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(54) **Printing method by a writing mechanism having either one print head with multiple arrays of side by side writing elements or a plurality of side by side print heads**

(57) A printing method by a writing mechanism having either one print head with multiple arrays of side by side writing elements or a plurality of side by side print heads is applied to a writing mechanism comprising a rotating drum (3) supporting a photosensitive plate, at least two engraving laser heads (1,2) movable parallel to the axis of rotation (x) of the rotating drum (3), an array of laser diodes (5) on each laser head (1,2) and displacing means for the laser heads (1,2) in order to move them

by a distance equal to the product of the number of laser diodes and the writing resolution. The laser heads (1,2) are side by side. The distances between the laser diodes (5) and a first laser diode (5) are not congruent modulo n. Spots that are generated by laser diodes (5) column by column, one per each laser diode, interlace to form a complete image.

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Description

[0001] The present invention relates to a printing method by a writing mechanism having either one print head with multiple arrays of side by side writing elements or a plurality of side by side print heads.

[0002] In the following, reference is made in particular to *Computer to plate* (CTP), i.e. to the technology that is used to transfer images and texts directly onto printing plates, as well as on the "printer" that physically transfers a digital image on a plate. However it should be understood that the method according to the invention is also applicable to other printers different from CTP.

[0003] Referring to CTP, given the current state of laser technology, it is difficult to manufacture individual heads that generate a high number of spots. The reason for this is that, in the case of diode laser heads, inserting a large number of diodes on a single chip significantly increases the likelihood of production waste. In addition, when using the laser heads, probability of failure increases also due to chip overheating. This severely reduces the productivity of CTP. A possible solution to the problem is the use of either multiple print heads operating simultaneously or one print head having multiple arrays of diodes inside it.

[0004] Almost all the existing printers use a writing algorithm developed by IBM (Patents Nos. US4069486A1 and US4401991A1) for inkjet printers. According to this writing algorithm the distance required between a writing element, that is a laser diode in the case of CTP, and the next one, must always be equal for all laser diode array. Further, such a distance when discretized, i.e. divided by the resolution distance (in the case of 2540 dpi, it is equal to 10 μm), has to be co-prime with the number of diodes of the array so that image columns are not overlapped in the writing. However, since a constant distance between a laser diode and the next one within a single chip can not be mechanically maintained between two diodes of different heads, it is not possible to have two print heads side by side, if the writing algorithm according to the IBM patents cited is used.

[0005] Other manufacturers in CTP field such as Heidelberg found a solution to the problem by ideally dividing a plate into multiple parts, each being engraved by a single head. Also this solution presents various drawbacks. First, the same increase in productivity is not achieved on all sizes of plate, but it is necessary to optimise the distance between the heads for a single size. Secondly, this distance must be maintained with an accuracy equal to a quarter of the resolution distance, at the most (2.5 μm in case of 2540 dpi). Of course, the greater the distance between the heads, the smaller the acceptable relative error. In order to maintain constant the distance between the two heads, Heidelberg is forced to mount an air conditioning system within its CTP so that the temperature variation of the laser carriage is kept within one Celsius degree. Furthermore, the laser heads are constrained, and a rupture of a laser if any forces to switch off the lasers in excess over the other heads, although working, since the laser carriage is unique and the helix pitch must be constant.

[0006] In this context, an object of the present invention is to provide a printing method by a writing mechanism having either one print head with multiple arrays of side by side writing elements or a plurality of side by side print heads, in order to overcome the above mentioned drawbacks, and in particular those of the IBM method.

[0007] In the following description certain terms that require definition are used.

[0008] Line clock is defined as a train of pulses generated by a data supply device through the zoom of signals from an angle encoder mounted on a drum. The zoom has to be sufficient to achieve a discretization of 10 μm of the surface of the same drum when a resolution of 2540 dpi is desired, or a discretization of 5 μm for a resolution of 5080 dpi, and so on.

[0009] Helix pitch is intended as the displacement in mm of the laser head on a respective linear guide for each drum rotation of 360°. The helix pitch depends on the number of spots generated by the head in correspondence of each clock line.

