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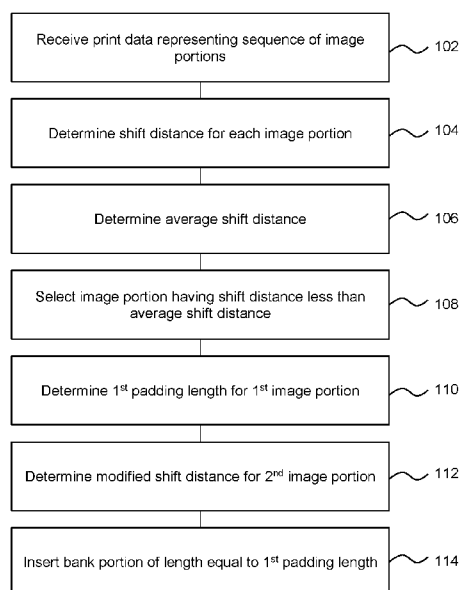


Fig. 1

(57) Abstract: In an example, a method comprises, by processing circuitry, receiving print data representing a sequence of image portions to be printed contiguously on a substrate. A shift distance for the image portions may be determined as a difference between an initial length of the preceding image portion in the sequence and a maximum image portion length. An average shift distance for the sequence of image portions may also be determined. A first image portion associated with a shift distance which is less than the average shift distance may be selected and a first padding length to be added to the initial length of the first image portion may be determined based on the difference between the shift distance for the first image portion and the average shift distance. The first padding length may be subtracted from the shift distance of a second image portion of the sequence of image portions to determine a modified shift distance for the second image portion. A blank portion of image data of length equal to the first padding length may be inserted into the print data of the first image portion.

SHIFT DISTANCES**BACKGROUND**

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[0001] In printing, print agents such as inks, toners, coatings and the like, may be applied to a substrate to print a sequence of image portions. The relative position between the substrate and a print apparatus may be shifted in some examples to reduce or remove a space on the substrate between image portions which would otherwise be a non-printed space.

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BRIEF DESCRIPTION OF DRAWINGS

[0002] Non-limiting examples will now be described with reference to the accompanying drawings, in which:

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[0003] Figure 1 is a flowchart of an example method of modifying print data;

[0004] Figures 2A, 2B, 2C and 2D show examples of padding image portions for printing;

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[0005] Figure 3 is an example of image portions with an overlap in the direction of travel of the substrate;

[0006] Figure 4 is a flowchart of an example of a method of printing;

[0007] Figures 5 and 6 are simplified schematic drawings of example apparatus for use in printing;

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[0008] Figure 7 is a simplified schematic drawing of an example of a machine-readable medium associated with a processor; and

[0009] Figure 8 is a simplified schematic drawing of an example of print instructions associated with a print apparatus.

DETAILED DESCRIPTION

[0010] Printing apparatus includes both analogue and digital printers, for example, offset printers, liquid electrophotography (LEP) printers, inkjet printers and dry toner based printers. Such apparatus may be used to apply a print agent (for example, ink, toner or the like) to a substrate. Substrates may in principle comprise any material, for example comprising paper, card, plastics, fabrics or the like, and may in some examples comprise a continuous web of material onto which a plurality of images are sequentially printed.

[0011] In some printing apparatus, an image is transferred to a substrate via or from a cylinder, drum, belt or roller. For example, in LEP printing, a photosensitive surface, sometimes referred to as a photo imaging plate (PIP), is selectively electrostatically charged in a pattern corresponding to an image to be printed. In some examples, the photosensitive surface is curved, for example forming the surface of a drum, belt or cylinder. For example, the entirety of the photosensitive surface may be charged, then selectively discharged by exposure to radiation from a radiation source such as a laser, to form the image pattern. Charged print agent is then applied to the photosensitive surface by print agent applicator(s) (which may be referred to as ink developer units, binary ink developers or BIDs in some examples). Due to the charge of the print agent and the charge on the surface of the photosensitive surface, the print agent forms a pattern corresponding to the image to be printed. The print agent is then transferred to a transfer cylinder, or blanket cylinder, where it may be heated to remove carrier fluid from the print agent. For example, a PIP cylinder may be urged against a transfer cylinder as both rotate in opposite directions to transfer the image. The remaining print agent, in the form of the image to be printed, may then be transferred to the substrate.

[0012] In some examples of a print apparatus, there may be a maximum 'frame size', which corresponds the largest image size which may be printed in 'one shot' or a cycle of a print apparatus. For example, in some apparatus, the dimensions of a cylinder in the printing apparatus may define a frame size, wherein the frame size corresponds to the maximum dimension of an image which can be printed by one rotation (or in some examples, a portion of a rotation, such as a half a rotation) of a component of the printing apparatus. In some examples, the maximum length of image which can be printed in a single cycle may be less than the circumference of an imaging surface. For example, the photosensitive surface may not extend entirely around a cylinder on which it is mounted or it may have an unusable portion where the photosensitive surface is secured to the

cylinder, or overlaps itself in a seam portion. In some examples, the frame length may be associated with another print apparatus component. For example, the frame length (also referred to herein as frame size, or simply 'frame') may be a characteristic of a dimension of a part of a print apparatus, such as a circumference of a roller, or the length of an
5 endless belt, or the like.

[0013] As mentioned above, in some examples, a substrate may comprise a web of material, and it may be intended to provide an image which is longer than a frame. For example, it may be intended to print a roll of wallpaper which has a continuous pattern. This roll may be many meters long, and many times longer than a single frame for a given
10 apparatus. While wallpaper provides a convenient example, many other examples may be provided such as large format posters, rolls of wrapping paper, murals, or the like. As this image cannot be printed in a single frame, it may be divided into image portions which are to be printed in a sequence of frames.

[0014] While the image could in principle be divided into image portions of equal
15 length, in some examples, it may be intended to divide the image so as to make the division into image portions less visible to the human eye. For example, image portions may be defined so as to avoid prominent image elements, as any misregistration may be more apparent in such image regions when compared, for example, to background regions. To consider an image with features such as people, a division may be placed so as to avoid
20 'splitting people in half', as any misregistration is likely to be readily apparent to a view when compared to a split which is made in a background region, or a region of consistent colour or the like. The same reasoning applies to any other prominent image feature, such as a region of contrast in a pattern, or any shape having defined boundaries. Alternatively, when printing a continuous image, it may be intended to define image portions of different
25 sizes as the human eye may be drawn to regular patterns in an image.

[0015] Therefore, a designer or a computer program may divide an image into image portions, which may be of different sizes to one another to reduce the potential for image quality issues.

[0016] Bearing in mind, for example, the seam portion or another unprintable
30 portion of the apparatus, when printing such a continuous image from a number of frames, the substrate or web may be retracted after printing a frame relative to the rotation of the apparatus. In other words, there may be a shift in the direction opposed to the direction of printing, which may be referred to as a shift backwards. Such a backwards shift may also be used when an image portion to be printed is smaller than the frame size, in order to

remove the unprinted portion which would otherwise be seen if the image continued to operate with the web moving at the same speed as the rollers.

[0017] In other words, when printing more than one image portion on a substrate, wherein an image portion to be printed is smaller than the maximum frame size, unless
5 the position of the substrate is adjusted (i.e., if the cylinder(s) of the printing apparatus and the substrate move continuously at a fixed speed) there will be a blank gap on the substrate between the printed images, relating to the unused portion of the frame (and in some examples other apparatus features, such as a seam). The distance the substrate is moved varies depending on the size of the printed portion relative to the frame. Therefore, when
10 printing portions of different dimensions, the distance the substrate is moved between frames may vary. However, moving the substrate different distances can introduce varying tensions on the substrate resulting in alignment and/or scaling errors.

[0018] Figure 1 is an example of a method, which may comprise a computer implemented method of modifying print data, which may be carried out by processing
15 circuitry comprising one or more processors. The method comprises, in block 102, receiving, by processing circuitry, print data representing a sequence of image portions to be printed contiguously (i.e. such that there is no perceptible gap between adjacent image portions) on a substrate. The print data may for example be received from a memory, or over a network or the like. The print data may comprise data that describes an image to
20 be printed, for example it may comprise data in an image format such as JPEG (Joint Photographic Experts Group), PDF (portable document format), TIFF (Tagged Image File Format), GIF (Graphics Interchange Format), bitmap, PNG (Portable Network Graphics), SVG (Scalable Vector Graphics) and the like. In some examples, the print data may be referred to as image data and may comprise graphical images and/or text. In some
25 examples, each of the image portions may be different from the other image portions, or in other examples some of the image portions may be different. For example, the different image portions may describe different printable content and/or may describe printable content of different dimensions. The image portions may form an image, and the image may have been divided into the image portions by a designer, or automatically using image
30 processing techniques which may for example divide the image so as to avoid or reduce the number of edges detected in the image, or regions of high contrast or the like.

[0019] The print data may comprise the lengths of the image portions explicitly, or the lengths (and/or other dimensions) of the image portions may be derivable therefrom.

