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(54) Method for registering colour separation images, and pattern of pictures obtained therewith.

(57) Method for registering colour separation images, at least comprising the steps of

- printing, in a reference colour and at a predetermined position on a substrate, a reference colour separation image of a picture;
- printing reference colour separation images of the same picture, in the reference colour, at a number of positions around the first picture;
- printing, in a different colour and at the same positions, colour separation images of the same picture of the different colour, a known registration correction of the colour separation image of the different colour having been performed for each of said pictures, in such a way that the pictures in the other colour have been set up as a function of the direction of correction and the size of the correction in a corresponding manner around the picture without registration correction; and
- determining, with the aid of the picture obtained, the optimal registration correction of the colour separation image of the different colour with respect to the reference colour separation image, and pattern of pictures thus obtained.

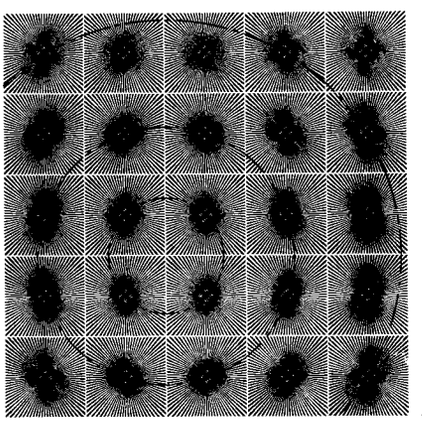

Fig. 3.

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The present invention relates to a method for registering colour separation images, at least comprising the steps of

- printing, in a reference colour and at a predetermined position on a substrate, a reference colour separation image of a picture;
- printing, in a different colour and at the same position on the substrate, a colour separation image of the different colour of the same picture; and
- determining, with the aid of the picture obtained, the optimal registration correction of the colour separation image of the different colour with respect to the reference colour separation image.

Multicoloured pictures are produced by colour separation images of a number of base colours, often yellow, magenta, cyan and black, being printed on top of one another. Each colour separation image contains the information of the colour in question in the picture. During printing, the colour separation images should be printed in accurate register on top of one another. Said registering is a comparatively time-consuming and difficult process.

Generally, a hairline cross is printed in the reference colour, whereafter an identical hairline cross is printed on top of this in the same position in a different colour. By determining the difference in position between the hairline crosses with the aid of a microscope or the like, it is possible to determine the correct registration correction of the colour separation image in the different colour with respect to the reference colour separation image. Such an operation, however, often needs to be carried out a number of times, before the optimal registration correction is obtained.

The object of the present invention is to provide a method by which the optimal registration correction of a colour separation image with respect to a reference colour separation image can be determined simply and rapidly. To this end, the method according to the invention is characterized in that reference colour separation images of the same picture are printed, in the reference colour, at a number of positions around the first picture, and in that colour separation images of the same picture of the different colour are printed, in the different colour, at the same positions, a known registration correction of the colour separation image of the different colour having been performed for each of said pictures, in such a way that the pictures in the other colour have been set up as a function of the direction of correction and the size of the correction in a corresponding manner around the picture without registration correction.

From the pattern of pictures thus obtained according to the invention, the optimal registration correction can be read off visually.

Advantageously, the pictures are of essentially rectangular shape, around the picture, without registration correction, in all directions at least two pictures being printed.

Preferably, each picture is an essentially square picture having a centre-symmetric pattern.

Centre-symmetric pictures have been found to give a good visual effect in the pattern obtained by the method according to the invention. All this will be explained in more detail in the description of the figures.

The use of such a picture results in circular, concentric colour structures appearing in the pattern of pictures, the optimal registration correction being situated approximately in the centre thereof.

Apart from such a pattern, very many other patterns can be used, such as a chessboard pattern, a grid pattern, a point pattern, and even an arbitrary pattern, if the pattern is identical in all pictures.