[0010] Spot is defined as the surface of the plate exposed by a single laser beam. In the thermal technology or in the infrared technology each of the n laser diodes produces a spot on the plate. In the deflection technology that is generally used with purple or ultraviolet light lasers, a particular deflection angle of the laser beam corresponds to each exposed spot on a single line

[0011] If the number of spots exposed or generated per clock line is indicated with n , the helix pitch with pe and the resolution distance, i.e. the distance in mm between the spots to achieve a determined resolution of exposure, with ds , the consequence is:

$$pe = n \times ds \quad (1)$$

[0012] In addition, the term pitch has two different meanings depending on the technology it refers to. In the diode array technology pitch is the distance on the plate between the spot exposed by a diode and the one exposed by the immediately following or preceding diode. In the deflection technology pitch is the distance between the spot generated by the single laser beam, deflected by a certain angle, and the spot generated by applying the next higher or lower

deflection angle. This discretization of the deflection angles is based on the need of having between one spot and another a distance, e.g. of 10 μm , to obtain an image resolution of 2540 dpi.

[0013] Relative distance of a diode is defined as the discretized distance between a diode (or any writing element) and the first diode of the laser array, the first diode being the diode which is in the entire one-dimensional array in the extreme opposite with respect to the direction of writing.

[0014] Therefore, the present invention provides a printing method by a writing mechanism having either one print head with multiple arrays of side by side writing elements or a plurality of side by side print heads, comprising:

- rotating a support member about its axis of rotation that supports means suitable for receiving marks on one surface thereof,
- displacing at least one print head on a linear guide parallel to the axis of rotation of the support member, an array of writing elements being adapted to generate respective marks being mounted on at least one print head along a straight line parallel to the axis of rotation of the support member, displacing means being provided for moving said at least one print head, with respect to said support member, on said linear guide,

wherein

- said at least one print head is moved by a distance equal to the product between the total number of writing elements being mounted on said at least one print head and the writing resolution or distance between the marks;
- the distances existing between the first writing element and the i^{th} writing element, i.e. the distances

$$d_0 = 0$$

$$d_1 = p (es_1, es_2) + d_0$$

$$d_2 = p (es_2, es_3) + d_1$$

...

$$d_{n-1} = p (es_{n-1}, es_n) + d_{n-2} ,$$

where n is the number of writing elements es_i , d_i is the distance from the first writing element to the i^{th} writing element, and $p (es_{i-1}, es_i)$ or pitch is the distance existing between two consecutive writing elements, comply the condition

$$d_0 \bmod n \neq d_1 \bmod n \neq d_2 \bmod n \neq \dots \neq d_{n-1} \bmod n$$

i.e. every d_i is not congruent modulo n , where units d and n are dimensionless integers, in such a manner that the marks are generated by the writing elements per columns, one for each writing element, that interlace together to form a complete image.

[0015] In short, the pitch is not homogeneous. For example, the condition above described allows a multi-head printing system to be implemented in a very simple way, i.e. by setting the print heads side by side. The printing method according to the invention has to be able to maintain the distance between the first writing element in each print head and the first writing element of the first print head by observing the feature that the distance between the print heads is equal to the pitch among the writing element inside the print head being multiplied by the number of writing elements plus one. Then, if the distance between the print heads is defined with D , the number of operating writing elements with n , the pitch inside each single print head with p , it is obtained

$$D = (n+1) \times p.$$

[0016] According to the method of the invention, the printing mechanism can advantageously be provided with means that allows the D or distance between the print heads to be changed. In fact, in case of failure of one or more writing

elements, it is sufficient to identify a number of writing elements that is co-prime with p , as provided in the European Patent Application EP 1998544 of the same inventor, i.e. their prime factorisation has no elements in common except the value equal to 1; and then to change the distance between the heads for recovering the system operation, even if, obviously, with less productivity.

[0017] The printing method according to the present invention permits obstacles meet by Heidelberg to be overcome, as it allows to write by means of one or more heads side by side at a short distance. In fact, although also in this case the distance between the extreme diodes of both heads has to be maintained under an error less than about a quarter of the resolution distance, in order to not influence the writing, according to the invention the distance between the writing elements of a same print heads or the distance between the print heads is of at least an order of magnitude lower, so that the relative error under which it need to stay, is mayor than at least an order of magnitude.

[0018] Further, as the printing mechanism of the method according to the invention operates as if the plurality of its print heads were as a single print head, it generates a productivity increase that is equal to the product of the productivity of a single print head per the number of print heads used independently from the size of the plate, for example, in the CTP technology.