[0020] Block 104 comprises determining, by the processing circuitry, a shift distance for the image portions based on a difference between an initial length of the preceding image portion in the sequence and a maximum image portion length.

5 [0021] The maximum image portion length may be the maximum frame length described above. As will be set out in greater detail below, the shift distance may be an initial shift distance, i.e. the shift distance may relate to the distance a substrate would be moved between printing image portions to provide contiguous printed image portions if the methods set out herein are not employed. In some examples, the distance a substrate would actually be shifted to avoid a non-printed portion may be determined as the
10 difference between the initial length of the preceding image portion in the sequence and the maximum image portion length plus a constant. The constant may be equal to a length corresponding to the length of a roller in a printing apparatus which cannot be used for forming images. The length may be a length in a direction of printing (for example, a length around the circumference of a cylinder).

15 [0022] In some examples, first image portion in the sequence may not be associated with a shift distance and may be disregarded in the subsequent method. However, if the sequence is a repeating sequence (as may be the case in some examples), the shift distance for the first image portion in the sequence may be determined based on the length of the last image portion in the sequence, using the difference between the
20 length of the last image portion and the maximum length.

[0023] Block 106 comprises determining, by the processing circuitry, an average shift distance for the sequence of image portions. The average shift distance may be calculated by determining the average (i.e. the mean) of the shift distances of each image portion determined in block 104.

25 [0024] Block 108 comprises selecting, by the processing circuitry, a first image portion associated with a shift distance which is less than the average shift distance. The determined shift distance for each image portion may be compared to the average shift distance. The first image portion may be an image portion which is not the first or leading image portion of the sequence. Indeed, as, as set out above, in some examples, such an
30 image portion may have no shift distance associated therewith. In some examples the shift distances are compared to the average shift distance in turn (for example in the order in which they are set out in the sequence), and the first image portion associated with a shift distance which is less than the average shift distance is selected. The method then continues to block 110 which comprises determining a first padding length to be added to

the initial length of the first image portion wherein the padding length is determined based on the difference between the average shift distance and the shift distance associated with that image portion.

5 **[0025]** As is further set out below, the 'padding' results in the insertion of blank data in the print data. Adding a padding length therefore increases the length of the first image portion. The padding may be added at the beginning of the image portion considering the direction of print.

10 **[0026]** In some examples, as discussed in greater detail below, padding may also be added after the print data, for example to provide a consistent size to the image portions of the sequence.

15 **[0027]** Block 112 comprises determining, by the processing circuitry, a modified shift distance for the second image portion by subtracting the first padding length from the shift distance of a second image portion of the sequence of image portions. The modified shift distance for the second image portion may be used in determining a second padding length for the second image portion. In other words, bearing in mind that the shift distance is determined by finding the difference between the length of the preceding image portion and a maximum image portion length, by adding the first padding length to the initial length of the first image portion, the shift distance is changed for the next image portion. In some examples, the second image portion is the image portion which immediately follows the first image portion in the sequence (i.e. is to be printed immediately thereafter).

20 **[0028]** Block 114 comprises inserting, by the processing circuitry, a blank portion of image data (or print data) of length equal to the first padding length in the print data of the first image portion. The blank portion of image data may comprise a portion of image data which results in no image being printed. For example, when printing on a substrate, 25 the blank image portion may comprise a plurality of non-printing pixels (for example, white pixels on a white substrate, if the apparatus is such that white pixels are left blank). The blank portion of image data may be inserted to be at the front of the image data in the direction of printing. The blank portion of image data causes the printed part of the image portion to be offset relative to where it would be printed without the blank portion. For 30 example, each image may be printed within a frame, wherein the frame corresponds to the maximum image portion size.

[0029] The shift distance for the first image portion may be set to be the average shift distance (or a value relatively close thereto). This may be carried out at any point in

the method after block 110 and/or as an instruction to a print apparatus. This shift distance (plus in some examples a constant) may be used by a print apparatus when printing the image portions. As is explained in greater detail below, this means that the padding portion of the first image portion will conceptually overlap the printed portion of the preceding image in the sequence.

[0030] As mentioned above, when the distance moved by the substrate between printing image portions varies, the tension induced on the substrate can also vary. This difference in tension can introduce alignment and/or scaling errors when printing the image portions. Therefore, by reducing the variation in the distance moved by the substrate between printing image portions, the image quality of the printed images can be improved. Including padding lengths and modifying shift distances may allow the shift distances associated with each image to be adjusted so as to reduce the variability.

[0031] In some examples, the method of Figure 1 may iterate through the image portions until they are all associated with the average shift distance, or at least are relatively close thereto.

[0032] Figures 2A, 2B and 2C illustrate the method described in Figure 1.

[0033] Figure 2A shows how received image or print data would be printed if there was no adjustment of the position of the substrate relative to the apparatus between printing each frame. The image/print data in this example comprises three image portions (a first image portion 202a, a second image portion 202b and a third image portion 202c) to be printed in a repeated sequence on a substrate 204 (i.e. the first image portion 202a is to be printed after the third image portion 202c, and so on through the sequence repeatedly). The substrate 204 is a continuous length i.e. all the image portions are printed on the same substrate. Each of the image portions 202 is a different length, with the second image portion 202b being the shortest and the third image portion 202c being the longest. The maximum image portion length 206 is indicated by the distance between the vertical dotted lines. Each of the portions of substrate between vertical dotted lines represents a single frame.

[0034] In this example, the substrate moves from right to left, as indicated by arrow 208. The positions of the image portions 202a-c on the substrate correspond to their positions if the substrate is not moved between printing of the images. Therefore, the distances 210a-c are the shift distances which are determined for each image portion as described in block 104 of Figure 1. In this example, each shift distance indicates the

distance that the substrate 204 would have to be moved backwards (i.e. left to right) between printing the image portions for them to appear contiguously. As can be seen in Figure 2A, each of the shift distances 210a-c are different, with the largest shift distance 210b following the smallest image portion (second image portion 202b) and being associated with the third image portion 202c and the smallest shift distance 210c following the largest image portion (third image portion 202c), and being associated with the first image portion 202a. This would result in different tensions being experienced by the substrate, which could give rise to image quality defects.

[0035] Figure 2B depicts the same image portions 202a-c, after the blank portions 212a-c have been added to the image data according to the method set out in Figure 1. The length of the blank portion 202a-c varies for each of the image portions 202a-c. In this example the size of the blank portions, the padding lengths determined as set out in block 110 are determined such that the distance the substrate is to be moved between printing images so that the images align is equal, and equal to the average shift distance 214. Therefore, in this example, the substrate 204 is 'shifted back' by the same distance relative to the printing apparatus between printing each image portion 202a-c.

[0036] Figure 2C shows the image portions 202a-c printed on the substrate 204, when blank portions 212a-c have been added to the image data and the substrate moved a distance equal to the average shift distance 214 between printing each of the images. A first printing of the sequence and a portion of the second printing of the sequence is shown. As can be seen in Figure 2C, the right edge of the first image portion 202a aligns with the left edge of the second image portion 202c, and the right edge of the second image portion 202b aligns with the left edge of the third image portion 202c.

[0037] Figure 2C also shows where the padding would be printed if the pixels were 'print' pixels rather than 'non-print' pixels. As can be seen, if the non-print pixels were printed this would result in some overprinting. However, by inserting blank portions in the image data as described herein, the printed images align as depicted in Figure 2C while the distance the substrate is moved backwards between printing image portions is kept constant, which reduces alignment and/or scaling errors, as described previously.

[0038] Figure 2D shows another representation of image data in which padding is added after each image portion such that the image portions, having padding before and after the received print data of the image portion, are the same size. In this example, 'frame filling' padding 216a-c is added, such that each image portion including padding is the maximum image portion length (i.e. the maximum frame length), but in principle the

length may be any size between the longest combination of an image portion in the received print data and added padding and the maximum image portion length. This may provide clarity in the instructions sent to a print apparatus, in which the instructions to print each image portion appear broadly identical in terms of the physical motion performed by the print apparatus. By providing an appropriate shift, the data may be printed contiguously, e.g. substantially as shown in Figure 2C.

[0039] Figure 3 is an example, similar to that shown in Figures 2A-D, however rather than rectangular image portions, each of the image portions 302a-c are non-rectangular and each image portion in the sequence of image portions overlaps with a subsequent image portion in a direction of travel of the substrate. As depicted in Figure 3, the top edge of the first image portion 302a is longer than the bottom edge of the first image portion 302a. Therefore, the first image portion 302a overlaps in the direction of travel of the substrate with the second image portion 302b. Similarly, the second image portion 302b overlaps in the direction of travel of the substrate with the third image portion 302c. Image portions with overlaps, such as depicted in Figure 3 may be printed to reduce visibility of the boundary between the image portions 302a-c. When rectangular image portions are printed, the boundary between image portions may be more visible to the human eye than when an oblique boundary between image portions is used. In some examples, a more complex shape of boundary may be used, for example a wavy line, a line which avoids dividing visually prominent image features or contrasting colors, or some other shape of dividing line.

