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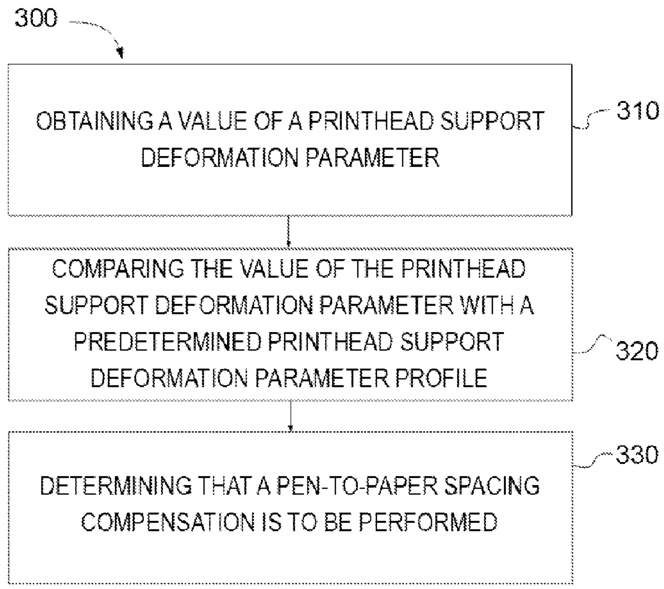

FIG. 1

(57) **Abstract:** Examples relate to systems and methods for compensating a printhead support deformation. The method comprises obtaining a value of a printhead support deformation parameter and comparing the value of the printhead support deformation parameter with a predetermined printhead support deformation parameter profile. In addition, the method comprises determining that a pen-to-paper spacing compensation is to be performed.

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PRINTHEAD SUPPORT DEFORMATION PARAMETERS

BACKGROUND

[0001] A printing system may include a pen or a printhead with a plurality of nozzles that deliver or deposit print agent onto a printing substrate. Printing systems can be two-dimensional (2D) printing systems or three-dimensional (3D) printing systems. In printing processes, a distance between the printhead and the printing substrate, known as the printhead-to-print substrate spacing (also known as pen–to–paper spacing, PPS), may influence print quality.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Various example features will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, wherein:

[0003] FIG. 1 is a block diagram of a method according to an example.

[0004] FIG. 2 is a block diagram of a method according to an example.

[0005] FIG. 3 schematically illustrates a system according to an example.

[0006] FIG. 4 represents a controller including a processor and a non-transitory machine-readable storage medium according to an example.

[0007] FIG. 5 is a block diagram of the instructions included in the non-transitory machine-readable storage medium of FIG. 4.

DETAILED DESCRIPTION

[0008] The present disclosure presents examples of methods and apparatuses for compensating pen-to-paper spacing variations in a printing process. Printing systems comprises a printhead to deliver print agent onto a printing substrate to place dots on the printing substrate. In this disclosure, delivering includes firing, ejecting, spitting, or otherwise depositing print agent or ink.

[0009] Printheads may comprise a plurality of print agent ejection assemblies that may eject or deliver print agent from a nozzle by activating a drop actuator associated with the nozzle, e.g. in fluid communication with the nozzle.

[0010] Printheads may be mounted on a printhead support. The printhead support thus supports a printhead. In some examples, the printhead support supports a plurality of printheads.

[0011] In some examples, the printhead support comprises a beam that supports the printhead. The beam may extend from an edge of the printing substrate to an opposite edge of the printing substrate. The printhead may be moved across the beam. This type of printing system is known as a scanning axis printing system.

[0012] In some examples, the printhead is static. The printhead may extend along a width of a printing substrate, from one edge to the opposite edge. These printer systems may be called page-wide array (PWA) printer systems.

[0013] Heat may be applied by a heating device to the delivered or deposited print agent. Examples of heating in printing processes may be drying, curing, dye-sublimating or, more generally, fixing the print agent to the printing substrate.

[0014] The printhead support may be exposed to the heat applied to the deposited print agent onto the printing substrate. The printhead support may thus be exposed at different temperatures. For example, the printhead support may be exposed at a temperature difference above 20ºC, e.g. above 40ºC. For example, the temperature of the printhead support may reach a temperature between 50ºC and 110ºC. This heat may cause a deformation of the printhead support. For example, the printhead support may expand in response to a change in temperature which may cause the printhead support to bend or deflect. The deformation of the printhead support may cause a variation of the pen-to-paper spacing, i.e. a distance between the printhead and the printing substrate. The printhead support may thus deflect towards the printing substrate. This variation of the pen-to-paper spacing may influence the placement of print agent dots on the printing substrate. Image quality may thus be affected by the variation of the pen-to-paper spacing.

[0015] FIG. 1 is a block diagram of a method according to an example. The method 300 may be used for compensating a pen-to-paper spacing variation caused by a deformation of the printhead support of a printing system. The method 300 comprises obtaining a value of a printhead support deformation parameter, as represented at block 310.

[0016] In this disclosure, the printhead support deformation parameter refers to a parameter that defines or indicates the deformation of the printhead support, e.g. of the beam that extends substantially perpendicular to the printing substrate advance direction.

[0017] The value of the printhead support deformation parameter is the amount or magnitude of the printhead support deformation parameter. Variations in the value of the printhead support deformation parameter may indicate a deformation of the printhead support. This deformation may influence the placement of print agent dots onto the printing substrate.

[0018] In some examples, obtaining the value of the printhead support deformation parameter may comprise measuring the printhead support deformation parameter with a sensor. Depending on the type of printhead support deformation parameter different types of sensors may be used. The sensor may measure the printhead support deformation parameter and a controller may receive the value of the printhead support deformation parameter from the sensor.

[0019] The printhead support deformation parameter may comprise a pen-to-paper spacing, a printhead support temperature and/or printhead support temperature exposure.

[0020] In one example, the printhead support deformation parameter may be the printhead support temperature. The printhead support temperature indicates the temperature experienced by the printhead support. Higher temperature variations may indicate greater deformations of the printhead support which may influence the placement of dots onto the printing substrate.

