non-uniform surface finish comprises a non-uniform surface roughness having a lower Ra value in one part of the area having the uniform curvature and an upper Ra value in anther part of that area.

[0023] Herewith a satisfactory and/or reproducible contrast results that makes it particularly possible to decorate a metal strip with images by rolling the metal strip with the work roll.

[0024] The difference between the upper Ra value and the lower Ra value is preferably at least 0.1 μm Ra (determined in accordance with DIN 4768), for obtaining sufficient contrast to imprint an observable image in the metal strip. Best results have been obtained using a difference between the upper Ra value and the lower Ra value of at least 0.2 μm Ra. A difference of 0.4 μm Ra and higher results in a very pronounced image clarity, even when the lower Ra surface roughness is relatively high.

[0025] In a preferred embodiment, the lower Ra value is less than 0.2 μm in accordance with DIN 4768. Herewith a very good visibility of the imprinted features is possible.

[0026] In an embodiment, a specular gloss of the working surface having the non-uniform surface finish, as measured in terms of gloss units in accordance with ISO 2813, has a lower gloss unit value in one part of the area having the uniform curvature and an gloss upper value in another part of that area.

[0027] In addition to the surface roughness, the specular gloss also reflects other characteristics of the surface finish such as roughness-peak density and shape. Irrespective of the surface roughness Ra value, images or a desired patterns can be defined satisfactory if the gloss unit value varies across the working surface.

[0028] For excellent visibility, it is preferred that the difference between the upper gloss unit value and the lower gloss unit value is at least 40 units. This provides sufficient contrast to imprint a conveniently observable image in the metal strip. More preferably, the difference is at least 80 units, so that the image is more easily discernable, even when in absolute reflectivity the surface reflectivity is relatively high such as is the case for bright or super bright finishes.

[0029] The lower gloss unit value is preferably less than 80 units, in order to achieve a very good observability of the imprinted features.

[0030] Optionally the working surface is chrome coated to increase the roll life and transfer effectiveness of the surface finish during rolling.

[0031] In yet another aspect, the invention is embodied in a method of producing a work roll, wherein a work roll having an essentially circular cylindrical working surface is subjected to a step of modifying its surface finish wherein the working surface is locally modified in an area having a uniform curvature, to obtain a non-uniform surface finish in that area.

[0032] Herewith a work roll is obtained with the above-mentioned properties and advantages.

[0033] It has been found extremely efficient to locally modify the working surface in the area having a uniform curvature, to obtain a non-uniform surface roughness, and particularly to locally modify the surface roughness to increase its value rather than to decrease its value.

[0034] There are many techniques at the disposal of the skilled person for increasing the surface roughness, such as laser etching, chemical etching, shot blasting, grinding, roll grinding, electric discharge texturing (EDT), electron beam texturing (EBT).

[0035] It has been found that EDT can produce higher roughness-peak densities than shot blasting for the same roll roughness.

[0036] Optionally, these techniques can be used in combination with a template mask for shielding areas of the working surface from being treated.

[0037] Thus, there is also provided an embodiment of the invention, whereby in one part of the area having the uniform curvature is covered while locally modifying the surface finish in a second part of the area which is kept uncovered. Covering of an area can be achieved by using a template mask. This way, a relatively abrupt transition can be achieved in surface roughness values of adjacent areas. Consequently, highly defined images can be introduced onto the work roll working surface, and in a later instance onto the metal sheet.

[0038] The template mask may be formed of any suitable material. Good results have been achieved with a rubberised polymer, which is also used for decorating polished stone monuments. For masking local isolated areas, a sticky template mask is preferred.

[0039] In an embodiment wherein the non-uniform surface roughness is obtained by subjecting the work roll to an electric discharge texturing (EDT) operation,

the EDT operation is performed during a period of time that is shorter than that is needed for producing a uniform surface roughness. Normally, an EDT treatment is continued until a uniform surface roughness is achieved over the entire working surface. However, it is now found that by subjecting the work roll to an electric discharge texturing (EDT) operation during a period of time that is shorter than that is needed for producing a uniform surface roughness, a working surface provided with aesthetically appealing randomly defined shaped areas of increased surface roughness is achieved, even without use of a template mask.