[0040] In some examples, therefore the images overlap in the direction of travel of the substrate. In such cases, the initial length of each image portion may be taken to be a projection of the image portion onto the printing direction. In other words, the length of each image portion may be the distance between the 'leftmost' point of the image portion and the 'rightmost' point of the image portion, as shown in Figure 3. For example, in Figure 3 the initial length of the first image portion 302a is first distance 306a, the initial length of the second image portion 302b is the second distance 306b and the initial length of the third image portion is the third length 306c.

[0041] Figure 4 is an example of a method, which may comprise a method of printing a sequence of image portions. In this example, there are N image portions to be printed, and each image portion is indicated by an index $i=1,2,\dots,N$.

[0042] The method comprises, in block 402 receiving print data representing a sequence of image portions to be printed contiguously on a substrate, for example as

described in relation to block 102 of Figure 1. In this example, the sequence is to be printed repeatedly.

5 **[0043]** Block 404 comprises determining a shift distance, S_i , for each image portion as a difference between an initial length, L_{i-1} , of the preceding image portion in the sequence and a maximum image portion length, L_{max} , and block 406 comprises determining an average shift distance, S_{avg} , for the sequence of image portions, for example as described in relation to blocks 104 and 106 of Figure 1. In some examples, the method may start at L_2 , and/or the method may treat the final image portion as the image portion preceding L_1 .

10 **[0044]** Block 408 comprises selecting an image portion associated with a shift distance, S_i , which is less than the average shift distance. The method may compare the shift distance, S_i , of each image portion in turn to the average shift distance, and select the first image portion which is associated with a shift distance, S_i , less than the average shift distance, S_{avg} . The selected image portion will be processed first in the blocks described
15 below. Whilst in principle the image portion associated with a shift distance which is less than the average shift distance could be selected in any order, for example randomly, or starting with the shift distance which is furthest from the average or the like, for simplicity of implementing the method, the selection may be based on a predetermined criterion. For example, the first image portion in the sequence which is associated with a shift distance
20 which is less than the average shift distance at the time block 408 is performed may be selected in some examples.

[0045] Block 410 comprises subtracting the shift distance, S_i , for the image portion i from the average shift distance, S_{avg} , to determine a padding length, P_i , to be added to the initial length, L_i , of the image portion i .

25 **[0046]** Block 412 comprises determining a modified shift distance for the next image portion, i.e. image portion $i+1$, by subtracting the padding length, P_i , from the shift distance, S_{i+1} , of a next image portion $i+1$ of the sequence of image portions. When i is the final image to be printed, i.e. $i=N$, then the next image portion may be the first image portion of the sequence i.e. the shift distance S_{i+1} is the shift distance of the image portion $i+1$
30 $\text{mod}(N)$. Therefore, if $i=N$, then $S_{i+1}=S_1$.

[0047] Block 414 comprises inserting a blank portion of image data, of length equal to the padding length, P_i , in the print data of the image portion i and prior to the image

portion i . The shift distance, S_i , for the image portion i may be set to be the average shift distance, S_{avg} .

[0048] The method then loops as indicated at 416, and another image portion, associated with a shift distance which is less than the average shift distance is selected and the method comprises performing the method of blocks 410, 412 and 414 with a new selected image portion i . This continues until there are no image portions which have a shift distance of less than the average shift distance (which means that all the image portions are associated with a shift distance which is equal to the average shift distance). It may be noted that, as is explained in greater detail below, an image portion may initially be associated with a shift distance which is greater than or equal to the average shift distance, but that as the algorithm progresses, the shift distance associated with that image portion may be adjusted to be less than the average shift distance. Therefore, an image portion which would not be selectable in one iteration of loop may be selectable in a subsequent iteration of the loop.

[0049] Block 418 comprises comparing the length of each image portion, after any padding length, or blank portion, is inserted, to the maximum image portion length, L_{max} . If, in block 420, it is determined that any image portion is greater than the maximum image portion length then the method continues to block 422, which comprises determining that the print data cannot be printed. When it is determined that the print data cannot be printed, the method may alert a user that the image portions cannot be printed. In some examples, such a situation may arise when the lengths of the image portions are significantly different from each other. In some examples, when it is determined that the print data cannot be printed, the image portions may be recalculated (for example, an original image may be repartitioned into image portions) and the method may be restarted. In other examples, the image itself may be manipulated, for example to reposition or resize features prior to being partitioned, such that the partitioning into image portions may be carried out again without interrupting such features. For example, a graphics program may perform the partitioning. In some examples, it may be possible for the image portions to be reordered in the sequence, and the method may restart with the reordered sequence.

[0050] As noted above in relation to Figure 2D, in some examples, padding may be added after the image portion to provide a consistent image size.

[0051] Block 424 comprises printing an image portion, j (for example, starting from the first image portion in the sequence. In block 426, the substrate is moved prior to printing the next image portion, $j+1$, by a distance equal to the average shift distance, S_{avg} . This

will mean that when printing (block 424) the sequence of image portions using a print apparatus, the second image portion is printed to align with an end of the first image portion, and so on such that each image portion is printed to align with the preceding image portion. This is achieved by moving the substrate relative to the print apparatus by the
5 average shift distance between printing image portions and inserting the padding, i.e. blank portions, of an appropriate size, determined as set out about, in the image data.

[0052] In this example, the substrate is moved by the average shift distance determined as set out above. However, in some examples the distance the substrate is moved relative to the print apparatus is a distance based on the average shift distance and
10 is in an opposing direction to the direction the substrate is moved during printing of the image portions. For example, in some print apparatus, the imaging cylinder circumference is greater than the maximum image portion length, for example it may be equal to the maximum image portion length plus a constant distance (e.g. a seam width). In such a print apparatus, the substrate may be moved a distance equal to the average shift distance
15 determined as set out above plus a constant distance relative to the print apparatus. In other examples, a variance in shift distances may be acceptable. For example, the shift distance for each image portion may be within a predetermined margin of the average shift distance, as a smaller variance may be associated with a relatively small difference in tension related to the shifting action.

20 [0053] Figure 5 shows an example of apparatus 500 comprising processing circuitry 502. The processing circuitry 502 comprises an image data module 504, a shift module 506, a padding module 508 and a modification module 510.

[0054] In use of the apparatus 500, the image data module 504 is to receive image data for a plurality of image portions of different dimensions to be printed. The image data
25 may be received as described in block 102 of Figure 1 or block 402 of Figure 4.

[0055] In use of the apparatus 500, the shift module 506 is to determine a single shift distance by which a print substrate is moved between printing each image. The shift module 506 may determine the average shift distance according to the method described in blocks 106 of Figure 1 or block 406 of Figure 4. This may for example be based on
30 values derived from the image data.

[0056] In use of the apparatus 500, the padding module 508 is to determine at least one padding length. The padding module 508 may for example determine the

padding length(s) according to the method described in blocks 108 to 110 of Figure 1 or block 410 of Figure 4.

5 **[0057]** In use of the apparatus 500, the modification module 510 is to modify the image data by inserting a blank portion with a length equal to the padding length into at least one image portion. As set out above, the padding length(s) may be selected so as result in the determined shift distance aligning consecutive printed images on the substrate. The modification module 510 may for example insert the blank portion(s) into image portions(s). The modification module 510 may in some examples modify the shift distances of at least one image portion.

10 **[0058]** For example, the modification module 510 may carry out the methods of block 114 of Figure 1, method block 412 of Figure 4 and/or at least part of the method block 414 of Figure 4.

15 **[0059]** Figure 6 shows an example of an apparatus 600, which comprises the processing circuitry 502. The processing circuitry 502 comprises the modules of the processing circuitry 502 of Figure 5. The apparatus 600 further comprises a print module 602 and a substrate shifting module 604. In some examples the apparatus 600 is a print apparatus such as any or any combination of an electrophotographic printer (in some examples, a LEP printer), an offset printer, a digital printer, a web printer (i.e. a printer which is designed to print to a long run of substrate), or the like.

20 **[0060]** In use of the apparatus 500, the print module 602 is to print the plurality of image portions on a substrate. The print module 602 may comprise means for depositing printing fluid, such as ink, on a substrate according to print instructions, for example via one or more surfaces, which may be photoconductive surfaces and/or intermediate transfer surfaces between a photoconductive surface and the substrate, and/or which may
25 provide the surfaces of cylinders or drums, or may be provided as endless belts.

30 **[0061]** In one example, the apparatus 600 may be a Liquid Electro Photographic (LEP) printing apparatus which may be used to print a print agent such as an electrostatic ink composition (or more generally, an electronic ink). In such examples, a photo charging unit may deposit a substantially uniform static charge on a photoconductor, for example a photo imaging plate, or 'PIP', which provides the surface of a cylinder and a write head dissipates the static charges in selected portions of the image area on the PIP to leave a latent electrostatic image. The latent electrostatic image is an electrostatic charge pattern representing the pattern to be printed. The electrostatic ink composition is then transferred

to the PIP from a print agent source, which may comprise a print agent application unit such as a Binary Ink Developer (BID) unit, and which may present a substantially uniform film of the print agent to the PIP. A resin component of the print agent may be electrically charged by virtue of an appropriate potential applied to the print agent in the print agent source. The charged resin component, by virtue of an appropriate potential on the electrostatic image areas, is attracted to the latent electrostatic image on the PIP. The print agent does not adhere to the charged, non-image areas and forms an image on the surface of the latent electrostatic image. The photoconductor will thereby acquire a developed print agent electrostatic ink composition pattern on its surface.

