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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 October 2017 (26.10.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/185095 A2

(51) International Patent Classification:
B29C 45/17 (2006.01)

(21) International Application Number:
PCT/US2017/029174

(22) International Filing Date:
24 April 2017 (24.04.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/326,655 22 April 2016 (22.04.2016) US

(71) Applicant: **UNIVERSAL SMART INC.** [US/US]; 4533 Route 60, PO Box 364, Gerry, NY 14740 (US).

(72) Inventors: **FOLARON, Robert**; 445 E. Cheyenne Mtn. Blvd., Suite C, Pmb-319, Colorado Springs, CO 80906 (US). **SANDO, Scott**; 4533 Route 60, Gerry, NY 14740 (US).

(74) Agent: **EYVAZZADEH, David** et al.; Rocky Mountain Patent LLC, 1518 Blake St., Denver, CO 80202 (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, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

(54) Title: INJECTION MOLDING APPARATUS AND METHOD OF USE

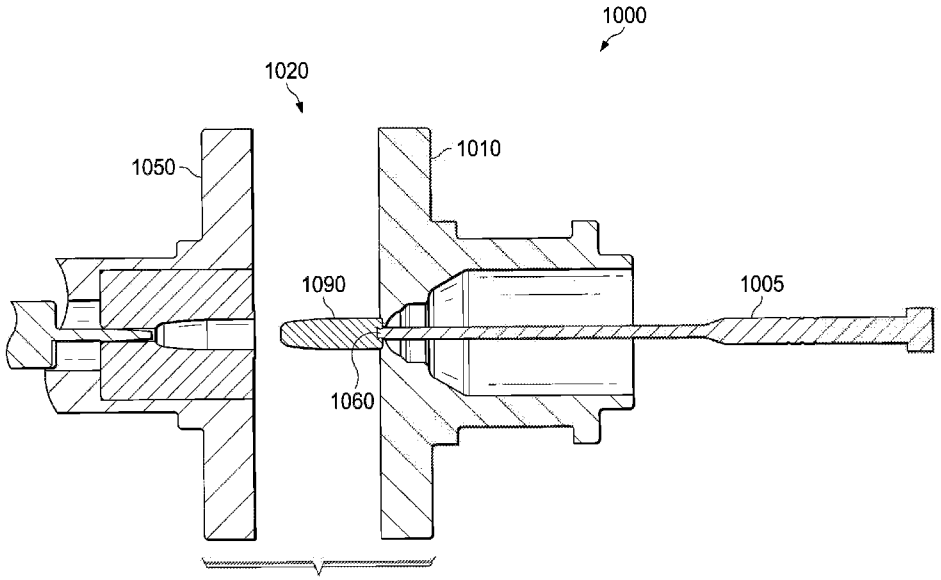

FIG. 4

(57) Abstract: The present invention surrounds an apparatus and method for the use in injection molding of articles of manufacture using an injection molding apparatus having a valve-gate pin or a plurality of valve- gate pins for actuation to extend and retract from a cavity within an injection mold. The valve-gate pin may have a retention feature or retention features configured for the retention of molded parts such that the retraction or extension of the valve-gate pin provides part removal from an associated injection mold. Further, the valve-gate pin may have a feature or features to facilitate the injection of fluids, gases or particles during or after the primary injection process. Additionally, a plurality of such valve-gate pins may be employed within each mold cavity, or within each valve-gate actuation system.

WO 2017/185095 A2

[Continued on next page]

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))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

INJECTION MOLDING APPARATUS AND METHOD OF USE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit to provisional patent application number 62/326,655, entitled "Injection Molding Apparatus and Method of Use", filed April 22, 2016, which is incorporated by reference in its entirety for all purposes.

FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus and process to decrease maintenance and increase process efficiency surrounding injection molding.

BACKGROUND OF THE INVENTION

[0002] The field of injection molding surrounds a manufacturing process for producing parts by injecting material into a mold having at least two adjoining portions creating a specifically designed cavity resembling the form of the desired part to be made. After a part is designed, a mold is manufactured from any suitable material, usually metals, and machined to form the features of the desired part. This mold is usually affixed to an injection molding machine which uses the mold to produce the part as designed. The injection molding process typically fills the cavity with a liquefied material which is then cooled, cured, and solidified to produce the part as designed.

[0003] An injection mold typically has two or more parts. A first side, sometimes referred to as the A-side, is the side from which the material is typically injected through an injector or valve-pin and into the cavity of the mold. The second side, sometimes referred to as the B-side, typically retains the part when the mold is open after the material injection process.

[0004] A typical injection molding process involves a series of steps. A first step of clamping, secures the first side to the second side in a manner that aligns the cavity of the A-side with the cavity of the B-side in preparation for the following steps. Following the clamping step, an injecting step involves the preparation and delivery of material under

pressure into the cavity of the mold. When the material is delivered into the cavity, the material for injection is initially fed into a heating chamber prior to being forced into the cavity. Material is delivered into the cavity through a flow control system, often through a valve-gate system, such as disclosed by U.S. Patent No. 5.948,450 to Swenson et al., the entirety of which is herein incorporated by reference. Such valve-gate systems are configured with a valve-pin that opens/closes flush with the outer boundary of the mold cavity to prevent interference with part molding. As the material is injected into the cavity of the mold, a vent is commonly used to allow the equalization of gasses to be purged from the cavity. Following the injecting step, a dwelling step involves a pause in the injection process. During the dwelling step, maintaining the material motionless under pressure, ensures that all voids of the cavity are filled with the injected material. A cooling step then allows the material to cool and harden to the configuration of the mold cavity. The mold is then opened and the part removed. In many scenarios, an additional step of removing the part from the opened mold is required. Part removal is often performed by a machine attendant or using a mechanism referred to as an ejector pin or knock-out pin.

[0005] Ejector pins, as used in the injection molding industry, provide the functionality of ejecting or removing molded parts from a mold without the direct physical involvement of a machine operator or attendant. Ejector pins have linear or rotational actuation functionality and are typically installed in the second side, or B-side, of the mold. When the mold is opened during the opening step, the ejector pins are actuated to extend the ejector pins outward from behind the molded part. The actuation of the ejector pins pushes the part away from the mold which releases the part and allows it to fall away from the mold.

SUMMARY OF THE INVENTION

[0006] In the field of injection molding, a large portion of the related mold maintenance is directly associated with the maintenance of ejector pins. Some injection molding

manufacturers attribute 30-40% of the cost of mold maintenance to the maintenance of ejector-pins and ejector-pin systems. When a mold undergoes maintenance, this typically includes down-time for the injection molding machine to which the mold is affixed. Ejector pin systems are often the cause of excess wear and tear for molds and as a result, molds are commonly made from steel, resulting in a heavy mold requiring costly machining to prepare.

[0007] Existing technologies surrounding the removal or ejection of a part from an injection mold include U.S. Patent No. 6,872,069 to Starkey, U.S. Patent No. 4,412,806 to Gaiser and Niepoky, U.S. Patent No. 3,893,644 to Drazick, and U.S. Patent No. 5,492,658 to Ohno et al., all of which are herein incorporated by reference in their entirety.

[0008] The elimination of ejector pins decreases the need for mold maintenance and decreases injection molding machine downtime. The elimination of ejector-pins also serves to allow the manufacture of injection molds from alternative materials from traditionally used steel, and eliminates injection mold complexity amongst other advantages.

[0009] Certain embodiments of the invention provide functionality for the mechanical extraction of a molded part from an injection mold while eliminating the need for ejector pins. The elimination of ejector pins serves to reduce mold preparation cost and decreases mold maintenance frequency.

[0010] The invention as presented eliminates the necessity of an ejector pin by using a valve-gate pin for part extraction. In certain embodiments, a valve-gate pin is installed on a first side of the mold with a distal portion of the valve-gate pin protruding into the cavity of the mold cavity. The valve-gate pin provides both the functionality of controlling flow of the liquefied material into the cavity of the mold as well as extracting the part from the mold. When the part is molded, the part forms and solidifies around the protruding portion of the valve-gate pin, thereby affixing the part to the protruding portion of the valve-gate pin. When the mold is opened, the part is pulled away from the second side of the mold by the

connection of the part to the valve-gate pin, thus essentially retaining the part in the first side of the mold. Once the connection between the part and the valve-gate pin is broken, the part may be removed. The valve-gate pin may be further actuated to retract or extend, to provide self-release of the part from the valve-gate pin.