[0021] In one example, the printhead support deformation parameter may be the pen-to-paper spacing. The pen-to-paper spacing is a distance between the printhead and the printing substrate. Variations in the pen-to-paper spacing may influence the position of the dots on the printing substrate.

[0022] In one example, the printhead support parameter may be a printhead support temperature exposure. Printhead support temperature exposure indicates the temperature of the printhead support over a time of exposure. The printhead support temperature exposure is the product of temperature, e.g. measured in Celsius degrees, and time of exposure, e.g. measured in seconds.

[0023] The method 300 further comprises, comparing the value of the printhead support deformation parameter with a predetermined printhead support deformation parameter profile, as represented at block 320 of FIG. 1.

[0024] A printhead support deformation parameter profile comprises a plurality of values of the printhead support deformation parameter for a given printing setting, wherein each of the values of the printhead support deformation parameter is associated with a dot placement deviation. The printhead support deformation parameter profile relates the evolution of the printhead support deformation parameter to the dot placement deviation. For example, the printhead support deformation parameter profile may relate an evolution of the printhead support deformation parameter over a period of time for a given printing setting to the corresponding dot placement deviation. The printing setting may comprise a heating setting defined by a heating temperature, heating time, and/or a heating increase.

[0025] In this disclosure, dot placement deviation refers to a deviation of the placement or position of the print agent dots on the printing substrate when compared with a reference. The dot placement deviation may be measured in millimeters or in dots. In this disclosure, the dot placement deviation shows a misalignment of the print agent dots on the printing substrate caused by the deformation of the printhead support.

[0026] The predetermined printhead support deformation parameter profile may comprise a plurality of predetermined values of the printhead support deformation parameter for a given printing setting, each of them associated with a dot placement deviation. The predetermined printhead support parameter profile indicates the expected evolution of the deformation of the printhead support and the corresponding dot placement deviation for a given printing setting, e.g. for a given heating setting.

[0027] In one example, the predetermined printhead support parameter profile comprises the expected evolution of the printhead support temperature at different operating times during printing for a given printing setting. In this example, the dot placement deviation is associated with the printhead support temperature. In one example, the predetermined printhead support parameter profile comprises the expected evolution of the pen-to-paper spacing at different operating times during printing with a given printing setting. In this example, each value of the predetermined pen-to-paper spacing is associated with the dot placement deviation.

[0028] In some examples, the predetermined printhead support parameter profile may be represented as a look-up table or as a function relating the plurality of predetermined values of the printhead support deformation parameter to the dot placement deviation.

[0029] In some examples, comparing the value of the printhead support deformation parameter with the printhead support deformation parameter profile comprises identifying, based on the obtained value of the printhead support deformation parameter, a predetermined value of the plurality of predetermined values of the printhead support deformation parameter. In some examples, the identified predetermined value is the predetermined value of the plurality of predetermined values of the printhead support deformation parameter closest or nearest to the obtained value of the printhead support deformation parameter. In some examples, the identified predetermined value corresponds to the nearest or closest predetermined value being higher than the obtained value of the printhead support deformation parameter. In some examples, the identified predetermined value corresponds to the nearest or closest predetermined value being lower than the obtained value of the printhead support deformation parameter.

[0030] In some examples, determining the dot placement deviation may comprise retrieving the dot placement deviation associated with the identified predetermined value of the plurality of predetermined values of the printhead support deformation parameter. Once the predetermined value of the printhead support deformation parameter is identified, the dot placement deviation associated with this identified predetermined value may be retrieved. Accordingly, the dot placement deviation for a value of the printhead support deformation parameter from the printing system may be determined.

[0031] Referring back to FIG. 1, the method 300 further comprises determining, based on the comparison, that a pen-to-paper spacing compensation is to be performed, as represented at block 330. For example, a pen-to-paper spacing compensation is to be performed if the deformation experienced by the printhead support reduces the image quality below a predetermined level.

[0032] In some examples, the determining that the pen-to-paper spacing compensation is to be performed comprises determining a dot placement deviation and comparing this dot placement deviation with a dot placement deviation reference. The dot placement deviation may be determined according to any of the examples herein. For example, if the dot placement deviation is greater than a dot placement deviation reference, the pen-to-paper spacing is to be performed. This implies that the dot placement deviation during printing is greater than an acceptable dot placement deviation. The dot placement deviation reference may be set according to the printing setting.

[0033] Referring back to FIG. 1, the method 300 may be used to determine that pen-to-paper spacing compensation is to be performed to compensate for a deformation of the printhead support. The precision of placement of print agent dots may thus be increased. Consequently, image quality may be improved.

[0034] Variations of the pen-to-paper spacing caused by a thermal variation experienced by the support structure may be precisely compensated during printing. For example, deformations, e.g. thermal expansions, caused by a heating system that heats print agent deposited on the printing substrate may thus be compensated to reduce print agent dot deviation. Pen-to-paper spacing variations may thus be dynamically compensated during an increase in temperature experienced by the printhead support when the printhead is printing. This allows to precisely determine to perform a pen-to-paper spacing compensation to counteract the effect of deformation of the printhead support. For example, the deformation of the printhead support may be monitored and compensated during an increase in temperature until reaching a predetermined temperature at which the deformation of the printhead support stabilizes. Warming-up times to reach the predetermined temperature may thus be avoided. Printing productivity may consequently be increased.

[0035] In some examples, the method 300 may comprise obtaining the printhead support deformation parameter profile from a storage medium. The expected values of the printhead support parameters at different operating times for a given printing setting may thus be obtained from the storage medium.

[0036] In addition, the method 300 may comprise generating the predetermined printhead support deformation parameter profile and storing the generated predetermined printhead support deformation parameter profile in the storage medium. The generation of the predetermined printhead support deformation parameter profile may comprise measuring the printhead support deformation parameter at different printing settings and measuring the dot placement deviation for each value of the printhead support deformation parameter. Sampling the printhead support deformation parameter at different printing settings and measuring the corresponding dot placement deviation may allow building the predetermined printhead support deformation parameter profile at different printing conditions.

