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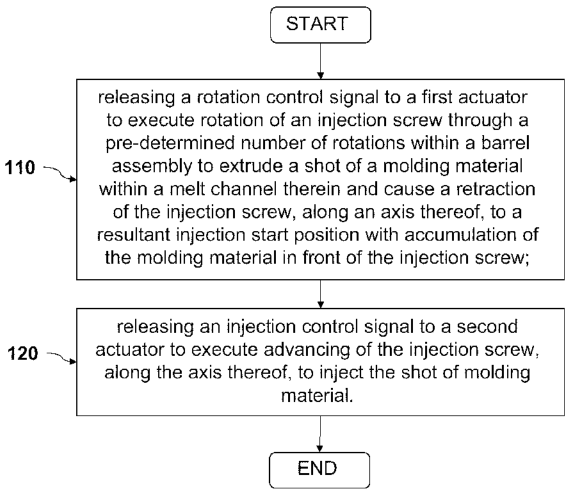

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(57) Abstract: There is provided a method (100, 200) of controlling an injection unit (20) for use in an injection molding system. The method (100, 200) includes releasing (1 10) a rotation control signal to a first actuator (40) to execute rotation of an injection screw (22) to extrude a shot of a molding material within a melt channel (38) therein and cause a retraction of the injection screw (22), along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw (22). In the method (100) the rotation control signal causes the first actuator (40) to execute rotation of the injection screw (22) through a pre-determined number of screw rotations to extrude the shot of the molding material. The method (100, 200) further includes releasing (220) an injection control signal to a second actuator (44) to execute advancing of the injection screw (22), along the axis thereof, to inject the shot of the molding material. In the method (200) the injection control signal transitions from a first injection control regime to a second injection control regime at a pre-determined injection transition distance from the resultant injection start position.

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A METHOD FOR CONTROLLING A SCREW POSITION IN AN INJECTION UNIT

TECHNICAL FIELD

Embodiments of the present invention generally relate to a method of controlling an injection unit for use in an injection molding system.

BACKGROUND OF THE INVENTION

US Patent 3,002,229 to FRIEDERICH Ernst, published on October 3, 1961 discloses a method of operating a die-casting machine of the type in which includes a hollow cylinder closed at its front end by a nozzle, a worm rotatably guided in the bore of the cylinder having a packing arrangement at the rear end of the cylinder for closing the cylinder bore, a feeding aperture for the plastic mass in the wall of the cylinder near the rear end closed by the packing arrangement, and with driving means for the worm, which method comprises the steps of first .driving the worm at a low speed to plasticize the molding material into a plastic mass behind the nozzle, and then driving the worm at a higher speed to extrude the plastic mass out of the nozzle.

US Patent 4,480,981 to TSUYOSHI, Togawa et al., published on November 6, 1984 discloses a system for controlling a temperature of a molten resin in a cylinder of an extruder includes a plurality of temperature detecting elements which are disposed in a wall of the cylinder generally in a plane perpendicular to a longitudinal axis of the cylinder to detect the temperature of the cylinder. The temperature detecting elements are radially spaced by different distances from an inner peripheral surface of the cylinder wall. Detecting devices are provided for detecting an ambient temperature of the extruder and the number of revolutions of a screw of the extruder. A microcontroller unit is programmed to be responsive to detecting signals from the temperature detecting elements and detecting devices to calculate a proper estimated temperature of the molten resin and to calculate a difference between a desired temperature of the resin and the estimated temperature and to determine in accordance with this difference a set temperature of the cylinder wall. A temperature regulating device compares the set temperature with one of the temperatures detected by the temperature detecting elements to produce a temperature control signal in response to which the temperature of the portion of the cylinder where the one temperature detecting element is disposed is brought into agreement with the set temperature.

US Patent 5,098,275 to MASAYOSHI, Kasai et al., published on March 24, 1992 discloses a raw material resin feeding apparatus for a molding machine, such as an injection molding machine or an extruder. In this system, upon carrying out a variable resin change operation by making use of material to be changed, raw material resin is intermittently fed to a feed section by intermittently opening and closing a resin passageway. The improvements reside in that the apparatus includes a raw resin material feed selection mechanism provided midway along a resin passageway for selectively either feeding a pre-determined amount intermittently or continuously to a feed section. A resin change resin feed start detector mechanism is provided for detecting completion of discharge of the amount of raw material corresponding to the pre-determined amount, and a resin change completion detector mechanism is provided. With this apparatus, raw material can be selectively fed to effect quick resin change or for normal operation.

US Patent 6,854,967 to KENJI, Tsutsui et al., published on February 15, 2005 discloses an electric injecting molder and an injection velocity and injection pressure controlling method for an electric injecting molder, and it is an object of the present invention to make it possible, in injection molding by an electric injection molder, to mold stable resin products having a minimized dispersion in the quality even if the operation environment varies. When an injection screw disposed in an injection cylinder is driven to move in forward and backward directions by an electric motor to inject resin material in the injection cylinder into a metal mold to fill the metal mold, the electric motor is first velocity controlled to fill the resin material into the metal mold, and, after the filling, the electric motor is pressure controlled to replenish the resin material for shrinkage of the resin. Upon the velocity control, a velocity target value for the injection screw is corrected in response to a force detection value so that the velocity target value for the injection screw may decrease as the force detection value increases to perform velocity feedback control of the electric motor so that a velocity detection value from velocity detection means may be equal to the velocity target value.

US Patent Application 2009/0191295 A1, to MASASHI, Onishi, published on July 30, 2009 discloses a molding machine has induction heating means for heating a heating cylinder by induction heating. The induction heating means includes a plurality of induction heating coils provided in the heating cylinder and a plurality of electric power supply control parts that control electric power supplied to those coils. The electric power supply control parts have heating part controlling inverters to which an electric power is supplied from a direct current power source circuit, respectively. Each of the heating part controlling inverters performs a frequency control or an electric current control of an electric power to supply.

SUMMARY OF THE INVENTION

The invention is set forth and characterized in the main claim(s), while the dependent claims describe other characteristics of the invention.

According to a first broad aspect of the present invention, there is provided a method of controlling an injection unit for use in an injection molding system, the method being executable at a controller. The method includes releasing a rotation control signal to a first actuator to execute rotation of an injection screw through a pre-determined number of screw rotations within a barrel assembly to extrude a shot of a molding material within a melt channel therein and cause a retraction of the injection screw, along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw. The method further includes releasing an injection control signal to a second actuator to execute advancing of the injection screw, along the axis thereof, to inject the shot of molding material.