[0011] The apparatus and method of use surrounding the invention may be used for pre-existing injection molding tools that use valve-gate pins to control the flow of liquid material into the mold cavity. Valve-gate pins of existing molds may be replaced with multi-functional valve-gate pins for the delivery of molding material and to extract the molded part from a mold, eliminating the need for ejection pins.

[0012] The present invention surrounds an apparatus and method for the improvement of the field of injection molding through the elimination of ejection pins by using valve-gate pins. Valve-gate pins as discussed herein provide the functionality of controlling the injection of material into a cavity of a mold through an aperture as well as extracting the part from the mold.

[0013] Certain embodiments of the invention allow the capability to precisely and repeatedly control the position, speed and flow aperture characteristics of a valve-gate pin. The precise control of the position of a valve-gate pin surrounding extension and retraction allows the finite control and adjustability of the location of the valve-gate pin throughout the injection molding process. The adjustment of flow aperture characteristics of the valve-gate pin allows for optimization of flow characteristics for the parts being made after the injection mold has been manufactured. In such embodiments, the valve-gate pin may be used to influence the speed and flow characteristics of the material entering the mold cavity, affecting part formation and effectiveness of the valve-gate pin to develop a desired connection to the molded part.

[0014] Certain embodiments of a valve-gate pin as described in the present application further comprise pathway through the length or partial length of the valve-gate pin, typically consistent with a central axis of the valve-gate pin. In such embodiments, the pathway provides the ability to inject or push a fluid, or other material, into the cavity within the injection mold. Such practice of injecting a gaseous fluid in the cavity of the injection mold with molten fluid, such as a polymer, is known as gas-assist injection molding such as disclosed by U.S. Patent No. 6,019,918 to Guergov, the entirety of which is herein incorporated by reference. Such a pathway may also be used for gas ejection of a part such as disclosed in U.S. Patent No. 4,653,997 to Sheffield et al., the entirety of which is herein incorporated by reference.

[0015] In certain embodiments, a part may still be retained by a first side of an injection mold after the retraction of a valve-gate pin. In such embodiments, it may be further desired to extend the valve-gate pin such that it once again protrudes into the injection mold cavity. The extension of the valve-gate pin following retraction serves to push the part away from the first side of the mold and release the part from the mold. The extension of the valve-gate pin following retraction may also serve to re-seal the part if additional fluids are injected through the valve-gate pin.

[0016] Certain embodiments of the protruding portion of the valve-gate pin comprise a retention feature. Certain embodiments of a valve-gate pin comprise a retention feature having an undercut around the perimeter of the protruding portion of the valve-gate pin. An undercut in this situation provides increased connection strength between the part and the valve-gate pin following part molding. The retention feature of a valve-gate pin may comprise any form, dimension, depth or profile. In certain embodiments, it may be desired to have a plurality of undercuts in the protruding portion of the valve-gate pin. A retention feature as disclosed herein may comprise any form or feature known to those skilled in the art

to provide an increased connection strength between a part and a valve-gate pin, including but not limited to, annular undercut features, helical undercut features, threaded features. Certain embodiments of a valve-gate pin comprise retention features that exceed a diameter of a portion of the valve-gate pin which protrudes into the cavity of an injection mold.

[0017] The configuration of a retention feature of a valve-gate pin depends upon the part for molding as well as the material used in the injection molding of the part. For instance, in the injection molding of thermoplastic plastics, it is possible to obtain a molded product with the desired dimensions using the mold shrinkage phenomenon. Mold shrinkage is the phenomenon where the volume of the flowable material filled inside the cavity of a mold shrinks at the same time as being cooled and solidifying. The extent of this shrinkage is commonly referred to as a molding shrinkage factor. The value of the molding shrinkage factor is generally a number in the range of about 0.02% to 2%. It will be appreciated by those skilled in the art that the molding shrinkage associated with a given injection mold and part is affected by type of molding material, internal surface temperature of the injection mold. In embodiments, such that a retention feature comprises an undercut, it may be desired to size the undercut in accordance with the molding shrinkage generally to approximately 75% of the determined shrinkage dimension. For instance, if mold shrinkage is determined to be 0.203 mm (0.008 in), it may be desired to size the undercut to be 0.152 mm (0.006 in) from a diameter of the protruding portion of the valve-gate pin. However, in embodiments such that a retention feature comprises threaded features, it may be desired to size the depth of the threaded features to approximately 100% of the determined shrinkage dimension. For instance, if mold shrinkage is determined to be 0.203 mm (0.008 in), it may be desired for depth thread to be 0.203 mm (0.008 in) from a diameter of a protruding portion of a valve-gate pin.

[0018] The inventive concept surrounding an injection molding apparatus having a valve-gate pin may be used in injection molding applications as well as known to be applicable by those skilled in the art. Furthermore, it will be appreciated that the inventive concept as disclosed may be used individually in applications, as a plurality of units controlled independently within a system, or a plurality of units controlled in concert within a system. Such control may be performed in an automotive manner such as disclosed by U.S. Patent No. 5,316,707 to Stanciu et al., herein incorporated by reference in its entirety. A system in which a plurality of valve-gate pins is used may comprise an injection mold having a cavity, an injection mold having a plurality of cavities, or a plurality of injection molds. It will be further appreciated that the features of a valve-gate pin as discussed herein, such as retention features, and a pathway, may be used independently in concert while remaining in-line with the inventive concepts as discussed herein. In embodiments comprising a plurality of valve-gate pins operating in a system, it will be appreciated that certain valve-gate pins may be used for the purposes of part retention and part extraction, while other valve-gate pins are used to control the flow of material into an injection mold for an injection molding process.

BRIEF DESCRIPTION OF FIGURES

[0019] Fig. 1A — A cross-sectional view of an embodiment of an injection molding apparatus

[0020] Fig. 1B — A cross-sectional detail view of an embodiment of an injection molding apparatus

[0021] Fig. 2 — A perspective view of an embodiment of a valve-gate pin

[0022] Fig. 3A — A cross-sectional detail view of an embodiment of an injection molding apparatus with a valve-gate pin in an open position

[0023] Fig. 3B — A cross-sectional detail view of an embodiment of an injection molding apparatus with a valve-gate pin in a closed position

[0024] Fig. 4 — A cross-sectional view of an embodiment of an injection molding apparatus with a first-side of an injection mold separated from a second side of an injection mold

[0025] Fig. 5 — A cross-sectional view of an embodiment of an injection molding apparatus with a first-side of an injection mold separated from a second side of an injection mold

[0026] Fig. 6A — A detailed view of an embodiment of a valve-gate pin showing an embodiment of a retention feature

[0027] Fig. 6B — A detailed view of an embodiment of a valve-gate pin showing an embodiment of a retention feature

[0028] Fig. 6C — A detailed view of an embodiment of a valve-gate pin showing an embodiment of a retention feature

[0029] Fig. 6D — A detailed view of an embodiment of a valve-gate pin showing an embodiment of a retention feature

[0030] Fig. 7 — A cross-sectional view of an embodiment of an injection molding apparatus with a first-side of an injection mold separated from a second side of an injection mold

[0031] Fig. 8 — A cross-sectional view of an embodiment of an injection molding apparatus

[0032] Fig. 9 — An embodiment of an injection molding method

[0033] Fig. 10 — An embodiment of an injection molding method

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0034] Certain embodiments of the present invention, shown in **Fig. 1A** and **Fig. 1B**, surrounds an injection molding apparatus **1000** comprising a valve-gate pin **1005** installed on a first side **1010** of an injection mold **1020**. The valve-gate pin **1005**, having a shaft **1025**, further comprises a first end **1030** for protruding into a cavity **1040** defined by a first side **1010** and a second side **1050** of the injection mold, with the second side having a vent mechanism **1052**. The first end **1030** of the valve-gate pin comprises a retention feature **1060**. The retention feature **1060** comprises a first dimension **1070** and a second dimension **1080**.