In particular, each picture comprises a number of wedges arranged evenly around the centre of the picture, the tips of the wedges touching one another in the centre. Preferably, at least 20 and more preferably at least 50 wedges are present.

In another preferred embodiment, the colour masking as seen over the circumference of an arbitrary circle having as the centre the centre of the picture, has an essentially even sinusoidal pattern. In this respect masking is intended to mean the extent in which a surface, e.g. the substrate, is covered by the colour.

By means of such a circular colour masking of an essentially sinusoidal profile it is likewise possible to determine, from the pattern of pictures, the quality of the printing technique, in terms of resolving power, sharpness and the like.

Advantageously, each correction step approximately corresponds to the pixel spacing used. The pixel spacing is the centre-centre spacing between two adjacent pixels. In the case of screen printing this is the centre-centre spacing between two adjacent screen holes, and in the case of ink jet printing, it is the spacing between two adjacent lines. In the case of ink jet printing, the picture to be printed is built up line by line (tangential lines on the substrate drum).

Of course, any colour can be used as a reference colour, but preferably the reference colour used is black.

The present invention further provides a pattern of pictures arranged around a centre and comprising pictures printed in two colours, from which, by blurring or shifting the colours, the optimal registration correction of a colour separation image of a colour can be determined with respect to a colour separation image of a reference colour, obtainable

with the aid of the method according to the invention.

The invention is now explained in more detail with reference to registering colour separation images in the case of an ink jet printer, although the invention is not limited thereto and can similarly be used for any other printing technique in which use is made of colour separation images.

Ink jet printers can globally be divided into two groups: the so-called continuous-flow ink jet printers, and the so-called drop-on-demand ink jet printers.

The drop-on-demand ink jet printers operate with jets in which, when a drop is to be dispensed, a gas bubble is formed with the aid of an electric current, as a result of which a drop is expelled towards the substrate, frequently a drum.

The continuous-flow ink jet printers comprise a jet in which ink drops are continuously fired towards the substrate. The drops can be charged as required with the aid of an electrode. Then they pass between two plates between which a voltage difference has been applied. Thus drops can be intercepted as required. Ink is often supplied with the aid of an ink pump, while a piezoelectric vibration element is present, to form the drops, in the outlet orifice upstream of the deflection plates.

Hereinafter the description, for the sake of clarity, will discuss only the continuous-flow ink jet printers.

The jets are present in an ink jet print head which can be displaced along a predetermined path along the drum on which a substrate is present. The drum is simultaneously rotated with respect to the ink jet print head.

Hereinafter in the description, X direction refers to the axial direction of the drum surface, and Y direction to the direction on the drum surface perpendicular to the axial direction. A picture to be printed is built up line by line (lines in the Y direction) in the X direction.

Pictures can be printed in a known manner by means of an ink jet printer, by accurate interaction between the displacement of the ink jet print head in the X direction and the displacement of the substrate to be printed in the Y direction.

Jets in an ink jet print head are often constructed as separate nozzles, but ink jet print heads are also known in which the nozzles together form a single unit. In both cases, there is a registration problem between the jets with respect to one another, which leads to a registration problem between the separation colour images to be printed, which is very difficult to resolve.

In practice it is known, as discussed above, to print, by means of a reference jet and in a reference colour on a predetermined position on a substrate, a reference colour separation image of the picture, the substrate frequently being a sheet of paper and the picture being a hairline cross. Then, by means of a second jet and in a different colour, the colour separation image of the same hairline cross of the different colour is printed on the same position, and then the shift of the colour separation image which has been printed in the different colour, with respect to the picture which has been printed in the reference colour, is determined under a microscope or the like, and the registration of the second jet is thus corrected. This correction can be carried out by a mechanical correction with the aid of setscrews or the like, but can equally be carried out with the aid of a control assembly of the ink jet printer. In the latter case, the software-type control of the jets is corrected in such a way that the ink droplet of the second colour to be dispensed touches the surface of the substrate at the correct instant.