[0037] The predetermined printhead support deformation parameter profile may be generated at a manufacturing or testing facility. In some examples, the predetermined printhead support deformation parameter profile may be generated for each printing system before shipping the printing system to the user facilities. The look-up table or function associating the predetermined values of the predetermined printhead support deformation parameter profile with the corresponding dot placement deviation may be built at the manufacturing plant. In some examples, a single predetermined printhead support deformation parameter profile may be used for different printing systems.

[0038] In some examples, the method 300 comprises performing the pen-to-paper spacing compensation. The pen-to-paper spacing compensation may be performed when the dot placement deviation is greater than the dot placement deviation reference. To reduce the dot placement deviation the pen-to-paper spacing compensation may be performed. The pen-to-paper spacing compensation aims at compensating for the deformation of the printhead support.

[0039] Several printing strategies may be defined for compensating the pen-to-paper spacing. For example, performing a pen-to-paper spacing compensation may comprise controlling a print agent ejection from a nozzle of the printhead. Firing time of print agent from the nozzle may be adjusted. The ejection of print agent from the nozzle may be set back or forward. These firing times adjustments take into account the change of position of the printhead caused by the deformation experienced by the printhead support.

[0040] FIG. 2 is a block diagram of a method according to an example. As the method 300 of FIG. 1, the method 400 of FIG. 2 may be used for compensating a pen-to-paper spacing variation caused by the deformation of the printhead support. In this example, the printhead support deformation parameter is the printhead support temperature.

[0041] The method 400 comprises obtaining a value of the printhead support temperature, as represented at block 410. A temperature sensor may be used to measure the printhead support temperature. In one example, this sensor may be arranged adjacent to the printhead support. In one example, this sensor may be adjacent to the print zone. The sensor may be a sensor used for controlling the heating system of the printing system. In this example, the printhead support temperature has a value of 54ºC.

[0042] The method 400 further comprises obtaining a predetermined printhead support temperature profile, as represented at block 420. The predetermined printhead support temperature profile comprises a plurality of predetermined values of the printhead support temperature, wherein each of these predetermined values is associated with a dot placement deviation. In this example, the predetermined printhead support temperature profile is represented as a lookup table stored in a storage medium.

[0043] The predetermined printhead support temperature profile of this example comprises four predetermined values of the printhead support temperature and its corresponding dot placement deviation. The first predetermined value of the printhead support temperature is 45ºC and a dot placement deviation of 0 dots is associated with this first predetermined value. The second predetermined value of the printhead support temperature is 50ºC and a dot placement deviation of 1 dot is associated with this second predetermined value. The third predetermined value of the printhead support temperature is 55ºC and a dot placement deviation of 1 dot is associated with this third predetermined value. The fourth predetermined value of the printhead support temperature is 60ºC and a dot placement deviation of 2 dots is associated with this fourth predetermined value.

[0044] Referring back to FIG. 2, the method 400 further comprises comparing the value of the printhead support temperature with the predetermined printhead support temperature profile, as represented at block 430 of FIG. 2.

[0045] In this example, a predetermined value of the plurality of predetermined values of the printhead support temperature, based on the value of the printhead support temperature, is identified. In this example, the predetermined value corresponds to the predetermined value of the plurality of predetermined values closest to the value of the printhead support temperature obtained from the sensor. In this example, as the value of the printhead support temperature is 54 ºC, the closest predetermined value is 55ºC.

[0046] As represented at block 440 of FIG. 2, determining a dot placement deviation is provided. The dot placement deviation is retrieved from the predetermined printhead support temperature profile. In this example, the dot placement deviation associated with the identified predetermined value of the plurality of predetermined values of the printhead support temperature profile (55º C in this example) is 1 dot. Accordingly, the dot placement deviation is 1 dot. This means that the expected dot placement deviation when the printhead support temperature is 54ºC is 1 dot. The deformation of the printhead support temperature caused by a temperature of 54ºC implies a dot placement deviation of 1 dot.

[0047] At block 450 of FIG. 2, the dot placement deviation is compared with a dot placement deviation reference. The dot placement deviation reference may be adjusted for a given print job or for a given printing setting. If the comparison result between the dot placement deviation is equal to or greater than the dot placement deviation reference, performing a pen-to-paper spacing compensation is determined, as represented at block 460.

[0048] In this example, the dot placement deviation reference is 1 dot. Accordingly, as the dot placement deviation is 1 dot which is equal to the dot placement deviation reference, performing the pen-to-paper spacing compensation is determined. The pen-to-paper spacing compensation may be performed according to any of the examples herein. The pen-to-paper spacing compensation may allow reducing the dot placement deviation.

[0049] After performing the pen-to-paper spacing compensation, the dot placement deviation may be updated to take into account the pen-to-paper spacing compensation. For example, if a dot placement deviation of 1 dot is compensated, the 1 dot may be added to the dot placement deviation reference.

[0050] If the dot placement deviation is not equal to or greater than the dot placement deviation reference, then the printing system continues printing, as represented at block 470.

[0051] The method 400 may be iteratively performed. For example, the printhead support temperature may be sampled during a period of time. In some examples, the method 400 may comprise obtaining additional values of the printhead support temperature, determining the dot placement deviation of these additional values, and determining to perform the pen-to-paper spacing compensation.

[0052] In some examples, the method may be iteratively performed until a predetermined temperature is reached. For example, the method may be performed while the printhead support temperature varies. The method may be stopped when the printhead support temperature stabilizes.

[0053] The method 400 obtains the printhead support temperature to determine the dot placement deviation. In some examples, the method may use pen-to-paper spacing and/or printhead support temperature exposition to determine the dot placement deviation.

[0054] FIG. 3 schematically illustrates a system according to an example. The system 100 comprises a printhead 30 to deliver print agent onto a printing substrate 200 to place dots on the printing substrate 200. The printhead 30 is supported by a printhead support 40. The system 100 further comprises a sensor 20 to measure a value of a printhead support deformation parameter. In addition, the system 100 comprises a controller 130 and a heater 10 to heat print agent on the printing substrate 200. The methods according to any of the examples herein may be implemented by the system 100 of this figure.