The first dimension, proximate to the first end **1030** of the valve-gate pin, is larger than the second dimension **1080**. Due to the retention feature **1060**, when a part **1090** forms in the injection mold **1020**, a connection is formed between the first end **1030** of the valve-gate pin and the part **1090**. Although a retention feature **1060** is typically consistent with the first end **1030** of the valve-gate pin, it will be appreciated that a retention feature **1060** may be offset from the first end **1030** of the valve-gate pin. The valve-gate pin **1005** traverses through a material delivery chamber **1095**, through which material passes for the injection into the cavity **1040** of the injection mold. The valve-gate pin **1005** protrudes into the cavity **1040** through an aperture **1055** extending between the material delivery chamber **1095** and the cavity **1040**.

[0035] A valve-gate pin **1005** as shown in **Fig. 1A** and **Fig. 1B**, and disclosed herein, may comprise a material composition of metal, composite materials such as nano-particle enhanced composites, plastics or other materials appreciated by those skilled in the art.

[0036] Certain embodiments of a valve-gate pin **1005**, for example shown in **Fig. 2**, comprise a first end **1030** with a retention feature **1060**. In such embodiments, the valve-gate pin **1005** comprises a round profile having a plurality of diameters. The retention feature comprises a first diameter **1100** consistent with the first end **1030** of the valve-gate pin and a second diameter **1110** offset from the first end **1030**. In such embodiments, the second diameter **1110** is equal to the minor diameter **1130** of an annular recess **1140**. In such embodiments, the second diameter **1110** of the valve-gate pin **1005** is equal with the major diameter **1150** of the annular recess. It will be appreciated, that in other embodiments, the minor diameter **1130** of the annular recess may not equal the second diameter **1110** of the valve-gate pin. Furthermore, in other embodiments, the major diameter **1150** of the annular recess may not equal the first diameter **1100** of the valve-gate pin. Alternatively, it will be further appreciated that a retention feature **1060** may comprise a feature providing differing form

from the first diameter **1100** or the second diameter **1110** of the valve-gate pin **1005**. Certain embodiments of a valve-gate pin may comprise a form which protrudes from the valve-gate pin.

[0037] In embodiments of the present invention, a valve-gate pin **1005,** for example shown in **Fig. 3A**, is longitudinally positionable to allow the extension and retraction of the valve-gate pin through an aperture **1055** and in relation to a cavity **1040** of an injection mold **1020**. It will be appreciated that when a valve-gate pin **1005** is in an open position, a second dimension **1080** of a valve gate pin is configured to interface an aperture **1055** such that material for injecting into a cavity **1040** can bypass the valve-gate pin **1005** into the cavity **1040**. In other embodiments of the present invention, for example shown in **Fig. 3B**, it will be appreciated that when a valve-gate pin **1005** is in a closed position, a first dimension **1070** is configured to be offset from an aperture **1055** such that material for injecting into a cavity **1040** cannot bypass the valve-gate pin **1005** into the cavity **1040**.

[0038] Certain embodiments of an injection molding apparatus **1000**, shown in **Fig. 4**, are used in conjunction with an injection mold **1020** comprising a first side **1010** and a second side **1050**. The connection of a part **1090** to a valve-gate pin **1005** is accomplished by accounting for material properties such as thermal expansion characteristics, stress/strain considerations and elasticity of the selected material or composition used for manufacturing the part **1090**. After forming, the part **1090** solidifies and contracts in volume causing the part **1090** to be affixed to a retention feature **1060** of the valve-gate pin. The connection between the part **1090** and valve-gate pin **1005** has a retention force defined by the force required, directed axially away from the valve-gate pin **1005**, to break the connection between the part **1090** and the valve-gate pin **1005**. This retention may be equal to or greater than the force needed to remove the molded part from the second side **1050** of the injection mold. When the first side **1010** is separated from the second side **1050**, the retention force of the attachment

between the part **1090** and the valve-gate pin **1005** pin extracts the part **1090** from the second side **1050** of the injection mold. If the retention force between the part **1090** and the valve-gate pin **1005** is equal to the retention forces between the part **1090** and the second side **1050** of the injection mold, the part releases from the second side **1050** and the first side **1010** of the injection mold simultaneously. If the retention between the part **1090** and the valve-gate pin **1005** exceeds the retention forces between the part **1090** and the second side **1050** of the injection mold, the part **1090** will be pulled away from the second side **1050** and remain in contact with the valve-gate pin. In certain embodiments, it may be required for a machine operator to manually extract, or a mechanical device to be used to extract, the part **1090** from the first side **1010** of the injection mold **1020** by applying enough force to break the connection between the part **1090** and the valve-gate pin **1005**.

[0039] Certain embodiments of an injection molding apparatus **1000**, shown in **Fig. 5**, comprise a valve-gate pin **1005** configured to retract and extend. It will be appreciated to those skilled in the art that such retraction and extension actions may be performed by linear actuating mechanisms **1065** such as, but not limited to, electro-mechanical actuators, mechanical actuators, hydraulic actuators, pneumatic actuators, piezoelectric actuators or other mechanisms known to those skilled in the art. Typically such actuating mechanisms interface with a second end **1035** of the valve-gate pin, but it will be appreciated that the connection between a valve-gate pin **1005** and an actuation mechanism may comprise alternate configurations as appreciated by those skilled in the art. In such embodiments, if the part **1090** is still connected to the valve-gate pin **1005** after the injection mold **1020** has been opened, the valve-gate pin **1005** may be retracted. The retraction of the valve-gate pin **1005** pulls the valve-gate pin **1005** from the part **1090** with enough force to exceed the retention force between the part **1090** and the valve-gate pin **1005**. The retraction distance of the valve-gate pin **1005** may be of distance less than, equal to, or greater than the distance

which the valve-gate pin **1005** protrudes into the cavity **1040** of the injection mold **1020**. Once the part **1090** has been molded and released, the valve-gate pin **1005** may be extended into the cavity **1040** of the injection mold, and the first side **1010** of the injection mold mated with the second side **1050** of the injection mold prior to manufacturing another part **1090**.

[0040] Certain embodiments of an injection molding apparatus **1000**, as shown in **Fig. 6A** – **Fig. 6D**, comprising a valve-gate pin **1005** further comprise a retention feature **1060**. In such embodiments, the retention feature **1060** may comprise at least one alternate form configured to provide retention of a part **1090**. Such embodiments may comprise an annular recess having a semi-circular undercut (**Fig. 6A**), a rectangular undercut (**Fig. 6B**), a threaded feature **1200** (**Fig. 6C**), or a projecting feature **1230** (**Fig. 6D**). It will be appreciated that a retention feature may comprise any form that provides a retention force between a retention feature **1060** and a part **1090**.

[0041] In certain embodiments of an injection molding apparatus **1000**, shown in **Fig. 7**, a valve-gate pin **1005** comprises a retention feature **1060** having a threaded feature **1200**. In such embodiments, the retention feature **1060** protrudes into the cavity **1040** of the injection mold **1020**. When a part **1090** is manufactured, the part **1090** cools and creates an attachment between the part **1090** and the retention feature **1060** of the valve-gate pin. In such embodiments, it may be desired to actuate the valve-gate pin **1005** rotatively to release the part from the retention feature **1060** using an actuating mechanism **1065**. Such actuation may be performed using rotative actuating mechanism **1065** independently or in conjunction with a linear actuating mechanism **1065** to retract the valve-gate pin **1005** from the cavity **1040** of the injection mold. Rotative actuating mechanisms **1065** include technologies such as but not limited to servo motors, stepper motors, hydraulic actuators, and pneumatic actuators. Typically, such actuating mechanisms interface with a second end **1035** of the valve-gate pin, but it will be appreciated that the connection between a valve-gate pin **1005** and an actuation

mechanism may comprise alternate configurations as appreciated by those skilled in the art. When the part **1090** is released from the retention feature **1060** in such embodiments, the part **1090** exhibits a negative threaded feature **1210** as a negative form of the threaded feature **1200** of the retention feature **1060**.

[0042] Certain embodiments of an injection molding apparatus **1000**, shown in **Fig. 8**, comprise a valve-gate pin **1005** having a pathway **1250** longitudinally in the valve-gate pin **1005** such that such a pathway **1250** is exposed to the cavity **1040** of an injection mold **1020**. Such a pathway **1250** and typically substantially consistent with a central axis **1260** of the valve-gate pin **1005**. Such a pathway **1250** provides capability for processes including gas-assist injection molding, and gas assisted part ejection.