A drawback of this technique is that the correction often needs to be carried out in a number of steps, since the correct correction value is difficult to determine.

A method for registering jets has been described in EP-A-0 470 813, where a calibration device is present next to a drum with a substrate. This device comprises a needle-like feeler whose tip is situated next to the drum in the line of the plane of the substrate. This therefore involves bringing the jets into register next to the drum and not on the substrate where the eventual printing process takes place. The adjustment of the needle has to be carried out mechanically, and errors in the position of the needle are therefore very likely. Even small errors in adjustment of the needle may give rise to considerable registering problems. This method has therefore not proved satisfactory.

With the method according to the invention, the determination of the optimal registration takes place on the substrate surface, in contrast to EP-A-0 470 813, and from the pattern of images obtained the optimal colour separation image registration correction with respect to the reference colour separation image can be determined in a very simple manner, as will be discussed later.

The invention will be explained below in more detail with reference to the accompanying drawing, in which:

- Figure 1 shows a schematic depiction of an ink jet printer;
- Figure 2 shows a schematic front view of an ink jet print head;
- Figure 3 shows a schematic depiction of the operation of a continuous-flow ink jet printer;
- Figure 4 shows a preferred embodiment of a picture to be printed;
- Figure 5 shows an enlargement of the por-

tion V from Figure 4;

Figure 6 shows a graph in which the colour masking is plotted against the distance A-A' in Figure 5;

Figure 7 shows an example of a pattern containing pictures according to the invention, and

Figure 8 shows the same pattern as in Figure 7, except that a number of concentric circles is indicated therein.

In Figure 1, 1 shows a rotatable drum on which a substrate S has been mounted. With the aid of an arrow 2, the direction of rotation of the drum is indicated.

3 indicates an ink jet print head, which comprises four jets 9a-9d, for each jet the ink supply being indicated, in part, by 4a-d. These supplies are connected to suitable supply means such as ink pumps or the like. As a rule, the ink colours used are: Black (B), Magenta (M), Cyan (C) and Yellow (Y). The arrows 6 and 6' indicate the displacement direction of the ink jet print head 3, this being the X direction, as discussed earlier.

7 shows, in schematic form, the pattern printed with the aid of a jet 4.

Figure 2 shows, schematically, a front view of the ink jet print head 3 with the various jets 9a-9d. In this case, the jets are constructed in the form of ducts in an ink jet print head 3 consisting of a single unit. It is equally possible, however, for the jets to be incorporated in separate nozzle units which can be separately replaced and adjusted.

Figure 3 shows, in schematic form, the mode of operation of a continuous-flow ink jet printer. In this type, a jet 11 of ink droplets is formed continuously, the droplets being charged by an electrode 10 and passing between two deflection plates 12 and 12', said plates being connected to a voltage source not shown in any detail. The plates 12, 12' have a voltage difference $\Delta V = V1 - V2$ applied to them, in order to deflect charged droplets towards a collection reservoir which is schematically indicated by 13. The number of droplets allowed to pass through as a group, as indicated at 14, is generally denoted as the "word value", which in this case is 4. In the course of the movement of such a group of drops, the frontmost drop will be slowed down by the resistance of the air, and the following drops while moving towards the substrate S will mix with said drop and form one drop, as is indicated schematically at 16.

The speed of movement of a drop 16 depends on the word value. Greater word values generally have higher velocities and will therefore reach the substrate S sooner. This difference in time leads to positional errors, owing to the rotation of the drum. These positional errors need to be compensated for, which is the so-called time-of-flight compensation. Generally, said time-of-flight compensation will be carried out by averaging the difference in velocity. The largest word value is 10, the smallest is 1.

Frequently, the device is adjusted in such a way that word value 10 reaches the substrate at the correct instant. It will be evident that all this depends on the dimensions and the velocity of the ink droplets. As a rule, word values 5, 6, 7, 8, 9 and 10 will have the same time of flight.

