(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
07 January 2021 (07.01.2021)

WIPO | PCT

(10) International Publication Number
WO 2021/003239 A1

(51) International Patent Classification:
B05C 5/02 (2006.01) *B05C 11/10* (2006.01)

(21) International Application Number:
PCT/US2020/040450

(22) International Filing Date:
01 July 2020 (01.07.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/870,164 03 July 2019 (03.07.2019) US

(71) Applicant: **NORDSON CORPORATION** [US/US]; 28601 Clemens Road, Westlake, OH 44145-1119 (US).

(72) Inventors: **QIU, Zhongquan**; 811 Dongchuan Rd., No. 115, Room 202, Minhang District, 200240 (CN). **CUI, Jian**; 811 DongChuan Rd., No. 115, Room 202, Minhang District, 200240 (CN).

(74) Agent: **BROWN, Craig, M.**; Baker & Hostetler LLP, 2929 Arch Street, Cira Centre, 12th Floor, Philadelphia, PA 19104-2891 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

(54) Title: FLUID DISPENSER WITH FOUR DEGREES OF FREEDOM

(57) Abstract: A fluid dispensing system, and associated methods, to dispense a viscous fluid onto a workpiece is disclosed. The fluid dispensing system has a working plate configured to support the workpiece. The fluid dispensing system also includes a dispenser disposed above the workpiece that dispenses the fluid on the workpiece, and a gantry positioning system that supports the dispenser. The gantry positioning system provides x, y, and z movements to move the dispenser, and C axis movement to rotate the dispenser. The fluid dispensing system also includes a controller to control the dispenser and the gantry positioning system.

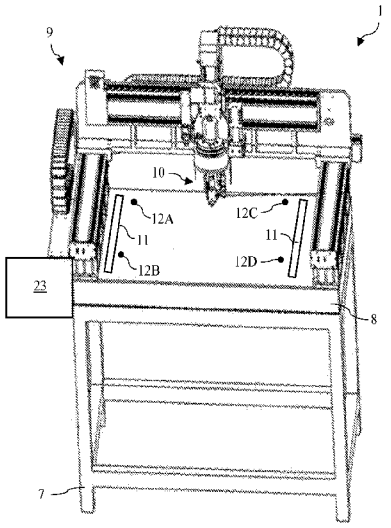


FIG. 1

WO 2021/003239 A1

[Continued on next page]

Published:
— *with international search report (Art. 21(3))*

FLUID DISPENSER WITH FOUR DEGREES OF FREEDOM

Cross Reference to Related Applications

[0001] This application claims priority to U.S. Provisional Patent Application No. 62/870,164 filed July 3, 2019, the entire disclosure of which is hereby incorporated by reference as if set forth in its entirety herein.

Technical Field

[0002] This disclosure generally relates to fluid dispensing systems and methods for applying a material to a workpiece and, more particularly to a fluid dispenser having four degrees of freedom.

Background

[0003] In the garment manufacturing field, fluid dispensing systems are commonly used to apply a material, such as a polyurethane (PUR) adhesive, to a fabric or cloth for binding pieces of the fabric or cloth together. When bonding pieces of fabric together, a fluid dispensing system needs to have the ability to spray a small amount of a material with a high degree of accuracy and precision. For example, the width of the desired strip of material to be applied to a fabric can have requirements of less than 8 mm in width and less than 0.2 mm in height. Current fluid dispensing systems do not adequately dispense certain dispense patterns common in the garment manufacturing field, such as curved dispense patterns.

[0004] Another issue with current fluid dispensing systems is material spray. Material is sprayed with low levels of accuracy and precision, which can result in the spraying of excessive amounts of material. In addition, in many conventional fluid dispensing systems, material will continue to flow out of the applicator system for some time after the spraying operation has completed due to the effects of gravity. Due to the fact that during a conventional fabric bonding process an operator needs to repeatedly start and stop the applicator system, material will constantly flow out of the applicator system, leading to big ends, silk drawing, and other defects.

[0005] Therefore, there is a need for a fluid dispensing system that adequately dispenses dispense patterns common to the garment manufacturing filed, such as curved dispense patterns. Further, there exists a need for a fluid dispensing system that accurately sprays material and minimizes continued flowing of material out of the applicator system during a nonoperational state due to gravity.

Summary of Invention

[0006] An embodiment of the present invention includes a method of dispensing fluid on a workpiece using a fluid dispensing system. The method includes positioning the workpiece on a working plate of the fluid dispensing system. The method also includes aligning a dispenser of the fluid dispensing system in an XY plane located a dispense height above a first dispense location of a dispense region of the workpiece. The XY plane defined by an X axis and a Y axis orthogonal to the X axis. Aligning the dispenser including providing x, y, and z movements, via a gantry positioning system of the fluid dispensing system, so as to move the dispenser from a pre-dispense position to the first dispense location, x movement being movement of the dispenser parallel to the X axis, y movement being movement of the dispenser parallel to the Y axis, and z movement being movement of the dispenser parallel to a Z axis, which is orthogonal to each of the X axis and the Y axis. The method further includes dispensing fluid from the dispenser at the first dispense location, and forming a dispense pattern on the dispense region of the workpiece. Forming a dispense pattern including providing x, y, and C axis movements, via the gantry positioning system, so as to move the dispenser from the first dispense position to each of a plurality of dispense locations of the dispense region and dispensing fluid from the dispenser at each of the plurality of dispense locations, C axis movement being rotational movement of the dispenser about a central axis of the dispenser.

[0007] Another embodiment of the present invention includes a fluid dispensing system configured to dispense a fluid onto a workpiece. The fluid dispensing system including a working plate configured to support the workpiece, and a dispenser disposed above the workpiece and configured to dispense the fluid on the workpiece. The fluid dispensing system further including a gantry positioning system that supports the dispenser. The gantry positioning system is configured to provide: x, y, and z movements to move the dispenser, x movement being movement of the dispenser parallel to an X axis, y movement being movement of the dispenser parallel to a Y axis orthogonal to the X axis, and z movement being movement of the dispenser parallel to a Z axis, which is orthogonal to each of the X axis and the Y axis, and C axis movement to rotate the dispenser, C axis movement being rotational movement of the dispenser about a central axis of the dispenser. The fluid dispensing system further including a controller that is configured to control the dispenser and the gantry positioning system.

[0008] Various additional features and advantages of the invention will become more

apparent to those of ordinary skill in the art upon review of the following detailed description of the illustrative embodiments taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

[0009] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the invention.

[0010] FIG. 1 shows a perspective view of a fluid dispensing system in accordance with aspects of the invention.

[0011] FIG. 2 shows a perspective view of a gantry positioning system of the fluid dispensing system in accordance with aspects of the invention.

[0012] FIG. 3 shows a top view of the gantry positioning system depicted in FIG. 2.

[0013] FIG. 4 is a perspective view of a dispenser embodiment in accordance with aspects of the invention.

[0014] FIG. 5 is a cross-sectional view of the dispenser shown in FIG. 4, taken along line 3-3 shown in FIG. 4.

[0015] FIG. 6 is a cross-sectional view of the dispenser shown in FIG. 4, taken along line 4-4 shown in FIG. 4.

[0016] FIG. 7 is an isometric view of another dispenser according to aspects of the present invention.

[0017] FIG. 8 is a cross-sectional view of a portion of the dispenser of FIG. 7 according to aspects of the present invention.

[0018] FIG. 9 is a perspective view of the yet another dispenser according to aspects of the present invention.

[0019] FIG. 10 is a cross-sectional view of the dispenser in FIG. 9, taken along line 2-2 shown in FIG. 9.

[0020] FIG. 11 shows an exemplary method of dispensing at a dispense region of the workpiece in accordance with aspects of the present invention.

[0021] FIG. 12 illustrates an exemplary workpiece having a curved dispense region.

Detailed Description

[0022] FIGS. 1-3 illustrate views of an embodiment of a fluid dispensing system 1 in accordance with aspects of the invention. FIG. 1 shows a perspective view of the fluid dispensing system 1 for dispensing viscous fluids at a plurality of dispense regions. FIG. 2 shows a perspective view of a gantry positioning system 9 of the fluid dispensing system 1, and FIG. 3 shows a top view of the gantry positioning system 9. The fluid dispensing system 1 may be particularly adapted for dispensing fluid at dispense regions on a workpiece, which may be a fabric or cloth, as a part of an assembly of the fabric or cloth into a garment or item of clothing. For example, the workpiece may be polyester, nylon, and/or cotton-based compound textiles that are relatively flexible and stretchable. The fluid may be a viscous fluid. In some embodiments, the fluid may be an adhesive, such as polyurethane (PUR) adhesive (i.e., hot melt adhesive), though other materials are contemplated. The fluid dispensing system 1 may be adapted to dispense on any desired number of workpieces arranged in any desired configuration. Alternatively, multiple dispense regions may be distinct regions of a workpiece, as described in detail herein.

[0023] Referring to FIG. 1, the fluid dispensing system 1 may include a frame 7, a working plate 8, the gantry positioning system 9, and a dispenser 10. The frame 7 may support any of the working plate 8, the workpiece, the gantry positioning system 9, and the dispenser 10. Unless explicitly stated to the contrary, the term "support" as used herein may include either direct or indirect support. The frame 7 may be a support table.

[0024] The working plate 8 may support any of the workpiece, the gantry positioning system 9, and the dispenser 10. For example, the working plate 8 may directly support each of the workpiece and the gantry positioning system 9, and may indirectly support the dispenser 10. The working plate 8 may be a flat surface, and the flat surface may include a surface finish. The working plate 8 may include a fixture 11 (e.g., one more clamps) to fix the workpiece to the working plate 8 for the dispense operation. The fixture 11 may be adjustable to accommodate workpieces of varying size and/or shape. According to one or more of the aforementioned aspects of the working plate 8, the working plate 8 may support flexible workpieces, such as fabric or cloth, during dispense operations. The working plate 8 may include one or more fixed positions 12A, 12B, 12C, 12D. As described below, the fixed positions 12A, 12B, 12C, 12D may be used to properly orient the workpiece to ensure accurate dispensing. The working plate 8 may be stationary. Alternatively, the working plate

8 may be integrated into a carrier system (not shown) that may convey the working plate 8 and a workpiece through the fluid dispensing system 1.

[0025] The gantry positioning system 9 defines a global origin O and three mutually orthogonal global axes X, Y, and Z. The gantry positioning system 9 may be a Cartesian robotic platform having a 4-axis workstation. The gantry positioning system 9 is configured to move the dispenser 10 in directions parallel to the global X, Y, and Z axes, denoted generally by x, y, and z, respectively, and corresponding directional arrows. "x movement," i.e., movement in the x directions, may include any movement parallel to the X axis. "y movement," i.e., movement in the y directions, may include any movement parallel to the Y axis. "z movement," i.e., movement in the z directions, may include any movement parallel to the Z axis.

[0026] The gantry positioning system 9 is further configured to rotate the dispenser 10 about a central axis C of the dispenser 10, which is parallel to the global Z axis, as depicted by arcuate directional arrows in FIGS. 2 and 3. That is, the gantry positioning system 9 is configured to provide "C axis movement" to rotate the dispenser 10; C axis movement being rotational movement of the dispenser 10 about the central axis C of the dispenser 10. The dispenser 10 may rotate a full 360 degrees about the central axis C. The dispenser 10 may rotate in any of clockwise and clockwise directions.

[0027] Accordingly, the gantry positioning system 9 may movably support the dispenser 10 such that the dispenser 10 has four degrees of freedom. That is, the gantry positioning system 9 may move the dispenser 10 in any of the x, y, and z directions and may further rotate the dispenser 10 about the central axis C. Further, the dispenser 10 may dispense fluid while being moved in any of the x, y, and z directions, and/or while rotated about the central axis C. As a result of the four degrees of freedom of movement of the dispenser 10 provided by the gantry positioning system 9, the fluid dispensing system 1 may more accurately, reliably, and efficiently dispense a diverse set of dispensing patterns, including for example curved dispense patterns. The fluid dispensing system 1 may also dispense straight line patterns.

[0028] The gantry positioning system 9 includes a first x support 13A and a second x support 13B. The first and second x supports 13A, 13B are each aligned parallel with the X axis and shown generally as longitudinal beams. The first and second x supports 13A, 13B may each be mounted to the working plate 8. Alternatively, the first and second x supports 13A, 13B may each be mounted to the frame 7, with the working plate 8 disposed

therebetween. The first and second x supports 13A, 13B are each respectively provided with first and second x bearings 14A, 14B, shown as linear bearings, for enabling x linear movement of the dispenser 10 parallel to the X axis. The first and second x bearings 14A, 14B are aligned parallel to the X axis.