[0043] Certain embodiments of an injection molding process **1300**, shown in **Fig. 9**, using injection valve-gate pins comprises: Clamping **1305** a first side of an injection mold to a second side of an injection mold creating a cavity between the first side of the injection mold and the second side of the injection mold, a first positioning step **1310** to position a valve-gate pin to an open position, injecting **1320** material into the cavity between the first side of the injection mold and the second side of the injection mold, dwelling **1330**, maintaining the material substantially motionless under pressure, to ensure all voids of the cavity between the first side of the injection mold and the second side of the injection mold are filled, a second positioning step **1335** to position the valve-gate pin to a closed position, cooling **1340** to allow the part to properly cure and cool thereby creating a connection between the part and the retention feature of the valve-gate pin, separating **1350** the first side of the injection mold from the second side of the injection mold, and a third positioning step **1360** to retract the valve-gate pin away from the part thereby breaking the connection between the retention feature of the valve-gate pin and the part to release the part from the first side of the injection mold. Other embodiments surrounding an injection molding process **1300** comprise: a

clamping **1305**, a first positioning step **1310**, an injecting step **1320**, dwelling **1330**, a second positioning step **1335**, a cooling step **1340**, and a separating step **1350**. In such embodiments eliminating a third positioning step **1360**, a part may be removed from a first side of an injection mold manually, mechanically, through the use of robotics or through the use of automated systems. In certain embodiments, breaking the connection between the retention feature of the valve-gate pin and the part may not release the part from the first side of the injection mold. In such embodiments, it may be desired to add fourth positioning step **1310** to position the valve-gate pin to force the part away from the first side of the injection mold. In certain embodiments of an injection molding apparatus which comprise a pathway in a valve-gate pin, as shown in **Fig. 10**, an additional step of pushing **1380** a fluid through the pathway may be desired. In such embodiments comprising a pushing step **1380**, it will be appreciated that the pushing step **1380** may occur anywhere throughout the process dependent upon the intended purpose of the pushing step **1380**. For instance, a pushing step may follow the injecting step for the introduction of a gas for gas-assist injection molding. However, a pushing step may occur following the dwelling step **1330** for the purposes of introducing a fluid — including a gas, liquid, powder or flowable solid — to encapsulate the fluid within the part. Furthermore, the pushing step may occur following the retracting **1360** step to provide gas-assisted ejection of a part from the injection mold. It will be appreciated by those skilled in the art that steps including, but not limited to, positioning **1310** the valve-gate pin and, retracting **1360** the valve-gate pin may occur at alternate stages of the process while remaining consistent with the inventive nature of the present invention.

[0044] In the foregoing specification, specific embodiments have been disclosed. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a

restrictive sense, and all such modifications are intended to be included within the scope of present teachings. It is understood that the invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present examples and embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein. The terms “first,” “second,” “proximal,” “distal,” etc., as used herein, are intended for illustrative purposes only and do not limit the embodiments in any way. Additionally, the term “plurality,” as used herein, indicates any number greater than one, either disjunctively or conjunctively, as necessary, up to an infinite number. The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims.

[0045] While various embodiments of the present invention have been described in detail, it is apparent that modifications and alterations of those embodiments will occur to those skilled in the art. However, it is to be expressly understood that such modifications and alterations are within the scope and spirit of the present invention. Further, the invention(s) disclosed herein are capable of other embodiments and of being practiced or of being carried out in various ways. Various embodiments of the present invention(s) have been described in detail, it is apparent that modifications and alterations of those embodiments will occur to those skilled in the art. In addition, it is to be understood that the phraseology and terminology used herein is for the purposes of description and should not be regarded as limiting. The use of "including," "comprising," or "adding" and variations thereof herein are meant to encompass the items listed thereafter and equivalents thereof, as well as, additional items.

CLAIMS

What is Claimed is:

1. An injection molding apparatus for the extraction of a part comprising:

   a first side of an injection mold and a second side of an injection mold having a cavity therebetween;

   said first side of said injection mold further comprising a material delivery chamber and an aperture extending from said material delivery chamber to said cavity;

   a first valve-gate pin having a first end, said first end of said first valve-gate pin disposed through said aperture with said first end protruding into said cavity;

   said valve-gate pin having a retention feature proximate to said first end of said first valve-gate pin; and

   said first valve-gate pin having connection to an actuating mechanism wherein said actuating said first valve-gate pin is positionable through said aperture.
2. The injection molding apparatus of Claim 1, wherein said retention feature comprises an annular recess.
3. The injection molding apparatus of Claim 1, wherein said retention feature comprises a threaded feature.
4. The injection molding apparatus of Claim 1, wherein said retention feature comprises a projecting feature.
5. The injection molding apparatus of Claim 1, wherein said first valve-gate pin further comprises a pathway.
6. The injection molding apparatus of Claim 5, wherein said pathway is consistent with a central axis of said first valve-gate pin.

7. The injection molding apparatus wherein said valve-gate pin is constructed of a material selected from the list consisting of: metals, polymeric, composite, nano-particle enhanced composite.
8. The injection molding apparatus of Claim 1, wherein said injection molding apparatus further comprises a second valve-gate pin.
9. The injection molding apparatus of Claim 1, wherein said actuating mechanism is programmably controlled.
10. A method for the injection molding of a part comprising:

    clamping a first side of an injection mold to a second side of an injection mold creating a cavity therebetween;

    a first positioning step to position a valve-gate pin to an open position;

    injecting a first material into said cavity;

    a maintaining step to hold said injected material under pressure within said injection mold for a predetermined period of time;

    a second positioning step to position a valve-gate pin to a closed position; and

    opening said injection mold, to separate said first side of said injection mold from said second side of said injection mold;
11. The method of Claim 10 further comprising a fourth positioning step following said third positioning step to position the valve-gate pin to force the part away from the first side of the injection mold.
12. The method of Claim 10 further comprising pushing a second material through a pathway in said valve-pin.
13. The method of Claim 11, wherein said second material comprises a gaseous material.
14. The method of Claim 10, wherein said first positioning step occurs prior to said clamping step.

15. The method of Claim 10 further comprising a third positioning step to retract said valve-gate pin thereby breaking a connection between said valve-gate pin and said part.