Figure 4 shows a preferred embodiment of a picture to be printed with the aid of the method according to the invention, which picture will then be printed a number of times in a pattern yet to be discussed in more detail, in a reference colour and a different colour, of which the colour separation image is to be registered. For the sake of clarity, this figure shows only sixteen wedges 18 touching one another in the centre.

Figure 5 shows an enlargement of the section V from Figure 4, in which the colour masking is indicated with the aid of hatching, which is shown yet again in Figure 6, in more detail, with the aid of a graph of the colour masking versus the distance A-A'. The points A and A' are situated on the centre lines between two wedges in each case, A in the middle between wedge 18a and 18b, and A' in the middle between wedges 18b and 18c. The colour masking is proportional to the average word value.

Using the picture according to Figure 4 thus makes it possible for not only the correct registration correction, but also the quality of the time-of-flight compensation to be determined on the basis of the degree of blurring of the centre of the picture. Substantial blurring means poor time-of-flight compensation.

Figure 7 shows an example of a pattern of 25 pictures according to the invention. The picture 23c is the picture for which the different colour separation image has been printed on top of the reference colour separation image without registration correction. For picture 24c, the jet of the different colour has been corrected to the right by one pixel spacing, whereas in picture 25c the jet has been corrected to the right by two pixel spacings.

In the case of picture 24b, the second jet has been corrected upwards by one pixel spacing and to the right by one pixel spacing. In picture 21e, the jet of the different colour has been corrected to the left by two pixel spacings and downwards by two pixel spacings.

If this pattern is observed from some distance, a set of concentric circles can be perceived, as is indicated schematically in Figure 8, the centre of said circles approximately representing the optimal registration correction for the colour separation image of the different colour with respect to the

reference colour separation image. In this case the optimal registration correction therefore is found to be half a pixel spacing to the left and half a pixel spacing downwards.

A similar pattern is likewise printed for the subsequent nozzles 4c and 4d, with respect to the reference jet 4a.

It will be obvious that the resolution of the colour separation image registration can be increased by selecting a smaller correction step than a pixel spacing

Preferably, the corrections are carried out with the aid of an input unit of the control assembly of the ink jet printer during the printing process, so that no mechanical interventions with respect to the nozzles are necessary, since any mechanical intervention involving one jet may affect the orientation of the jets situated adjacent thereto. With the aid of the current ink jet printers such patterns, as depicted in Figure 7, can be built up line by line from left to right, account being taken in each case of the registration correction associated with the colour separation image in question.

As Figures 7 and 8 clearly show, the time-of-flight compensation for the outermost pictures is still reasonable, notwithstanding the fact that the jet is printing out of register.

Claims

1. Method for registering colour separation images, at least comprising the steps of
   - printing, in a reference colour and at a predetermined position on a substrate, a reference colour separation image of a picture;
   - printing, in a different colour and at the same position on the substrate, a colour separation image of the different colour of the same picture; and
   - determining, with the aid of the picture obtained, the optimal registration correction of the colour separation image of the different colour with respect to the reference colour separation image,

   characterized in that reference colour separation images of the same picture are printed, in the reference colour, at a number of positions around the first picture, and in that colour separation images of the same picture of the different colour are printed, in the different colour, at the same positions, a known registration correction of the colour separation image of the different colour having been performed for each of said pictures, in such a way that the pictures in the other colour have been set up as a function of the direction of correction and the size of the correction in a corresponding manner around the picture without registration correction.

2. Method according to claim 1, **characterized in that** the pictures are of essentially rectangular shape, around the picture, without registration correction, in all directions at least two pictures being printed.

3. Method according to claim 1 or 2, **characterized in that** each picture is an essentially square picture having a centre-symmetric pattern.

4. Method according to claim 3, **characterized in that** each picture comprises a number of wedges arranged evenly around the centre of the picture, the tips of the wedges touching one another in the centre.

5. Method according to claim 4, **characterized in that** the colour masking, as seen over the circumference of an arbitrary circle having as the centre the centre of the picture, has an essentially even sinusoidal pattern.