[0029] The gantry positioning system 9 further includes a transversely oriented y support 15 aligned parallel with the Y axis and shown generally as a lateral beam or cross beam. The y support 15 is provided with a y bearing 16, shown as a linear bearing, for enabling y linear movement of the dispenser 10 parallel to the Y axis. The y bearing 16 is aligned parallel to the Y axis. The y support 15 is movably coupled to the first and second x supports 13A, 13B so as to engage with and slide along each of the first and second x bearings 14A, 14B for x movement. That is, the y support 15 is slidably arranged on the first and second x bearings 14A, 14B. For example, the y support 15 may include head clamps that movably couple the y support 15 to the first and second x supports 13A, 13B.

[0030] The gantry positioning system 9 further includes a y carriage 17 having a first YZ side (i.e., a side extending in a YZ plane) that engages and is slidable along the y bearing 16 for y movement. The y carriage 17 has a second YZ side to which is attached a vertically oriented z bearing 18, shown as a linear bearing, for enabling z linear movement of the dispenser 10 in a direction parallel to the Z axis. The z bearing 18 is arranged parallel to the Z axis.

[0031] The gantry positioning system 9 further includes a z carriage 19 having a first YZ side that engages and is slidable along the z bearing 18 for z movement. That is, the z carriage 19 is slidably arranged on the z bearing 18. The z carriage 19 has a second YZ side to which a horizontally oriented rotatable bearing 20 may be provided on or attached to. The dispenser 10 may be rotatably supported by the rotatable bearing 20 above the working plate 8.

[0032] The fluid dispensing system 1 may further include a camera 21 for identifying reference fiducials 22A, 22B, 22C, 22D, 22E of the workpiece. The fluid dispensing system 1 may identify the location and orientation of each workpiece in an XY plane relative to a global origin O, based on the positions of reference fiducials 22A, 22B, 22C, 22D, 22E. For example, with reference to the workpiece W shown in FIG. 12 (discussed below), the reference fiducials 22A, 22B, 22C, 22D, 22E may be provided at predetermined locations about the workpiece. While shown herein as an "x" enclosed by a circle, the fiducials may be any identifiable mark such as a letter, number, dot, or pattern, for example. The fiducials may

be removable after dispensing is complete. In this manner, the fluid dispensing system 1 may determine whether each workpiece is rotated and/or translated in the XY plane relative to a corresponding reference position defined with respect to origin O.

[0033] The camera 21 may be mounted to the gantry positioning system 9 at any suitable location, such as on the second YZ side of the z carriage 19, as shown in FIGS. 2 and 3. For fiducial identification, the gantry positioning system 9 may be controlled to move the camera 21 along a pre-programmed path based on expected locations of the fiducials in the XY plane. In one mode, the gantry positioning system 9 may be controlled to sequentially pause at the expected location of each fiducial so that the camera 21 may capture a visual image of a fiducial during each pause. In another mode, the gantry positioning system 9 may be controlled to continuously move and the camera 21 may capture visual images of the fiducials during movement. Based on the images of the fiducials captured by the camera 21, a controller 23 (described below) may determine the actual position the workpiece in the XY plane.

[0034] Movement of the dispenser 10 may be accomplished through a series of controllable, powered drive mechanisms, or drives, of the gantry positioning system 9. More specifically, each direction of movement x, y, z, and rotation about the central axis C, may be powered by at least one corresponding powered drive mechanism. As shown, first and second x drive mechanisms 24A, 24B, or drives, may operate in parallel to power x movement along the first and second x bearings 14A, 14B, respectively, and may be provided internally within or adjacent to the first and second x bearings 14A, 14B, respectively. Alternatively, x movement may be powered by a single drive mechanism (not shown). For example, the first and second x drives 24A, 24B may drive the y support 15 along the first and second x bearings 14A, 14B to provide x movement for the y support 15 and other structures attached thereto. A y drive mechanism 25, or drive, may power y movement along the y bearing 16 and may be provided internally within or adjacent to the y bearing 16, as shown. For example, the y drive 25 may drive the y carriage 17 along the y bearing 16 to provide the y movement of the y carriage 17 and other structures attached thereto. A z drive mechanism 26, or drive, may power z movement along the z bearing 18 and may be provided adjacent to the z bearing 18, as shown. For example, the z drive 26 may drive the z carriage 19 along the z bearing 18 to provide the z movement of the z carriage 19 and structures attached thereto. A C drive mechanism 27, or drive, may power rotational movement about the central C axis and may be provided internally within or adjacent to the rotatable bearing 20. The C drive 27 may

drive the dispenser 10 to provide C axis movement. That is, the C drive 27 may be supported by the rotatable bearing 20 so as to move together with the rotatable bearing 20 in any of the x, y, and z directions.

[0035] In one embodiment, the drive mechanisms may include stepper motors. Alternatively, the drive mechanisms may include any other suitable electric, pneumatic, or hydraulic drive adapted to movement with a high degree of accuracy, repeatability, and stability. The drive mechanisms may include any additional mechanical drive elements suitable for moving the dispenser 10. For example, the C drive 27 may include a motor 28 that drives a pulley system 29 (including, e.g., one or more pulleys and a belt) that is attached to the dispenser 10. In an embodiment (not shown) the x, y, z drive mechanisms 24A, 24B, 25, 26 may include stepper motors each having an output shaft connected with a flexible drive coupling to a lead screw. The lead screw may rotate with the motor and engage a threaded or toothed element mounted on a corresponding support to actuate movement along a corresponding linear bearing. The drive mechanisms may be mounted at any suitable locations within the fluid dispensing system 1 different from those shown and described herein. First and second wire bundles 30A, 30B may provide power to one or more of, e.g., the dispenser 10 and the drive mechanisms to control operation thereof.

[0036] The fluid dispensing system 1 may further include a height sensor for performing height sensing operations, which includes measuring the position of the workpiece along the Z axis, relative to the XY plane. The height sensor may be a non-contact laser sensor, or alternatively may be a contact mechanical sensor. The height sensor may, for example, be integrated into the unit that houses the camera 21. In operation, the gantry positioning system 9 may be controlled to move the height sensor along a pre-programmed path for measuring the position of the workpiece along the Z axis. These measurements, referred to herein as Z height measurements, enable the controller 23 to determine a proper height along the Z axis, referred to as a dispense height, to which the dispenser 10 should be lowered for dispensing fluid onto the workpiece. In this manner, the fluid dispensing system 1 may ensure a proper dispense gap between the dispenser 10 and the corresponding workpiece while dispensing.

[0037] The gantry positioning system 9, the dispenser 10, the camera 21, etc. are controllable with at least one controller 23, such as a computer. Preferably, the controller 23 is configured to instruct the x, y, z, movements, as well as rotation about the central axis C, of the dispenser 10 by controlling the drive mechanisms of the gantry positioning system 9. In

this manner, the gantry positioning system 9 is controllable such that the dispenser 10 may be properly positioned relative to and dispense at dispense regions of the workpiece.

[0038] The dispenser 10 may be any dispenser suitable for dispensing the fluid on the workpiece. For example, as shown in FIGS. 4-6, the fluid dispensing system 1 may be provided with a first, slotted nozzle type dispenser 1010. The dispenser 1010 may include a material supply 1012, a pump 1016, and a slotted nozzle assembly 1100a for applying the fluid to the workpiece. Certain terminology may be used to describe the dispenser embodiments (i.e., the dispensers 1010, 2010, 3010) in the following description for convenience only and is not limiting. The words "right", "left", "lower," and "upper" designate directions in the drawings to which reference is made. The words "inner" and "outer" refer to directions toward and away from, respectively, the geometric center of the respective dispenser embodiment. The words “forward” and “rearward” refer to directions in a longitudinal direction 2 and a direction opposite the longitudinal direction 2 along the dispenser 1010 and related parts thereof. The terminology includes the above-listed words, derivatives thereof and words of similar import.

[0039] Unless otherwise specified herein, the terms “longitudinal,” “lateral,” and “vertical” are used to describe the orthogonal directional components of various components of the dispenser 1010, as designated by the longitudinal direction 2 (corresponding the y direction), lateral direction 4 (corresponding to the x direction), and vertical direction 6 (corresponding to the z direction). It should be appreciated that while the longitudinal and lateral directions 2, 4 are illustrated as extending along a horizontal plane, and the vertical direction 6 is illustrated as extending along a vertical plane, the planes that encompass the various directions may differ during use.

[0040] Referring to FIGS. 4-6, the dispenser 1010 includes a material supply 1012 for storing a supply of the fluid. In the depicted embodiment, the material supply 1012 defines a cavity 1015 for receiving a prepackaged syringe 1017 that contains a supply of the fluid. However, other embodiments for supplying the material supply 1012 with fluid are contemplated, such as directly filling the material supply 1012 with a volume of the fluid or pumping fluid to the material supply 1012 from an external supply (not shown) that is spaced from the dispenser 1010. The material supply 1012 can be configured to melt and/or maintain the fluid at an elevated temperature while it remains within the material supply 1012. In some embodiments, the material supply 1012 can be designed to hold up to 300 milliliters (ml) of fluid, though the material supply 1012 can be larger or smaller as desired. For example, the

material supply 1012 can also be designed to hold 30 ml of fluid. The material supply 1012 can include a heating element (not shown) to provide heat to the fluid within the material supply 1012, or, alternatively, to maintain a desired temperature within the material supply 1012. This prevents the fluid from cooling when it is being dispensed, thus preserving the desired flow properties. In some embodiments, the dispenser 1010 may include a second heating element (not shown) that is configured to maintain the fluid at a different temperature than the heating element described above. Further, the material supply 1012 can include a cap 1013 for securing the syringe 1017 within the cavity 1015, where the cap 1013 defines a passage 1014 extending therethrough. The passage 1014 can be connected to an external pressurized air source (not shown) that is configured to apply pressure to the fluid within the cavity 1015 for pumping the fluid out of the material supply 1012.

[0041] The material supply 1012 further includes a fluid channel 1021 that extends from the cavity 1015 to a fluid outlet 1022. The fluid outlet 1022 is configured to provide the fluid to an inlet 1026a of the pump 1016, as will be described below. A check valve 1023 can be disposed in the fluid channel 1021 between the cavity 1015 and the fluid outlet 1022 to prevent fluid that has flowed past the check valve 1023 from returning to the cavity 1015. This prevents the contamination of new fluid disposed in the cavity 1015 after an old supply of fluid has been replaced. Though shown the check valve 1023 may be a ball-type check valve, other conventional types of check valves can alternatively be incorporated.

[0042] The dispenser 1010 also includes the pump 1016 releasably attached to the material supply 1012 and fluidly connected to the material supply 1012. The pump 1016 can include a pump body assembly 1032 comprising a pump body 1032b, a cap 1032a attached to the upper end of the pump body 1032b, and a nozzle body 1032c attached to the lower end of the pump body 1032b. It will be understood that the pump 1016 can alternatively define a monolithic body or have any other number of components. The pump body 1032b can define the portion of the pump body assembly 1032 that directly connects to the material supply 1012, though other arrangements are contemplated.

[0043] The pump body assembly 1032 can define several hollow portions. For example, the pump body 1032b and the nozzle body 1032c of the pump body assembly 1032 can collectively define a fluid channel 1026 that extends from the inlet 1026a to an outlet 1026b. The fluid channel 1026 is configured to receive fluid from the material supply 1012 through the inlet 1026a and provide the fluid to the nozzle assembly 1100a through the outlet 1026b, as will be described further below. Additionally, the pump body 1032b and the nozzle

body 1032c can collectively define an upper chamber 1036 and a lower chamber 1038. Upper and lower seal packs 1040a, 1040b are positioned within the pump body assembly 1032 to separate the upper and lower chambers 1036, 1038.

[0044] The pump 1016 also includes a valve member 1048 positioned within the pump body assembly 1032. The valve member 1048 defines an upper end 1048a and a valve stem 1048b that extends from the upper end 1048a along the vertical direction 6. The upper end 1048a is positioned within the upper chamber 1036, while the valve stem 1048b extends from the upper end 1048a through the upper chamber 1036, through the upper and lower seal packs 1040a, 40b, and into the lower chamber 1038, which can define a portion of the fluid channel 1026. The valve member 1048 is configured to be movably disposed within the upper and lower chambers 1036, 38, and thus the fluid channel 1026. The upper and lower seal packs 1040a, 40b are configured to prevent fluid migration from the lower chamber 1038 to the upper chamber 1036 and pressurized air migration from the upper chamber 1036 to the lower chamber 1038. A valve seat (not shown) is disposed at the lower end of the lower chamber 1038 and is defined by the nozzle body 1032c. In operation, the valve member 1048 is configured to reciprocate within the pump body assembly 1032 between a first, retracted position and a second, extended position. In the retracted position, the valve stem 1048b is spaced in an entirety from the valve seat 1054, allowing fluid to flow past the valve stem 1048b and the valve seat 1054 and to the outlet 1026b of the fluid channel 1026. In the extended position, the valve stem 1048b contacts the valve seat 1054 and the fluid is blocked from flowing to the outlet 1026b of the fluid channel 1026. As such, the valve member 1048 is configured to selectively block the flow of fluid through the fluid channel 1026.