[0062] The pattern may then be transferred to an intermediate transfer member, by virtue of an appropriate potential and/or pressure applied between the photoconductor and the intermediate transfer member such that the charged print agent is attracted to the intermediate transfer member, which may be provided about the surface of a cylinder or as an endless belt. The print agent pattern may then be dried and fused on the intermediate transfer member before being transferred to a print media sheet (for example, adhering to the colder surface thereof). In some examples, the intermediate transfer member is heated.

[0063] A similar process may be used for toner-based electrophotographic printing.

[0064] In other examples, the apparatus 600 may comprise a different form of print apparatus. The print module 602 may print the image portions as described in block 424 of Figure 4.

[0065] In use of the apparatus 600, the substrate shifting module 604 is to move the substrate a distance equal to the determined shift distance between printing of consecutive image portions. The substrate shifting module may control motion of the substrate through the apparatus when the print module 602 is printing the image portions on the substrate. The substrate shifting module 604 may also control motion of the substrate between printing the image portions, for example as described in block 426 of Figure 4. This may for example comprise reversing the direction of one or more drive rollers within the apparatus, or changing a length of a substrate path (for example by increasing a distance between rollers guiding a substrate, or the like).

[0066] The processing circuitry 502 may in some examples carry out any or any combination of the blocks of Figure 1 or blocks 402 to 422 of Figure 4.

[0067] Figure 7 shows a machine readable medium 702 associated with a processor 704. The machine readable medium 702 comprises instructions 706 which, when executed by the processor 704, cause the processor 704 to carry out tasks.

5 [0068] In this example, the instructions 706 comprise instructions 708 to 716 to cause the processor 704 to generate print instructions for image data comprising a sequence of image portions which are to form a continuous image on a substrate. The print instructions, when executed by a processor of a print apparatus, may cause the print apparatus to print the plurality of image portions. The image data and image portions may correspond to the print data/image data and image portions described in Figures 1 to 6
10 respectively.

[0069] The instructions 706 comprise instructions 708 to cause the processor 704 to determine a shift distance for each image portion as a difference between an initial length of the preceding image portion in the sequence and a maximum image portion length. The shift distance may for example be determined according to the method of
15 blocks 104 of Figure 1 or block 404 of Figure 4.

[0070] The instructions 706 further comprise instructions 710 to cause the processor 704 to determine an average shift distance for the sequence of image portions. The average shift distance may for example be determined according to the method of blocks 106 of Figure 1 or block 406 of Figure 4.

20 [0071] While an (i.e. any) image portion is associated with a shift distance which is less than the average shift distance, for such an image portion, instructions 712 to 716 are performed. As noted above, while an image portion may initially be associated with a shift distance which is equal to or greater than the average shift distance, this may change as the instructions are executed.

25 [0072] The instructions 712 comprise instructions to cause the processor 704 to determine a padding length to be added to the initial length of that image portion, wherein the padding length is equal to the average shift distance minus the shift distance for that image portion. The padding length may be determined as described in block 110 of Figure 1 or block 410 of Figure 4.

30 [0073] The instructions 714 comprise instructions to cause the processor 704 to insert a blank portion of image data of length equal to the padding length in the print data of first image portion. When the padding length is determined as described herein, the insertion of the blank portion can allow the variation in distance moved of the substrate

between printing image portions to be reduced. Inserting the blank portion may be performed as described in block 114 of Figure 1 or block 414 of Figure 4. The shift distance to that image portion may be set to be the average shift distance.

5 **[0074]** The instructions 716 comprise instructions to cause the processor 704 to subtract the padding length from the shift distance of the image portion which immediately follows the image portion in the sequence to determine a modified shift distance for the following image portion. The modified shift distance of the following image portion may then be used in determining a padding length for a blank portion to be inserted in the image data for that image portion. Subtracting the padding length may be performed as described
10 in block 410 of Figure 4.

[0075] The instructions may continue to operate until all the image portions are associated with a shift distance which is equal, or in some examples close to, the average shift distance.

15 **[0076]** Figure 8 shows print instructions 802 associated with a print apparatus 804. The print instructions 802 may be print instructions generated by the instructions 706 described in relation to Figure 7.

[0077] The instructions 802 comprise instructions 806 to print the image portions according to the image data including the blank portions.

20 **[0078]** The instructions 802 further comprise instructions 808 to move the substrate between printing consecutive image portions a distance equal to at least the average shift distance. In some examples, the distance moved is equal to the average shift distance. In other examples, the distance moved may be the average shift distance plus a constant, e.g. when the maximum image portion length is less than the frame size. In such examples, the constant may account for an unprintable region of a print apparatus
25 component, for example a seam region. Therefore, the distance the substrate is moved relative to the print apparatus between printing image portions may be at least substantially the same for each image portion.

30 **[0079]** In practice, the shift may be achieved by reversing the direction of at least one drive roller of the apparatus, and/or a dispensing roller for the substrate. The distance that the substrate is shifted may for example be controlled by operating a motor on a roller or the like until an encoder (which may be a rotary encoder) indicates that the intended shift has been achieved. In other examples, a length of a printing path may be increased, for example by increasing the separation between guide or drive rollers, to cause the shift.

Therefore, the instructions 808 may comprise instructions to control substrate handling apparatus of print apparatus to provide the intended movement of the substrate.

[0080] The numbered lines below are a simplified example of computer executable code, which when executed by a processor may perform an example of the methods described herein, for example the method of Figure 1 or 4, and/or which may provide functions of the shift module 506, padding module 508 and/or the modification module 510, and/or which may provide the instructions described in relation to Figure 7 or 8.

[0081] In this example, the code is based on the Matlab language, however other programming languages may be used in other examples.

```

10      1.    L_max = 110 ;
        2.    L = [110 56 80] ;
        3.    N = length(L) ;
        4.    S(2:N) = L_max - L(1:N-1) ;
        5.    S(1)= L_max - L(N) ;
15      6.    S_orig = S ;
        7.    S_avg = mean(S) ;
        8.    P = zeros(N,1) ;
        9.    while sum( S < (S_avg - 1e-6)) ;
        10.         i = find( S < S_avg) ;
20      11.         i1 = i(1) ;
        12.         P(i1)= S_avg - S(i1) ;
        13.         S(mod(i1, N)+1) = S(mod(i1, N)+1) - P(i1) ;
        14.         S(i1) = S_avg;
        15.    end ;
25      16.    S_avg ;
        17.    P' ;
        18.    L_out=P'+L ;

```

[0082] In line 1 of the above code, the maximum image portion length, $L_{\max}$ ($L_{\max}$), is set to be equal to 110. In this example, this means the largest image portion the print apparatus is capable of printing is 110cm in length, i.e. 'frame length' for this example print apparatus is 110cm.

5 **[0083]** Line 2 of the above code indicates that the lengths of three image portions (L_i) to be printed are 110cm, 56cm and 80cm respectively, so $L_1=110\text{cm}$, $L_2=56\text{cm}$ and $L_3=80\text{cm}$. These are indicated in a matrix L . This data may be derived from, or supplied with, print data. Viewed another way, the print data may comprise such values, or data from which the lengths of the image portions may be derived. The matrix L may therefore
10 be expressed as $L = [110 \ 56 \ 80]$

[0084] In line 3 of the above code, the number of image portions (N) to be printed is determined from the size of the matrix L . In this example there are 3 image portions to be printed, or three elements in L , so $N=3$.

15 **[0085]** In lines 4 and 5 of the above code the shift distances (S_i) are determined for each image portion.

[0086] Line 4 deals with each image portion other than the first. For these image portions, the shift distances are determined to be the difference between $L_{\max}$ and the length of the preceding image portion in the sequence, so $S_2=L_{\max}-L_1=110-110=0\text{cm}$ and $S_3=L_{\max}-L_2=110-56=54\text{cm}$.

20 **[0087]** In line 5 the first shift distance (S_1) is the maximum image portion length ($L_{\max}$) minus the length of the final image portion (L_N). Therefore, the first image portion length is $S_1=L_{\max}-L_N=110-80=30\text{cm}$.

[0088] This results in a matrix $S = [30 \ 0 \ 54]$

25 **[0089]** It may be noted that this could otherwise be expressed as: $S =$
`wshift('ld',  $L_{\max} - L$ , -1).`

[0090] In line 6, S_{orig} is set equal to S , to maintain a record of the original value of S , which will be modified in subsequent lines, therefore $S_{\text{orig}}=[30,0,54]$.