6. Method according to one or more of the preceding claims, **characterized in that** each correction step approximately corresponds to the pixel spacing used.

7. Method according to one or more of the preceding claims, **characterized in that** the reference colour employed is black.

8. Pattern of pictures arranged around a centre and comprising pictures printed in two colours, from which, by blurring or shifting the colours, the optimal registration correction of a colour separation image of a colour can be determined with respect to a colour separation image of a reference colour, obtainable with the aid of the method according to the invention.

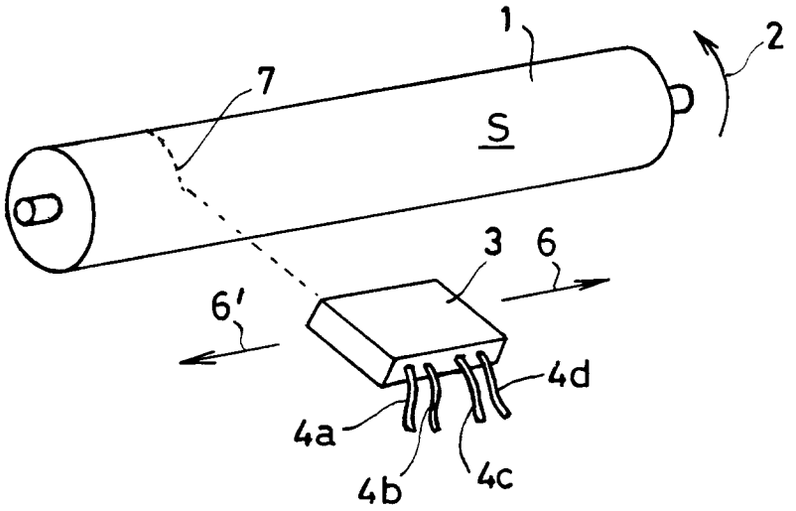

Fig. 1.

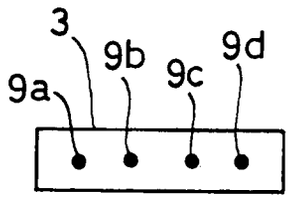

Fig. 2.

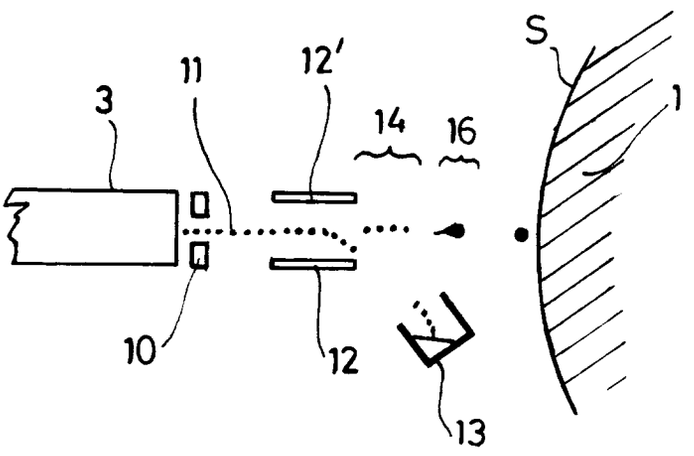

Fig. 3.