According to a second broad aspect of the present invention, there is provided another method of controlling an injection unit for use in an injection molding system, the method being executable at a controller. The method includes releasing a rotation control signal to a first actuator to execute rotation of an injection screw within a barrel assembly to extrude a shot of a molding material within a melt channel therein and cause a retraction of the injection screw, along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw. The method further includes releasing an injection control signal to a second actuator to execute advancing of the injection screw, along the axis thereof, to inject the shot of the molding material, wherein the injection control signal transitions from a first injection control regime to a second injection control regime at a pre-determined injection transition distance from the resultant injection start position.

These and other aspects and features of non-limiting embodiments of the present invention will now become apparent to those skilled in the art upon review of the following description of specific non-limiting embodiments of the invention in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its embodiments will be more fully appreciated by reference to the following detailed description of illustrative (non-limiting) embodiments in accordance with the present invention when taken in conjunction with the accompanying drawings, in which:

FIG. 1 depicts a partially sectioned side view of an injection unit implemented according to a non-limited embodiment of the present invention;

FIG. 2 depicts a flow chart showing steps of a method of controlling the injection unit of FIG. 1;

FIG. 3A depicts a plot of axial position, angular velocity, and torque applied to an injection screw of the injection unit of FIG. 1 over a time required to perform a recovery portion of a known method of controlling the injection unit of FIG. 1;

FIG. 3B depicts a theoretical plot of axial position, angular velocity, and torque applied to the injection screw of the injection unit of FIG. 1 over a time required to perform a recovery portion of the non-limiting embodiment of the method of controlling the injection unit of FIG. 1;

FIG. 4 depicts a flow chart showing steps of another method of controlling the injection unit of FIG. 1.

The drawings are not necessarily to scale and may be illustrated by phantom lines, diagrammatic representations and fragmentary views. In certain instances, details that are not necessary for an understanding of the embodiments or that render other details difficult to perceive may have been omitted.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to FIG. 1, there is depicted a non-limiting embodiment of an injection unit 20 for use in an injection molding system (not shown). The injection unit 20 is configured to plasticize and inject molding material into a mold (not shown).

The injection unit 20 includes a barrel assembly 30 that is adapted to receive an injection screw 22.

The barrel assembly 30 includes a barrel 24, a cylinder head 26 and a nozzle 28. The cylinder head 26 closes off an end of the barrel 24, and mounts a nozzle 28 that is coaxially aligned therewith. A melt channel 38 is defined between them, extending through the barrel 24, the cylinder head 26 and nozzle 28.

In operation, molding material, such as, for example, high-density polyethylene, and the like, is fed from a hopper 32, through a feed throat 34 into the melt channel 38. With rotational movement of the injection screw 22 and heating of the barrel 24 the molding material is melted as it is conveyed past a non-return valve 36 at the end of the injection screw 22. The injection screw 22 may include a plurality of specialized zones. For example, a first zone might be adapted for conveying solid material from the hopper 32, a latter zone for compressing the material, and a final zone for mixing the now-molten material prior to passing through the non-return valve 36. The implementation of injection screw 22 is not particularly limited and other implementations will occur to those of skill in the art.

The heating of the molding material within the barrel 24 is provided, in part, by heaters 46, such as, for example, band heaters, that are provided along a portion of the length thereof. Thermocouples 60 are provided within the various zones of the barrel to provide an indication of the temperature thereof. The thermocouples 60 are operatively connected to a controller 50 to provide an indication of the temperature of the various zones.

The rotational movement of injection screw 22 is provided by a first actuator 40, such as, for example, an electric servomotor, that is connected thereto via a transmission 42. The implementation of the first actuator 40 is not particularly limited and other implementations will occur to those of skill in the art.

A rotation sensor 62, such as, for example, a rotary encoder, is associated with the first actuator 40. The rotation sensor 62 is configured to sense a current angular position of a rotor (not shown) within the first actuator 40. The implementation of the rotation sensor 62 is not particularly limited and other implementations will occur to those of skill in the art. The rotation sensor 62 is operatively connected to the controller 50 from which an indication (i.e. feedback) of the current rotational state (i.e. angular position, and rotational velocity) of the injection screw 22 may be calculated therein.

In addition to rotating, the injection screw 22 is operable to reciprocate, along an axis thereof, to inject the melted molding material out through the nozzle 28 and into the mold (not shown) and thereafter to apply a hold pressure thereto. The reciprocating movement of the injection screw 22 is provided by a second actuator 44 that is connected thereto. The second actuator 44 depicted in FIG. 1 is a hydraulic actuator having a piston slidably arranged within a cylinder. The implementation of the second actuator 44 is not particularly limited and other implementations will occur to those of skill in the art.

An axial position sensor 66 is associated with the second actuator 44 with which to sense a current axial position of the piston therein. The implementation of the axial position sensor 66 is not particularly limited and other implementations will occur to those of skill in the art. The axial position sensor 66 is operatively connected to the controller 50 from which an indication of the position and velocity of the injection screw 22 may be calculated therein.

A pressure sensor 64 is also associated with the second actuator 44 with which to sense a current hydraulic pressure behind the piston therein. The implementation of the pressure sensor 64 is not particularly limited and other implementations will occur to those of skill in the art. The pressure sensor 64 is operatively connected to the controller 50 from which an indication of the pressure of the molding material that is in front of the non-return valve 36 may be calculated therein.

With the indications received from the various sensors (such as thermocouples 60, rotation sensor 62, axial position sensor 66, and pressure sensor 64) located within injection unit 20, the controller 50 is operable to control the overall operation of injection unit 20, including the rotational and reciprocating movement of the injection screw 22 (via first actuator 40 and second actuator 44), and heaters 46. The controller 50 regulates the operating condition of injection unit 20 using closed or open loop control systems. The controller 50 may include a general-purpose or purpose-specific computing apparatus having hardware or software PID controller, or another type of closed or open loop controller. The implementation of the controller 50 is not particularly limited and other implementations will occur to those of skill in the art.