[0019] In case of failure of a laser diode it is not necessary to switch off also diodes of the not damaged print head but it is enough to change the distance between the print heads.

[0020] Additional features and advantages of the present invention will appear most clear from the indicative and not limiting description of a preferred embodiment, with reference to the attached drawings in which:

- Figure 1 is a diagrammatic block view of a multi-head printing mechanism according to the present invention applied in the CTP technology; and
- Figure 2 is an enlarged cut cross-sectioned diagrammatic view of a portion of Figure 1.

[0021] With reference to Figure 1, a CTP printing mechanism is shown. Two engraving laser heads 1, 2 are set side by side on a linear track (not shown) to move parallel to the axis x of rotation of a cylindrical drum 3, that is a rotating support member supporting means, e.g. a photosensitive plate, being adapted to receive spots or engraving marks from two laser heads 1, 2.

[0022] With reference to the enlarged diagrammatic view of Figure 2, there is shown partially an array of laser diodes 5 in the end 4 of each laser head 1, 2, this array determining a large number of laser beams that generate helixes on the surface of the photosensitive plate that is set on the external surface of the rotating cylindrical drum 3.

[0023] By using displacing means known and not shown in the figures, the laser heads 1, 2 are displaced, for every single rotation of drum 3, by a distance equal to the product of the number of laser diodes in the heads and the writing resolution. The marks or spots are generated by laser diodes 5 column by column, one per each laser diode, which interlace to form the complete image. The task of the multi-head printing mechanism is to take advantage from the interlacing of the columns generated by each writing element or diode, to completely fill a surface without any overlapping or empty columns.

[0024] To achieve this result, in the printing method according to the invention, the writing elements or laser diodes are such that:

- helix pitch pe is equal to the number n of laser diodes multiplied by the resolution distance ds , i.e.

$$pe = n \times ds \quad (1)$$

- pitches p (diode _{$i-1$} , diode _{i}), i.e. the $n-1$ distances between the n diodes comply the following relation:

$$\begin{aligned} d_0 &= 0 \\ d_1 &= p(\text{diode}_1, \text{diode}_2) + d_0 \\ d_2 &= p(\text{diode}_2, \text{diode}_3) + d_1 \\ &\dots \\ d_{n-1} &= p(\text{diode}_{n-1}, \text{diode}_n) + d_{n-2} \end{aligned} \quad (2)$$

where n is the number of laser diodes and d_i is the distance (that is the summation of the pitches from the first diode to diode i^{th}). A necessary condition is that: $d_0 \bmod n \neq d_1 \bmod n \neq d_2 \bmod n \neq \dots \neq d_{n-1} \bmod n$ that is all d_i be not congruent modulo n . This means that $n-1$ different values are present.

[0025] Then, it is assumed, with respect to the relation (2), to have a laser head with five diodes and the $n-1$ following pitches:

$$p(\text{diode}_1, \text{diode}_2) = 3 \text{ (pixel)}$$

$$p(\text{diode}_2, \text{diode}_3) = 4 \text{ (pixel)}$$

$$p(\text{diode}_3, \text{diode}_4) = 2 \text{ (pixel)}$$

$$p(\text{diode}_4, \text{diode}_5) = 2 \text{ (pixel)}$$

with:

$$d_1 = 3 \rightarrow 3 \bmod 5 = 3$$

$$d_2 = 7 \rightarrow 7 \bmod 5 = 2$$

$$d_3 = 9 \rightarrow 9 \bmod 5 = 4$$

$$d_4 = 11 \rightarrow 11 \bmod 5 = 1$$

[0026] The following table shows, for example, the development of writing after eight rotations of the drum. The columns of the image are marked with the index of the laser that writes them, and the not yet written columns are marked with zero, each rotation is marked with a colour, as in Table 0.

Table 0

Violet (Vi)	1st rotation
Blue (B)	2nd rotation
Red (R)	3rd rotation
Fucsia (F)	4th rotation
Yellow (Gi)	5th rotation
Green (Ve)	6th rotation
Celeste (C)	7th rotation
Grey (Gr)	8th rotation

[0027] The situation after the first rotation is shown in Table 1.