[0055] The heater 10 may heat print agent deposited on the printing substrate 200. This heater 10 may be used in any of the heating processes of the examples herein. The printhead support 40 may experience a portion or a part of the heat directed towards the print agent.

[0056] The heater 10 may extend in a direction perpendicular to the printing substrate advance direction 210. The heater 10 of this example is downstream the printhead 30. Examples of heaters 10 may comprise infrared heater elements, electrical resistance elements, radiation emitters, ultraviolet heater elements, diode lasers and/or inductive heating elements.

[0057] The printhead 30 of this figure ejects or delivers print agent onto the printing substrate 200 from a nozzle by activating a drop actuator associated with the nozzle. Print agent is delivered in form of dots that are precisely formed on the printing substrate 200.

[0058] In some examples, the drop actuator may be a heating element, e.g. a thermal resistor element. An electrical current may pass through the heating element to generate heat. This heat may cause rapid vaporization of print agent in a print agent chamber or firing chamber, increasing an internal pressure inside this print agent chamber. This increase in pressure makes a drop of print agent exit from the print agent chamber to the printing substrate 200 through a nozzle. These printing systems may be called thermal inkjet printing systems.

[0059] In some examples, the drop actuator may be a piezoelectric element. A piezoelectric element may be used to force a drop of print agent to be delivered from a print agent chamber or reservoir onto the printing substrate 200 through a nozzle. A voltage may be applied to the piezoelectric element, which may change its shape. This change of shape may force a drop of print agent to exit through the nozzle. These printing systems may be called piezoelectric printing systems.

[0060] The printhead support 40 may extend between opposite edges of the printing substrate 200. The printhead support 40 may comprise a beam that supports the printhead 30. The beam may extend from an edge of the printing substrate 200 to an opposite edge of the printing substrate 200 in a direction substantially perpendicular to the printing substrate advance direction 210.

[0061] In some examples, the system 100 may be a scanning axis printing system. The printhead 30 may be movable across the beam. The printhead 30 may move across a scan axis. The printhead 30 may travel repeatedly across the scan-axis for delivering print agent onto the printing substrate 200, which may advance along a printing substrate advance direction 210. The scan axis may be substantially perpendicular to the printing substrate advance direction 210. In some examples, several printheads 30 may be movable mounted on the printhead support 40. For example, a carriage may be provided for moving the printhead 30 across the printhead support 40. In some examples, four printheads 30 may be mounted on a single carriage. In some examples, eight printheads 30 may be mounted on a single carriage.

[0062] In some examples, the system 100 may be a page-wide array (PWA) printer system. The printhead 30 may be static. The printhead 30 may extend along a width of a printing substrate 200, from one edge to the opposite edge. The plurality of nozzles may be distributed within the printhead 30 along the width of the printing substrate 200. Such an arrangement may allow most of the width of the printing substrate 200 to be printed simultaneously.

[0063] Referring back to FIG. 3, the controller 130 is to obtain, from the sensor 20, a value of the printhead support deformation parameter. The sensor 20 may measure the value of the printhead support deformation parameter and the controller 130 may receive the value from the sensor 20.

[0064] As explained before, the printhead support deformation parameter may comprise a printhead support deformation parameter, a pen-to-paper spacing and/or printhead support temperature exposure. Different types of sensors may be used for measuring these different types of printhead support deformation parameters. For example, a temperature sensor may be used for measuring the printhead support temperature and temperature sensor and a timer may be used to measure the printhead support temperature exposure. Distance sensors may be used to measure pen-to-paper spacing.

[0065] Examples of distance sensors may be optic sensors, ultrasound sensors, strain gauges, or piezoelectric sensors. These distance sensors may be mounted in a central portion of the printhead support.

[0066] The controller 130 of this figure is to compare the value of the printhead support deformation parameter with a predetermined printhead support deformation parameter profile. The predetermined printhead support deformation parameter profile may be obtained from a storage medium. The predetermined printhead support deformation parameter profile and to compare the value of the printhead support deformation parameter with the predetermined printhead support deformation parameter profile may be according to any of the examples herein.

[0067] In addition, the controller 130 of this figure is to determine, based on the comparison, a dot placement deviation. The controller 130 may thus be used to determine the dot placement deviation caused by the deformation of the printhead support 40.

[0068] In some examples, the controller 130 may be to determine a pen-to-paper spacing compensation. To determine a pen-to-paper spacing compensation may comprise to compare the dot placement deviation with a dot placement deviation reference. The controller 130 may receive the dot placement deviation reference from a storage medium.

[0069] The dot placement deviation may be compared with the dot placement deviation reference according to any of the examples herein. For example, the controller 130 may determine to perform a pen-to-paper spacing compensation if the dot placement deviation is equal or greater than the dot placement deviation reference.

[0070] The controller 130 may be to calculate a dot placement deviation difference between the dot placement deviation and the dot placement deviation reference. Based on the dot placement deviation difference, the controller 130 may be to control the ejection of print agent from a nozzle of the printhead 30. In some examples, to control the ejection of print agent from the nozzle of printhead 30 may comprise to adjust the operation of a drop actuator associated with the nozzle. Firing time of print agent may thus be adjusted. Depending on the position of the printhead and on the dot placement deviation difference, the ejection of print agent may be set back or forward. Adjusting the firing time may allow to modify the position of the print agent dots on the printing substrate 200. Adjusting the print agent ejection may thus be used to compensate the dot placement deviation.

[0071] FIG. 4 represents the controller 130 including a processor 131 and a non-transitory machine-readable storage medium 132 coupled to the processor. The processor 131 performs operations on data, for example, operations for determining a pen-to-paper spacing compensation to compensate for a deformation of the printhead support 40. The processor 131 may also be a central processing unit for controlling the operation of the system, e.g. of a printing system.

[0072] The non-transitory machine-readable storage medium 132 is encoded with instructions 133 which, when executed by the processor 131, cause the processor 131 to determine a pen-to-paper spacing compensation.