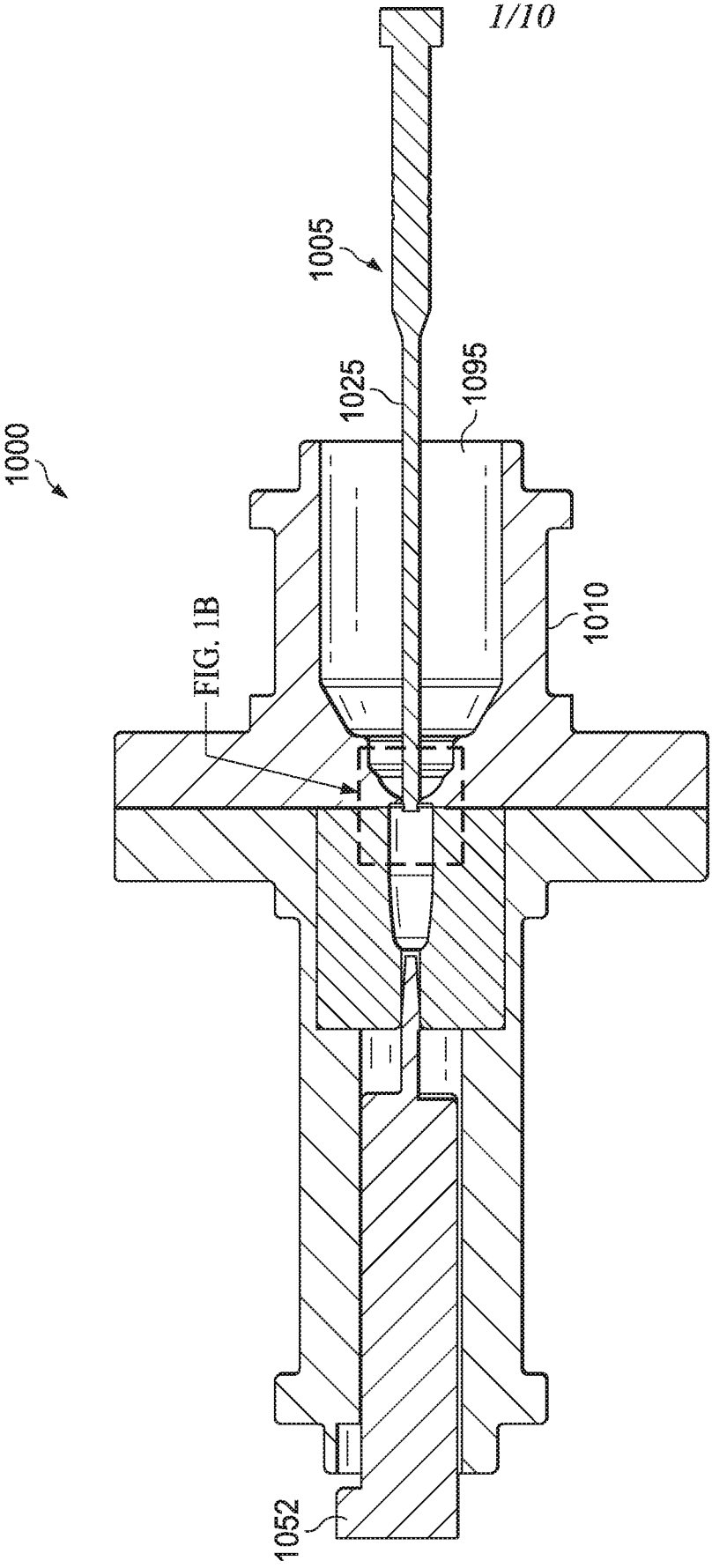

FIG. 1A

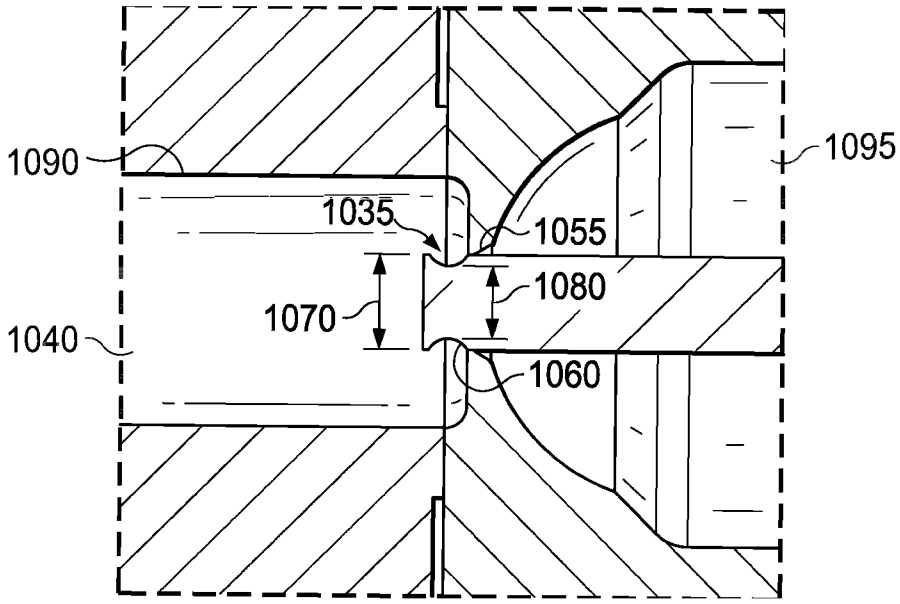
1090
1095
1035
1055
1080
1070
1040
1060

FIG. 1B

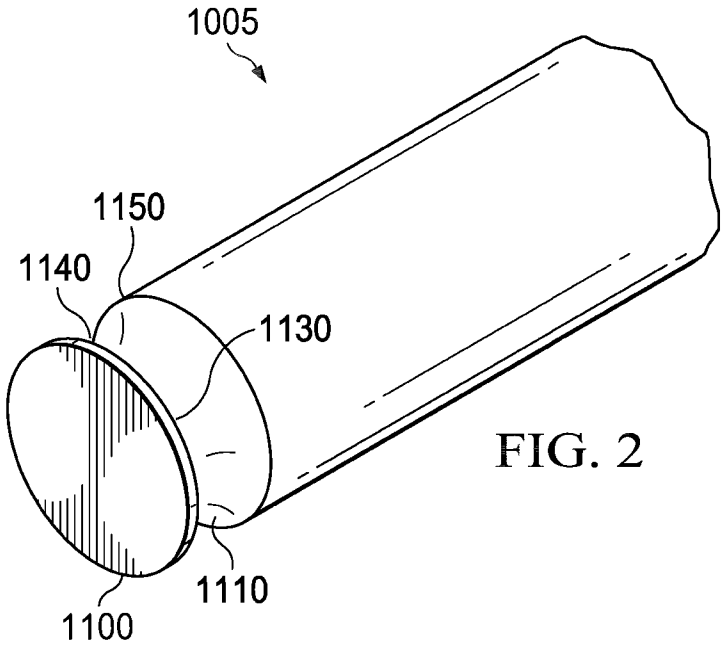
1005
1150
1140
1130
1110
1100

FIG. 2

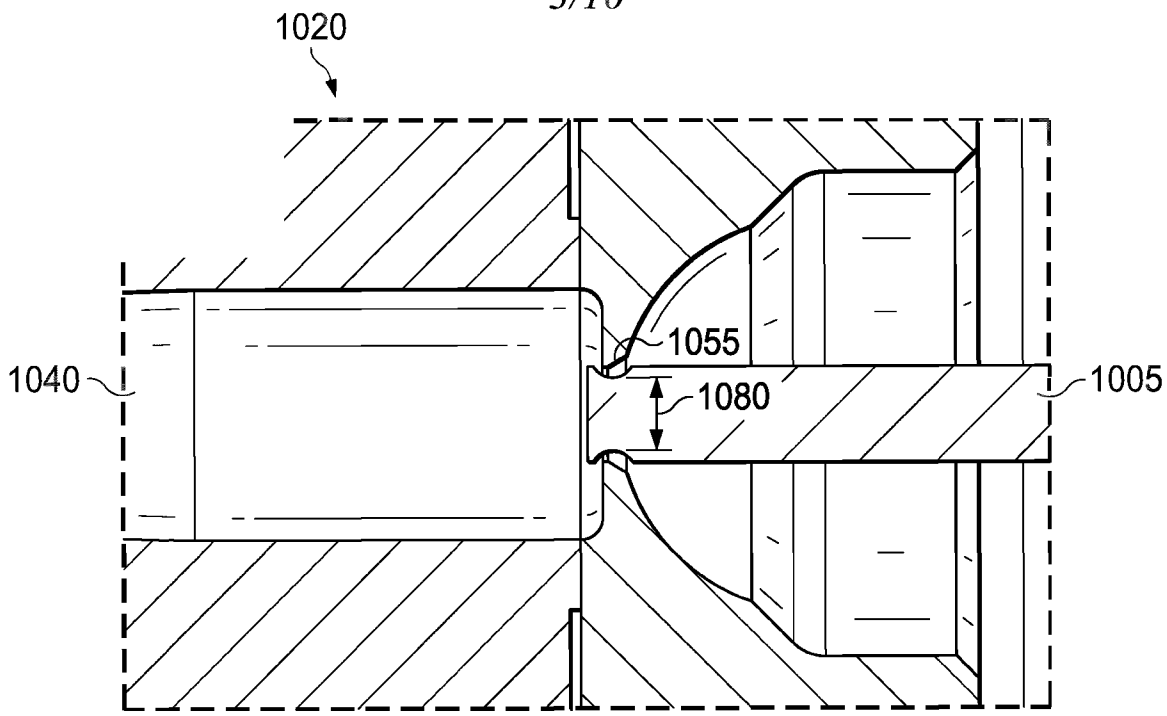

FIG. 3A

