FORM 25 (12) PATENT granted by (19) AP

AFRICAN REGIONAL INDUSTRIAL PROPERTY ORGANISATION (ARIPO) 1082

(11) (A)

(21) Application Number: AP/P/1999/001522
(22) Filing Date: 19971107
(24) Date of Grant & (45) Publication: 20020705

(30) Priority Data
(33) Country: GB
(31) Number: 9623214.5
(32) Date: 19961107

(84) Designated States:
GH KE LS MW SD SZ
UG ZW

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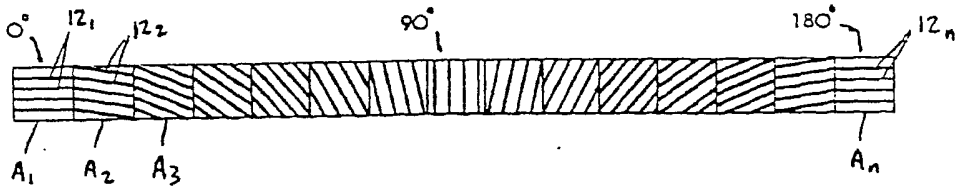
(51) International Patent Classification (Int.Cl.7): G02B 27/02, B42D 15/10, G09F 19/14

(54) Title: Optical Images

(57) Abstract:

A substrate is arranged to provide at least one optically variable image, the substrate being formed with a plurality of groups of elemental areas, the different groups forming respective image pixels. The different elemental areas (A_1 to A_n) of each group are formed with respective grooves or ridges or sets of grooves or ridges (12_1 to 12_n), which are at different orientations in the different elemental areas such that each elemental area of each pixel directs light to the viewer for a respective angle of view: for any given angle of view, the image seen by the viewer is made up of light reflected or refracted without interference from the different pixels, but only from a respective elemental area of each pixel.



(56) Documents Cited: US 5032003; WO 4588212; WO 9002658

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ARIPO Patent Application No. AP/P/99/01522
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The present invention relates to a substrate which is arranged to provide an optically variable image without the use of diffractive effects. The optically variable image is composed of a plurality of pixels: the substrate of claims 1 has a front surface which is formed with a plurality of groups of elemental areas, the different groups of elemental areas corresponding to respective image pixels. The different elemental areas of each such group are formed with respective grooves or ridges (or with respective set of grooves or ridges), the grooves or ridges of the different elemental areas of each group being at different orientations within the plane of the substrate: as a result, at different orientations of the substrate within its own plane, different elemental areas of each group contribute to the respective pixel of the image seen by the viewer.

This arrangement is clearly defined in claim 1 and clearly understood from the description of Figure 3 of the application. Thus, Figure 3 shows one group of elemental areas A_1 to A_n of a substrate, this group relating to one pixel of the image provided by the substrate: it will be noted that the different elemental areas A_1 to A_n of the group or pixel are formed with grooves or ridges at different orientations within the plane of the substrate.

Further in the substrate defined by claim 1, the grooves or ridges are arranged to direct rays of light to the viewer: this is achieved by the ridges or grooves reflecting light incident on the front surface of the substrate; however, at any orientation of the substrate within its own plane, only those grooves or ridges which lie at a corresponding orientation will reflect or direct light to the viewer.

Accordingly, at each orientation of the substrate within its own plane, an image is seen which is composed of a plurality of pixels: light is directed to the viewer from only one elemental area of each group, being the elemental area which has its grooves or ridges at a corresponding orientation. In particular, as the substrate is turned to a different orientation within its own plane, different elemental areas from the respective group or pixel contribute to the image seen by the viewer.

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It is a further feature of the invention that the substrate avoids light interference or diffractive effects. In the case of substrates having grooves or ridges which provide for diffraction, the diffractive effects cause the image to be made up of very bright colours, which vary as the substrate is tilted: thus, under incident white light, differently coloured beams of light emerge from the substrate at different angles and are visible at different angles of tilt, these beams being produced by interference between the rays of light reflected from the various diffractive grooves or ridges. Because of the bright colours which are produced, and because these bright colours change as the substrate is tilted, the image seen by the viewer is bold and distracting. In the substrate of the present invention, incident white light is reflected as white light, at a predetermined angle of reflection: there is no change of colour as the angle of tilt is changed, and the image seen by the viewer is substantially less distracting. There are many applications which require an optically variable image of discrete, non-distracting appearance; for example an optically variable image may be produced on a banknote as a security feature (to prevent counterfeit replication of the banknote), in which case it is desirable to provide a relatively discrete optically variable image, which is not overly eye-catching and so does not distract those handling the banknote in normal use. Such an optically variable image of discrete nature is achieved by the substrate of the present invention, because it avoids light interference or diffractive effects.