The controller 50 may be controlled by an operator through a Human-Machine Interface (HMI) 52. HMI 52 may include a visual display unit (not shown) for the operator as well as an input device (not shown) for the operator. The implementation of the HMI 52 is not particularly limited and other implementations will occur to those of skill in the art.

The controller 50 may also include internal memory 54 that is configured to store one or more instructions for executing one or more routines. The internal memory 54 can also store and/or update various parameters, such as but not limited to:

(i) a pre-determined number of screw rotations;
(ii) an indication of a resultant injection end position;
(iii) a pre-determined injection transition distance;
(iv) an indication of a resultant injection start position;
(v) a velocity profile;
(vi) a pressure profile;
(vii) a pre-determined minimum injection start position;
(viii) a pre-determined maximum injection start position;
(ix) a pre-determined minimum injection end position;
(x) a pre-determined maximum injection end position;
(xi) a pre-determined screw rotation offset; and/or
(xii) a pre-determined screw position offset.

Given the architecture described with reference to FIG. 1, it is possible to execute a method 100 for controlling the injection unit 20. Within non-limiting embodiments the method 100 is executable at a controller 50 for controlling the injection unit 20. FIG. 2 depicts a flow chart of steps associated with the method 100.

Step 110 - releasing a rotation control signal to the first actuator 40

The method 100 begins at step 110, where controller 50 releases a rotation control signal to the first actuator 40 to execute rotation of an injection screw 22 through a pre-determined number of screw rotations within the barrel assembly 30 to extrude a shot of a molding material within the melt channel 38 therein and cause a retraction of the injection screw 22, along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw 22.

That is, for sake of extruding a shot of molding material, during a recovery portion of the method 100, the controller 50 controls the first actuator 40 to rotate the injection screw 22 through the pre-determined number of rotations that is known to extrude enough molding material to fill and pack the mold during a subsequent injection portion of the method 100. The foregoing is made possible because it has been recognized that for a given set of operating conditions the injection screw 22 behaves like a constant volume pump and displaces a consistent quantity of molding material per revolution, with only minor variations.

In contrast, the known method of operating the injection unit 20 to extrude a shot of molding material, during a recovery portion thereof, is to rotate the injection screw 22 until it has been displaced, along the axis thereof, to a pre-determined injection start position that is known to provide enough molding material to fill and pack the mold during a subsequent injection portion of the method.

A technical effect of the method 100 may include tighter control of the injection unit 20, during the recovery portion, whereby the time required to extrude the shot of molding material may be reduced or it may be possible to extrude an increased amount of molding material. The foregoing technical effect may be appreciated by contrasting plots of axial position of the injection screw 22 over time, wherein it can be seen additional time T is required for recovery of the shot of molding material with the known method (i.e. curve P – FIG. 3A) in comparison with the method 100 (i.e. curve P' – FIG. 3B). A reason for the foregoing may be appreciated by contrasting plots of torque applied to the injection screw 22 over time, wherein it can be seen that there is a relatively long transient response near the end of recovery for the known method (i.e. curve T – FIG. 3A) in comparison with the method 100 (i.e. curve T' – FIG. 3B). This is also reflected in the resultant fluctuations of a rotational velocity of the injection screw 22 with the known method (i.e. curve R – FIG. 3A) in comparison with the method 100 (i.e. curve R' – FIG. 3B). Accordingly, with the known method the controller 50 is much more constrained with control of the first actuator 40 (i.e. injection screw rotation) to achieve a pre-determined injection start position with an indication (i.e. feedback) of the axial position of the injection screw 22 (via the axial position sensor 66). The foregoing is made all the worse with injection screw 22 pull-back at the end of the preceding cycle, whereby the injection screw 22 may not start moving, along the axis thereof, until a significant portion of the recovery has been completed. In contrast, with the method 100 the controller 50 is relatively un-constrained in that it simply controls the first actuator 40 to rotate through the pre-determined number of screw rotations with (or without – open loop) an indication (i.e. feedback) of the angular position of the injection screw 22 (via the rotation sensor 62). This is reflected in the relatively tight control (i.e. near absence of transient response) in the applied torque (i.e. curve T' – FIG. 3B) and the rotational velocity (i.e. curve R' – FIG. 3B). Furthermore, such a method 100 of control is relatively unaffected by injection screw 22 pull-back.

The rotational position at which to initiate braking can be calculated based on knowledge of the rotational inertia of the system and the plasticizing torque behaviour which can be determined from the acceleration phase of recovery as shown in Figure 3

Step 120 - releasing an injection control signal to the second actuator 44

The method 100 ends at step 120, where controller 50 releases an injection control signal to a second actuator 44 to execute advancing of the injection screw 22, along the axis thereof, to inject the shot of molding material. The method 100 is repeatable with subsequent cycles of operation of the injection unit 20 (i.e. process loops back to step 110).

The injection control signal may include a transition from a first injection control regime to a second injection control regime at a pre-determined injection transition distance from the resultant injection start position. A technical effect of defining the transition between the first injection control regime and the second injection control regime to be undertaken at a pre-determined distance (i.e. pre-determined injection transition distance) from the resultant injection start position may include that the injection behavior is expected be the same regardless of what resultant injection start position the injection screw 22 reached at end of the recovery portion of the method 100.

As with a typical molding process, the first injection control regime may include velocity control, whereas the second control regime may include pressure control. As such, the injection control signal to the second actuator 44 may further provide for velocity controlled advancing of the injection screw 22, along the axis thereof, over the pre-determined injection transition distance from the resultant injection start position to a resultant transition position (i.e. to fill the mold, not shown, with the molding material), and thereafter provide for pressure controlled advancing of the injection screw 22, along the axis thereof, upon reaching the resultant transition position, whereby the injection screw 22 is advanced from the resultant transition position to a resultant injection end position (i.e. to hold a molding material pressure within the mold, not shown). The velocity control and pressure control of the second actuator 44 are performed in the known manner and hence will not be further described herein.

Overall, a technical effect of the foregoing may include an improved strategy for controlling the recovery and injection functions that makes the two functions independent.

With the method 100 it is possible that the injection start position may drift (i.e. increase or decrease) from shot to shot with slight variances in recovery. That being said it may be necessary in some embodiments to set minimum and maximum bounds to limit the drift. For instance, it may be practical to maintain a minimum injection end position to maintain a cushion of molding material within the barrel assembly 30. Likewise, a maximum injection start position would limit the amount of excess molding material in the barrel assembly 30 and thus reduce the residence time thereof to avoid thermal degradation.