[illegible]

[0028] The situation after the second rotation is shown in Table 2.

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[0029] The situation after the third rotation is shown in Table 3.

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Table 3

Vi	B	R	B		B	R		R		R																
5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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[0030] The situation after the fourth rotation is shown in Table 4.

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Table 4

Vi	B	R	B	F	B	R	F	R		R	F		F		F										
5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0
5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0
5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0
5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0
5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	0	0	0	0

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[0031] The situation after the fifth rotation is shown in Table 5.

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Table 5

Vi	B	R	B	F	B	R	F	R	Gi	R	F	Gi	F		F	Gi		Gi		Gi							
5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	
5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	
5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	
5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	
5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5	0	0	0	0	0	0	

[0032] The situation after the sixth rotation is shown in Table 6.

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Table 6

Vi	B	R	B	F	B	R	F	R	Gi	R	F	Gi	F	Ve	F	Gi	Ve	Gi		Gi	Ve		Ve		Ve
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5
5	3	2	4	1	5	3'	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5	3	0	4	0	5

[0033] The situation after the seventh rotation is shown in Table 7.

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Table 7

Vi	B	R	B	F	B	R	F	R	Gi	R	F	Gi	F	Ve	F	Gi	Ve	Gi	C	Gi	Ve	C	Ve		Ve
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	0	5

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[0034] The situation after the eighth rotation is shown in Table 8.

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Tabella 8

Vi	B	R	B	F	B	R	F	R	Gi	R	F	Gi	F	Ve	F	Gi	Ve	Gi	C	Gi	Ve	C	Ve	Gr	Ve
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5
5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5	3	2	4	1	5

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[0035] As from the above example, all the columns of the image are covered without any overlap.

[0036] Now a demonstration is given that any multiple writing system, i.e. having more than one writing element, system which uses the interlacing of columns generated by each writing element, can completely fill a surface without any overlaps or empty columns, as long as the previous relations (1) and (2) are valid.

[0037] It is assumed that a print head having multiple writing elements that has a series of pitches observing the assumptions above made. For each rotation of the drum all the components of the print head move jointly with the latter by a number of pixels of the image equal to n . This means that all the columns covered by the print head are defined as:

$$j = r n + d_i \quad (3)$$

where n is the number of writing elements, r the rotations of the drum and d_i the distance between the first element of the print head and the considered i^{th} element. It is demonstrated that two columns that are generated by two different writing elements during two different rotations, can not be overlapped. In order that two columns are overlapped, it should occur as follow:

$$r_m n + d_j = r_n n + d_i$$

[0038] This relation can be written also as follows:

$$d_j - d_i = (r_n - r_m) n \quad (4)$$

[0039] Two positive integers a and b are congruent modulo n when the following relation is valid:

$$a - b = kn \quad (5)$$

that is the difference between the two numbers is a multiple of n .

[0040] Supposing d_j and d_i are not congruent modulo n , so that the relation (4) can not occur and therefore the proposition is demonstrated by a reductio ad absurdum. Now, it is demonstrated that any j can be obtained by the relation (3), and then all the columns of the image can be filled. The relation (3) is written again by putting $d_i = k_i n + s_i$ where s_i is the rest of the division d_i/n and k_i is the quotient. Thus, it is achieved:

$$j = r n + k_i n + s_i \quad \text{with } r \in \mathbb{Z}, k \in \mathbb{N}, 0 \leq s_i \leq n-1$$

and then:

$$j = (r + k_i) n + s_i$$

[0041] The element $(r + k_i)n$ allows all multiples of n to be achieved, and s_i for the initial hypothesis allows all values between kn and $(k+1)n$ to be obtained by virtue of the initial supposition.

[0042] If an hypothetical having five diodes with the following intervals of pitches is considered:

$$p(\text{diode}_1, \text{diode}_2) = 3$$

$$p(\text{diode}_2, \text{diode}_3) = 4$$

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$$p(\text{diode}_3, \text{diode}_4) = 2$$

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$$p(\text{diode}_4, \text{diode}_5) = 2$$

[0043] the following replenishment is obtained:

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1-0-0-2-0-1-0-3-2-4-1-5-3-2-4-1-5-3-2-4-1-5-3-2-4-1-5-3-2-4-1-5-3-2-4-1-

[0044] The columns are separated by a dash in order to simplify reading. Columns are designated with 0 are not written by any laser. Otherwise they are designated by the index of the laser covering that column. A simulator returns a mistake in case of overlap. In this case any overlap is not been detected.

