such that sets of two images are produced that are separately viewed by each respective eye of a viewer at a range of viewing distances of for instance 20-100 cm. In this manner a stereoscopic effect is achieved through the range of viewing distances.

The interlaced images may be printed on a substrate, for instance polycarbonate, where after the line-shaped lens structure may be applied over each set of interlaced pixel tracks using a die or mould. Alternatively, the lens structure is first formed and the interlaced images are subsequently written onto the substrate by means of a scanning optical beam, such as a laser.

A disadvantage of using a number of interlaced images is that upon viewing these images via the lenticular device, patterns of dark shading appear to run across the image when changing the angle of view. This produces an unstable visual effect which especially for the use of the lenticular device as a security device hinders accurate and reliable identification.

~~It is h~~Hence, ~~an object~~embodiments of the invention seek to provide a lenticular device in which the above effect is reduced. Embodiments~~It is another object~~ of the invention seek to provide a lenticular device which is especially suitable for producing accurate and reliable identity or security document.

Summary of the invention

A~~Thereto the method a~~according to a first aspect, there is provided a method of manufacturing a display device, in particular a security document, comprising the steps of:

- providing m images of an object, wherein m is at least equal to 2,
- dividing each image into n sets adjacent arrays $(l_{1,1},l_{1,2},\ldots l_{1n}),\ldots,(l_{m1},l_{m2},\ldots l_{mn})$ of picture elements, spaced at a mutual distance δ
- applying the images in an interlaced manner on an image layer in sets of interlaced arrays $(l_{11},l_{21}\ldots l_{m1}),\ldots,(l_{1n},l_{2n},\ldots l_{mn})$ below a lens structure comprising line-shaped lens elements over the image layer with one line shaped lens element overlying a corresponding set of adjacent arrays.

~~the invention is~~ characterised in that upon applying the arrays into the image layer, and/or upon providing the lens elements, each array of picture elements is provided onto the image layer in an out of focus manner to form a blurred array or each array is imaged by the lens elements to form a blurred array, wherein a mutual distance of the edges of adjacent blurred arrays is smaller than the mutual distance δ.

The pixel tracks can be processed in a digital processor to be blurred so that their width increases and the spacing between adjacent pixel tracks is reduced. Preferably, the pixel tracks will increase in width such that edges of neighbouring pixel tracks touch.

According to a second aspect, there is provided a display device comprising an array of lens elements overlying an image layer with sets of pixel tracks produced by the method according to the first aspect.

According to a third aspect, there is provided an apparatus for producing a display device, such as a security document, comprising an optical beam generator, a substrate carrier for carrying an image layer having a top surface, a scanning device for scanning an optical beam across an image layer on the substrate carrier in a line pattern, characterised in that the optical beam is focussed above the top surface of the image layer or below the image layer.

According to a fourth aspect, there is provided an apparatus for producing a display device such as a security document, comprising an optical beam generator, a substrate carrier, a scanning device for scanning an optical beam across an image layer on the substrate carrier in a line pattern, a control unit for storing a number of arrays of pixel elements of width w spaced at a mutual distance δ, and for controlling the optical beam generator and/or the scanning device for scanning the arrays onto the image layer on the substrate carrier, and a tilting drive for tilting the substrate carrier around an axis extending substantially transversely to the optical beam, wherein the control unit is adapted to form blurred interlaced pixel arrays of an out of focus width w' larger than width w, that can be written onto an image layer placed on the substrate carrier such that a mutual distance δ' of the edges of adjacent blurred pixel arrays is smaller than the mutual distance δ.

A suitable device for producing a security document comprises an optical beam generator, a substrate carrier, a scanning device for scanning an optical beam across an image layer on the substrate carrier in a line pattern and a control unit for controlling the optical beam generator for scanning the beam across an image layer on the substrate carrier, and a tilting drive for tilting the substrate carrier around an axis extending substantially transversely to the optical beam. The control unit is adapted to form blurred interlaced pixel arrays that can be written into a substrate placed on the substrate carrier such that a mutual distance of the edges of adjacent blurred pixel arrays is smaller than the mutual distance δ.

The image layer may comprise a polycarbonate layer over which the lenticular structure has been formed. The laser is scanned across the lens structure in a line pattern and is imaged by the lenticualr array onto the image layer in an out of focus manner to form (blurred) pixel tracks where it produces light and dark pixels by locally carbonising the image layer. The substrate table tilts the substrate each time through a small angle such that an image is formed for each tilting angle.

According to a fifth aspect, there is provided a display device comprising an image layer, a substrate having at a distance H above the image layer a number of line-shaped lens elements which are adapted to focus a light beam for applying arrays of picture elements onto the image layer in a focal plane situated at a distance L from the lens-elements in which L is larger or smaller than H.

Brief description of the drawings

Some embodiments of a method and device according to the present invention will by way of non-limiting example be explained in detail with reference to the accompanying drawings. In the drawings:

Fig. 1 shows a schematic cross-sectional view of a known lenticular structure,
Fig. 2 shows a top view of three adjacent interlaced pixel tracks,

Fig. 3 shows a schematic lay-out of an embodiment of a device for producing an interlaced image in a lenticular structure according to the invention,

Fig. 4 shows a schematic lay-out of a preferred embodiment for laser engraving an interlaced image in an out-of focus lenticular structure according to the invention,

Figs. 5a and 5b show a cross-sectional view of a lenticular lens array projecting a laser beam onto an image layer in a focussed and out-of focus manner, respectively,