In general, drift may be compensated for by small changes in the pre-determined number of screw rotations needed for recovery.

As such, the method 100 may further include appreciating an indication of the resultant injection start position (via the axial position sensor 66) and responsive to the resultant injection start position being less than a pre-determined minimum injection start position increasing the pre-determined number of screw rotations of the injection screw 22. The amount by which the pre-determined number of screw rotations is increased may be in accordance with a pre-determined screw rotation offset (e.g. quarter-turn, half-turn, or other). Alternatively, the controller 50 may calculate a rotation correction and thereafter increase the pre-determined number of screw rotations of the injection screw 22 by the rotation correction. The rotation correction may be calculated, for example, as a quotient of a difference between the resultant injection start position and the pre-determined minimum injection start position over (i.e. divided by) a pre-determined screw position offset, where the pre-determined screw position offset is an amount that the injection screw 22 known to move, along the axis thereof, for each revolution thereof.

Likewise, the method 100 may further include responsive to the resultant injection start position being greater than a pre-determined maximum injection start position reducing the pre-determined number of screw rotations of the injection screw 22. Similar to before, the pre-determined number of screw rotations of the injection screw 22 may be reduced by a pre-determined screw rotation offset or by a rotation correction that is calculated in the controller 50. In this case the rotation correction would be a quotient of a difference between the resultant injection start position and the pre-determined maximum injection start position over the pre-determined screw position offset.

Alternatively, the method 100 may compensate for drift by appreciating an indication of the resultant injection end position (via the axial position sensor 66). That is, responsive to the resultant injection end position being less than a pre-determined minimum injection end position increasing the pre-determined number of screw rotations of the injection screw 22. Similar to before, the pre-determined number of screw rotations of the injection screw 22 may be increased by a pre-determined screw rotation offset or by a rotation correction that is calculated in the controller 50. In this case the rotation correction would be a quotient of a difference between the resultant injection end position and the pre-determined minimum injection end position over the pre-determined screw position offset.

Lastly, responsive to the resultant injection end position being greater than a pre-determined minimum injection end position decreasing the pre-determined number of screw rotations of the injection screw 22. Similar to before, the pre-determined number of screw rotations of the injection screw 22 may be decreased by a pre-determined screw rotation offset or by a rotation correction that is calculated in the controller 50. In this case the rotation correction would be a quotient of a difference between the resultant injection end position and the pre-determined maximum injection end position over the pre-determined screw position offset.

It is furthermore possible to execute another method 200 for controlling the injection unit 20. Within non-limiting embodiments the method 200 is executable at the controller 50 for controlling the injection unit 20. FIG. 4 depicts a flow chart of steps associated with the method 200.

Step 210 - releasing a rotation control signal to the first actuator 40

The method 200 begins at step 210, where controller 50 releases a rotation control signal to the first actuator 40 to execute rotation of an injection screw 22 within the barrel assembly 30 to extrude a shot of a molding material within the melt channel 38 therein and cause a retraction of the injection screw 22, along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw 22.

As with the method 100, the rotation control signal may cause the first actuator 40 to execute rotation of the injection screw 22 through a pre-determined number of screw rotations to extrude the shot of the molding material.

Alternatively, the rotation control signal may cause the first actuator 40 to execute rotation of the injection screw 22 towards achieving a target injection start position to extrude the shot of the molding material. This approach encompasses the known process of controlling the injection unit 20 to perform the step of recovery. In practical terms, even with control of the injection unit 20 towards achieving a target injection start position it may come to pass that the controller 50 undershoots or overshoots, whereby the resultant injection start position may be different than the target injection start position. This approach also encompasses a variation on the known process of controlling the injection unit 20 to perform the step of recovery, wherein looser control is provided over the first actuator 40 in terms of achieving the target injection start position for sake of accommodating faster rotational braking of the injection screw 22 (e.g. negative torque applied to first actuator 40). A technical effect of the foregoing may include reduced time requirement for recovery – albeit potentially at the expense of increased drift in the resultant injection start position. To limit the drift it is possible to implement corrections in view of minimum and maximum bounds for one or both of the resultant injection start position and the resultant injection end position. For instance, it may be practical to maintain a minimum injection end position to maintain a cushion of molding material within the barrel assembly 30. Likewise, a maximum injection start position would limit the amount of excess molding material in the barrel assembly 30 and thus reduce the residence time thereof to avoid thermal degradation. To perform any necessary corrections the controller 50 may implement suitable variations in the rotation control signal.

Step 220 - releasing an injection control signal to the second actuator 44

The method 200 ends at step 220, where controller 50 releases an injection control signal to a second actuator 44 to execute advancing of the injection screw 22, along the axis thereof, to inject the shot of molding material, wherein the injection control signal transitions from a first injection control regime to a second injection control regime at a pre-determined injection transition distance from the resultant injection start position. The method 200 is repeatable with subsequent cycles of operation of the injection unit 20 (i.e. process loops back to step 210).

As described previously, the first injection control regime may include velocity control, whereas the second control regime may include pressure control.

A technical effect of defining the transition between the first injection control regime and the second injection control regime to be undertaken at a pre-determined distance (i.e. pre-determined injection transition distance) from the resultant injection start position may include that the injection behavior would be the same regardless of what resultant injection start position the injection screw 22 reached at end of the recovery portion of the method 100.

It is noted that the foregoing has outlined some of the more pertinent non-limiting embodiments of the present invention. This invention may be used for many applications. Thus, although the description is made for particular arrangements and methods, the intent and concept of the invention is suitable and applicable to other arrangements and applications. It will be clear to those skilled in the art that modifications to the disclosed embodiments can be effected without departing from the spirit and scope of the invention. The described embodiments ought to be construed to be merely illustrative of some of the more prominent features and applications of the invention. Other beneficial results can be realized by applying the disclosed invention in a different manner or modifying the invention in ways known to those familiar with the art. This includes the mixing and matching of features, elements and/or functions between various embodiments is expressly contemplated herein so that one of ordinary skill in the art would appreciate from this disclosure that features, elements and/or functions of one embodiment may be incorporated into another embodiment as skill in the art would appreciate from this disclosure that features, elements and/or functions of one embodiment may be incorporated into another embodiment as appropriate, unless described otherwise, above.