[0073] The non-transitory machine-readable storage medium 132 may include any electronic, magnetic, optical, or other physical storage device that stores executable instructions. The non-transitory machine-readable storage medium may be, for example, Random Access Memory (RAM), an Electrically-Erasable Programmable Read-Only Memory (EEPROM), a storage drive, an optical disk, and the like.

[0074] FIG. 5 is a block diagram of the instructions included in the non-transitory machine-readable storage medium of FIG. 4.

[0075] The non-transitory machine-readable storage medium 132 is encoded with instructions 133 which, when executed by the processor 131, cause the processor 131 to receive a value of a printhead support deformation parameter, as represented at block 710 and obtain, from a storage medium, a predetermined printhead support deformation parameter profile, wherein the predetermined printhead support deformation parameter profile comprises a plurality of predetermined values of the printhead support deformation parameter, each of the predetermined values associated with a dot placement deviation, as represented at block 720. In addition, the non-transitory machine-readable storage medium 132 is encoded with instructions 133 which, when executed by the processor 131, cause the processor 131 to compare the value of the printhead support deformation parameter with the predetermined printhead support deformation parameter profile, as represented at block 730; identify a predetermined value of the plurality of predetermined values of the printhead support deformation parameter, as represented at block 740; and determine, based on the identify a predetermined value of the plurality of predetermined values of the printhead support deformation parameter, a pen-to-paper spacing compensation, as represented at block 750.

[0076] The instructions encoded in the non-transitory machine-readable storage medium represented at blocks 710, 720, 730, 740 and 750 may participate in determining that a pen-to-paper spacing compensation is to be performed or to determine a dot placement deviation according to any of the examples herein.

[0077] The processor 131 may receive a value of a printhead support deformation parameter according to any of the examples herein. For example, the processor 131 may receive from a sensor the value of the printhead support deformation parameter. The sensor may be communicatively coupled with the processor 131.

[0078] The predetermined printhead support deformation parameter profile may be stored in a lookup table of the storage medium. The storage medium may store a plurality of printhead support deformation parameter profile, each of them associated with a specific printhead setting. In some examples, the printhead support deformation parameter profiles may be associated with a specific heating profile.

[0079] In some examples, the processor 131 may obtain the printing setting. In some examples, the processor 131 may obtain the printing setting from a user interaction device. In some examples, the processor 131 may obtain the printing setting from a print job data defining a given print job. The processor 131 may select the predetermined printhead support deformation parameter profile corresponding to the print job.

[0080] The processor 131 compares the value of the printhead support deformation parameter with the predetermined printhead support deformation parameter profile according to any of the examples herein. For example, the printhead support deformation parameter may be compared with the plurality of predetermined values of the printhead support deformation parameter.

[0081] The processor 131 may identify the predetermined value of the plurality of predetermined values of the printhead support deformation parameter according to any of the examples herein. For example, the processor 131 may identify the predetermined value as the predetermined of the plurality of predetermined values closest to the value obtained from the sensor.

[0082] In some examples, the processor 131 may retrieve the dot placement deviation associated with the identified predetermined value of the plurality of predetermined values of the printhead support deformation parameter. The processor may compare the dot placement deviation with a dot placement deviation reference.

[0083] The pen-to-paper spacing compensation may be determined according to any of the examples herein. For example, the processor 131 may determine a pen-to-paper spacing compensation based on the result of the comparison of the dot placement compensation with the dot placement compensation reference.

[0084] In some examples, the processor 131 may operate, based on the pen-to-paper spacing compensation, a printhead mounted on the printhead support. In some examples, the processor 131 may operate a plurality of printheads mounted on the printhead support. The printhead or plurality of printheads may be operated for compensating the printhead support deformation during printing a print job.

[0085] The processor 131 may control the operation of the drop actuator associated with each of the nozzles of the printhead. The processor 131 may thus adjust the activation of the drop actuator. For example, the processor 131 may activate the drop actuator earlier or later than expected to take into account the dot placement deviation caused by the deformation of the printhead support. By controlling the time of activation of the drop actuator, the drops may be ejected earlier or later than expected, reducing the dot placement deviation.

[0086] The preceding description has been presented to illustrate and describe certain examples. Different sets of examples have been described; these may be applied individually or in combination, sometimes with a synergetic effect. This description is not intended to be exhaustive or to limit these principles to any precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is to be understood that any feature described in relation to any one example may be used alone, or in combination with other features described, and may also be used in combination with any features of any other of the examples, or any combination of any other of the examples.

CLAIMS

1. A method comprising:

obtaining a value of a printhead support deformation parameter;

comparing the value of the printhead support deformation parameter with a predetermined printhead support deformation parameter profile; and

determining, based on the comparison, that a pen-to-paper spacing compensation is to be performed.

2. The method of claim 1, wherein the determining that the pen-to-paper spacing compensation is to be performed comprises:

determining a dot placement deviation; and

comparing the dot placement deviation with a dot placement deviation reference.

3. The method of claim 2, wherein the predetermined printhead support deformation parameter profile comprises a plurality of predetermined values of the printhead support deformation parameter, each of them associated with a dot placement deviation.

4. The method of claim 3, wherein the comparing the value of the printhead support deformation parameter with the predetermined printhead support deformation parameter profile comprises identifying, based on the obtained value of the printhead support deformation parameter, a predetermined value of the plurality of predetermined values of the printhead support deformation parameter.

5. The method of claim 4, wherein the determining the dot placement deviation comprises retrieving the dot placement deviation associated with the identified predetermined value of the plurality of predetermined values of the printhead support deformation parameter.

6. The method of claim 1, wherein the printhead support deformation parameter comprises a pen-to-paper spacing, a printhead support temperature and/or a printhead support temperature exposure.

7. The method of claim 1, comprising obtaining the predetermined printhead support deformation parameter profile from a storage medium.

8. The method of claim 7, comprising generating the predetermined printhead support deformation parameter profile and storing the generated predetermined printhead support deformation parameter profile in the storage medium.

9. The method of claim 1, comprising performing the pen-to-paper spacing compensation.

10. The method of claim 9, wherein the performing the pen-to-paper spacing compensation comprises controlling a print agent ejection from a nozzle of a printhead supported by the printhead support.