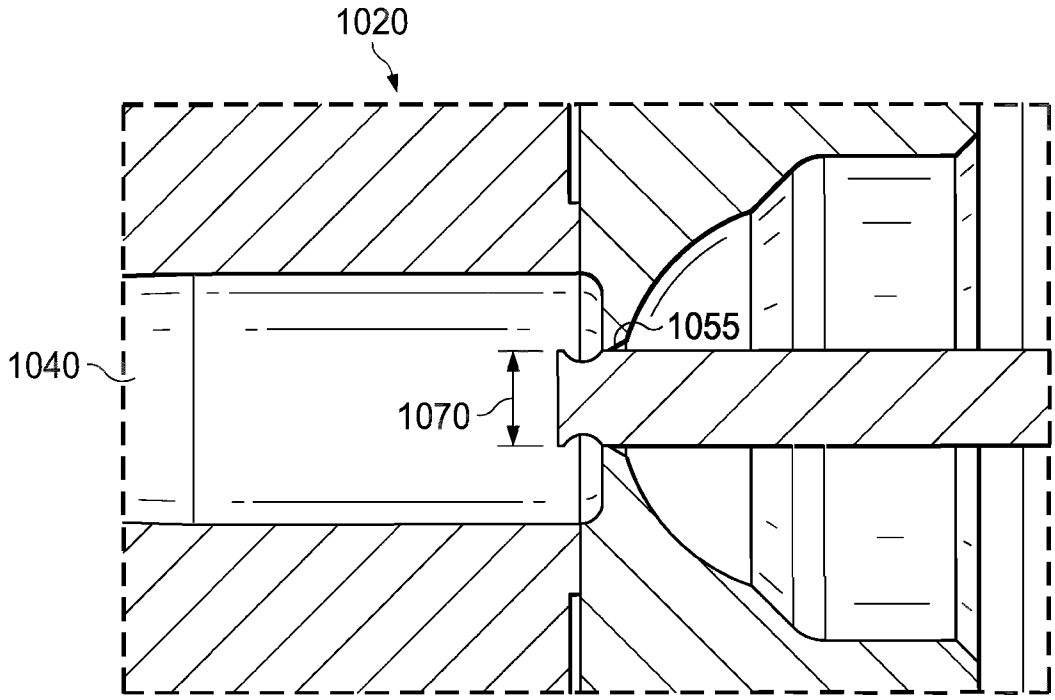

FIG. 3B

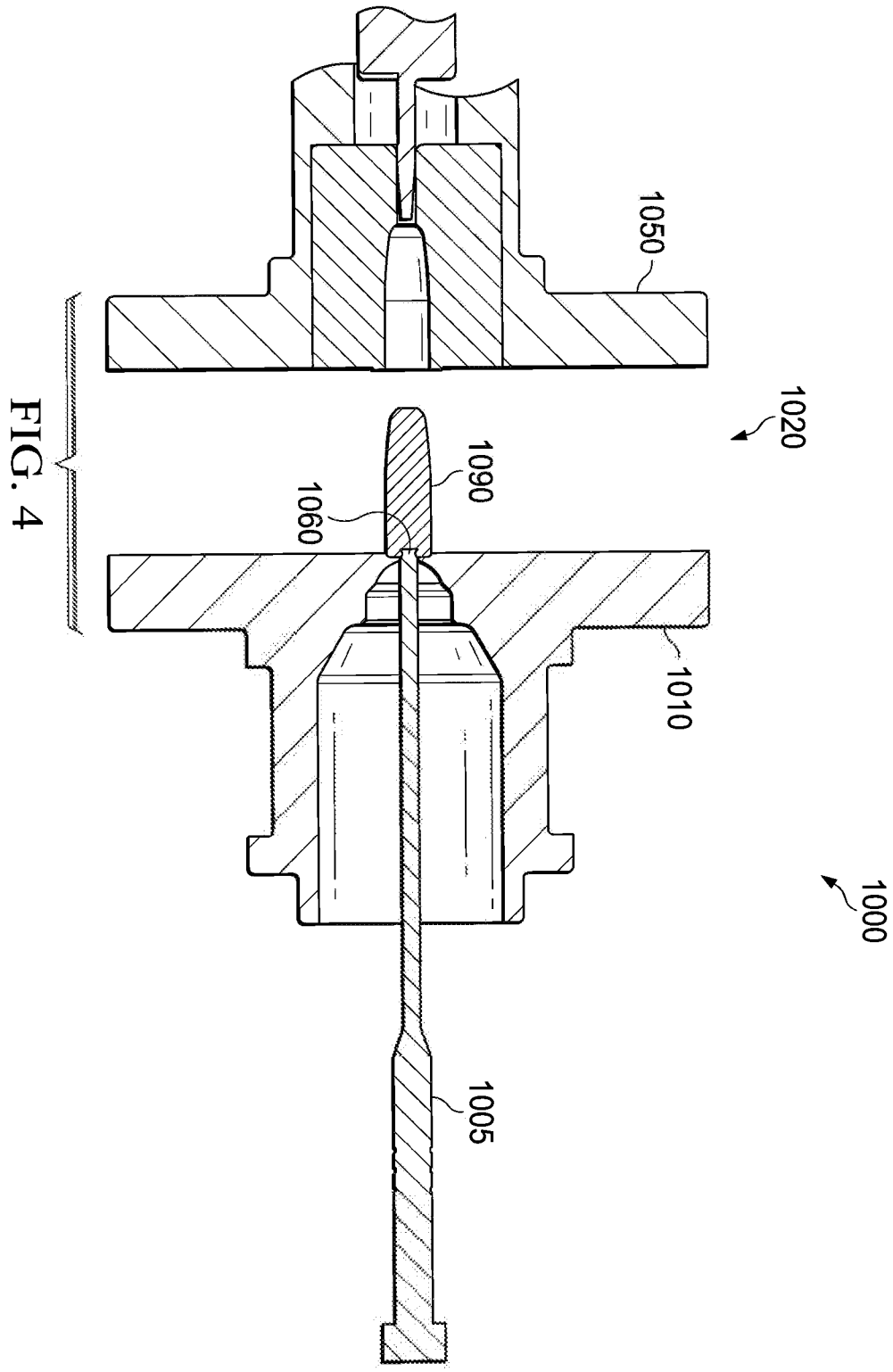

FIG. 4

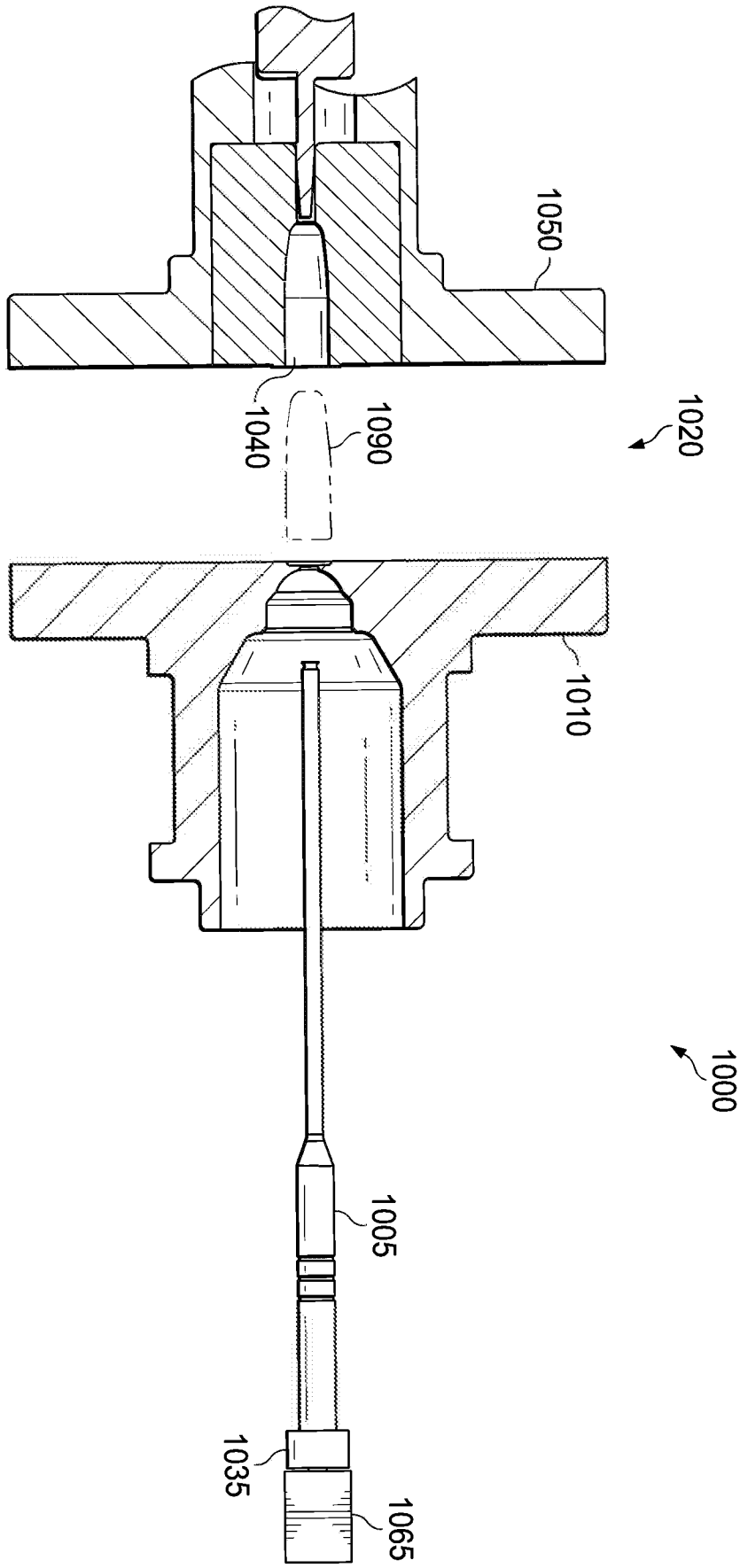

FIG. 5

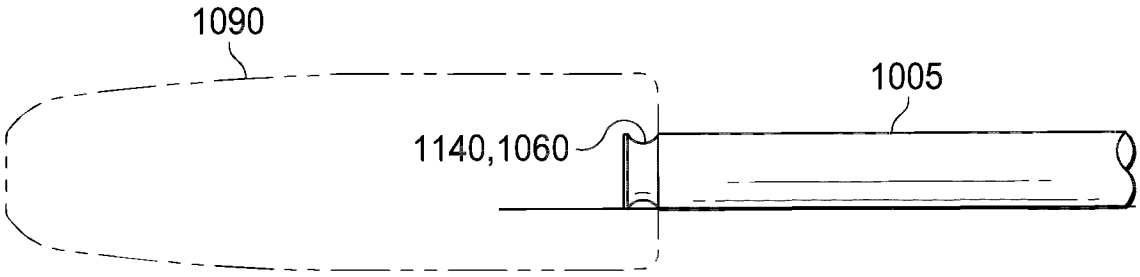

FIG. 6A

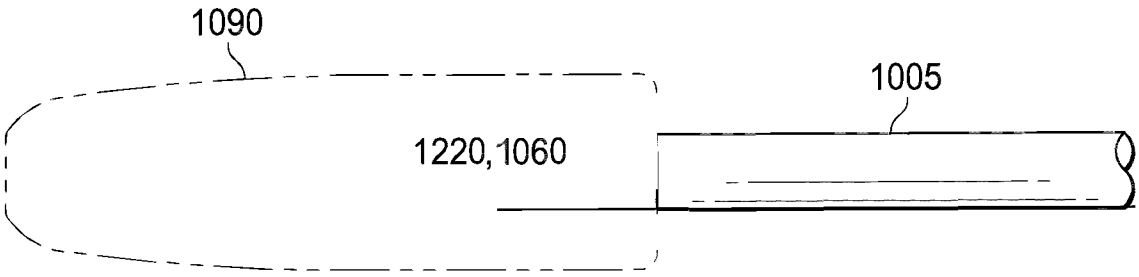

FIG. 6B

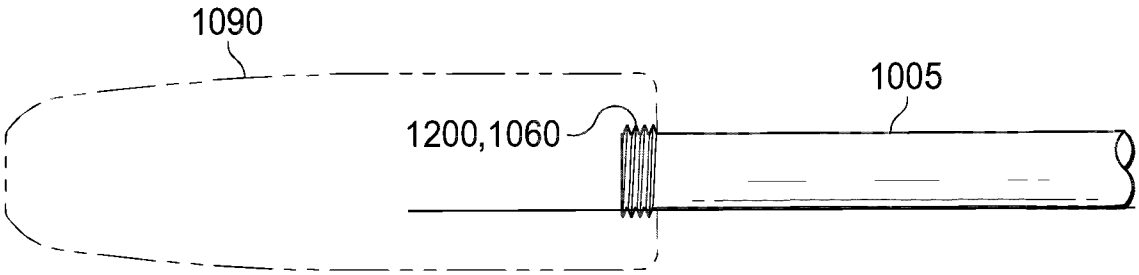