[0045] The translation of the valve member 1048 can be caused by pressurized air that flows into the upper chamber 1036 through first and second air paths 1052a, 1052b of a connector 1024. Each of first and second air paths 1052a, 1052b can receive pressurized air from a valve 1020, which is connected to the pump 1016 through the connector 1024. The valve 1020 can be a pneumatic valve, an electronic valve, or any other type of valve as desired. The valve 1020 can be connected to and receive the pressurized air from a pressurized air source 1025, such that the valve functions to control the flow of air from the pressurized air source 1025 to the pump 1016. The upper end 1048a of the valve member 1048 divides the upper chamber 1036 into first and second portions 1036a, 1036b, where the first portion 1036a can receive pressurized air from the first air path 1052a, and the second portion 1036b can receive pressurized air from the second air path 1052b. Specifically, the

first portion 1036a can be defined between the cap 1032a and the upper end 1048a of the valve member 1048, and the second portion 1036b can be defined between the upper end 1048a of the valve member 1048 and the pump body 1032b. When pressurized air flows through the first air path 1052a and into the first portion 1036a of the upper chamber 1036, the valve member 1048 is driven downwards along the vertical direction 6 into the extended position. In contrast, when pressurized air flows through the second air path 1052b and into the second portion 1036b of the upper chamber 1036, the valve member 1048 is driven upwards along the vertical direction 6 into the retracted position.

[0046] When the valve member 1048 transitions from the retracted position to the extended position along the vertical direction 6, the valve member 1048 travels a distance that can be referred to as the stroke length. The required stroke length can vary between dispensing operations, types of materials dispensed, wear of internal parts over time, etc. In one embodiment of the pump 1016, the stroke length can be adjusted using a limiting rod (not shown) that extends through the cap 1032a of the pump body assembly 1032 and into the first portion 1036a of the upper chamber 1036. When the valve member 1048 is in the retracted position, the upper end 1048a can contact the lower end of the limiting rod, such that the limiting rod controls the how far upwards the valve member 1048 moves in the retracted position. The limiting rod can threadedly engage the cap 1032a, such that rotation of the limiting rod relative to the cap 1032a moves the limiting rod further into or out of the upper chamber 1036, thus changing the maximum upward position of the valve member 1048 in the retracted position, and likewise the stroke length. However, other methods for adjusting the stroke length are also contemplated.

[0047] The fluid dispensing system 1 in accordance with other aspects of the invention may include a second, multi-dot nozzle type dispenser 2010. Referring to FIGS. 7 and 8, the dispenser 2010 includes a material supply 2012 for storing a supply of the material. The material supply 2012 include any combination of the features of the material supply 1012, discussed above. The dispenser 2010 also includes a pump 2016 fluidly connected to the material supply 2012. The pump 2016 can include a body 2031 comprising a top component 2032a and a middle component 2032b attached to and positioned below the top component 2032a. It will be understood that the pump 2016 can alternatively define a monolithic body or have any other number of components. The body 2031 of the pump 2016 defines a substantially hollow body, such that an upper chamber 2036 and a lower chamber

2038 are defined within the body 2031. A seal pack 2040 is positioned within the body 2031 and divides the interior of the body 2031 into the upper and lower chambers 2036, 2038.

[0048] A nozzle 2100 can be removably coupled to the body 2031 and positioned, for example, below the middle component 2032b. The nozzle 2100 can be selected from a plurality of nozzles 2100 that are each configured to jet different patterns. In alternative embodiments, the nozzle 2100 can be part of the monolithic body 2031. The lower chamber 2038 may be disposed within the nozzle 2100. A valve seat 2104 is disposed at the lower end of the lower chamber 2038 and is defined by the nozzle 2100. A plurality of outlet channels 2108 are disposed adjacent to the valve seat 2104 and extend through the nozzle 2100. The plurality of outlet channels 2108 are in fluid communication with the lower chamber 2038.

[0049] The pump 2016 also includes a firing pin 2048 positioned within the body 2031. The firing pin 2048 defines an upper end 2048a and a valve stem 2048b that extends from the upper end 2048a along the vertical direction 6. The upper end 2048a is positioned within the upper chamber 2036, while the valve stem 2048b extends from the upper end 2048a through the upper chamber 2036, through the seal pack 2040, and into the lower chamber 2038.

[0050] In operation, the firing pin 2048 is configured to reciprocate within the body 2031 between a retracted and an extended position. This reciprocation can be caused by pressurized air that flows into the upper chamber 2036 through first and second air paths 2052a, 2052b. Each of first and second air paths 2052a, 2052b can receive pressurized air from a valve 2020, which is connected to the pump 2016 through connector (not shown). The valve 2020 can be a pneumatic valve, an electronic valve, or any other type of valve as desired. The upper end 2048a of the firing pin 2048 divides the upper chamber 2036 into first and second portions 2036a, 2036b, where the first portion 2036a can receive pressurized air from the first air path 2052a, and the second portion 2036b can receive pressurized air from the second air path 2052b. When pressurized air flows through the first air path 2052a and into the first portion 2036a of the upper chamber 2036, the firing pin 2048 is driven downwards along the vertical direction 6 into an extended position. In contrast, when pressurized air flows through the second air path 2052b and into the second portion 2036b of the upper chamber 2036, the firing pin 2048 is driven upwards along the vertical direction 6 into a retracted position.

[0051] Continuing with FIGS. 7 and 8, the pump 2016 includes a circumferential chamber 2054 defined between an outer surface of the nozzle 2100 and an inner surface of

the middle component 2032b. The circumferential chamber 2054 is fluidly connected to the material supply 2012, such that the circumferential chamber 2054 is configured to receive material from the material supply 2012 and allow the material to flow through the circumferential chamber 2054 to radial holes 2056 defined within the nozzle 2100. The material can then flow through the radial holes 2056 to the lower chamber 2038. In some embodiments, the radial holes 2056 comprise four radial holes spaced equidistantly circumferentially around the nozzle 2100. However, it is contemplated that the radial holes 2056 can comprise more or less holes, as well as holes having non-equidistant spacing.

[0052] When the firing pin 2048 is in the retracted position, the valve stem 2048b is spaced from the valve seat 2104 defined by the nozzle 2100. In this position, material flows through the circumferential chamber 2054, through the radial holes 2056, and into the lower chamber 2038. Then, when the firing pin 2048 is transitioned into the extended position, the valve stem 2048b of the firing pin 2048 moves rapidly downward along the vertical direction 6 through the lower chamber 2038 towards the valve seat 2104. During this transition, the firing pin 2048 causes an amount of the material within the lower chamber 2038 to be discharged through the outlet channels 2108. When in the extended position, the lower end of the valve stem 2048b may contact the valve seat 2104 and thus create a fluid seal between the lower chamber 2038 and each of the outlet channels 2108, or may be positioned slightly above the valve seat 2104.

[0053] When the firing pin 2048 transitions from the retracted position to the extended position along the vertical direction 6, the firing pin 2048 travels a distance that can be referred to as the stroke length. The required stroke length can vary between dispensing operations, types of materials dispensed, wear of internal parts over time, etc. As a result, the stroke length can be adjusted using the limiting rod 2044, which extends through the top component 2032a of the body 2031 and into the first portion 2036a of the upper chamber 2036. When the firing pin 2048 is in the retracted position, the upper end 2048a can contact the lower end of the limiting rod 2044, such that the limiting rod 2044 controls the how far upwards the firing pin 2048 moves in the retracted position. The limiting rod 2044 can threadedly engage the top component 2032a, such that rotation of the limiting rod 2044 relative to the top component 2032a moves the limiting rod 2044 further into or out of the

upper chamber 2036, thus changing the maximum upward position of the firing pin 2048 in the retracted position, and likewise the stroke length.

[0054] The nozzle 2100 may include three outlet channels 2108, although it will be understood that the nozzle 2100 may include another suitable number of outlet channels 2108, for example, one, two, four, five, or six outlet channels. For example, suitable nozzles 2100 may have a single outlet channel 2108, two outlet channels 2108, or more. Each of the outlet channels 2108 may be disposed at an angle from the vertical direction 6 between 0° and 90°. In some embodiments, some or all of the outlet channels 2108 may be parallel to one or more of the other outlet channels 2108 and may be disposed along the vertical direction 6. The specific angle of each of the outlet channels 2108 can depend on the size and/or shape of the valve seat 2104, the size and/or shape of the valve stem 2048b, the material that is being dispensed, on the desired distance between the droplets dispensed from each of the outlet channels 2108, or on other manufacturing requirements and/or preferences.

[0055] When the firing pin 2048 transitions from the retracted position to the extended position and then from the extended position back to the retracted position, this can be referred to as a stroke. With each stroke, the material within the lower chamber 2038 of the nozzle 2100 is moved through the outlet channels 2108. The firing pin 2048 is configured to impact the valve seat 2104, such that a discrete volume of the material is forcefully ejected (i.e. jetted) from the nozzle towards the workpiece due to the momentum of the impact between the valve stem 2048b of the firing pin 2048 and the valve seat 2104. Jetting is contrasted with extrusion or other types of material dispensing, where liquid material is dispensed as a continuous, elongate filament, generally referred to as a "bead" of fluid. While drops can be formed by rapidly opening and closing a valve during extrusion of liquid material, or by using air to break up an extruded bead as it is dispensed, these processes are distinctly different from jetting processes, in which the discrete liquid mass is rapidly ejected directly from the dispenser 2010 at a high velocity when the firing pin 2048 strikes the valve seat 2104. The liquid material (e.g. fluid) is received into the lower chamber 2038 at a low pressure and is jetted out of the lower chamber 2038 at a higher pressure. The high pressure is developed as the valve stem 2048b is moved towards the valve seat 2104. When the valve stem 2048b impacts the valve seat 2104, a portion of the liquid material (in the form of a droplet or a dot) can break away from the nozzle assembly 2100. So, in some embodiments,

the jetted material can be separated from the nozzle assembly 2100 before it contacts the workpiece.

[0056] By providing a plurality of outlet channels 2108, a single stroke can result in the dispensing of multiple droplets from the nozzle 2100 onto a workpiece. It will be understood that the stroke length, the amount of material present in the lower chamber 2038, and the number and dimensions of the outlet channels 2108 are all parameters that can be modified to achieve the desired dispensing.

[0057] In the exemplary embodiments of, three outlet channels 2108 are depicted in the nozzle 2100. With each stroke of the firing pin 2048, three separate droplets are jetted from the nozzle 2100 onto the workpiece. This allows for simultaneous dispensing of more material, resulting in decreased manufacturing time and associated costs. The number and arrangement of the outlet channels 2108 can be adjusted based on the desired usage, which adds versatility to each dispensing device and nozzle 2100.

[0058] The distance between adjacent droplets that are dispensed onto the workpiece can be controlled by the distance between the outlet channels 2108 and the angle of each outlet channel 2108 relative to the vertical direction 6. Alternatively, or additionally, the distance between dispensed droplets can be altered by moving the nozzle 2100 closer to or farther from the workpiece. In some embodiments, a first outlet channel is disposed along the vertical direction 6, a second outlet channel is disposed at an angle between 0° and 90° from the vertical direction 6 in the negative horizontal direction 4, and a third outlet channel is disposed at an angle between 0° and 90° from the vertical direction 6 in the positive horizontal direction 4 opposite the negative horizontal direction. In this depicted embodiment, the distance on the workpiece between each of the three droplets dispensed from the outlet channels will positively correlate with the distance of the nozzle 2100 from the workpiece. Specific arrangements of the outlet channels 2108 on the nozzle 2100 can also determine the dispensing pattern on the workpiece.

[0059] The fluid dispensing system 1 in accordance with yet other aspects of the invention may include a third, slotted nozzle type dispenser 3010. Referring to FIGS. 9 and 10, the dispenser 3010 comprises a material supply 3012 for storing a supply of the material. The material supply 3012 may include any of the features of the material supply 1012, described above.