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[0045] For confirming the validity of the algorithm as stated, d_i that are obtained from said ranges are indicated below:

$$d_1 = 3 \rightarrow 3 \bmod 5 = 3$$

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$$d_2 = 7 \rightarrow 7 \bmod 5 = 2$$

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$$d_3 = 9 \rightarrow 9 \bmod 5 = 4$$

$$d_4 = 11 \rightarrow 11 \bmod 5 = 1$$

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[0046] The experiment was repeated simulating a writing by means of ten diodes with the following ranges on the pitch:

$$p(\text{diode}_1, \text{diode}_2) = 2$$

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$$p(\text{diode}_2, \text{diode}_3) = 4$$

$$p(\text{diode}_3, \text{diode}_4) = 3$$

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$$p(\text{diode}_4, \text{diode}_5) = 2$$

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$$p(\text{diode}_5, \text{diode}_6) = 3$$

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$$p(\text{diode}_6, \text{diode}_7) = 3$$

$$p(\text{diode}_7, \text{diode}_8) = 6$$

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$$p(\text{diode}_8, \text{diode}_9) = 2$$

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$$p(\text{diode}_9, \text{diode}_{10}) = 3$$

[0047] In this case it is obtained:

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$$d_1 = 2 \rightarrow 2 \bmod 10 = 2$$

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$$d_2 = 6 \rightarrow 6 \bmod 10 = 6$$

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$$d_3 = 9 \rightarrow 9 \bmod 10 = 9$$

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$$d_4 = 11 \rightarrow 11 \bmod 10 = 1$$

$$d_5 = 14 \rightarrow 14 \bmod 10 = 4$$

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$$d_6 = 17 \rightarrow 17 \bmod 10 = 7$$

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$$d_7 = 23 \rightarrow 23 \bmod 10 = 3$$

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$$d_8 = 25 \rightarrow 25 \bmod 10 = 5$$

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$$d_9 = 28 \rightarrow 28 \bmod 10 = 8$$

[0048] The replenishment of the columns is listed below

1- 0- 2- 0- 0- 0- 3- 0- 0- 4- 1- 5- 2- 0- 6- 0- 3- 7- 0- 4- 1- 5- 2- 8- 6- 9- 3- 7- 10- 4- 1- 5- 2- 8- 6- 9- 3- 7- 10- 4- 1- 5- 2- 8- 6- 9- 3- 7- 10- 4- 1- 5- 2- 8- 6- 9- 3- 7- 10- 4- 1- 5- 2- 8- 6

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Claims

1. A printing method by a writing mechanism having either one print head with multiple arrays of side by side writing

elements or a plurality of side by side print heads, comprising:

- rotating a support member about its axis of rotation that supports means suitable for receiving marks on one surface thereof,

- displacing at least one print head on a linear guide parallel to the axis of rotation of the support member, an array of writing elements being adapted to generate respective marks being mounted on at least one print head along a straight line parallel to the axis of rotation of the support member, displacing means being provided for moving said at least one print head, with respect to said support member, on said linear guide,

characterised in that:

- said at least one print head is moved by a distance equal to the product between the total number of writing elements being mounted on said at least one print head and the writing resolution or distance between the marks;
- the distances existing between the first writing element and the i^{th} writing element,
i.e. the distances

$$d_0 = 0$$

$$d_1 = p(es_1, es_2) + d_0$$

$$d_2 = p(es_2, es_3) + d_1$$

...