WHAT IS CLAIMED IS:

1. A method (100) of controlling an injection unit (20) for use in an injection molding system, the method being executable at a controller (50), the method (100) comprising:

   releasing (110) a rotation control signal to a first actuator (40) to execute rotation of an injection screw (22) through a pre-determined number of screw rotations within a barrel assembly (30) to extrude a shot of a molding material within a melt channel (38) therein and cause a retraction of the injection screw (22), along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw (22);

   releasing (120) an injection control signal to a second actuator (44) to execute advancing of the injection screw (22), along the axis thereof, to inject the shot of the molding material.

2. The method (100) of claim 1, wherein:

   the injection control signal to the second actuator (44) provide for velocity controlled advancing of the injection screw (22), along the axis thereof, over a pre-determined injection transition distance from the resultant injection start position to a resultant transition position.

3. The method (100) of claim 2, wherein:

   the injection control signal to the second actuator (44) provide for pressure controlled advancing of the injection screw (22) upon reaching the resultant transition position, whereby the injection screw (22) is advanced from the resultant transition position to a resultant injection end position.

4. The method (100) of claim 3, further comprising:

   appreciating an indication of the resultant injection start position;

   responsive to the resultant injection start position being less than a pre-determined minimum injection start position increasing the pre-determined number of screw rotations of the injection screw (22).

5. The method (100) of claim 4, wherein:

   the pre-determined number of screw rotations of the injection screw (22) is increased by a pre-determined screw rotation offset.

6. The method (100) of claim 4, further comprising:

   calculating a rotation correction; and

increasing the pre-determined number of screw rotations of the injection screw (22) by the rotation correction.

7. The method (100) of claim 3, further comprising:

appreciating an indication of the resultant injection start position;

responsive to the resultant injection start position being greater than a pre-determined maximum injection start position reducing the pre-determined number of screw rotations of the injection screw (22).

8. The method (100) of claim 7, wherein:

the pre-determined number of screw rotations of the injection screw (22) is reduced by a pre-determined screw rotation offset.

9. The method (100) of claim 7, further comprising:

calculating a rotation correction; and

reducing the pre-determined number of screw rotations of the injection screw (22) by the rotation correction.

10. The method (100) of claim 3, further comprising:

appreciating an indication of the resultant injection end position;

responsive to the resultant injection end position being less than a pre-determined minimum injection end position increasing the pre-determined number of screw rotations of the injection screw (22).

11. The method (100) of claim 10, wherein:

the pre-determined number of screw rotations of the injection screw (22) is increased by a pre-determined screw rotation offset.

12. The method (100) of claim 10, further comprising:

calculating a rotation correction; and

increasing the pre-determined number of screw rotations of the injection screw (22) by the rotation correction.

13. The method (100) of claim 3, further comprising:

appreciating an indication of the resultant injection end position;

responsive to the resultant injection end position being greater than a pre-determined maximum injection end position reducing the pre-determined number of screw rotations of the injection screw (22).

14. The method (100) of claim 13, wherein:

the pre-determined number of screw rotations of the injection screw (22) is reduced by a pre-determined screw rotation offset.

15. The method (100) of claim 13, further comprising:

calculating a rotation correction; and

reducing the pre-determined number of screw rotations of the injection screw (22) by the rotation correction.

16. A method (200) of controlling an injection unit (20) for use in an injection molding system, the method being executable at a controller (50), the method (200) comprising:

releasing (210) a rotation control signal to a first actuator (40) to execute rotation of an injection screw (22) within a barrel assembly (30) to extrude a shot of a molding material within a melt channel (38) therein and cause a retraction of the injection screw (22), along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw (22);

releasing (220) an injection control signal to a second actuator (44) to execute advancing of the injection screw (22), along the axis thereof, to inject the shot of the molding material, wherein the injection control signal transitions from a first injection control regime to a second injection control regime at a pre-determined injection transition distance from the resultant injection start position.

17. The method (100) of claim 16, wherein:

the rotation control signal causes the first actuator (40) to execute rotation of the injection screw (22) through a pre-determined number of screw rotations to extrude the shot of the molding material.

18. The method (100) of claim 16, wherein:

the rotation control signal causes the first actuator (40) to execute rotation of the injection screw (22) towards achieving a target injection start position to extrude the shot of the molding material.

19. The method (100) of claim 16, wherein:

the first injection control regime provide for velocity controlled advancing of the injection screw (22), along the axis thereof, over the pre-determined injection transition distance from the resultant injection start position to a resultant transition position; and

the second injection control regime provide for pressure controlled advancing of the injection screw (22) upon reaching the resultant transition position, whereby the injection screw (22) is advanced from the resultant transition position to a resultant injection end position.