[0091] In line 7, S_{avg} is calculated as the average of S_i . In this example $S_{\text{avg}} = [28 \ 28 \ 28]$ (or simply $S_{\text{avg}} = 28$ in some examples).

30 **[0092]** In line 8 the vector which will be used as variables for the padding length, P_i , is set to zero (i.e. $P=[0,0,0]$).

[0093] In line 9 a 'while' loop begins. The loop depends on the condition $\text{sum}(S < (S_{\text{avg}} - 1e-6))$ being true. This condition sums the number of values in the vector S which are less than the corresponding values in the vector $(S_{\text{avg}} - 1e-6)$. The minus $1e-6$ is included to avoid rounding errors, but can be conceptually ignored. Therefore, at least initially, in this example $\text{sum}(S < (S_{\text{avg}} - 1e-6)) = \text{sum}([30, 0, 54] < [28 - 1e-6, 28 - 1e-6, 28 - 1e-6]) = \text{sum}([0, 1, 0]) = 1$ which is true (i.e. non-zero). Therefore, the method proceeds to execute lines 10 to 14 of the while loop. It may be noted that any non-zero result will result in the 'while' loop continuing to operate.

[0094] In another example, the condition of the 'while' loop may relate to values being within a range of the average. If the values are similar to one another, the variation in tension may be minimal and therefore this may result in an acceptable result.

[0095] In line 10, the image portions which are associated with a shift distance which is less than the average shift distance (S_{avg}) are identified in a matrix i and in line 11, an index $i1$ is set to be equal to the position of the first image portion which is less than the average shift distance (S_{avg}). In this example the second image portion is associated with a shift distance ($S_2 = 0\text{cm}$) less than the average shift distance ($S_{\text{avg}} = 28$). Therefore, $i1 = 2$.

[0096] In line 12 the padding length is determined for the selected image portion (i.e. $i = 2$). The padding length is $P_2 = S_{\text{avg}} - S_2 = 28 - 0 = 28\text{cm}$.

[0097] In line 13 the shift distance for the next image portion $S(\text{mod}(i1, N) + 1) = S(3)$, is modified using the determined padding length. Therefore, $S_3 = S_3 - P_2 = 56 - 28 = 26\text{cm}$. The 'modulo' function is used such that the last image portion in the sequence is associated with the first image portion of the sequence, or in other words such that padding length for the last image portion in the sequence is used to adjust the shift distance for the first image portion in the sequence.

[0098] In line 14 the shift distance is then set to be equal to the average shift distance, $S_2 = 28\text{cm}$. Therefore, at the end of the first iteration of the while loop $S = [30, 28, 26]$ and $P = [0, 28, 0]$.

[0099] The loop will then evaluate the while condition again. Now the shift distance vector $S = [30, 28, 26]$. The third image portion is associated with a shift distance, S_3 , equal to 26cm which is less than the average shift distance ($S_{\text{avg}} = 28\text{cm}$). It may be noted that the third image portion was not initially associated with a shift distance which was less than the average, and that the operation of the method is such that this is now the case.

Therefore, the while loop performs another iteration and the lines 10 to 14 are repeated with $i=3$. After the while loop is performed for the second time $P_3=S_{avg}-S_3=28-26=2\text{cm}$ (line 12) and $S_1=S_1-P_3=30-2=28\text{cm}$ (line 13). The shift distance for the third image portion is then set to the average shift distance by the action of line 14, $S_3=S_{avg}$. Therefore the vectors

5 S and P are $S=[28,28,28]$ and $P=[0,28,2]$ at the end of this iteration. It may be noted that while the shift distance S_2 and S_3 were set to be the average shift distance by the action of line 14, the shift distance S_1 was set to be the average shift distance by the action of line 13.

[00100] The condition of the while loop is tested again, however, now all of

10 the values of S are equal to the average shift distance S_{avg} . Therefore, the condition is false and the 'while' loop ends.

[00101] The method then outputs the new shift distance $S_{avg}=28$, the padding for each image $P=[0,28,2]$ and the new lengths of each image portion including the blank portion which has a length equal to the padding length

15 $L_{out}=[0,28,2]+[110,56,80]=[110,84,82]$. Therefore, the lengths of the images including the blank, or padding, portions are 110cm, 84cm and 82cm respectively.

[00102] Examples in the present disclosure can be provided as methods, systems or machine readable instructions, such as any combination of software, hardware, firmware or the like. Such machine readable instructions may be included on a computer

20 readable storage medium (including but not limited to disc storage, CD-ROM, optical storage, etc.) having computer readable program codes therein or thereon.

[00103] The present disclosure is described with reference to flow charts and/or block diagrams of the method, devices and systems according to examples of the present disclosure. Although the flow diagrams described above show a specific order of

25 execution, the order of execution may differ from that which is depicted. Blocks described in relation to one flow chart may be combined with those of another flow chart. It shall be understood that each block in the flow charts and/or block diagrams, as well as combinations of the blocks in the flow charts and/or block diagrams can be realized by machine readable instructions.

[00104] The machine readable instructions may, for example, be executed

30 by a general purpose computer, a special purpose computer, an embedded processor or processors of other programmable data processing devices to realize the functions described in the description and diagrams. In particular, a processor or processing

apparatus may execute the machine-readable instructions. Thus functional modules of the apparatus and devices (for example, the image data module 506, shift module 506, padding module 508 and/or modification module 510) may be implemented by a processor executing machine readable instructions stored in a memory, or a processor operating in accordance with instructions embedded in logic circuitry. The term 'processor' is to be interpreted broadly to include a CPU, processing unit, ASIC, logic unit, or programmable gate array etc. The methods and functional modules may all be performed by a single processor or divided amongst several processors.

[00105] Such machine-readable instructions may also be stored in a computer readable storage that can guide the computer or other programmable data processing devices to operate in a specific mode.

[00106] Such machine readable instructions may also be loaded onto a computer or other programmable data processing devices, so that the computer or other programmable data processing devices perform a series of operations to produce computer-implemented processing, thus the instructions executed on the computer or other programmable devices realize functions specified by block(s) in the flow charts and/or block diagrams.

[00107] Further, the teachings herein may be implemented in the form of a computer software product, the computer software product being stored in a storage medium and comprising a plurality of instructions for making a computer device implement the methods recited in the examples of the present disclosure.

[00108] While the method, apparatus and related aspects have been described with reference to certain examples, various modifications, changes, omissions, and substitutions can be made without departing from the spirit of the present disclosure. It is intended, therefore, that the method, apparatus and related aspects be limited only by the scope of the following claims and their equivalents. It should be noted that the above-mentioned examples illustrate rather than limit what is described herein, and that those skilled in the art will be able to design many alternative implementations without departing from the scope of the appended claims.

[00109] The word "comprising" does not exclude the presence of elements other than those listed in a claim, "a" or "an" does not exclude a plurality, and a single processor or other unit may fulfil the functions of several units recited in the claims.

[00110] The features of any dependent claim may be combined with the features of any of the independent claims or other dependent claims.

CLAIMS

- 5 1. A method comprising, by processing circuitry:
 receiving print data representing a sequence of image portions to be printed
 contiguously on a substrate;
 determining a shift distance for the image portions as a difference between an
 initial length of the preceding image portion in the sequence and a maximum image
10 portion length;
 determining an average shift distance for the sequence of image portions;
 selecting a first image portion associated with a shift distance which is less than
 the average shift distance and determining a first padding length to be added to the initial
 length of the first image portion based on the difference between the shift distance for the
15 first image portion and the average shift distance;
 subtracting the first padding length from the shift distance of a second image
 portion of the sequence of image portions to determine a modified shift distance for the
 second image portion; and
 inserting a blank portion of image data of length equal to the first padding length in
20 the print data of the first image portion.
2. A method as claimed in claim 1 comprising, after determining the first padding
length, setting the shift distance for the first image portion to the average shift distance.
- 25 3. A method as claimed in claim 1, further comprising, for each of the other image
portions, if the shift distance for that image portion is less than the average shift distance:
 determining a padding length for that image portion based on the difference
 between the shift distance for that image portion and the average shift distance;
 subtracting the determined padding length for the next image portion in the
30 sequence from the shift distance for that next image portion to determine a modified shift
distance for the next image portion;
 inserting a blank portion of image data of length equal to the padding length of that
image portion in the print data for that image portion; and

setting the shift distance for that image portion to the average shift distance.

4. A method as claimed in claim 1 wherein inserting the blank portion comprises inserting the blank portion of image data in the print data prior to the image portion.

5

5. A method as claimed in claim 4 further comprising inserting a blank portion of image data in the print data after the image portion such that that the length of each image portion having blank portions inserted prior to and after received image portion is substantially equal for all image portions of the sequence.

10

6. A method as claimed in claim 1, further comprising:
comparing the length of the first image portion, after the blank portion is inserted, to the maximum image portion length;
when the length of the first image portion is greater than the maximum image
15 portion length determine that the print data cannot be printed.