[0040] Apparently, when a relatively smooth work roll surface is subjected to an EDT treatment, some small areas with increased surface roughness are initially formed on apparently random locations. These areas seem to grow in size, while close to these areas new small areas start to form. Thus, a random pattern of larger relatively rough areas is formed, whereby each of these larger relatively rough areas is surrounded by a number of smaller rough areas.

[0041] The resulting random pattern is reminiscent of a tiger print.

[0042] It has also been found possible to form interesting patterns by continuing the EDT treatment for longer than normally necessary.

[0043] Either of these can be combined by performing the EDT operation with increased spacing between adjacent active electrodes.

[0044] In still another aspect, the invention relates to an apparatus for rolling a metal strip, the apparatus comprising a final roll stand for rolling the metal strip, whereby the final roll stand is provided with at least one work roll according to any embodiment of the invention in its first aspect.

[0045] By applying the work roll according to the invention in the final roll stand, the desired surface finish is best controlled. Optionally, the final roll stand is preceded by one or more intermediate roll stands.

[0046] In still another aspect, the invention relates to a metal strip product, comprising an essentially flat surface. According to the invention, in an essentially flat area of the essentially flat surface, the surface is provided with a non-uniform surface finish.

[0047] Herewith a product is achieved that distinguishes over normally available metal strip products and has added value over normally available metal strip products, in that it is provided with a desired decorated surface. The non-uniform surface roughness can form a deliberate pattern on the surface of the metal strip for decorating, including preferably a desired image that can be defined by virtue of the apparent contrasts in various types of finishes. Typical possible images comprise a brand-name or a logo.

[0048] In still another aspect, the invention relates to a metal article formed out of the metal strip product concerned comprising at least a part of the essentially flat area that is provided with the non-uniform surface finish. Possible metal articles that can advantageously comprise at least a part of the essentially flat area that is provided with the non-uniform surface finish include furniture, wall hangings, lamp shade, picture frame, flooring element, ceiling element, white goods paneling, box.

[0049] In particular, the article can be a metal container, such as a beverage or food container, or a component thereof.

[0050] The metal container, or component thereof, may be formed in a number of ways, such as drawing and forming, drawing and redrawing, pressing, and forming, bending, welding.

[0051] The invention will now be illustrated with reference to the schematic drawing wherein

FIG. 1, parts a and b, shows a view of a work roll provided with a template mask; and

FIG. 2, parts a, b, and c, shows various examples of metal sheets that have been rolled with a work roll according to various embodiments of the invention.

[0052] FIG. 1a shows a schematic view of a work roll 1, of which its working surface is enveloped with a template mask 2. The template mask 2 is made of a rubberised polymer sheet material, that is provided with openings 13 for defining areas in which the working surface of the work roll to be treated to locally modify its surface finish.

[0053] FIG. 1b shows a similar work roll 1, of which the working surface is locally covered with pieces of sticky template mask material 3.

[0054] By subjecting the work roll to, for instance, a shot blasting operation, the surface roughness of the uncovered areas of the working surface will be increased. After such operation, the template masks are to be removed from the work roll, and the work roll can be applied in, for instance, a temper roll stand.

[0055] An impress of the various surface finishes of the work roll is brought about in the metal strip that is passed through, for instance, the temper roll stand.

[0056] For instance, the surface roughness of the untreated work roll can be max. 0.10 μm Ra which is locally increased by 0.4 μm Ra by shot blasting.

[0057] A reversed effect will be achieved in the case of FIG. 1a as compared to the case of FIG. 1b when subjecting the work rolls to the same surface roughening operation.

[0058] The surface may also be smoothed, for instance by a polishing operation, to achieve a reversed effect.

Typical surface finishes on the working surface of the work roll that may be employed include:

Finish type	Roughness value Ra (μm)
Bright	max. 0.10
Super Bright	max. 0.08

(continued)

Finish type	Roughness value Ra (μm)
Matte A	1.35 - 1.55
Silver Glow	3.20 - 3.60
Stone	0.40 - 0.60
Fine Stone	0.20 - 0.40

[0059] FIG. 2 shows schematic views of various possible metal strips that can be produced using the work roll with the non-uniform surface finish.