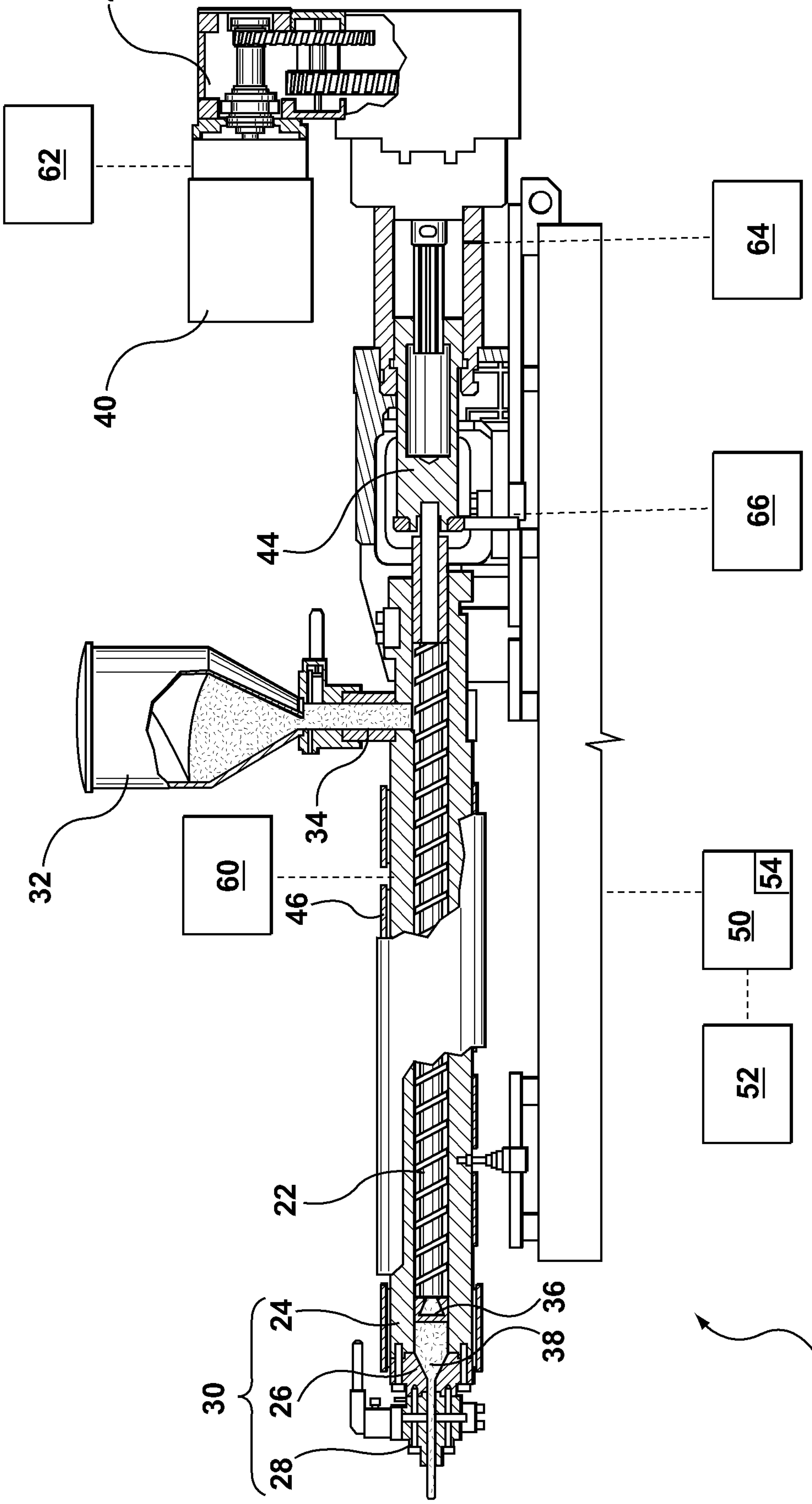

FIG. 1

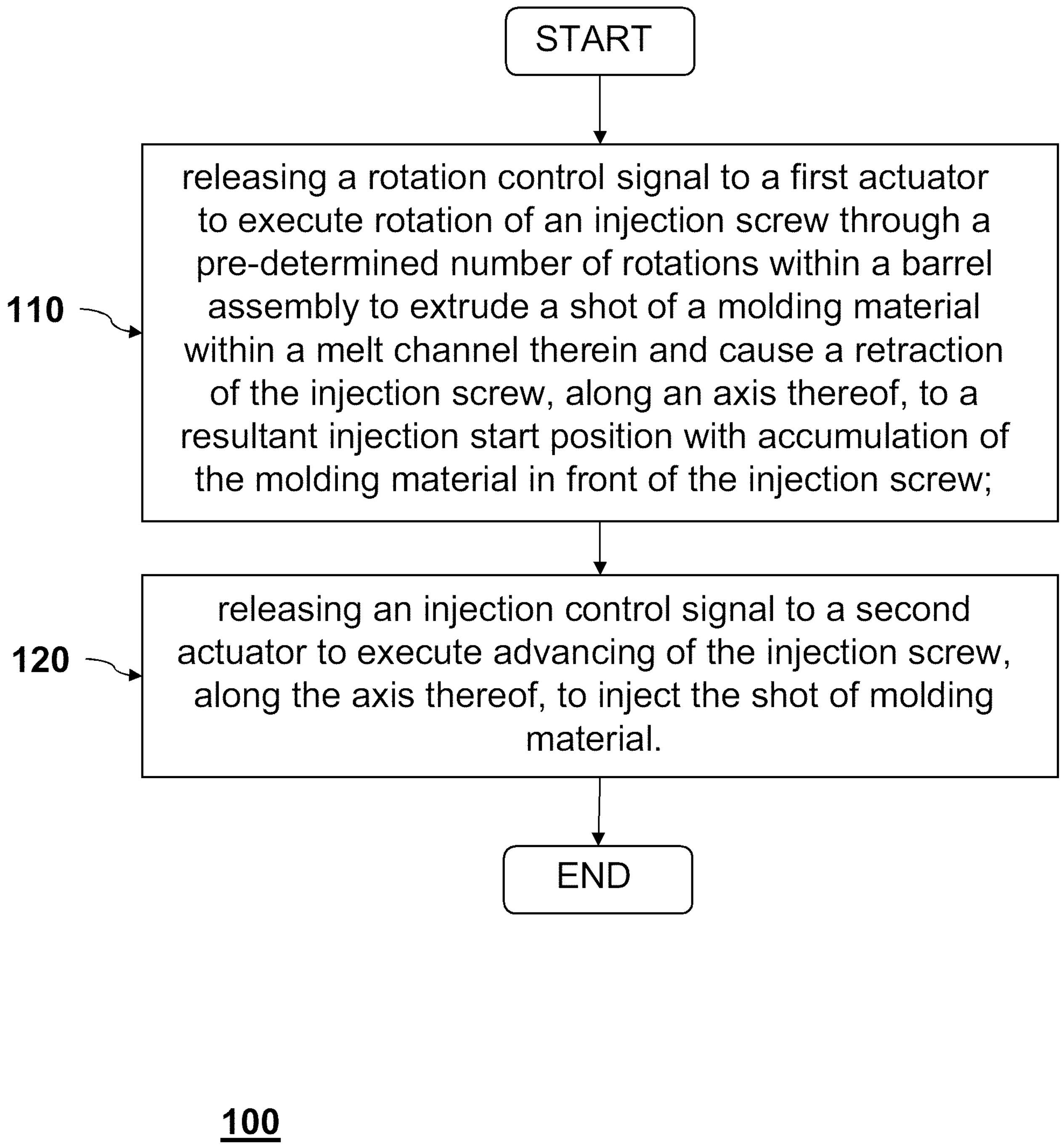
START
releasing a rotation control signal to a first actuator to execute rotation of an injection screw through a pre-determined number of rotations within a barrel assembly to extrude a shot of a molding material within a melt channel therein and cause a retraction of the injection screw, along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw;
110
releasing an injection control signal to a second actuator to execute advancing of the injection screw, along the axis thereof, to inject the shot of molding material.
120
END
100