11. A system comprising:

a printhead to deliver print agent onto a printing substrate to place dots on the printing substrate;

a printhead support supporting the printhead;

a heater to heat print agent on the printing substrate;

a sensor to measure a value of a printhead support deformation parameter; and

a controller to:

obtain, from the sensor, the value of the printhead support deformation parameter;

compare the value of the printhead support deformation parameter with a predetermined printhead support deformation parameter profile; and

determine, based on the comparison, a dot placement deviation.

12. The system of claim 11, wherein the controller is to determine a pen-to-paper spacing compensation.

13. The system of claim 11, wherein the printhead support comprises a beam extending from an edge of the printing substrate to an opposite edge of the printing substrate in a direction substantially perpendicular to a printing substrate advance direction; and wherein the printhead is movable across the beam.

14. A non-transitory machine-readable storage medium encoded with instructions which, when executed by a processor, cause the processor to:

receive a value of a printhead support deformation parameter;

obtain, from a storage medium, a predetermined printhead support deformation parameter profile, wherein the predetermined printhead support deformation parameter profile comprises a plurality of predetermined values of the printhead support deformation parameter, each of the predetermined values associated with a dot placement deviation;

compare the value of the printhead support deformation parameter with the predetermined printhead support deformation parameter profile;

identify a predetermined value of the plurality of predetermined values of the printhead support deformation parameter; and

determine, based on the identify the predetermined value of the plurality of predetermined values of the printhead support deformation parameter, a pen-to-paper spacing compensation.

15. The non-transitory machine-readable storage medium of claim 14 encoded with instructions which, when executed by the processor, cause the processor to:

operate, based on the pen-to-paper spacing compensation, a printhead mounted on a printhead support.

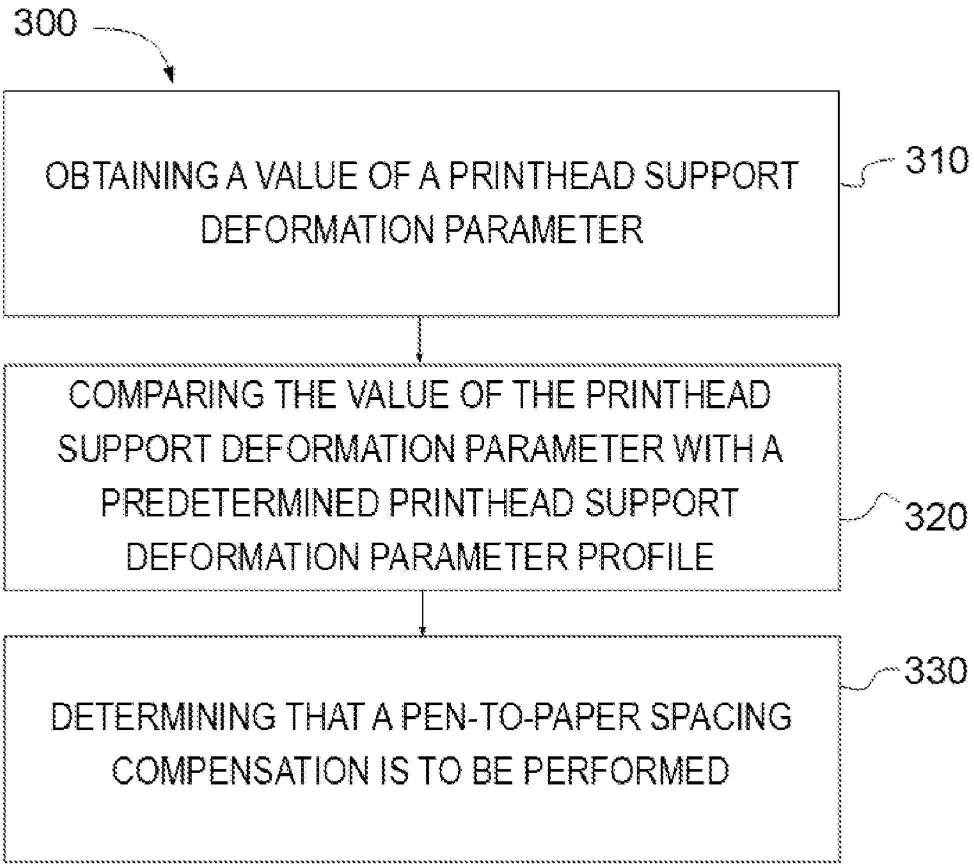

300
OBTAINING A VALUE OF A PRINTHEAD SUPPORT DEFORMATION PARAMETER
310
COMPARING THE VALUE OF THE PRINTHEAD SUPPORT DEFORMATION PARAMETER WITH A PREDETERMINED PRINTHEAD SUPPORT DEFORMATION PARAMETER PROFILE
320
DETERMINING THAT A PEN-TO-PAPER SPACING COMPENSATION IS TO BE PERFORMED
330