[0060] The dispenser 3010 can also include a pump 3016 fluidly connected to the material supply 3012. The pump 3016 may be similar to the pump 2016, described above. For

example, the pump 3016 can include a body 3031 comprising a top component 3032a, a middle component 3032b attached to and positioned below the top component 3032a, and a bottom component 3032c attached to and positioned below the middle component 3032b.

[0061] The body 3031 of the pump 3016 may define a substantially hollow body, such that an upper chamber 3036 and a lower chamber 3038 are defined within the body 3031. A seal pack 3040 is positioned within the body 3031 and divides the interior of the body 3031 into the upper and lower chambers 3036, 38. The pump 3016 also includes a firing pin 3048 positioned within the body 3031. The firing pin 3048 defines an upper end 3048a and a stem 3048b that extends from the upper end 3048a along the vertical direction 6. The upper end 3048a is positioned within the upper chamber 3036, while the stem 3048b extends from the upper end 3048a through the upper chamber 3036, through the seal pack 3040, and into the lower chamber 3038.

[0062] The pump 3016 may operate in a similar manner as the pump 2016, described above. For example, the firing pin 3048 is configured to reciprocate within the body 3031 between a retracted and an extended position. This reciprocation can be caused by pressurized air that flows into the upper chamber 3036 through first and second air paths 3052a, 3052b. Each of first and second air paths 3052a, 3052b can receive pressurized air from a valve 3020, which is connected to the pump 3016 through connector 3024. The upper end 3048a of the firing pin 3048 divides the upper chamber 3036 into first and second portions 3036a, 3036b, where the first portion 3036a can receive pressurized air from the first air path 3052a, and the second portion 3036b can receive pressurized air from the second air path 3052b. When pressurized air flows through the first air path 3052a and into the first portion 3036a of the upper chamber 3036, the firing pin 3048 is driven downwards along the vertical direction 6 into an extended position. In contrast, when pressurized air flows through the second air path 3052b and into the second portion 3036b of the upper chamber 3036, the firing pin 3048 is driven upwards along the vertical direction 6 into a retracted position.

[0063] The pump 3016 includes a circumferential chamber 3054 defined between an outer surface of the bottom component 3032c of the body 3031 and an inner surface of the middle component 3032b. The circumferential chamber 3054 is fluidly connected to the material supply 3012, such that the circumferential chamber 3054 is configured to receive material from the material supply 3012 and allow the material to flow through the circumferential chamber 3054 to radial holes 3056 defined within the bottom component 3032c. The material can then flow through the radial holes 3056 to the lower chamber 3038.

In one embodiment, the radial holes 3056 comprise four radial holes spaced equidistantly circumferentially around the bottom component 3032c.

[0064] When the firing pin 3048 is in the retracted position, the stem 3048b is spaced from a valve seat 3060 defined by the bottom component 3032c at the lower end of the lower chamber 3038. In this position, material flows through the circumferential chamber 3054, through the radial holes 3056, and into the lower chamber 3038. Then, when the firing pin 3048 is transitioned into the extended position, the stem 3048b of the firing pin 3048 moves rapidly downward along the vertical direction 6 through the lower chamber 3038 towards the valve seat 3060. During this transition, the firing pin 3048 causes an amount of the material within the lower chamber 3038 to be discharged through an outlet channel 3064 that extends from the lower chamber 3038 at a lower end of the lower chamber 3038. The outlet channel 3064 is configured to guide this amount of the material from the lower chamber 3038 to a nozzle assembly 3028, attached to the pump 3016. When in the extended position, the lower end of the stem 3048b may contact the valve seat 3060 and thus create a fluid seal between the lower chamber 3038 and the outlet channel 3064, or may be positioned slightly above the valve seat 3060.

[0065] When firing pin 3048 transitions from the retracted position to the extended position along the vertical direction 6, the firing pin 3048 travels a distance that can be referred to as the stroke length. The required stroke length can vary between dispensing operations, types of materials dispensed, wear of internal parts over time, etc. As a result, the stroke length can be adjusted using the limiting rod 3044, which extends through the top component 3032a of the body 3031 and into the first portion 3036a of the upper chamber 3036. When the firing pin 3048 is in the retracted position, the upper end 3048a can contact the lower end of the limiting rod 3044, such that the limiting rod 3044 controls the how far upwards the firing pin 3048 moves in the retracted position. The limiting rod 3044 can threadedly engage the top component 3032a, such that rotation of the limiting rod 3044 relative to the top component 3032a moves the limiting rod 3044 further into or out of the upper chamber 3036, thus changing the maximum upward position of the firing pin 3048 in the retracted position, and likewise the stroke length.

[0066] The nozzle assembly 3028 can include a nozzle body. The nozzle body 3029 can include an upper flange 3100, an arm 3104 extending from the upper flange 3100, and a nozzle head 3108 attached to the arm 3104 opposite the upper flange 3100. The upper flange 3100 can include an inlet port on its upper surface, as well as two bores that extend through

the upper flange. When the dispenser 3010 is fully assembled, the upper surface contacts the pump 3016 and the inlet port can be in fluid communication with the outlet channel 3064 of the pump 3016, such that the nozzle assembly 3028 receives the material from the pump 3016 through the inlet port. The bores can be configured to receive a bolt to secure the upper flange 3100 to the pump 3016. However, it should be appreciated that the upper flange 3100 can include more or less bores. Alternatively, the nozzle assembly 3028 can be attached to the pump 3016 through alternative means, such as through snap fit engagement, engagement via dovetail slots, clamping, etc.

[0067] FIG. 11 shows an exemplary method 4000 of dispensing at a dispense region of the workpiece in accordance with aspects of the present invention. FIG. 12 illustrates an exemplary workpiece W, such as a fabric or cloth, having a curved dispense region. The method 4000 may be performed with the fluid dispensing system 1 or any suitable variation thereof, for example.

[0068] At step 4002, the workpiece is positioned on the working plate 8 of the fluid dispensing system 1. For example, an operator or automated system may place the workpiece on the working plate 8. The workpiece may be fixed to the working plate 8 via the fixture 11. Alternatively, the workpiece may lay a top the working plate 8 without being fixed thereto.

[0069] Step 4002 may include, subsequent or prior to positioning the workpiece on the working plate 8, determining positions of dispense locations (i.e., the first dispense location and of each of the plurality of dispense locations described below). The dispense locations may be determined based upon a number of factors. For example, a user may input a desired fluid dispensing pattern (i.e., a first dispensing pattern) into the controller 23 of the fluid dispensing system 1 via a human machine interface (not shown). The desired fluid dispensing pattern may include a number of characteristics including, for example, a size of the desired dispense pattern, a shape of the desired dispense pattern, an amount of fluid to be dispensed at each location of the desired dispense pattern, etc. The dispense locations may be locations calculated to achieve the desired dispense pattern. As shown in FIG. 12, the desired fluid dispense pattern may be curved pattern. The desired dispense pattern may be curved, straight, or combinations thereof.

[0070] To ensure that the desired fluid dispensing pattern is accurately dispensed at the desired dispensing region of the workpiece, step 4002 may include a relative alignment of the fluid dispensing system 1. In one embodiment, the relative alignment may include inputting into the controller 23 (e.g., via the human machine interface) the location of one or

more fixed positions 12A, 12B, 12C, 12D of the working plate 8. The workpiece may then be positioned in a predetermined orientation on the working plate 8 relative to the one or more fixed positions 12A, 12B, 12C, 12D. The predetermined orientation may also be input into the controller 23. Based upon the locations of the one or more fixed positions 12A, 12B, 12C, 12D of the working plate 8, the orientation of the workpiece, and the desired fluid dispensing pattern, the controller 23 may automatically calculate a dispense protocol (discussed below) to achieve the desired fluid dispensing pattern. That is, the locations of the one or more fixed positions 12A, 12B, 12C, 12D of the working plate 8 and the orientation of the workpiece may be included in the factors used to determine the positions of the dispense locations.

[0071] In another embodiment, ensuring that the desired fluid dispensing pattern is accurately dispensed at the desired dispensing region of the workpiece may include identifying reference fiducials 22A, 22B, 22C, 22D, 22E (e.g., with the camera 21) associated with the dispensing region, for example in the manner described above. For example, each dispense region may be provided with its own set of corresponding reference fiducials 22A, 22B, 22C, 22D, 22E. Alternatively, multiple dispense regions may be associated with a single set of reference fiducials 22A, 22B, 22C, 22D, 22E. The fluid dispensing system 1 may then determine the location and orientation (i.e., the position) of each dispense location, based on the identified reference fiducials 22A, 22B, 22C, 22D, 22E. That is, the identified reference fiducials 22A, 22B, 22C, 22D, 22E may be included in the factors used to determine the positions of the dispense locations.

[0072] At step 4004, the fluid dispensing system 1 may align the dispenser (i.e., any of the dispenser embodiments 1010, 2010, 3010) in an XY plane located a dispense height above a first dispense location of the dispense region of the workpiece. The fluid dispensing system 1 may collect Z height measurements for the dispense regions through height sensing. Such height sensing may include collecting multiple height measurements for the dispense region. The fluid dispensing system 1 may then determine the dispense height for the dispenser based upon the Z height measurements, and/or based upon user inputs. The first dispense location may be determined in step 4002, as described above. The XY plane may be defined by the X axis and the Y axis orthogonal to the X axis. Aligning the dispenser may include providing x, y, and z movements, via the gantry positioning system 9 of the fluid dispensing system 1, so as to move the dispenser from a pre-dispense position to the first dispense location. The x, y, and z movements may be provided via the x, y, and z drive mechanisms 24A, 24B, 25, 26, discussed above. "x movement" being movement of the

dispenser parallel to the X axis, or movement in the x direction shown in FIGS. 2 and 3. "y movement" being movement of the dispenser parallel to the Y axis, or movement in the y direction shown in FIGS. 2 and 3. "z movement" being movement of the dispenser parallel to the Z axis, which is orthogonal to each of the X axis and the Y axis, or movement in the z direction shown in FIGS. 2 and 3.

[0073] At step 4006, the dispenser is controlled to start dispensing fluid from the dispenser at the first dispense location. The fluid may be a viscous fluid. The fluid may be an adhesive, such as polyurethane (PUR) adhesive, though other materials are contemplated.

[0074] At step 4008, the gantry positioning system 9 and the dispenser are controlled to form a dispense pattern on the dispense region of the workpiece. Forming the dispense pattern may include providing x, y, and C axis movements, via the gantry positioning system 9, so as to move the dispenser from the first dispense position to each of the plurality of dispense locations of the dispense region and dispensing fluid from the dispenser at each of the plurality of dispense locations. C axis movement being rotational movement of the dispenser about a central axis of the dispenser, and may be provided via the C drive 27. The rotational movement may include full rotation about the C axis in any of clockwise and counterclockwise directions. The x, y, and C axis movements may be automatically calculated based upon, e.g., the positions of the first dispense location and each of the plurality of dispense locations. The dispenser may dispense any number of patterns. For example, the dispenser may dispense beads at each dispense locations. Alternatively, the dispenser may continuously dispense while being moved by the gantry positioning system 9 so as to dispense straight or curved linear patterns on the workpiece, as shown in FIG. 12. As a result of the four degrees of freedom of movement of the dispenser, the method 4000 may more accurately, reliably, and efficiently dispense a diverse set of dispensing patterns, including for example curved dispense patterns.

[0075] Upon completion of dispensing the fluid pattern, the fluid dispensing system 1 may raise the dispenser back up along the Z axis to a pre-dispense height, which may be the same height as when the method 4000 began. The system may evaluate whether there are additional fluid patterns to be dispensed, for example at second, third, fourth, ... n dispense regions. If there remains additional dispensing to be performed, the system may return to step 4002. If all dispensing is complete, the system may end dispensing operations.

[0076] While the present invention has been illustrated by the description of specific embodiments thereof, and while the embodiments have been described in considerable detail,

it is not intended to restrict or in any way limit the scope of the appended claims to such detail. The various features discussed herein may be used alone or in any combination. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the scope or spirit of the general inventive concept.

What is claimed is:

1. A method of dispensing fluid on a workpiece using a fluid dispensing system, the method comprising:

positioning the workpiece on a working plate of the fluid dispensing system;

aligning a dispenser of the fluid dispensing system in an XY plane located a dispense height above a first dispense location of a dispense region of the workpiece, the XY plane defined by an X axis and a Y axis orthogonal to the X axis, aligning the dispenser including providing x, y, and z movements, via a gantry positioning system of the fluid dispensing system, so as to move the dispenser from a pre-dispense position to the first dispense location, x movement being movement of the dispenser parallel to the X axis, y movement being movement of the dispenser parallel to the Y axis, and z movement being movement of the dispenser parallel to a Z axis, which is orthogonal to each of the X axis and the Y axis;

dispensing fluid from the dispenser at the first dispense location; and

forming a dispense pattern on the dispense region of the workpiece including providing x, y, and C axis movements, via the gantry positioning system, so as to move the dispenser from the first dispense location to each of a plurality of dispense locations of the dispense region and dispensing fluid from the dispenser at each of the plurality of dispense locations, C axis movement being rotational movement of the dispenser about a central axis of the dispenser.