FIG. 6C

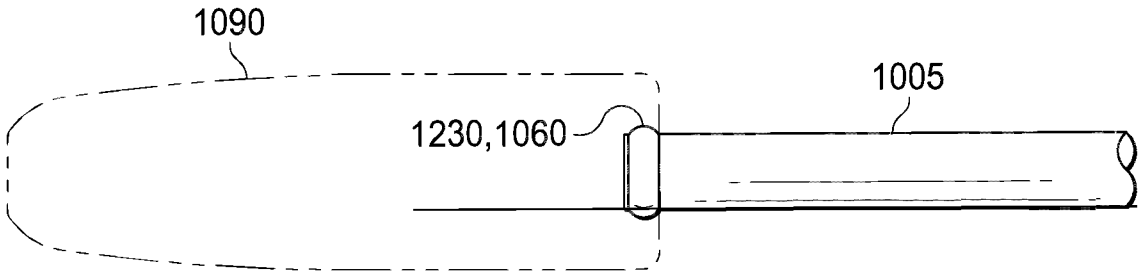

FIG. 6D

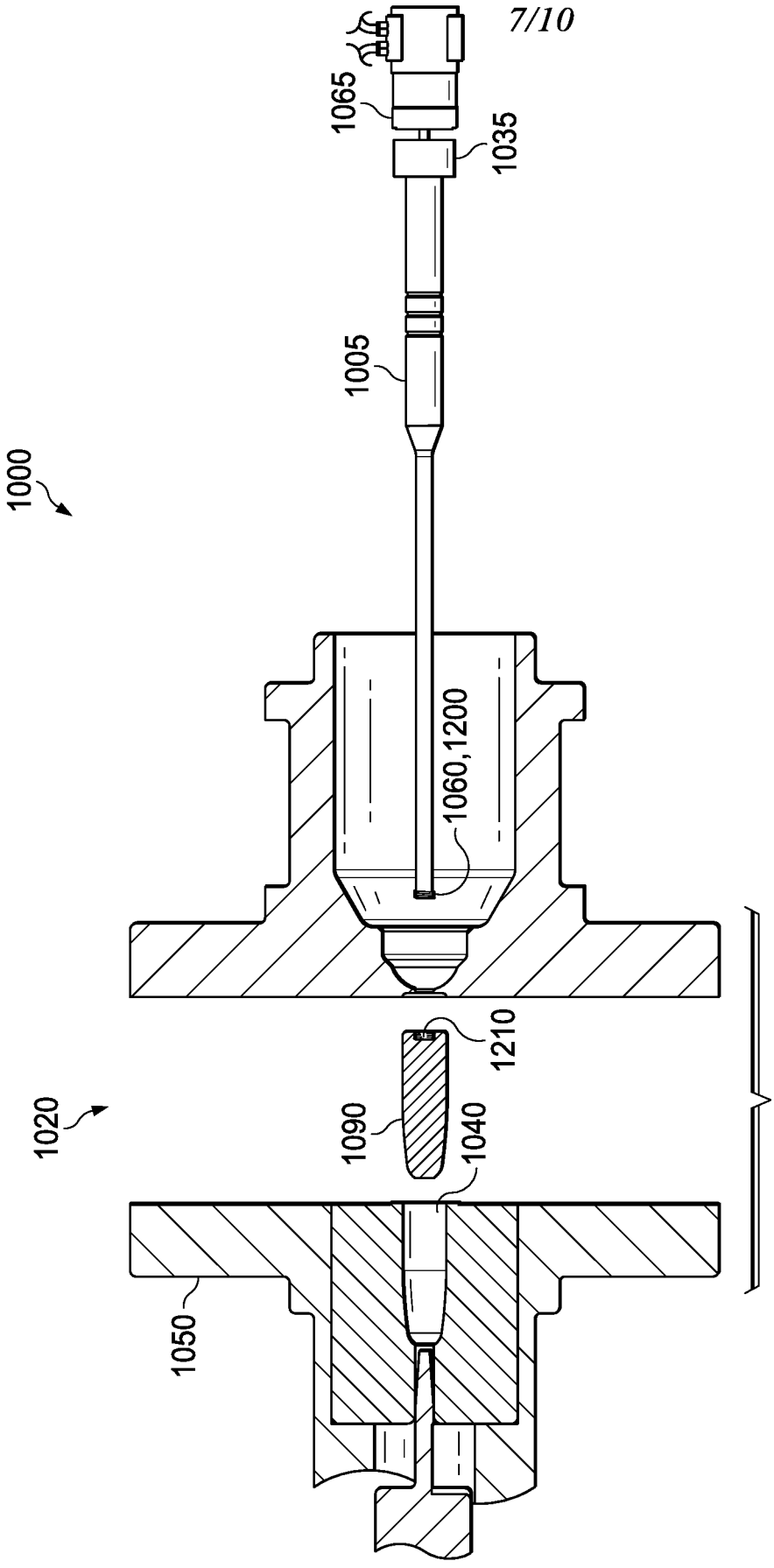

FIG. 7

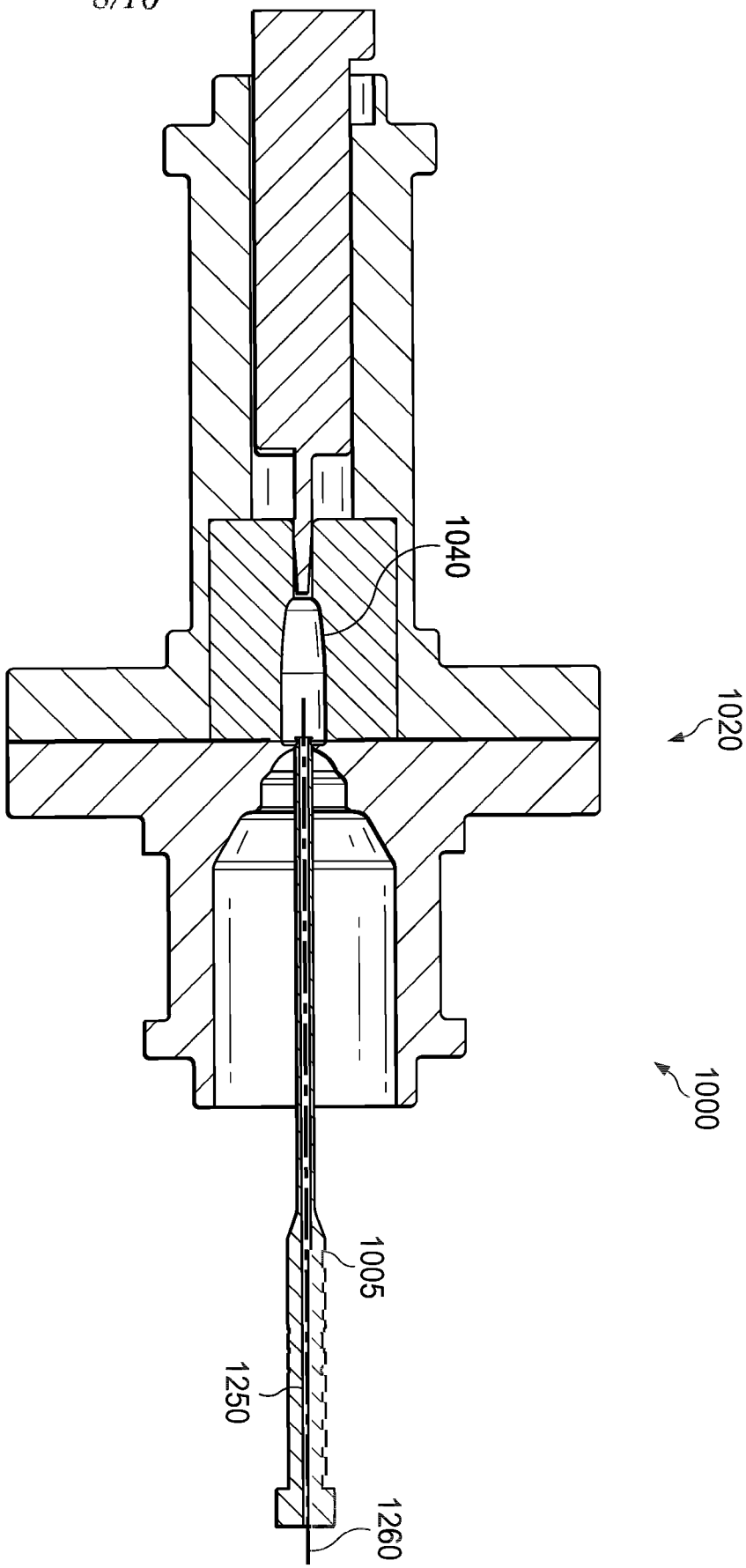

FIG. 8

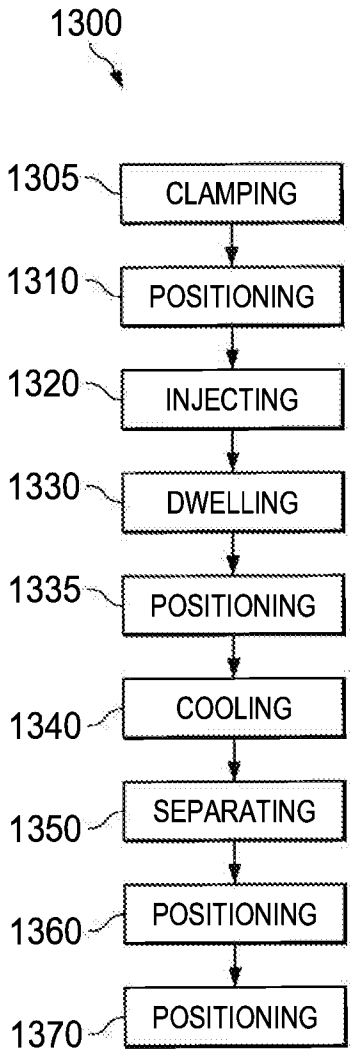
1300
1305
CLAMPING
1310
POSITIONING
1320
INJECTING
1330
DWELLING
1335
POSITIONING