7. A method as claimed in claim 1, further comprising printing the sequence of image portions using a print apparatus.

20

8. A method as claimed in claim 7 further comprising:
between printing each image portion, moving the substrate relative to the print apparatus a distance based on the average shift distance in an opposing direction to the direction the substrate is moved during printing the image portions.

25

9. A method as claimed in claim 7, wherein printing comprises printing the second image portion to align with an end of the first image portion.

30

10. A method as claimed in claim 1, wherein at least one image portion of the sequence of image portions overlaps with a subsequent image portion in a direction of travel of the substrate.

11. An apparatus comprising processing circuitry, the processing circuitry comprising:
an image data module to receive image data for a plurality of image portions of different dimensions to be printed;

a shift module to determine a single shift distance by which a print substrate is moved between printing each image portion;

a padding module to determine a padding length for at least one image portion;
and

5 a modification module to modify the image data by inserting a blank portion with a length equal to the padding length into at least one image portion,

wherein the at least one padding length is a distance which results in the determined shift distance aligning consecutive printed images on the substrate.

10 12. An apparatus as claimed in claim 11, further comprising:

a print module to print the plurality of image portions on a substrate.

13. An apparatus as claimed in claim 12, further comprising:

15 a substrate shifting module, to move the substrate a distance equal to the determined shift distance between printing of consecutive image portions.

14. A machine-readable medium storing instructions which, when executed by a processor, cause the processor to generate print instructions for image data comprising a sequence of image portions which are to form a continuous image on a substrate,

20 wherein the instructions to generate the print instructions comprise:

instructions to determine a shift distance for each image portion as a difference between an initial length of the preceding image portion in the sequence and a maximum image portion length;

25 instructions to determine an average shift distance for the sequence of image portions;

instructions to, while an image portion is associated with a shift distance which is less than the average shift distance, for such an image portion:

30 determine a padding length to be added to the initial length of that image portion wherein the padding length is determined based on the difference between the average shift distance and the shift distance associated with that image portion;

insert a blank portion of image data of length equal to the padding length in the print data of first image portion; and

subtract the padding length from the shift distance of the image portion which immediately follows the image portion in the sequence to determine a modified shift distance for the following image portion.

- 5 15. A machine-readable medium storing instructions as claimed in claim 14, wherein the instructions to generate the print instructions further comprise:
- instructions to generate print instructions which instruct a print apparatus to:
- print the image portions according to the image data including the blank
- portions; and
- 10 move the substrate between printing consecutive image portions a distance equal to at least the average shift distance.

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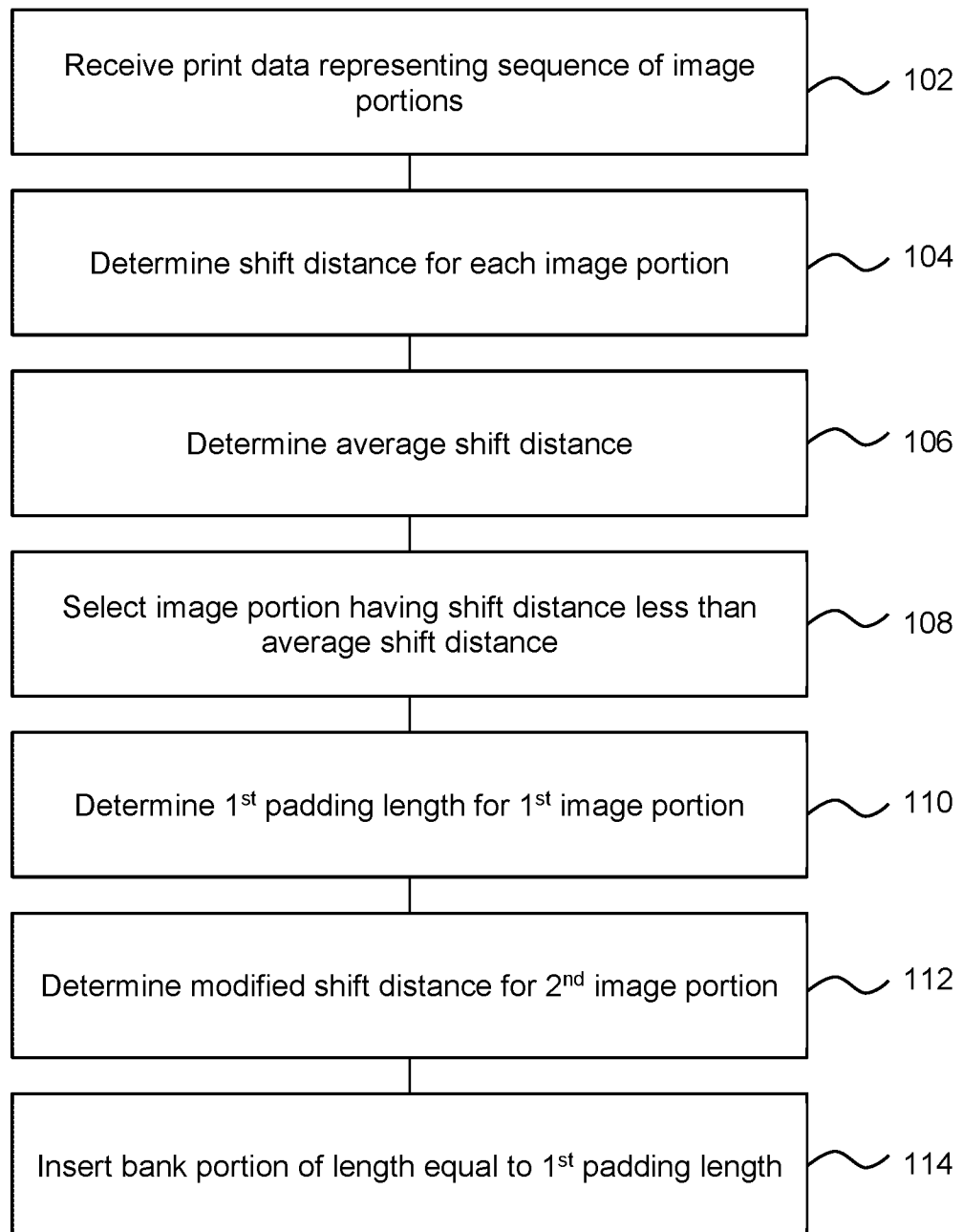