FIG. 1

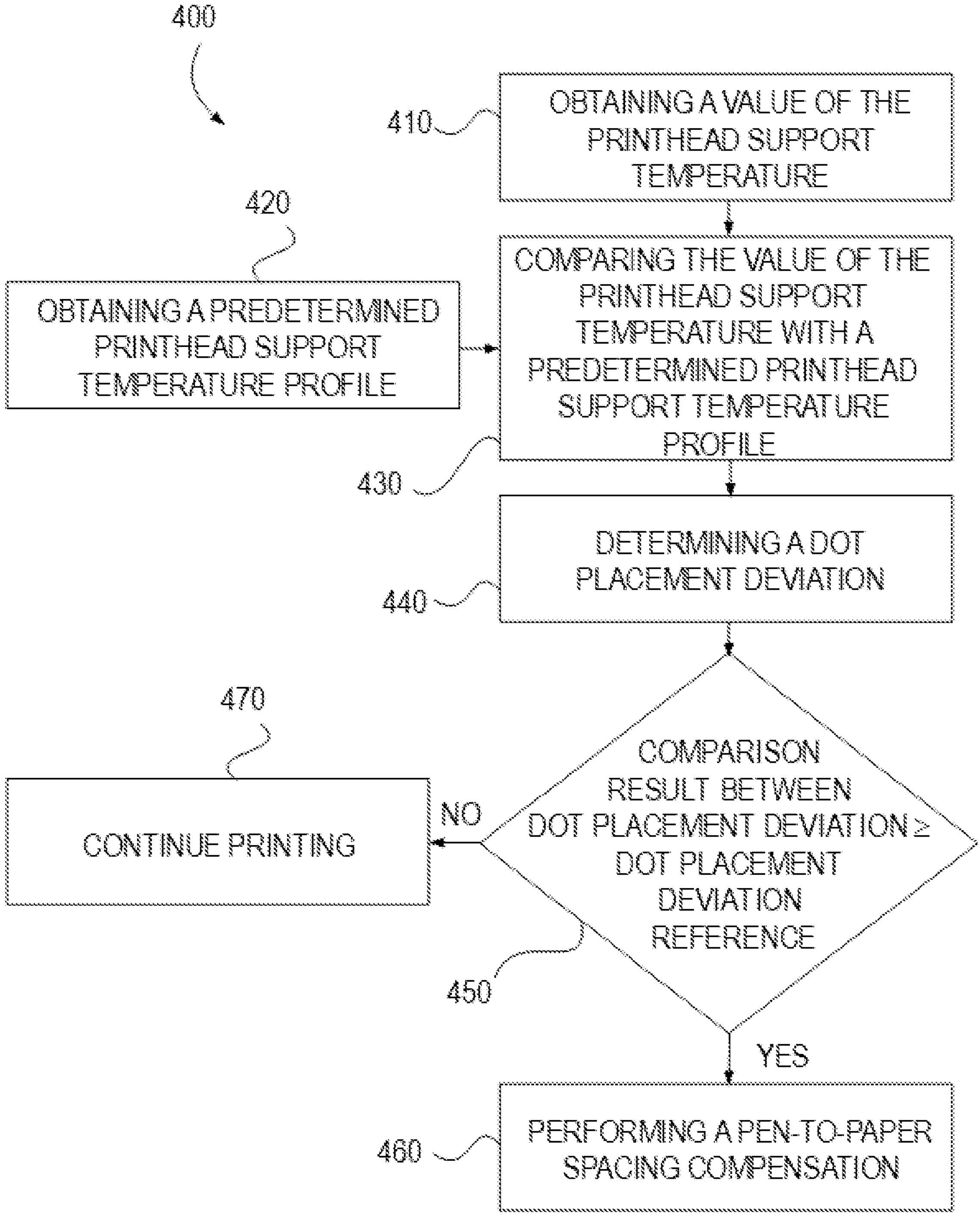
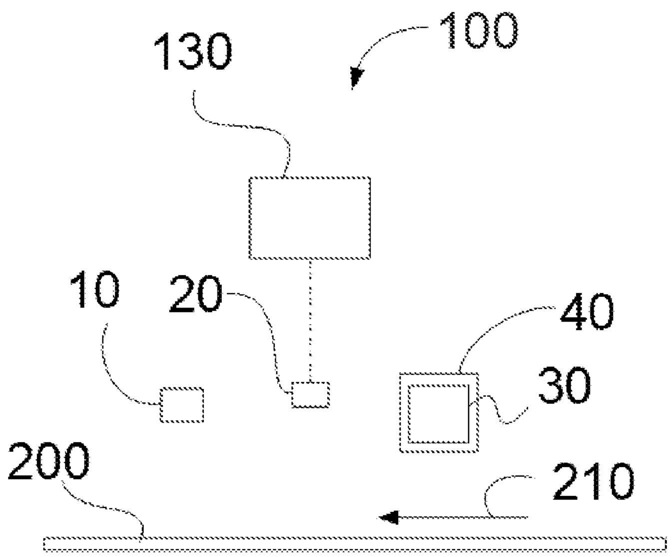
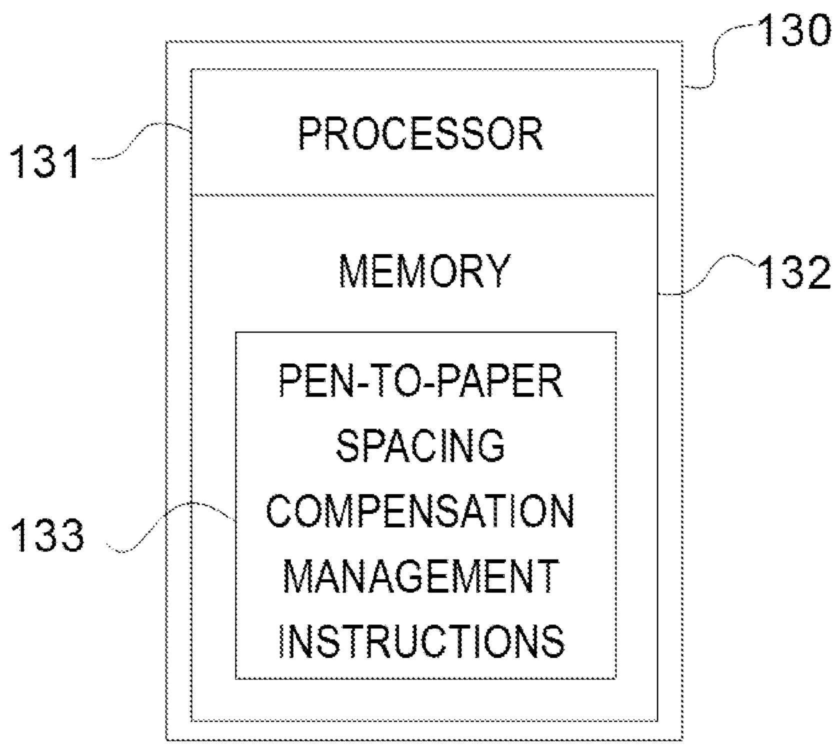