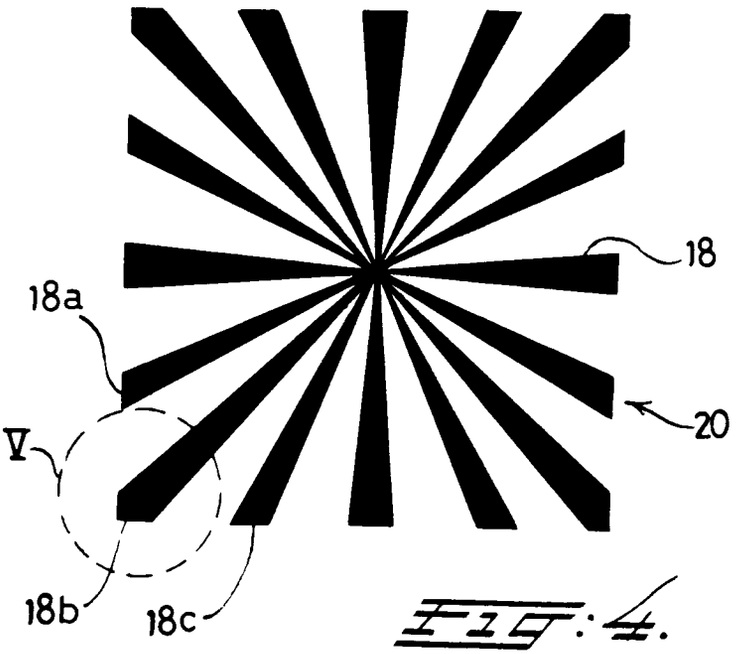

Fig. 4.

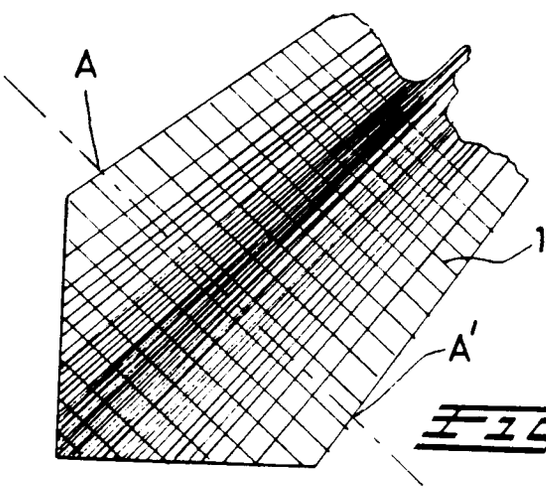

Fig. 5.

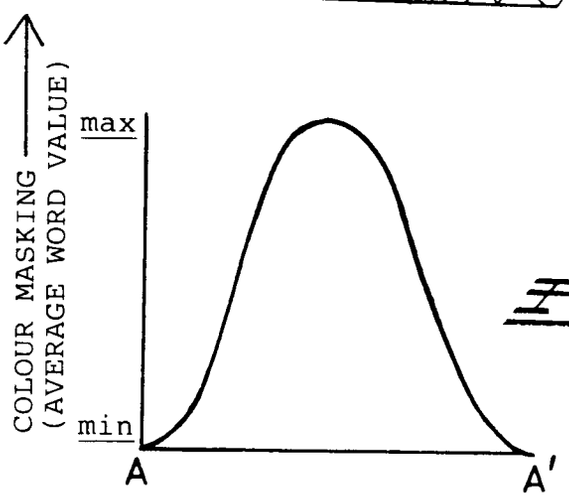

Fig. 6.