2. The method of dispensing fluid of claim 1, further comprising:

determining, prior to aligning the dispenser, positions of the first dispense location and of each of the plurality of dispense locations relative to one or more fixed positions of the working plate.

3. The method of dispensing fluid of claim 2, wherein positioning the workpiece on the working plate includes aligning the workpiece with the one or more fixed positions.

4. The method of dispensing fluid of claim 2, further comprising automatically calculating the x, y, and C axis movements based upon the positions of the first dispense location and each of the plurality of dispense locations.

5. The method of dispensing fluid of claim 1, further comprising, subsequent to positioning the workpiece on the working plate of the fluid dispensing system, identifying reference fiducials associated with the dispense region on the workpiece.

6. The method of dispensing fluid of claim 5, further comprising determining positions of the first dispense location and of each of the plurality of dispense locations relative to the reference fiducials.

7. The method of dispensing fluid of claim 6, further comprising automatically calculating the x, y, and C axis movements based upon the positions of the first dispense location and each of the plurality of dispense locations.

8. The method of dispensing fluid of claim 1, wherein the workpiece is fabric or cloth.

9. The method of dispensing fluid of claim 1, wherein the fluid is an adhesive.

10. A fluid dispensing system configured to dispense a fluid onto a workpiece, the fluid dispensing system comprising:

a working plate configured to support the workpiece;

a dispenser disposed above the workpiece and configured to dispense the fluid on the workpiece; and

a gantry positioning system that supports the dispenser, the gantry positioning system is configured to provide:

x, y, and z movements to move the dispenser, x movement being movement of the dispenser parallel to an X axis, y movement being movement of the dispenser parallel to a Y axis orthogonal to the X axis, and z movement being movement of the dispenser parallel to a Z axis, which is orthogonal to each of the X axis and the Y axis; and

C axis movement to rotate the dispenser, C axis movement being rotational movement of the dispenser about a central axis of the dispenser; and

a controller that is configured to control the dispenser and the gantry positioning system.

11. The fluid dispensing system of claim 10, wherein the working plate includes a fixture that is configured to fix the workpiece to the working plate.

12. The fluid dispensing system of claim 10, wherein the dispenser comprises:

a pump comprising:

a pump body assembly including a nozzle body defining a recess that extends into the nozzle body, and a fluid channel that has an inlet configured to receive the fluid and an outlet, wherein the outlet is open to the recess; and

a valve movably disposed in the fluid channel and configured to selectively block the fluid from flowing to the outlet of the fluid channel; and

a slotted nozzle assembly for dispensing the fluid, wherein

the slotted nozzle assembly is received in the recess of the nozzle body.

13. The fluid dispensing system of claim 10, wherein the dispenser comprises:

a body defining a chamber therein between an inlet and an outlet, the chamber being configured to receive the fluid through the inlet and to allow the fluid to exit through the outlet;

a valve seat disposed adjacent to the outlet;

a valve stem configured to slidably move within the chamber towards and away from the valve seat and to contact the valve seat; and

a plurality of outlet channels in fluid communication with the outlet of the chamber, each of the plurality of outlet channels being configured to receive the fluid from the chamber,

wherein the valve stem is configured to impact the valve seat, such that a discrete volume of the fluid is forcefully ejected from the plurality of outlet channels due to momentum of impact between the valve stem and the valve seat onto the workpiece.

14. The fluid dispensing system of claim 10, wherein the gantry positioning system comprises:

first and second x supports, each respectively including first and second x bearings, the first and second x supports and the first and second x bearings being aligned parallel to the X axis;

a y support slidably arranged on the first and second x bearings, the y support being aligned parallel to the Y axis; and

first and second x drives configured to drive the y support along the first and second x bearings to provide the x movement.

15. The fluid dispensing system of claim 14, wherein the gantry positioning system further comprises:

a y bearing provided on the y support, the y bearing being aligned parallel to the Y axis;

a y carriage slidably arranged on the y bearing; and

a y drive configured to drive the y carriage along the y bearing to provide the y movement.

16. The fluid dispensing system of claim 15, wherein the gantry positioning system further comprises:

a z bearing provided on the y carriage, the z bearing being arranged parallel to the Z axis;

a z carriage slidably arranged on the z bearing; and

a z drive configured to drive the z carriage along the z bearing to provide the z movement.

17. The fluid dispensing system of claim 16, wherein the gantry positioning system further comprises:

a rotatable bearing provided on the z carriage, the rotatable bearing rotably supporting the dispenser above the working plate; and

a C drive, the C drive being supported by rotatable bearing so as to move together with the rotatable bearing, the C drive being configured to drive the dispenser to provide the C axis movement.

18. The fluid dispensing system of claim 10, wherein the workpiece is a fabric or cloth.

19. The fluid dispensing system of claim 10, wherein the fluid is an adhesive.

20. The fluid dispensing system of claim 10, wherein the controller is configured to control the dispenser and the gantry positioning system to dispense a curved dispense pattern.

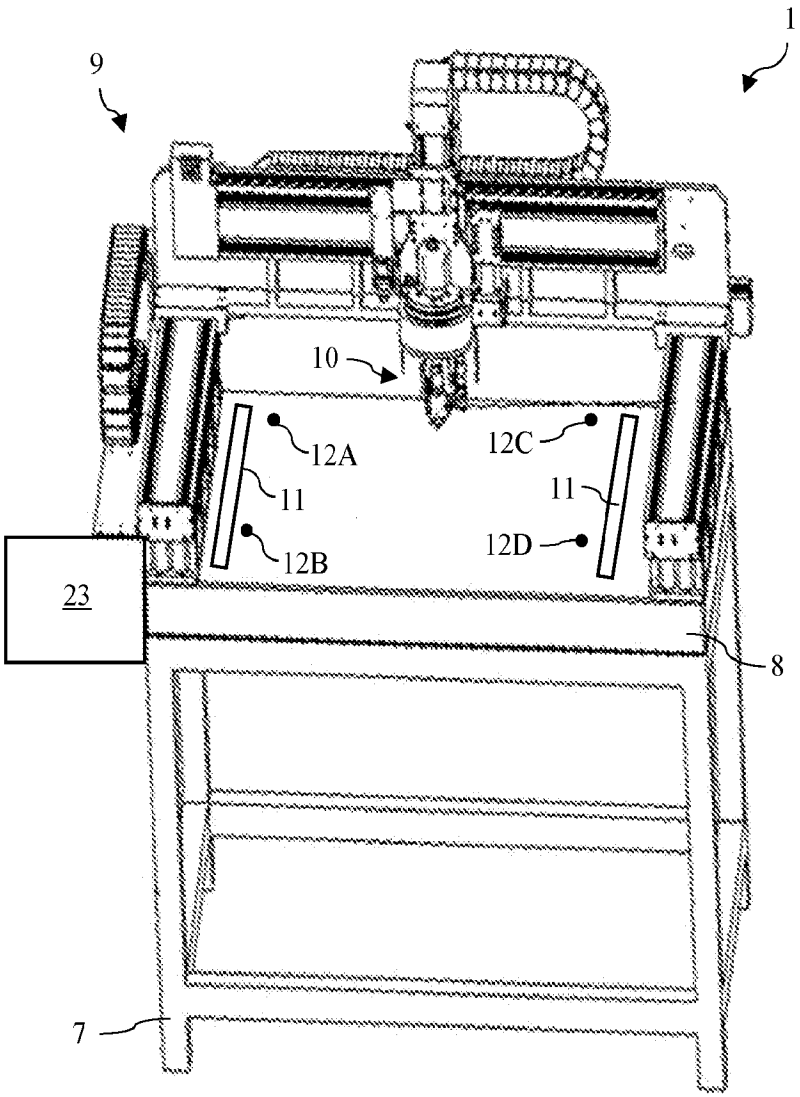


FIG. 1

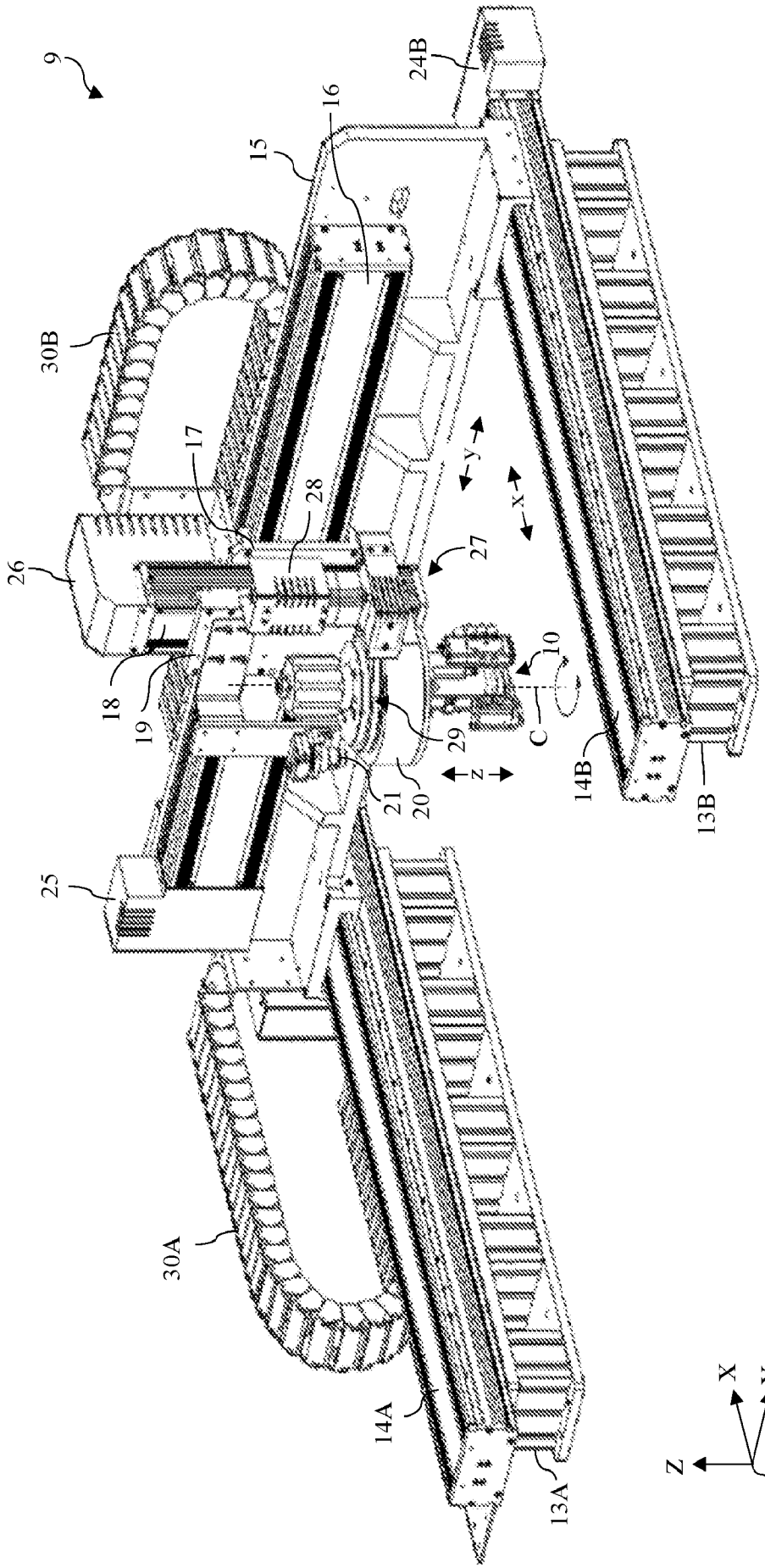

9
24B
16
15
30B
17
28
26
27
y
x
18
19
29
10
C
21
20
z
14B
13B
25
30A
14A
13A
Z
X
Y
O