APT/99/01522

In order to provide diffractive effects, it is necessary to provide a large number of closely-spaced grooves which are accurately parallel to each other and uniformly spaced. By contrast, in the substrate of the present invention, it is not necessary for the grooves of each set (i.e. of each elemental area of each pixel) to be accurately parallel, not is it necessary for them to be uniformly spaced. Moreover, it is not necessary for there to be a large number of grooves in each set: there may be a small number of grooves in each set, or even just a single groove. These considerations give the designer greater scope when designing the optically variable image.

The arrangement of US patent No. 4,588,212 works in a significantly different manner to the present invention. Thus, as explained above, at each orientation of the substrate of claim 1, the correspondingly oriented grooves or ridges direct light from the substrate to the viewer. In US-4,588,212, by contrast,

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the substrate has ridges of different heights: at the appropriate orientation of the substrate, the higher ridges (of corresponding orientation) cast shadows, such that the ridges of different heights appear to be of lighter or darker hue (see column 2, lines 53 to 62); thus an image is created due to a shadow effect or variable occlusion of reflected light due to varying height of the ridges of corresponding orientation. The resulting image is substantially less bright than the image produced for an equivalent-size substrate according to claim 1 of the present application.

US patent No. 5.032,002 discloses a substrate which is formed with various series of grooves or ridges which are arranged as diffraction gratings, deliberately so that interference will occur between the light rays which emerge from the front surface of the substrate and pass towards the viewer. From the above comments, it will be appreciated that the invention of claims 1 of the present application is distinctly different from this.

Independent claim 10 of the present application relates to an embodiment of the invention in which the substrate is of transparent material to allow the transmission of light through the substrate from its rear. The grooves or ridges are formed on the front surface of the substrate and act to direct light to the viewer by refracting the light transmitted through the substrate: the substrate of claim 10 is therefore quite different from the substrate of US-4,588,212. Again, there is no interference between the rays of light directed to the viewer from the substrate (i.e. no diffractive effects) and the substrate of claim 10 is therefore distinctly different from the substrate of US-5,032,003.

Urquhart-Dykes & Lord
17th October 2000

For Keeling & Jackson
Advocates
Agents for the Applicant

view, the image seen by the viewer is made up of light reflected from the different pixels, but only from one elemental area of each such pixel: the substrate does not use diffraction effects and there is no interference between the light rays passing from the substrate to the viewer. As the substrate is turned or viewed from a changing angle, different elemental areas of each pixel reflect light to the viewer, such that a dynamically changing image is produced.

The resolution of the individual grooves may be as low as 2 micron. Each elemental area may have any desired number of grooves, although as few as one or two grooves may be provided in each such elemental area. In general, each elemental area may be as small as 5 microns but there is no upper limit to its size.

Although square elemental areas are shown, they can in principle be of any desired shape and size. Also, whilst straight grooves are shown, they may instead be curved or of any other shape. Further, the grooves of each elemental area need not be absolutely parallel to each other and may vary in orientation within that elemental area. In other words, the groove can have the property of a vector image or pixel orientated image or any combination of the two.

In a modification, at least some of the elemental area of at least some of the pixels may be arranged to contribute to a three-dimensional image, in accordance with the teachings of our UK patent application No. 9617314.1. Each such elemental area is made up of two series of grooves forming a stereo pair, the two series of grooves being inclined to each other so as to be viewed by the respective eyes of the viewer, and thus forming an image of a point at a predetermined distance from the plane of the substrate. A plurality of such point images is provided by those stereo pairs, of different pixels, which are seen at the relevant angle of view: the plurality of such point images together form an overall three-dimensional image.

Although the principles of the invention have been described with reference to a substrate formed with grooves and to be viewed under reflected light (the light being reflected from the grooves themselves), the substrate may instead be

transparent and formed with ridges instead of grooves, for viewing by light transmitted through the substrate and refracted (or both refracted and reflected) by the ridges.

Claims

1) A substrate which is arranged to provide an optically variable image to a viewer, said image being composed of a plurality of pixels, the substrate having a front surface which is formed with a plurality of groups of elemental areas, the different said groups corresponding to respective pixels of said image, and the different elemental areas of each group being formed with respective grooves or ridges or with respective sets of grooves or ridges, the grooves or ridges of the different elemental areas of each group being at different orientations within the plane of said substrate such that, at different orientations of the substrate within its said plane, different elemental areas of each said group contribute to the respective pixel of the image seen by the viewer, and said grooves or ridges being arranged to direct light rays to the viewer, by reflecting light incident on said front surface, without interference occurring between said light rays directed to the viewer from the substrate.

2) A substrate as claimed in claim 1, in which at least some of said elemental areas comprise a plurality of said grooves or ridges which are parallel or substantially parallel to each other.

3) A substrate as claimed in claim 1 or 2, in which the grooves or ridges of at least some said elemental areas are rectilinear.