[0060] FIG. 2a shows a steel strip 4, provided with stripes 6 in the rolling direction having a higher roughness than the remaining portions 5 of the strip. This strip is produced by temper rolling with at least one work roll having been provided with annular bands of increased surface roughness. Such a work roll can be produced without the need of using a template mask, by roll grinding with mutually spaced grinding on ground or shot blast rolls. This can be achieved by modification of existing grinding wheel face widths.

[0061] FIG. 2b shows a steel strip 7 provided with a logo 9 having a higher surface roughness than that of the remainder 8 of the strip. As can be seen, the pattern repeats itself over a period that corresponds to one revolution of the work roll. Of course, the logo can also be defined by providing a background having a higher surface roughness than the areas 9 corresponding to the logo.

[0062] FIG. 2c shows a steel strip 10 provided with a tiger print formed of random areas 12, elongate in the rolling direction, on a polished background 11. Such a strip is obtained by rolling it with an EDT treated work roll. By subjecting the work roll to an electric discharge texturing (EDT) operation during a period of time that is shorter than that is needed for producing a uniform surface roughness, a working surface provided with aesthetically appealing randomly defined shaped areas of increased surface roughness is achieved, even without use of a template mask.

[0063] Apparently, when a relatively smooth work roll surface is subjected to an EDT treatment, some small areas with increased surface roughness are initially formed on apparently random locations. These areas seem to grow in size, while close to these areas new small areas start to form. Thus, a random pattern of larger relatively rough areas is formed, whereby each of these larger relatively rough areas is surrounded by a number of smaller rough areas which become smaller and less dense as the distance to such a large area is larger.

[0064] Metal strips as shown in FIG. 2 can be in the form of black plate, but the impressed images are also visible when the surface is coated with a metallic layer such as chromium or tin, or organic coated or polymer coated.

[0065] Aesthetically appealing products, in particular metal containers, are formed from the metal strip such that the images are displayed on for instance a side wall of the container.

Claims

1. Method of producing a metal strip, wherein a metal strip is rolled using at least one work roll having an essentially cylindrical working surface that, in an area having a uniform curvature, is provided with a non-uniform surface finish, and a corresponding non-uniform surface finish is therewith imprinted into the metal strip.

2. Work roll for rolling a metal strip, comprising an essentially circular cylindrical working surface, **characterised in that**, in an area having a uniform curvature, the working surface is provided with a non-uniform surface finish.

3. Work roll according to claim 2, wherein the non-uniform surface finish forms a desired image for imprinting into a metal strip when rolled by the work roll.

4. Work roll according to claim 2, wherein the non-uniform surface finish forms a random pattern, preferably a random pattern of larger areas surrounded by a number of smaller areas which become smaller and less dense as the distance to such a large area is larger.

5. Work roll according to claim 2, 3 or 4, wherein the non-uniform surface finish comprises a non-uniform surface roughness having a lower Ra value in one part of the area having the uniform curvature and an upper Ra value in another part of that area.

6. Work roll according to claim 5, wherein the difference between the upper Ra value and the lower Ra value is at least 0.1 micrometers Ra in accordance with DIN 4768.

7. Work roll according to claim 5 or 6, wherein the lower Ra value is less than 0.2 μm in accordance with DIN 4768.

8. Work roll according to any one of the claims 2 to 7, wherein a specular gloss of the working surface having the non-uniform surface finish, as measured in terms of gloss units in accordance with ISO 2813, has a lower gloss unit value in one part of the area having the uniform curvature and an upper gloss unit value in another part of that area.

9. Work roll according to claim 8, wherein the difference between the upper gloss unit value and the

lower gloss unit value is at least 40 units.

10. Work roll according to any one of the claims 2 to 9, wherein the lower gloss unit value is less than 80 units.

11. Work roll according to any one of the claims 2 to 10, whereby at least the working surface is chrome coated.

12. Method of producing a work roll, wherein a work roll having an essentially circular cylindrical working surface is subjected to a step of modifying its surface finish, **characterised in that** the working surface is locally modified in an area having a uniform curvature, to obtain a non-uniform surface finish **in that** area.

13. Method according to claim 12, wherein the working surface is locally modified in the area having the uniform curvature, to obtain a non-uniform surface roughness.

14. Method according to claim 13, wherein the working surface is, in a part within the area having the uniform curvature, locally modified to locally increase the surface roughness.