FIG. 2

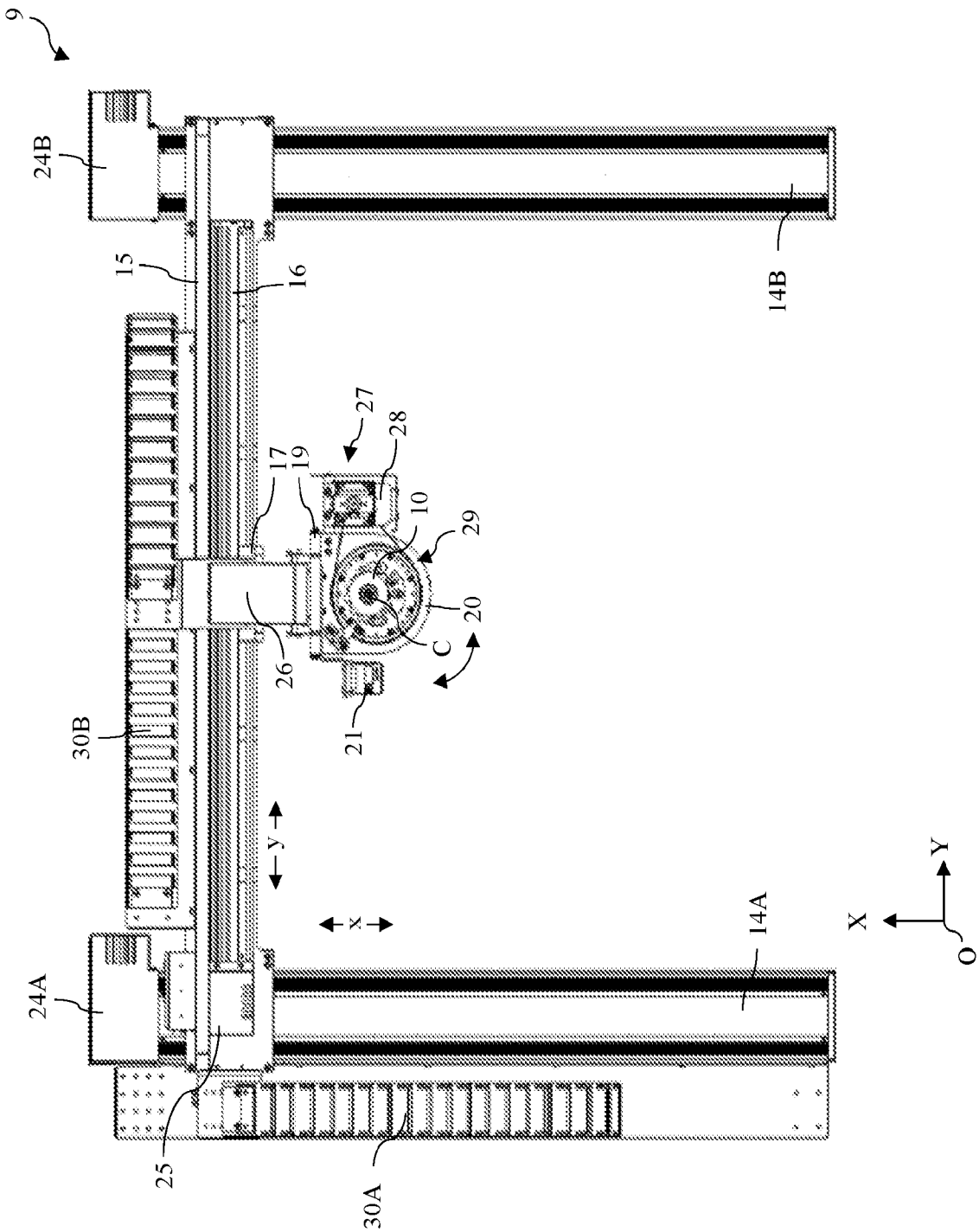


FIG. 3

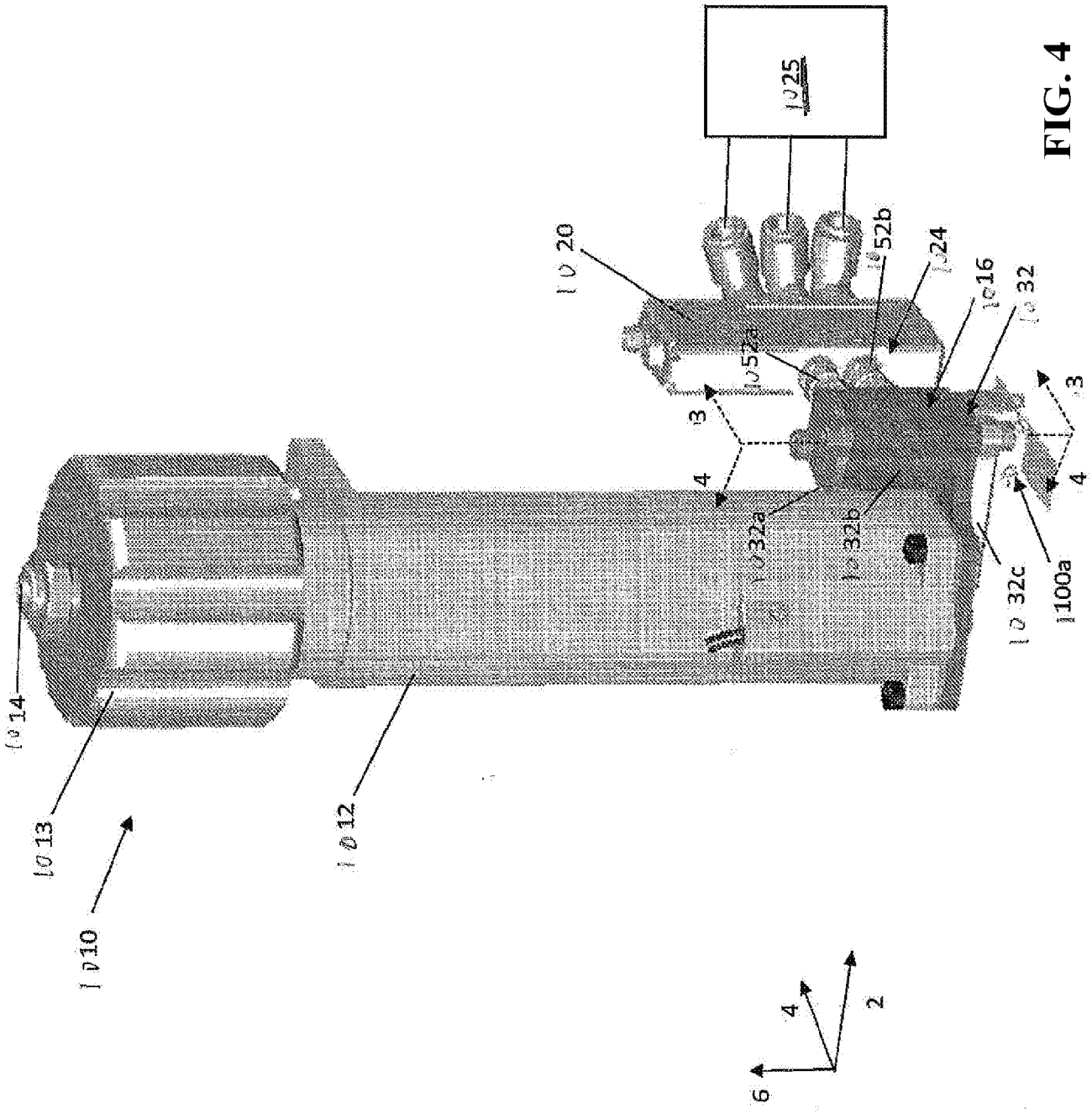


FIG. 4

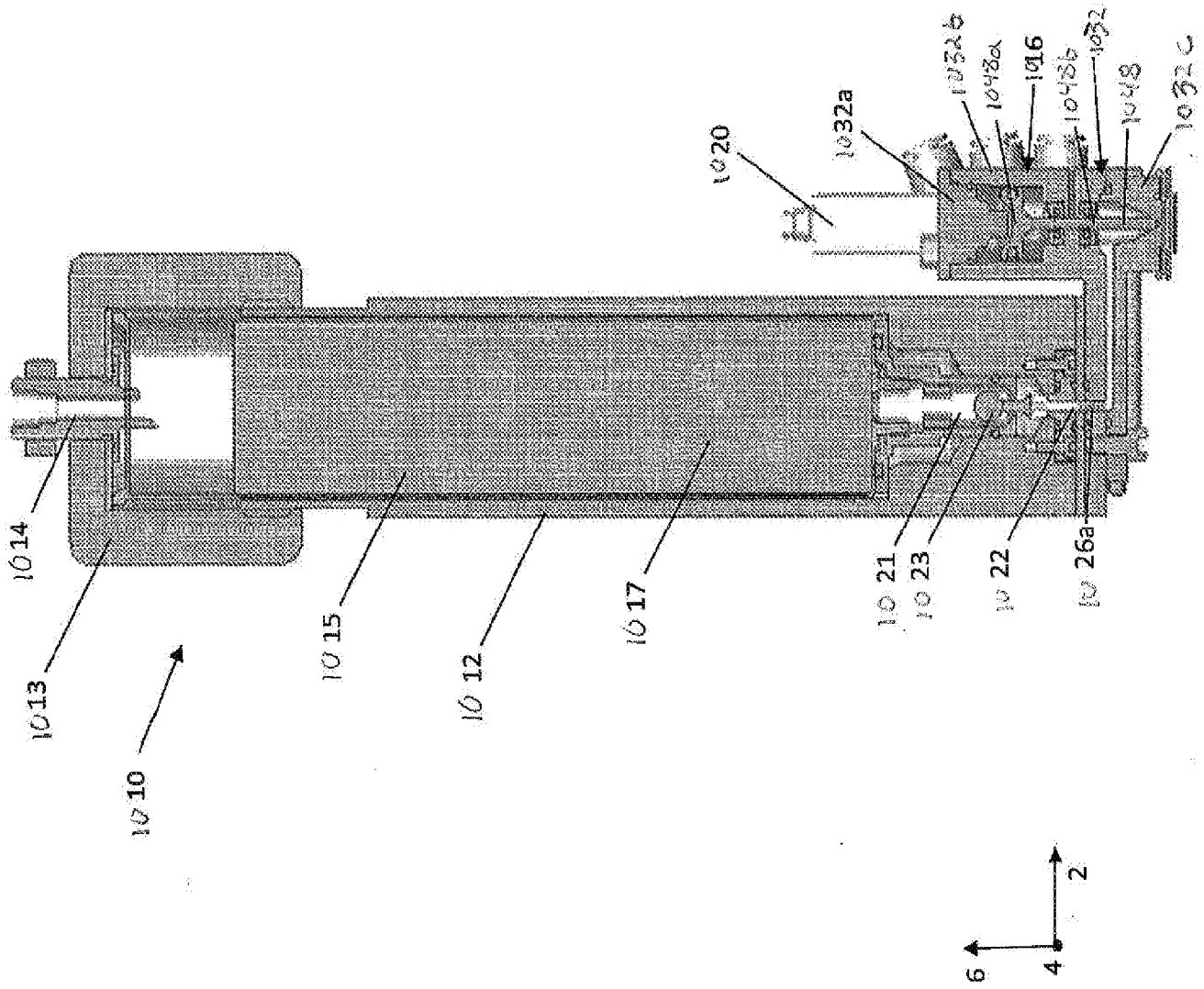

1010
1012
1013
1014
1015
1017
1020
1021
1022
1023
1026a
1032a
1032b
1032c
1032
1048
1048a
1048b
1016
2
4
6