FIG. 2

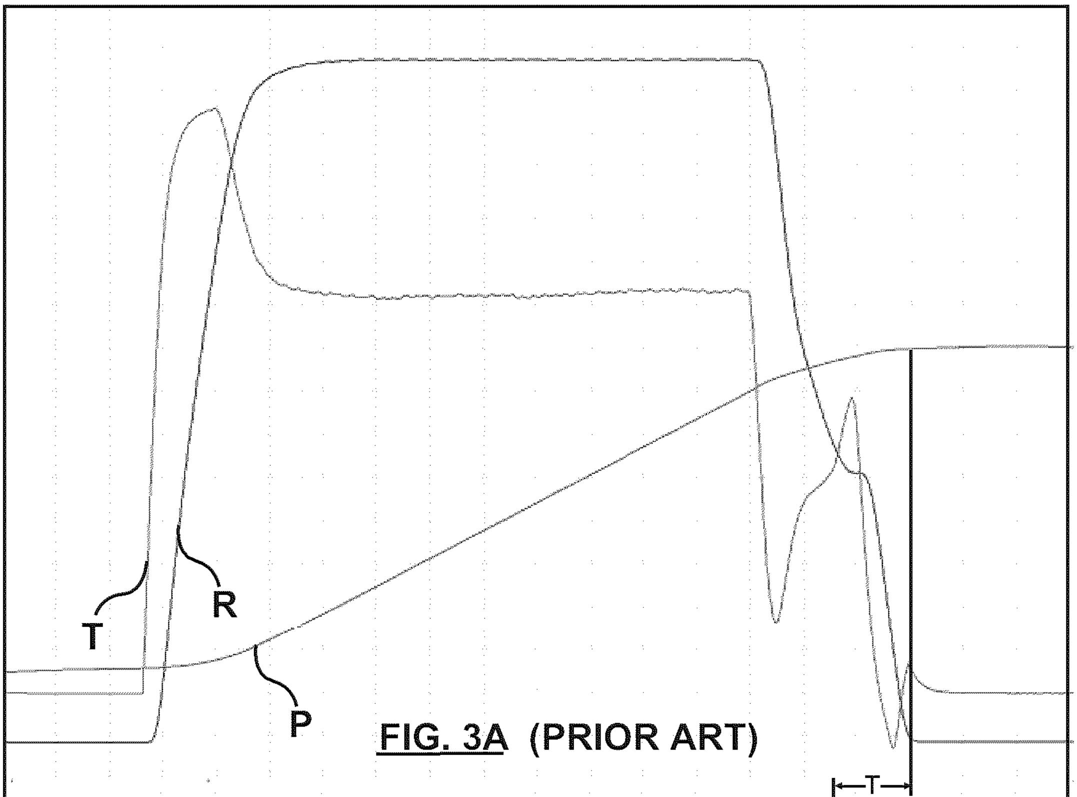

FIG. 3A (PRIOR ART)