15. Method according to any one of claims 12 to 14, wherein in one part of the area having the uniform curvature is covered while locally modifying the surface finish in a second part of the area which is kept uncovered.

16. Method according to any one of claims 12 to 15, wherein the non-uniform surface finish is obtained by subjecting the work roll to an electric discharge texturing (EDT) operation during a period of time that is shorter than that is needed for producing a uniform surface finish.

17. Apparatus for rolling a metal strip, comprising a final roll stand, optionally preceded by one or more intermediate roll stands, for rolling the metal strip, whereby the final roll stand is provided with at least one work roll according to any one of claims 2 to 11.

18. Metal strip product, comprising an essentially flat surface, **characterised in that** in an essentially flat area thereof, the surface is provided with a non-uniform surface finish.

19. Metal strip product according to claim 18, whereby the non-uniform surface finish forms a desired image.

20. Metal article formed out of a section of the metal strip product according to claim 18 or 19 comprising at least a part of the essentially flat area that is provided with the non-uniform surface finish.

21. Metal article according to claim 20, being a metal container, such as a beverage or food container.

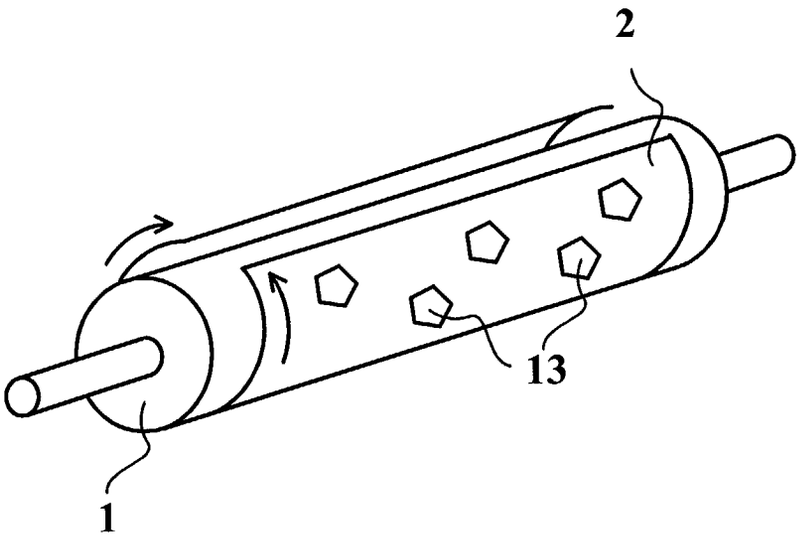

Fig. 1a

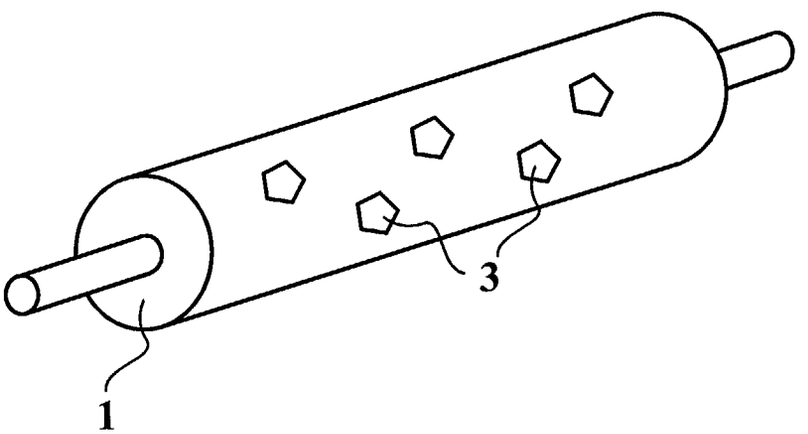

Fig. 1b

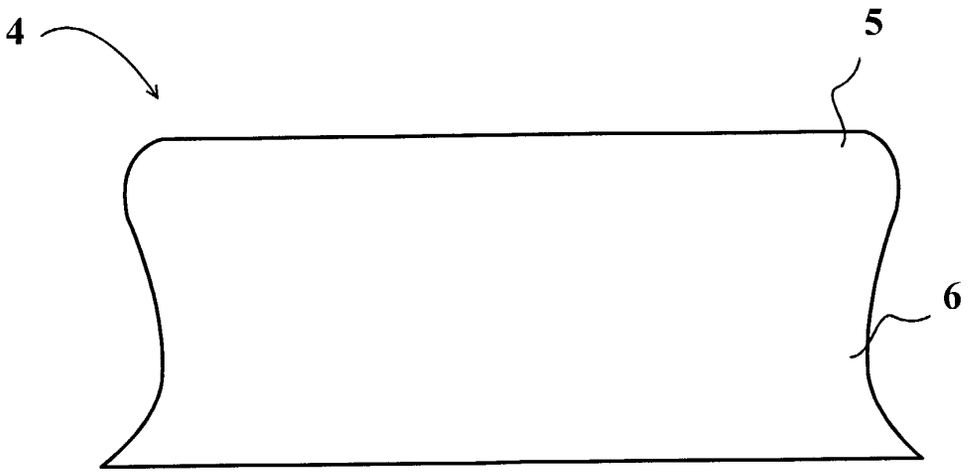

Fig. 2a

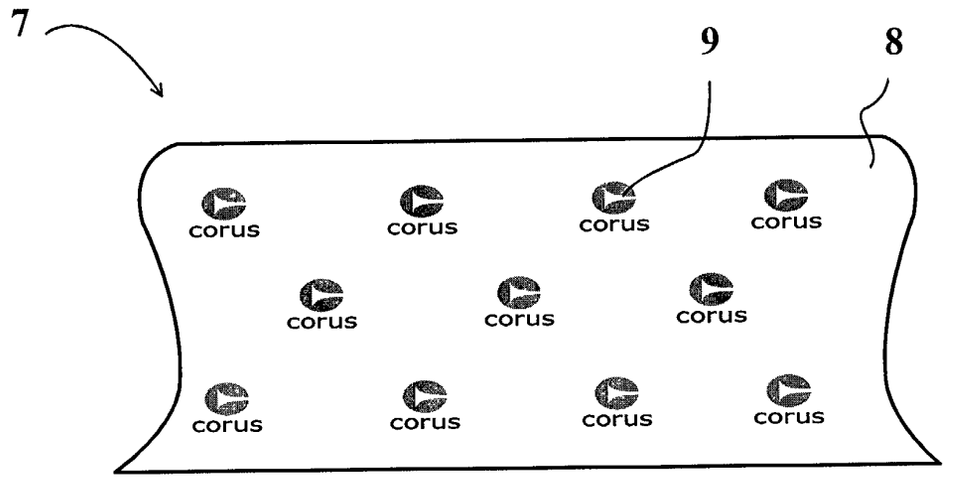

Fig. 2b

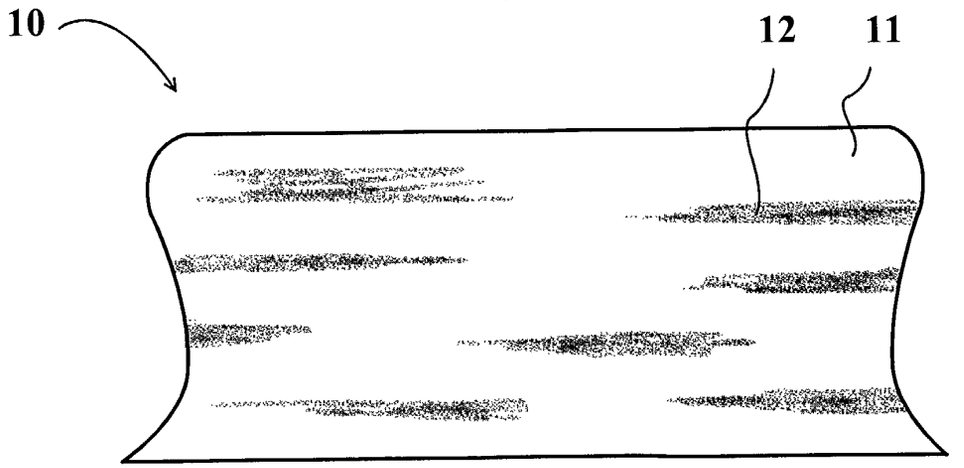

Fig. 2c

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 07 6960

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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	19 August 2002	Plastiras, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT

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L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 02 07 6960

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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