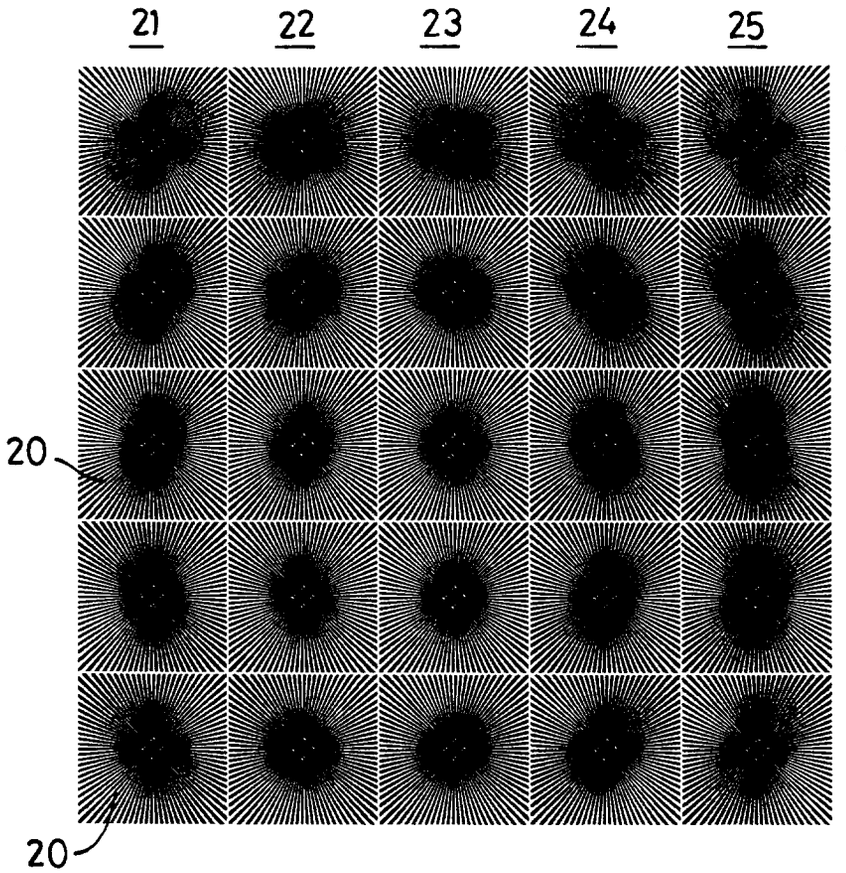

Fig. 7.

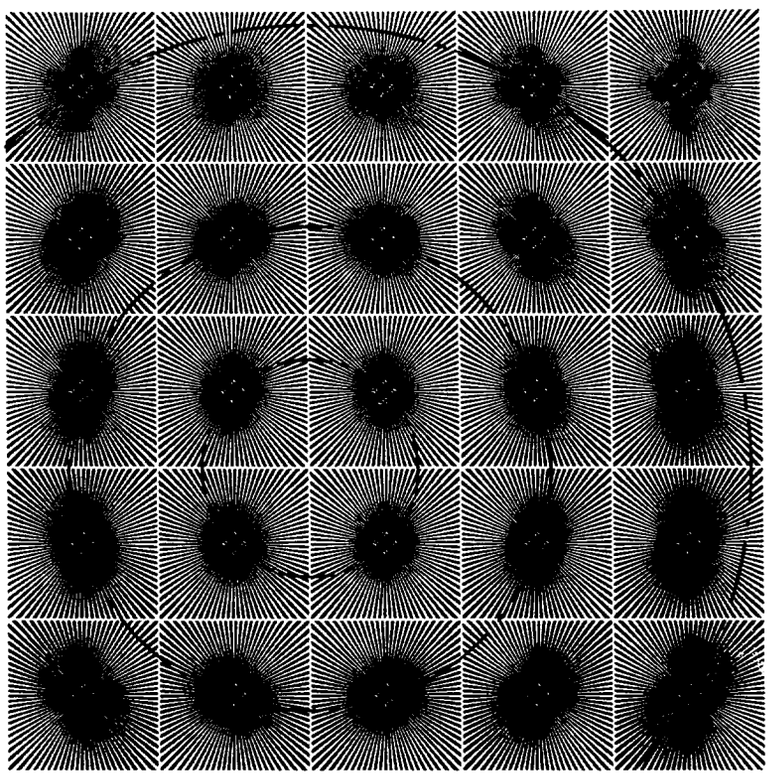

Fig. 8.

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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 0541

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US-A-4 675 696 (SUZUKI) * column 2, line 24 - column 9, line 29; figures 1-16 *	1	B41J2/21 B41J2/205
A	EP-A-0 011 722 (IBM) * abstract; figures 1-4 *	1	
D,A	EP-A-0 470 813 (IRIS GRAPHICS) * abstract; figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 April 1995	De Groot, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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