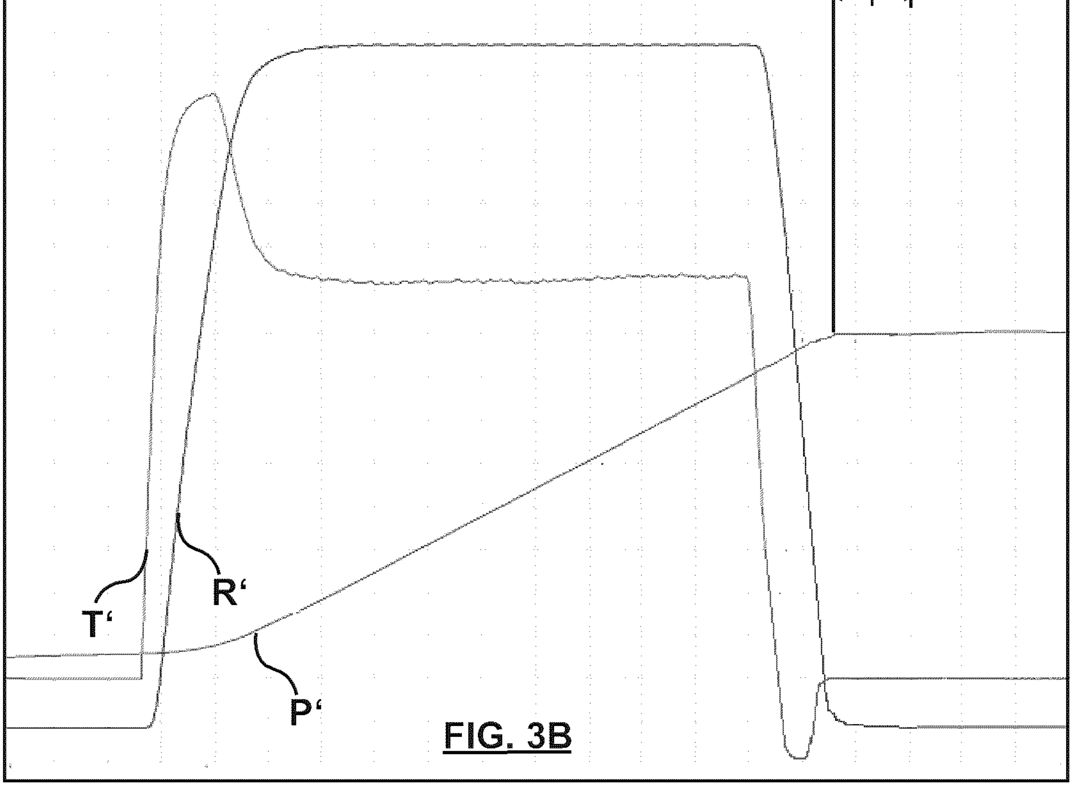

FIG. 3B

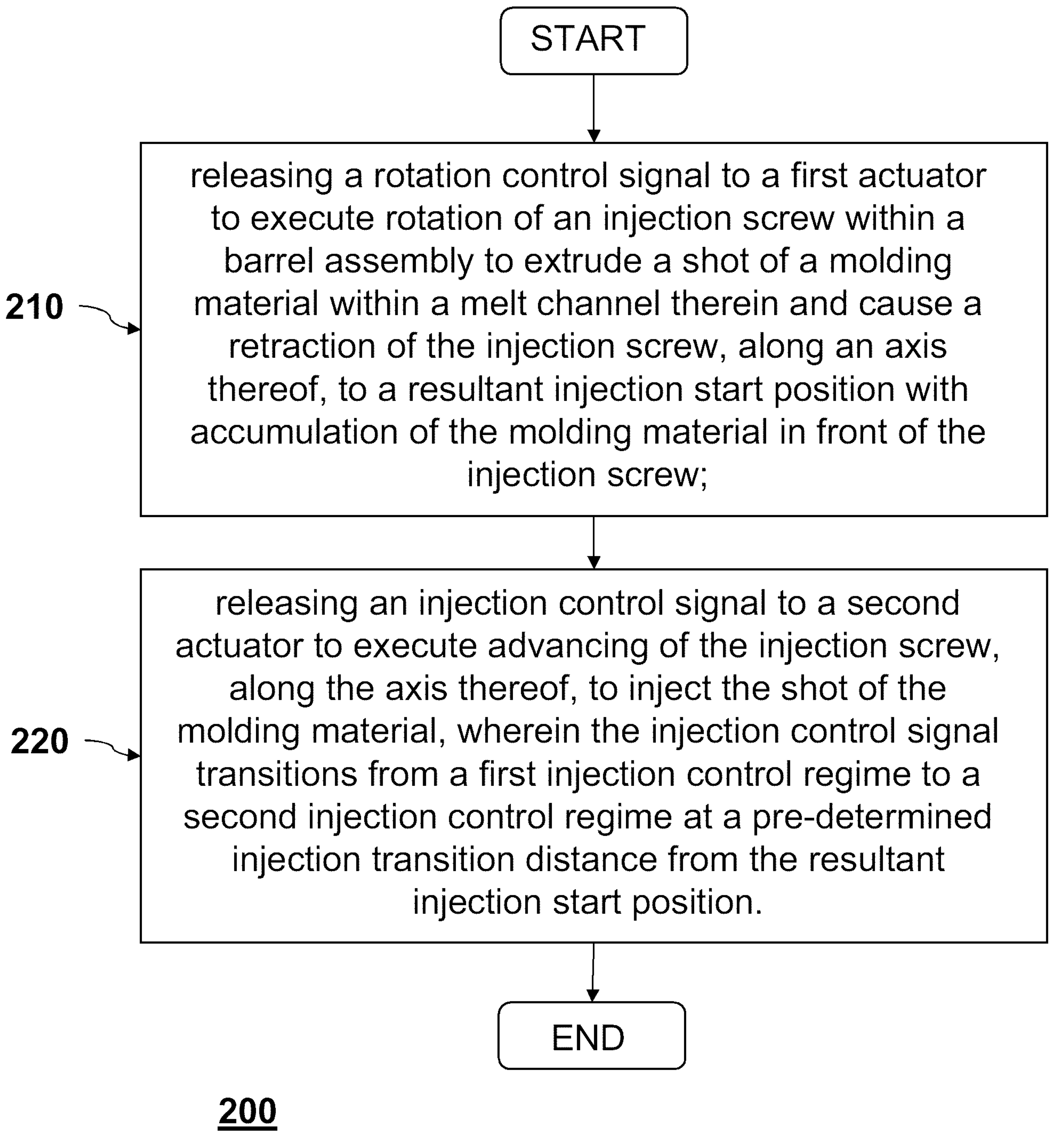
START
releasing a rotation control signal to a first actuator to execute rotation of an injection screw within a barrel assembly to extrude a shot of a molding material within a melt channel therein and cause a retraction of the injection screw, along an axis thereof, to a resultant injection start position with accumulation of the molding material in front of the injection screw;
210
releasing an injection control signal to a second actuator to execute advancing of the injection screw, along the axis thereof, to inject the shot of the molding material, wherein the injection control signal transitions from a first injection control regime to a second injection control regime at a pre-determined injection transition distance from the resultant injection start position.
220
END
200

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2011/050027

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B29C 45/76*** (2006.01)
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)
IPC (2006.01): B29C 45/76

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patent Database, EPOQUE, Google
keywords: heat, induct+, mold+, rotat+, actuator, shot, retract+, minimum, maximum, position, start, end, offset, correction, predeter+, screw, tolerance, out+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US5013231A (FUJITA, S. et al.) 07 May 1991 (07-05-1991) *Figures 1, 4 and 7; Column 2, lines 51 to 58; Column 3, line 48 to Column 4, line 5; Column 4, lines 15 to 28 and 29 to 39; Column 5, lines 5 to 18 and line 62 to Column 6, line 9*	1 - 19
A	US7826928B2 (OLOMSKI, J.) 02 November 2010 (02-11-2010) *Figures 3 to 5; Column 5, line 36 to Column 8, line 4*	1 - 19
A	US2005161847A1 (JAMES WEATHERALL, D. et al.) 28 July 2005 (28-07-2005) *Figures 1 to 3; Paragraphs [0040], [0042], [0049] and [0050]*	1 - 19
A	US5929583A (CATANZARO, J. et al.) 27 July 1999 (27-07-1999) *Figures 1 to 3; Column 8, line 49 to Column 9, line 24*	1 - 19
A	EP1439047A1 (HIROSHI, W. et al.) 21 July 2004 (21-07-2004) *Figures 1 and 8 to 11; Paragraph [0049]*	1 - 19
A	US2003090018A1 (BULGRIN, T.) 15 May 2003 (15-05-2003) *abstract*	1 - 19
A	US3752363A (FEGLEY, D. et al.) 14 August 1973 (14-08-1973) *Figures 2 and 6; Column 8, line 57 to Column 11, line 44*	1 - 19

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :
"A" document defining the general state of the art which is not considered to be of particular relevance
"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
22 March 2011 (22-03-2011)	30 March 2011 (30-03-2011)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Branka Ristovski (819) 934-2578

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		CA2249032C	27 December 2005 (27-12-2005)
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		EP1448352A4	05 May 2010 (05-05-2010)
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		WO03028976A1	10 April 2003 (10-04-2003)
US3752363A	14 August 1973 (14-08-1973)	None	