FIG. 5

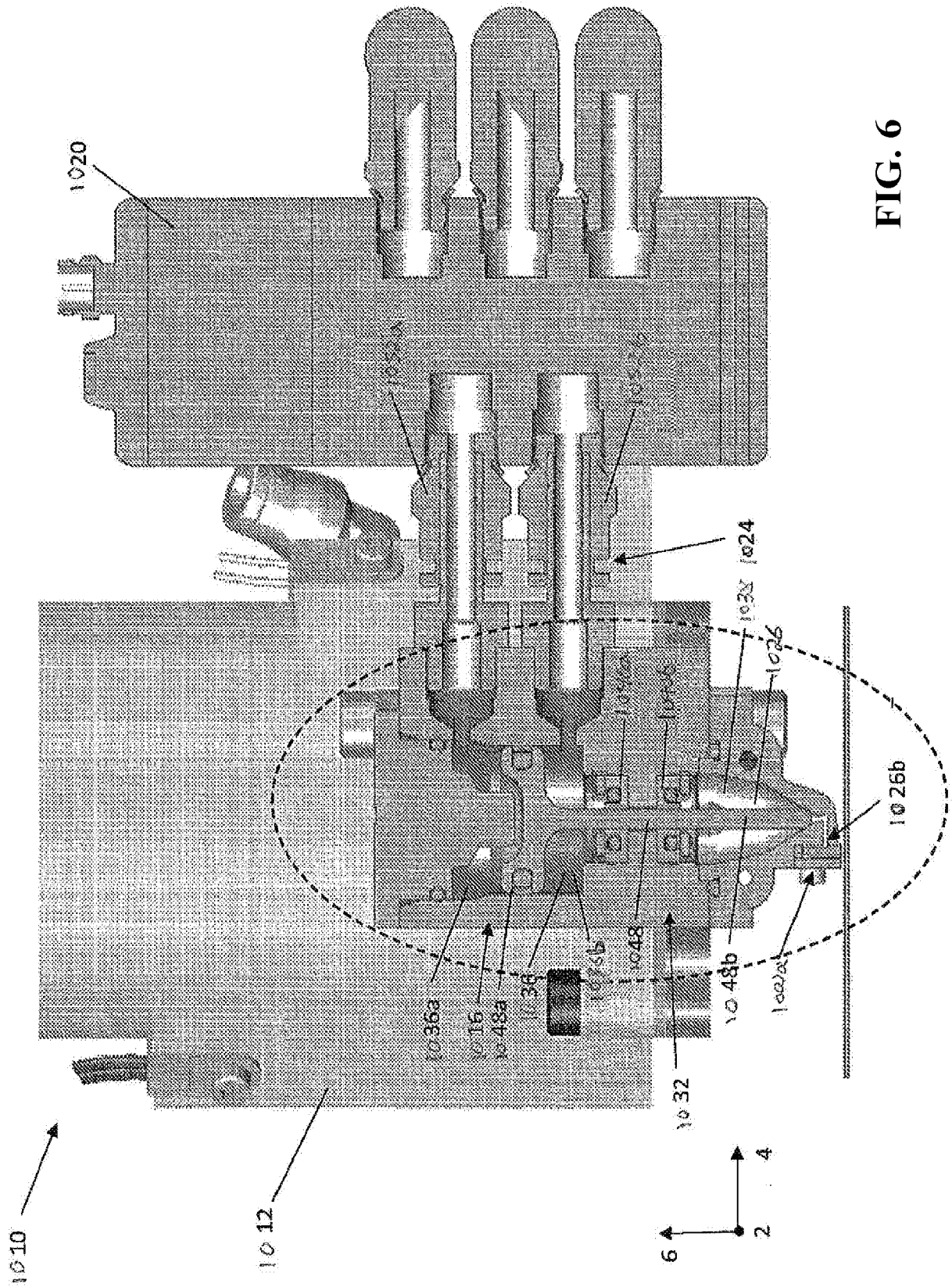

1020
1024
1026
1026b
1036a
1016
1043a
1036
1026b
1048
1048b
1032
1012
1010
6
2
4

FIG. 6

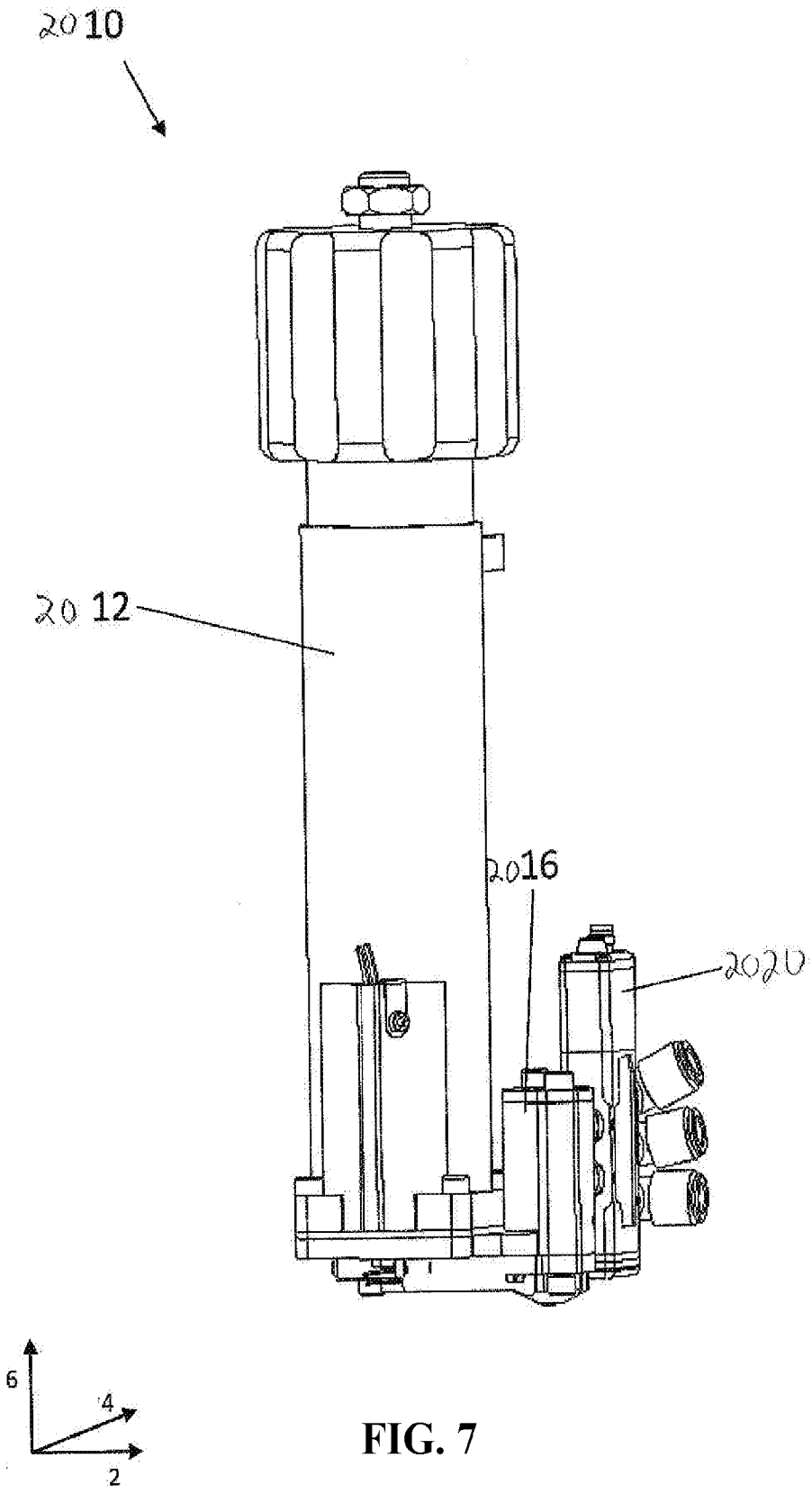


FIG. 7

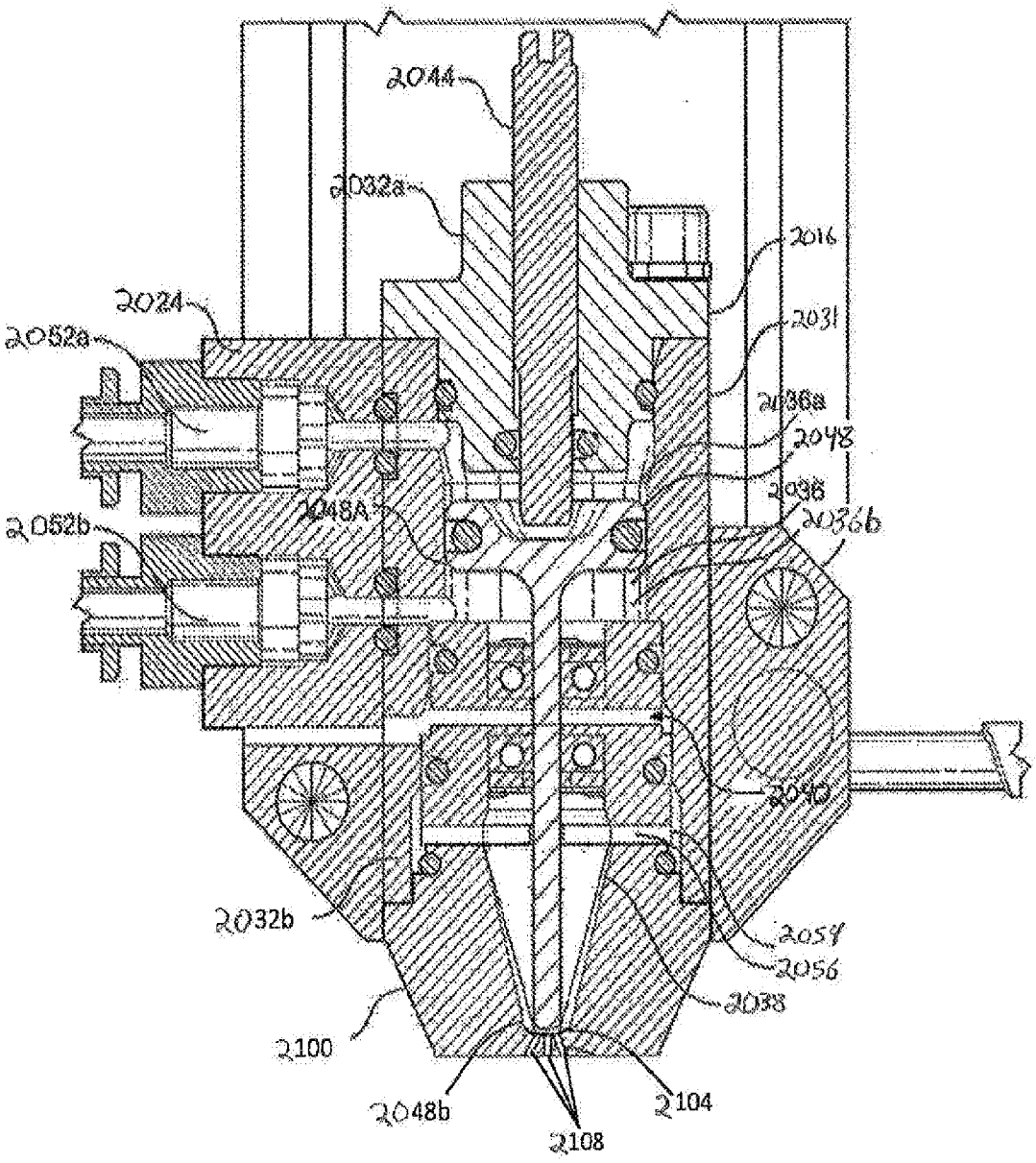

2044
2032a
2016
2024
2052a
2031
2036a
2048
2048A
2036
2052b
2036b
2040
2032b
2054
2056
2038
2100
2048b
2104
2108