400
410
OBTAINING A VALUE OF THE PRINTHEAD SUPPORT TEMPERATURE
420
OBTAINING A PREDETERMINED PRINTHEAD SUPPORT TEMPERATURE PROFILE
COMPARING THE VALUE OF THE PRINTHEAD SUPPORT TEMPERATURE WITH A PREDETERMINED PRINTHEAD SUPPORT TEMPERATURE PROFILE
430
DETERMINING A DOT PLACEMENT DEVIATION
440
470
CONTINUE PRINTING
NO
COMPARISON RESULT BETWEEN DOT PLACEMENT DEVIATION ≥ DOT PLACEMENT DEVIATION REFERENCE
450
YES
PERFORMING A PEN-TO-PAPER SPACING COMPENSATION
460

FIG. 2



100
130
10
20
40
30
200
210

FIG. 3



130
131
PROCESSOR
MEMORY
132
133
PEN-TO-PAPER SPACING COMPENSATION MANAGEMENT INSTRUCTIONS

FIG. 4

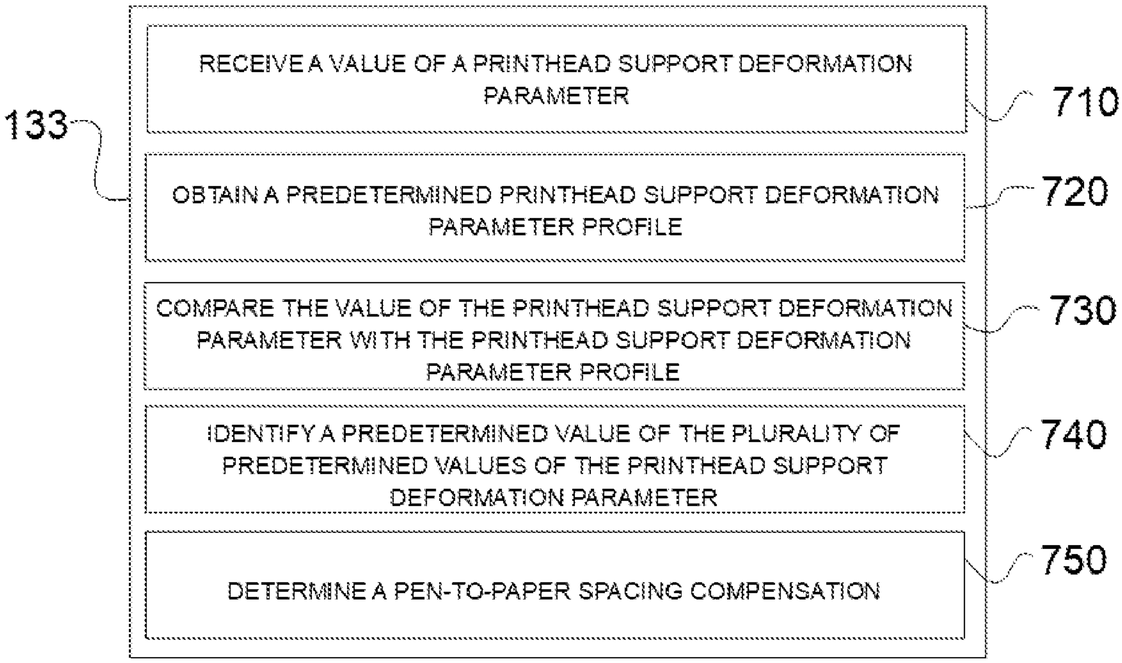

133
RECEIVE A VALUE OF A PRINTHEAD SUPPORT DEFORMATION PARAMETER
710
OBTAIN A PREDETERMINED PRINTHEAD SUPPORT DEFORMATION PARAMETER PROFILE
720
COMPARE THE VALUE OF THE PRINTHEAD SUPPORT DEFORMATION PARAMETER WITH THE PRINTHEAD SUPPORT DEFORMATION PARAMETER PROFILE
730
IDENTIFY A PREDETERMINED VALUE OF THE PLURALITY OF PREDETERMINED VALUES OF THE PRINTHEAD SUPPORT DEFORMATION PARAMETER
740
DETERMINE A PEN-TO-PAPER SPACING COMPENSATION
750

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/030137

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41J19/00 B41J11/00 B41J2/21
ADD.

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)
B41J

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2016 182695 A (SEIKO EPSON CORP) 20 October 2016 (2016-10-20) the whole document -----	1,7 2-6,8-15
X	JP 2011 161911 A (SEIKO I INFOTECH INC) 25 August 2011 (2011-08-25) the whole document -----	1-15
A	US 2009/058895 A1 (KIDA AKIRA [JP]) 5 March 2009 (2009-03-05) the whole document -----	1
A	US 2009/051715 A1 (VERHOEST BART [BE] ET AL) 26 February 2009 (2009-02-26) the whole document -----	1
	-/--	

[x] Further documents are listed in the continuation of Box C.

[x] 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

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"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	Date of mailing of the international search report
8 December 2022	19/12/2022

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hartmann, Mathias

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/030137

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2021/347188 A1 (GONZALEZ PERELLO DANIEL [ES] ET AL) 11 November 2021 (2021-11-11) the whole document -----	1
A	US 2020/369053 A1 (KISHI HIDEHITO [JP]) 26 November 2020 (2020-11-26) the whole document -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2022/030137

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2016182695 A	20-10-2016	NONE	
JP 2011161911 A	25-08-2011	JP 5553710 B2	16-07-2014
		JP 2011161911 A	25-08-2011
US 2009058895 A1	05-03-2009	JP 5159212 B2	06-03-2013
		JP 2009051092 A	12-03-2009
		US 2009058895 A1	05-03-2009
US 2009051715 A1	26-02-2009	CN 101171138 A	30-04-2008
		EP 1721753 A2	15-11-2006
		US 2009051715 A1	26-02-2009
		WO 2006120167 A2	16-11-2006
US 2021347188 A1	11-11-2021	CN 113348090 A	03-09-2021
		EP 3877188 A1	15-09-2021
		US 2021347188 A1	11-11-2021
		WO 2020159475 A1	06-08-2020
US 2020369053 A1	26-11-2020	JP 2020189458 A	26-11-2020
		US 2020369053 A1	26-11-2020