4) A substrate as claimed in any preceding claim, in which the grooves or ridges of at least some said elemental areas are curved.

5) A substrate as claimed in any preceding claim, in which at least some of said elemental areas are square in shape.

6) A substrate as claimed in any preceding claims, in which at least some of said elemental areas are circular in shape.

7) A substrate as claimed in any preceding claim, in which, in at least some said groups, the elemental areas are arranged in a linear disposition.

8) A substrate as claimed in any preceding claim, in which, in at least some of said groups of elemental areas, said elemental areas are closely packed together.

9) A substrate as claimed in any preceding claim, in which at least some of the elemental areas of at least some of said groups comprise two grooves or ridges, or two series of grooves or ridges, forming a stereo pair, the two grooves or ridges, or two series of grooves or ridges, being inclined to each other so as to direct light to the respective eyes of the viewer when the viewer views the substrate from a predetermined angle of view.

10) A substrate which is arranged to provide an optically variable image to a viewer, said image being composed of a plurality of pixels, the substrate being formed of transparent material and having a front surface which is formed with a plurality of groups of elemental areas, the different said groups corresponding to respective pixels of said image, and the different elemental areas of each group being formed with respective grooves or ridges or with respective sets of grooves or ridges, the grooves or ridges of the different elemental areas of each group being at different orientations within the plane of said substrate such that, at different orientations of the substrate within its said plane, different elemental areas of each said group contribute to the respective pixel of the image seen by the viewer, and said grooves or ridges being arranged to direct light rays to the viewer, by refracting

light transmitting through said substrate from its rear, without interference occurring between said light rays directed to the viewer from the substrate.

11) A substrate as claimed in claim 10, in which at least some of said elemental areas comprise a plurality of said grooves or ridges which are parallel or substantially parallel to each other.

12) A substrate as claimed in claim 10 or 11, in which the grooves or ridges of at least some said elemental areas are rectilinear.

13) A substrate as claimed in any one of claims 10 to 12, in which the grooves or ridges of at least some said elemental areas are curved.

14) A substrate as claimed in any one of claims 10 to 13, in which at least some of said elemental areas are square in shape.

15) A substrate as claimed in any one of claims 10 to 14, in which at least some of said elemental areas are circular in shape.

16) A substrate as claimed in any one of claims 10 to 15, in which, in at least some said groups, the elemental areas are arranged in a linear disposition.

17) A substrate as claimed in any one of claims 10 to 16, in which, in at least some of said groups of elemental areas, said elemental areas are closely packed together.

18) A substrate as claimed in any one of claims 10 to 17, in which at least some of the elemental areas of at least some of said groups comprise two grooves or ridges, or two series

of grooves or ridges, forming a stereo pair, the two grooves or ridges, or two series of grooves or ridges, being inclined to each other so as to direct light to the respective eyes of the viewer when the viewer views the substrate from a predetermined angle of view.

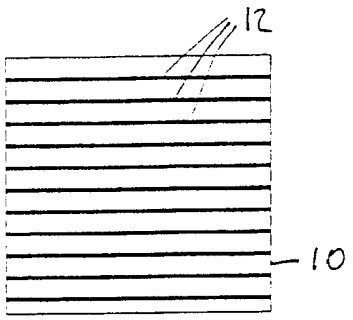

FIGURE 1

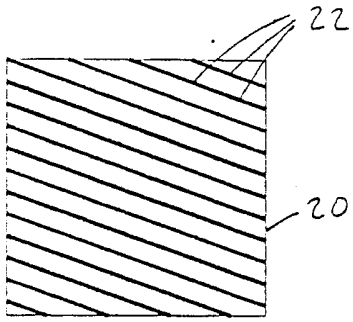

FIGURE 2

AP/P/99/01522

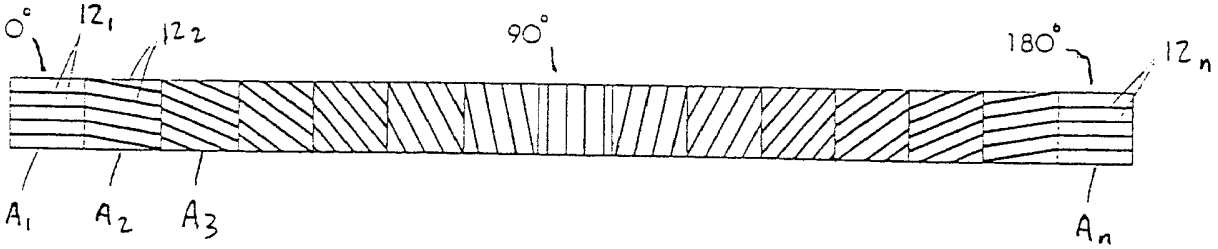

FIGURE 3