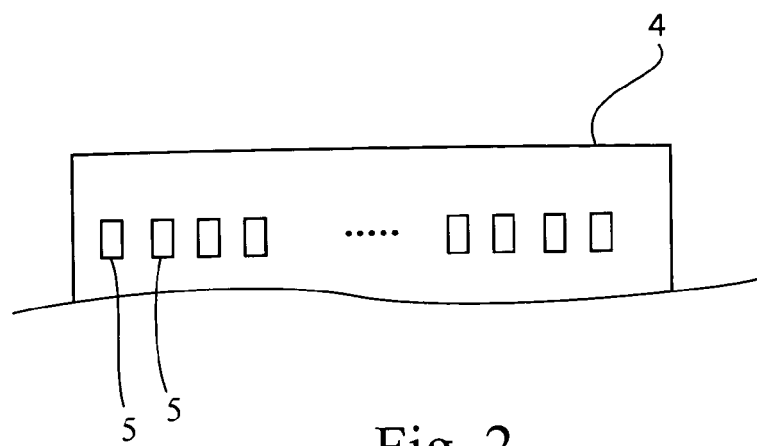
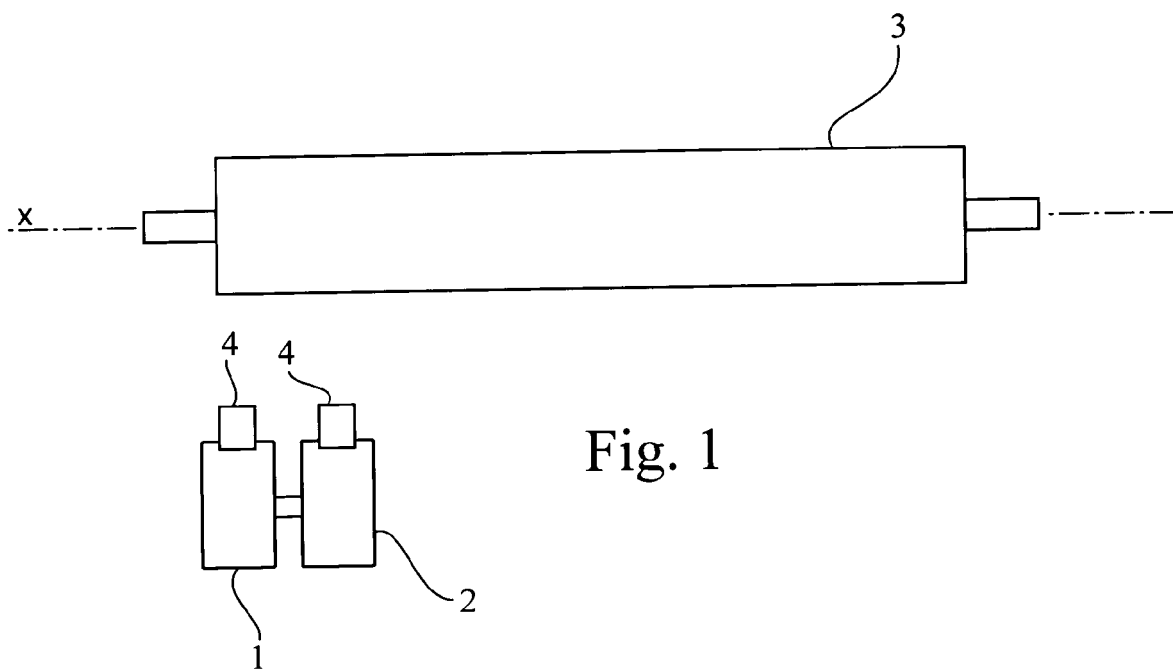
$$d_{n-1} = p(es_{n-1}, es_n) + d_{n-2} ,$$

where n is the number of writing elements es_i , d_i is the distance from the first writing element to the i^{th} writing element, and $p(es_{i-1}, es_i)$ or pitch is the distance existing between two consecutive writing elements, comply the condition

$$d_0 \bmod n \neq d_1 \bmod n \neq d_2 \bmod n \neq \dots \neq d_{n-1} \bmod n$$

i.e. every d_i is not congruent modulo n , where units d and n are dimensionless integers, in such a manner that the marks are generated by the writing elements per columns, one for each writing element, that interlace together to form a complete image.

2. Printing method according to claim 1, in which said at least one print head is a laser head (1, 2), the writing elements are laser diodes (5) and the marks are laser beam spots that are received on means supported by a rotating drum (3).
3. Printing method according to claims 1 and 2, in which the writing mechanism is provided with means suitable to change the distance between the printer heads (1, 2).
4. Printing method according to claim 2, in which the laser diodes (5) are rigidly connected together in one print head in the form of a chip.





EUROPEAN SEARCH REPORT

Application Number
EP 11 42 5150

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Place of search The Hague		Date of completion of the search 12 September 2011	Examiner De Groot, Ronald
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