1340
COOLING
1350
SEPARATING
1360
POSITIONING
1370
POSITIONING

FIG. 9

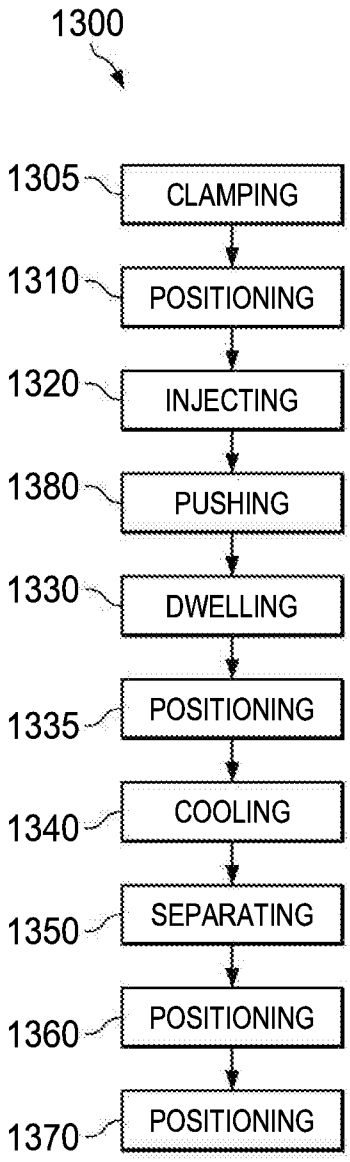
1300
1305
CLAMPING
1310
POSITIONING
1320
INJECTING
1380
PUSHING
1330
DWELLING
1335
POSITIONING
1340
COOLING
1350
SEPARATING
1360
POSITIONING
1370
POSITIONING

FIG. 10