Fig. 1

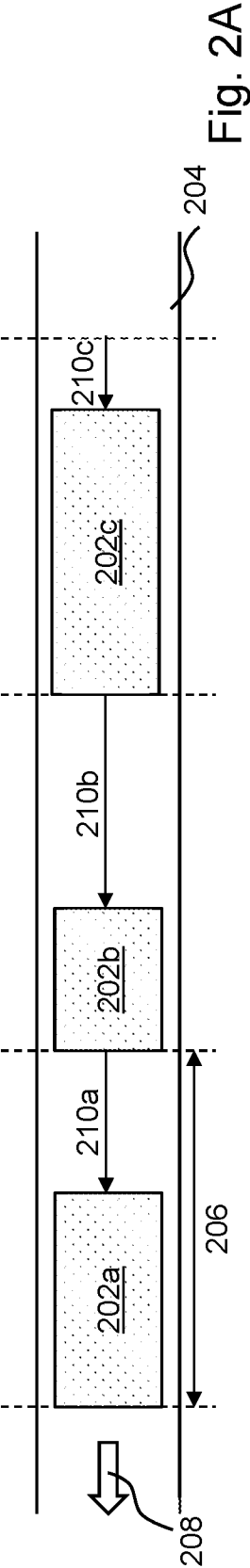


Fig. 2A

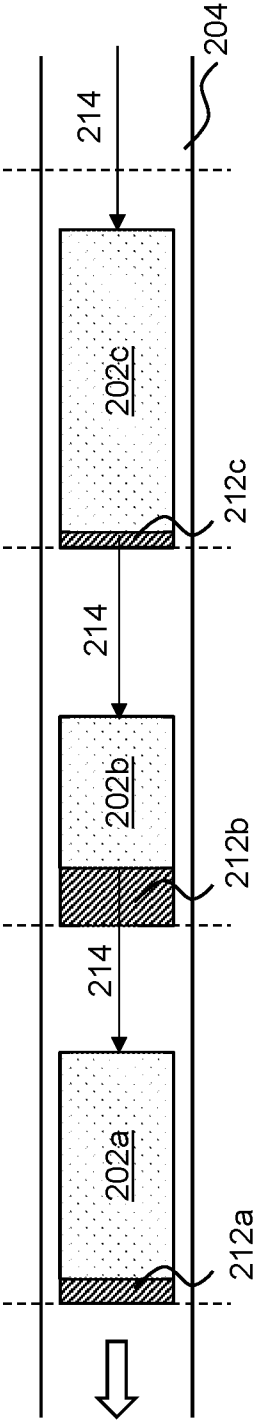


Fig. 2B

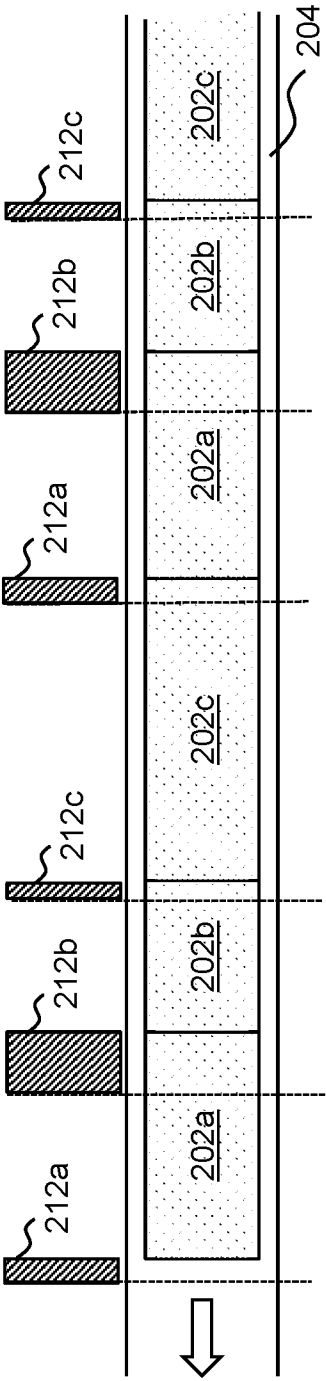


Fig. 2C

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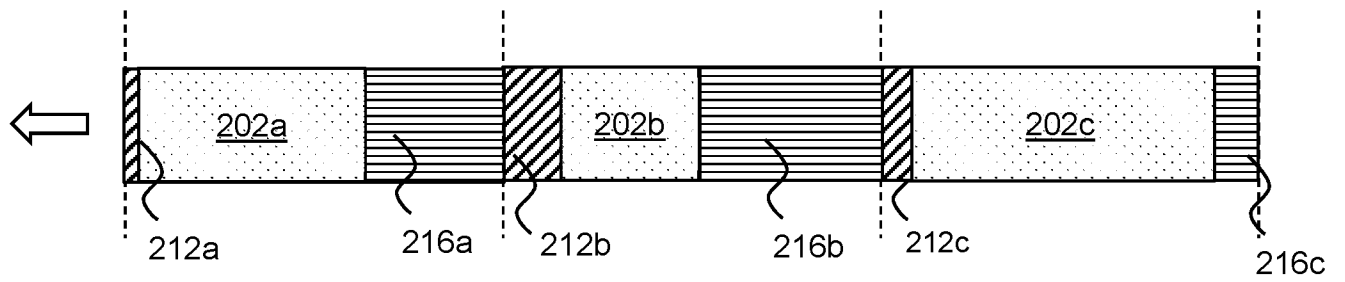


Fig. 2D

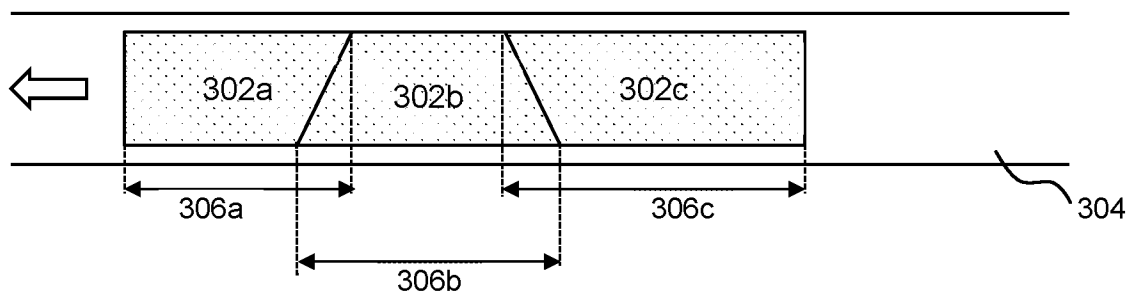


Fig. 3

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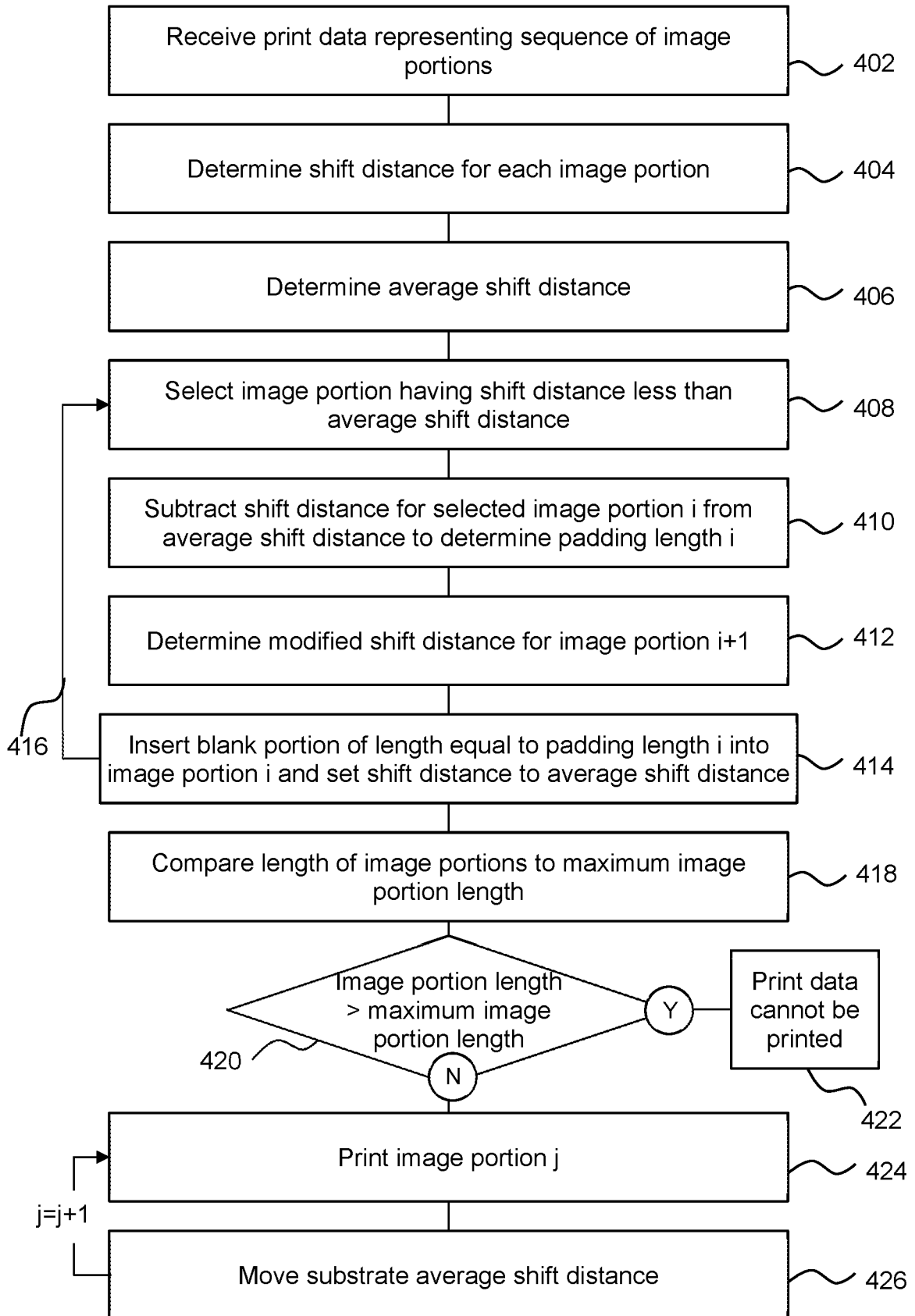


Fig. 4

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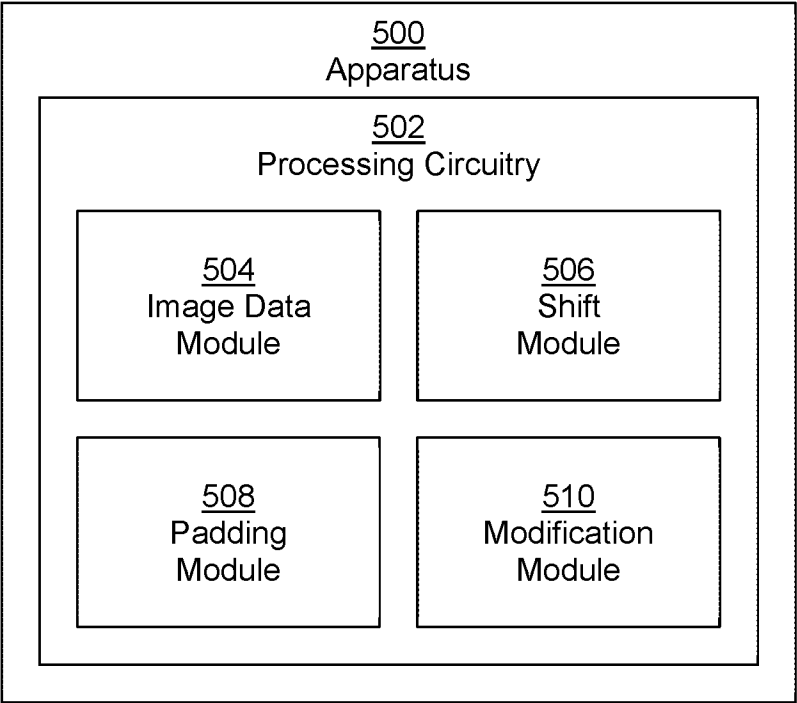