FIG. 8

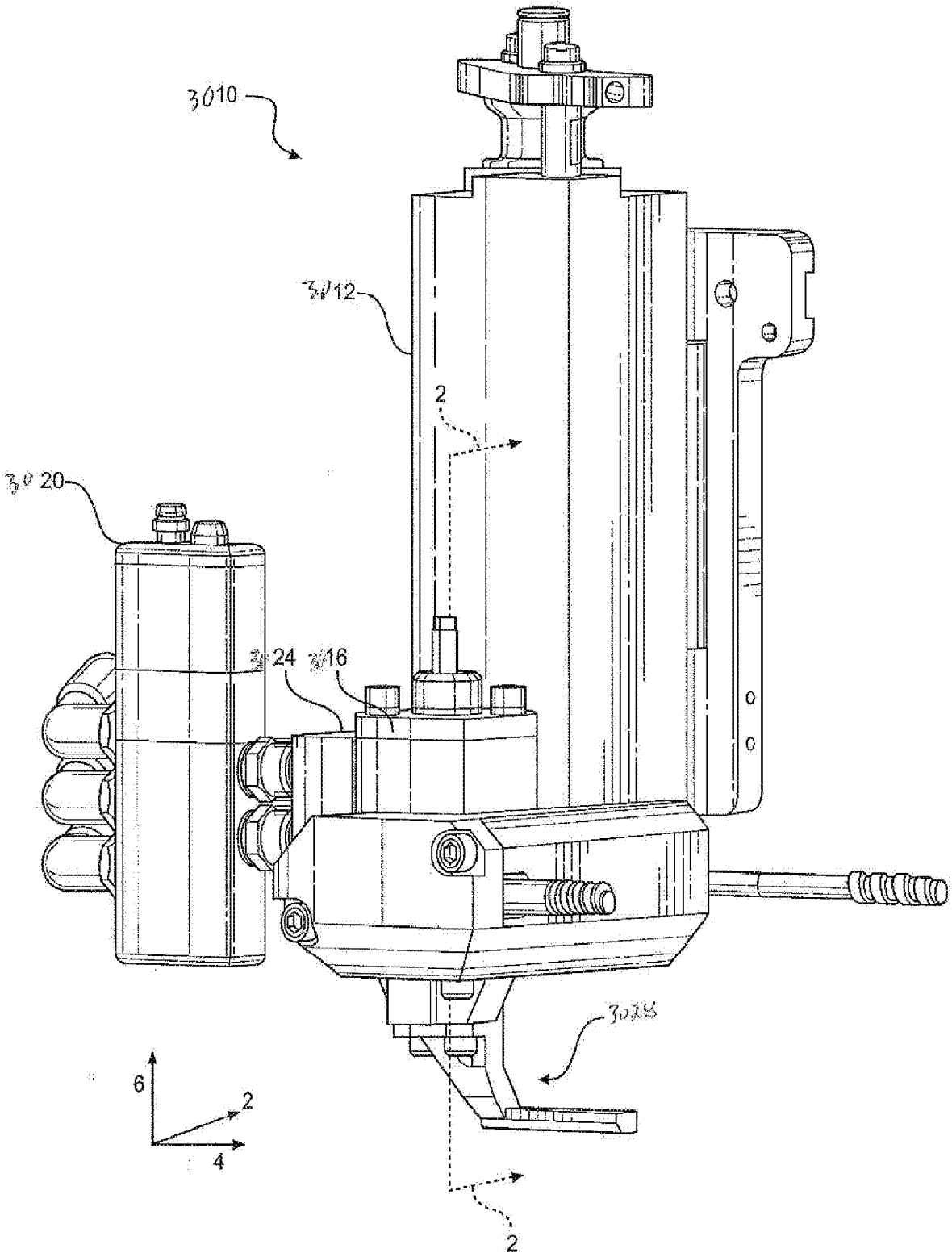


FIG. 9

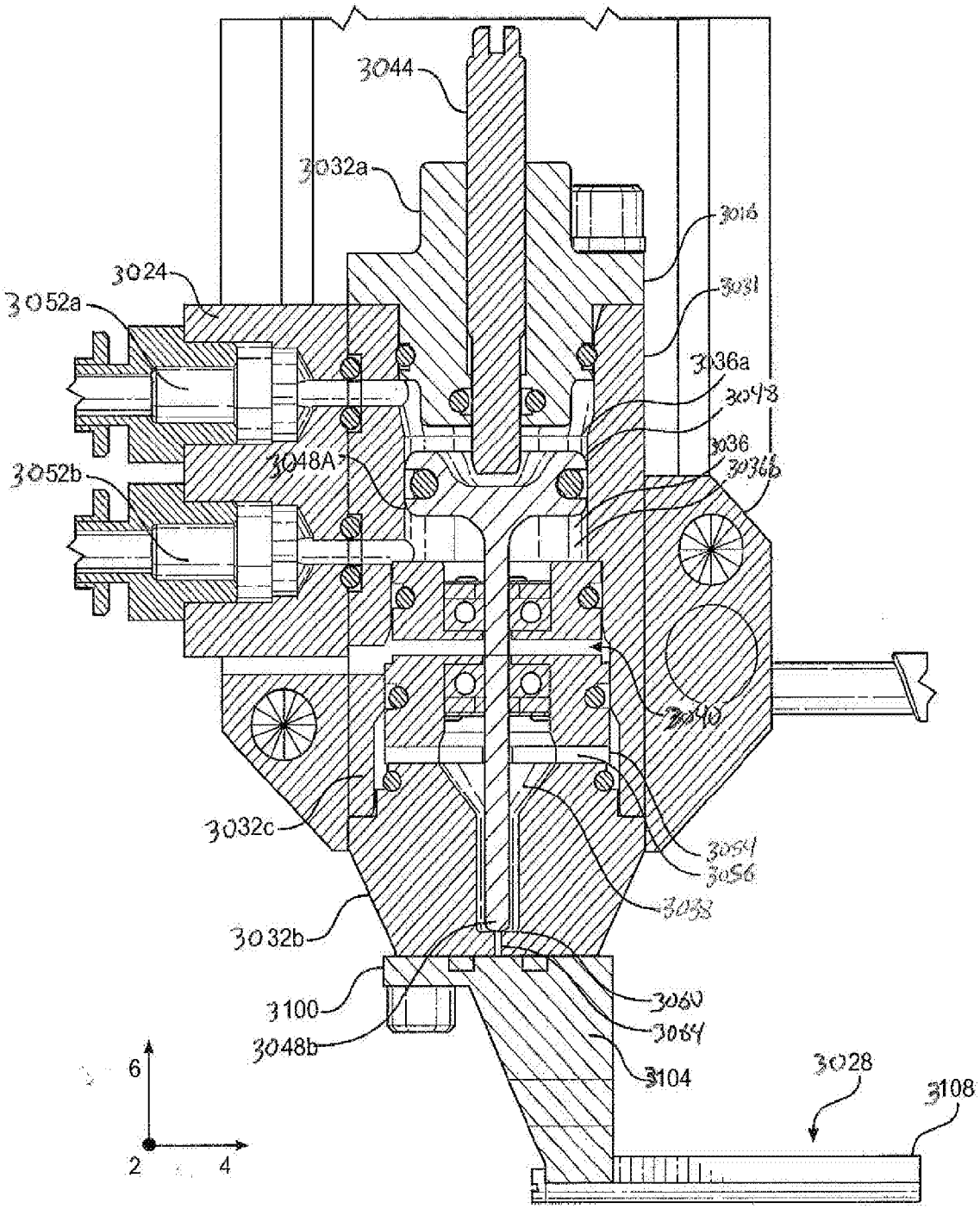

3044
3032a
3016
3024
3052a
3031
3036a
3043
3048A
3036
3036b
3052b
3040
3032c
3054
3056
3058
3032b
3100
3060
3064
3048b
3104
3028
3108
6
2
4

FIG. 10

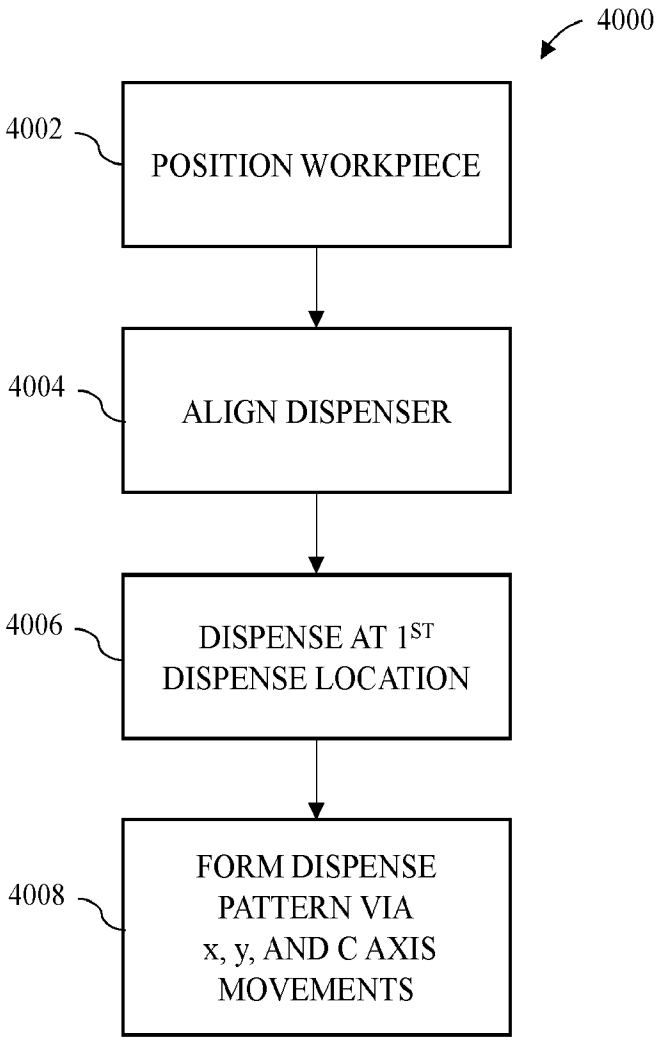

4000
4002
POSITION WORKPIECE
4004
ALIGN DISPENSER
4006
DISPENSE AT 1ST DISPENSE LOCATION
4008
FORM DISPENSE PATTERN VIA x, y, AND C AXIS MOVEMENTS

FIG. 11

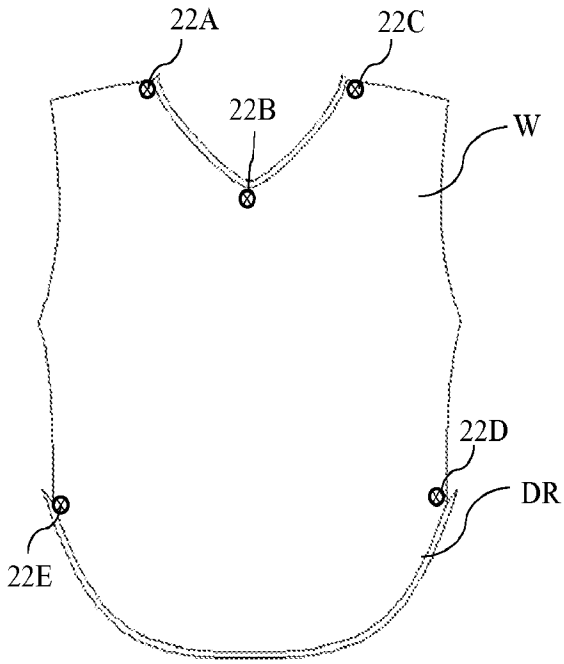


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/040450

A. CLASSIFICATION OF SUBJECT MATTER
INV. B05C5/02 B05C11/10
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)
B05C

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/081784 A1 (SAKAYORI TOSHIMASA [JP] ET AL) 21 April 2005 (2005-04-21) paragraphs [0043] - [0046], [0048] - [0050]; figures	1,2,4, 8-20
Y	US 2019/070623 A1 (GIUSTI CHRISTOPHER L [US] ET AL) 7 March 2019 (2019-03-07) paragraphs [0004] - [0005], [0049] - [0051]; figures	1-10, 14-20
Y	US 2012/097097 A1 (IKUSHIMA KAZUMASA [JP]) 26 April 2012 (2012-04-26) paragraphs [0002], [0060] - [0070]; figures	1-10, 14-20
A	US 2017/066005 A1 (IKUSHIMA KAZUMASA [JP]) 9 March 2017 (2017-03-09) paragraphs [0056], [0064]; figures	1,10,12, 13

☐ 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

"E" earlier application or patent 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	Date of mailing of the international search report
1 October 2020	12/10/2020

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	Brévier, François

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2020/040450

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005081784 A1	21-04-2005	CN 1620340 A	25-05-2005
		KR 20040086287 A	08-10-2004
		MY 133543 A	30-11-2007
		TW I285563 B	21-08-2007
		US 2005081784 A1	21-04-2005
		WO 03061847 A1	31-07-2003
US 2019070623 A1	07-03-2019	CN 106488806 A	08-03-2017
		CN 111495684 A	07-08-2020
		DE 112015003159 T5	13-04-2017
		JP 6573962 B2	11-09-2019
		JP 2017523034 A	17-08-2017
		US 2016008835 A1	14-01-2016
		US 2017282207 A1	05-10-2017
		US 2019001361 A1	03-01-2019
		US 2019001362 A1	03-01-2019
		US 2019001363 A1	03-01-2019
		US 2019070623 A1	07-03-2019
		WO 2016007596 A1	14-01-2016
US 2012097097 A1	26-04-2012	CN 102421536 A	18-04-2012
		EP 2422886 A1	29-02-2012
		HK 1164212 A1	18-09-2015
		JP 5638768 B2	10-12-2014
		JP 2010253376 A	11-11-2010
		KR 20120006557 A	18-01-2012
		MY 160656 A	15-03-2017
		SG 175342 A1	28-11-2011
		SG 10201401442T A	27-06-2014
		TW 201041660 A	01-12-2010
		US 2012097097 A1	26-04-2012
		WO 2010123097 A1	28-10-2010
US 2017066005 A1	09-03-2017	CN 106102933 A	09-11-2016
		EP 3117909 A1	18-01-2017
		JP 6538649 B2	03-07-2019
		JP WO2015137271 A1	06-04-2017
		KR 20160132381 A	18-11-2016
		TW 201544186 A	01-12-2015
		US 2017066005 A1	09-03-2017
		WO 2015137271 A1	17-09-2015