Fig. 5

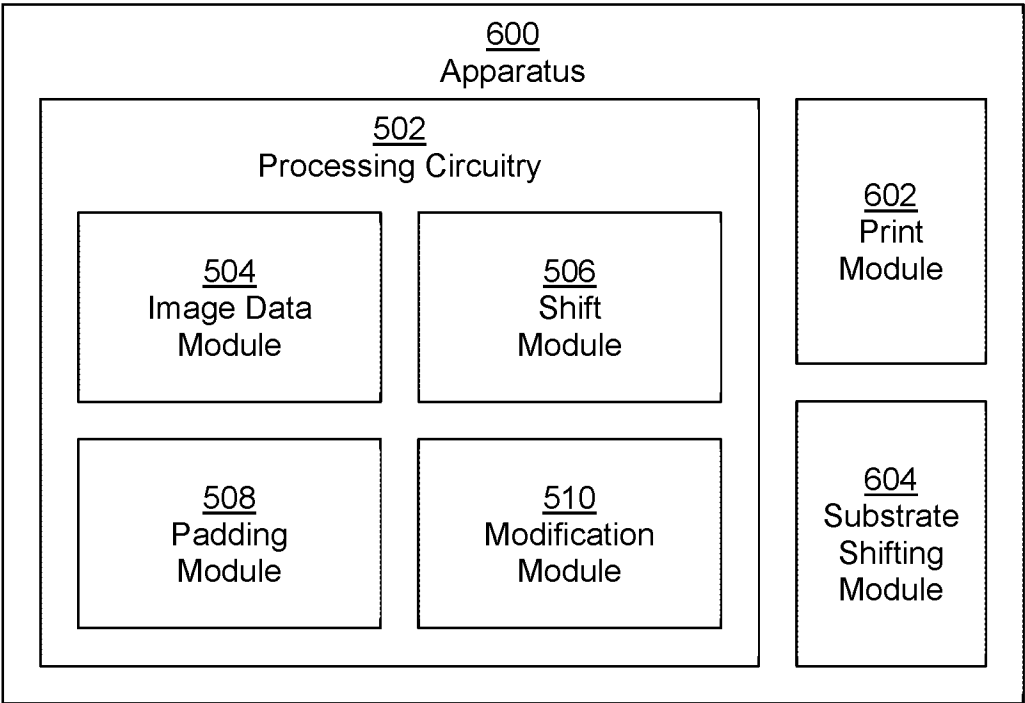


Fig. 6

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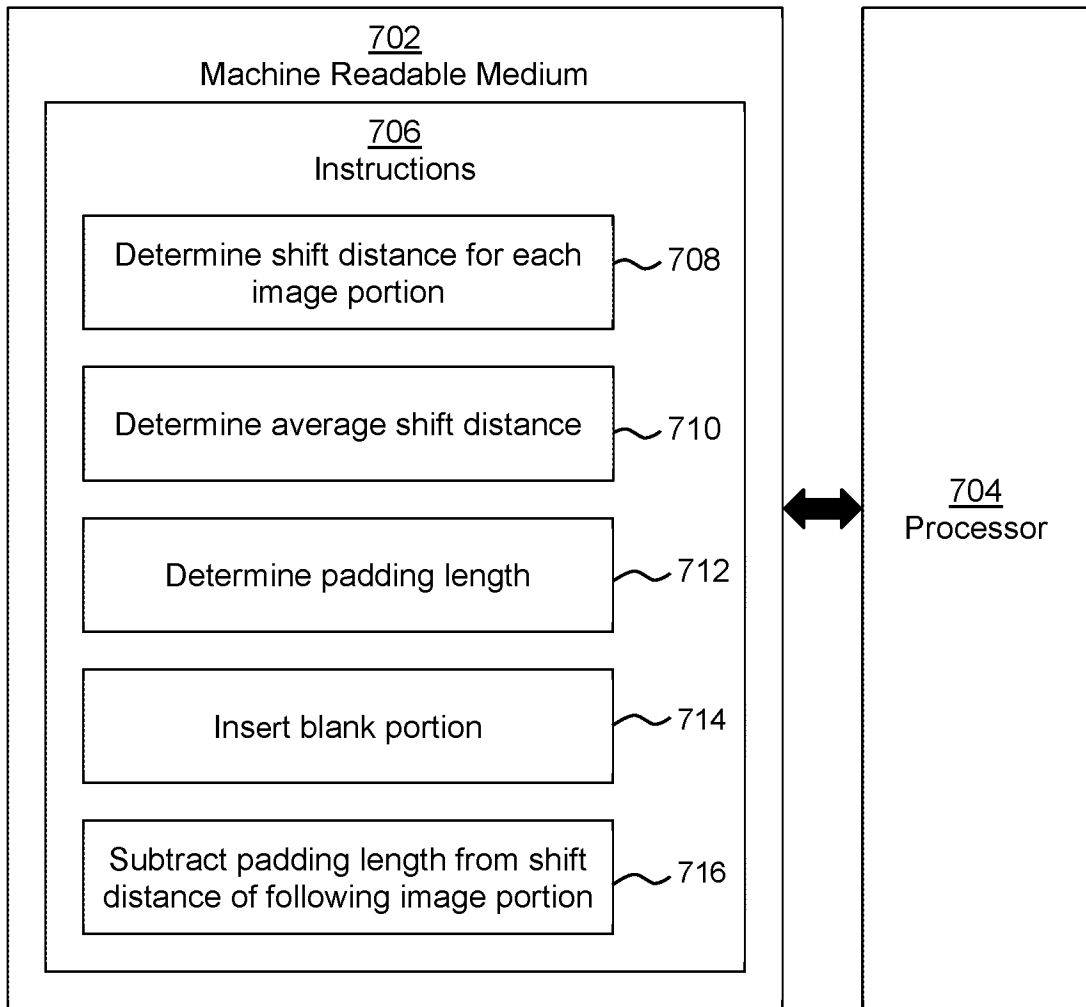


Fig. 7

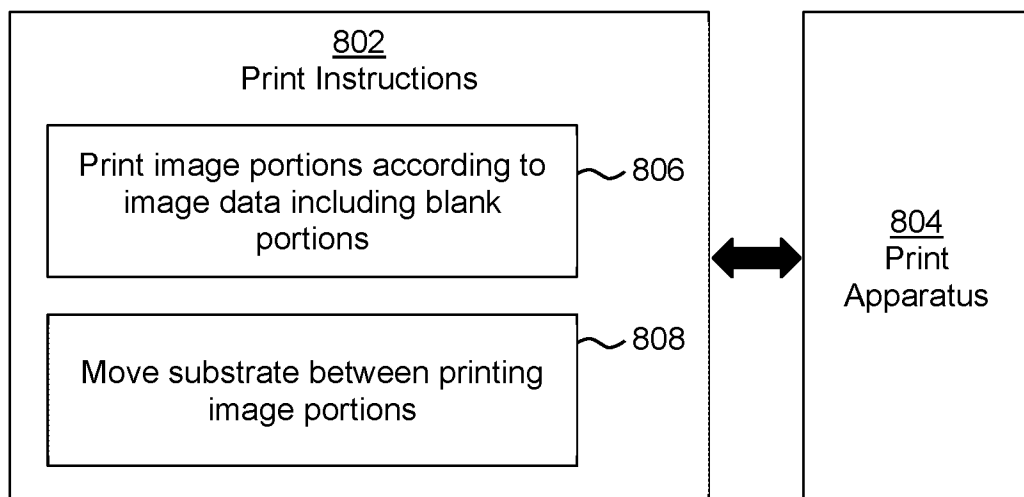


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/045355

A. CLASSIFICATION OF SUBJECT MATTER <i>B41M 3/00 (2006.01)</i> According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B41M 3/00-3/18, G03G 13/045, 15/045 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatSearch (RUPTO internal), USPTO, PAJ, K-PION, Esp@cenet, Information Retrieval System of FIPS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2018/030918 A1 ("REMAGE RUS" LIMITED LIABILITY COMPANY) 15.02.2018	1-15
A	HU 180634 B (OFFSET ES JATEKKARTYA NYOMDA) 28.03.1983	1-15
A	JP H0390357 A (TOPPAN PRINTING CO LTD) 16.04.1991	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 07 December 2020 (07.12.2020)		Date of mailing of the international search report 18 February 2021 (18.02.2021)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer E. Poretskova Telephone No. 499-240-60-15