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(54) **Title**: INJECTION MOLDING MACHINE WITH OFFSET MOVING PLATEN ACTUATOR

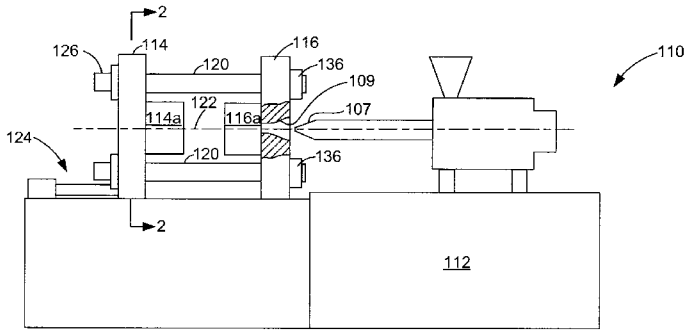


FIG. 2

(57) **Abstract**: An injection molding machine comprises a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions, and a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens. At least a first locking device is mounted to the first platen and associated with a first one of the tie bars for selectively locking and unlocking the moving platen relative to the tie bar. At least a first clamping mechanism is mounted to the second platen and associated with the first tie bar, the clamping mechanism including clamp and unclamp chambers on either side of a piston for moving the piston towards clamp and unclamp positions to exert a clamping force and a mold break force, respectively. The machine further includes a traverse actuator comprising one or more linear actuators coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and closed positions, the one or more linear actuators together being free of provision for applying a mold break force to the platens.

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TITLE: INJECTION MOLDING MACHINE WITH OFFSET MOVING PLATEN ACTUATOR

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority from United States Provisional Patent Application No. 61/102,633, filed on October 3, 2008, which is incorporated herein by reference in its entirety.

FIELD

[0002] The specification relates to injection molding machines, elements thereof, and methods and apparatuses for controlling motion of molds in an injection molding machine.

BACKGROUND

[0003] U.S. Pat. No. 2,976,569 (Quere et al.) discloses a material forming apparatus comprising mould sections adapted to be slidably displaced with respect to each other, a hydraulic pressure mechanism including a plurality of pressure cylinders, said pressure mechanism being adapted to draw the mould sections together under high pressure, releasable coupling rods and intermediate coupling means adapted to effect a selective coupling between the pressure cylinders and one of the mould sections, a driving mechanism working independently of the pressure cylinders and adapted to drive said rods and intermediate coupling means so that a selective coupling can be effected in unloaded condition of the coupling means, said coupling means including a plurality of claws on each coupling rod, and coupling sleeves carried by the other of said mould sections and internally including claws for engaging the first said claws, the coupling sleeves and the coupling rods being adapted for rotation with respect to each other by means of said driving mechanism, each pressure

cylinder of the pressure mechanism being arranged adjacent the associated coupling means which are rotatable in the driving means.

[0004] U.S. Pat. No. 5,620,723 (Glaesener et al.) discloses an injection molding machine that includes a stationary platen including at least one stationary mold half and a first movable platen. The first movable platen is movable relative the stationary platen and has a second mold half adapted to engage the stationary mold half to form a first mold. A second movable platen may also be provided which is movable toward the stationary platen and includes a third mold half adapted to engage a fourth mold half included with one of the stationary platen and the first movable platen. The third and fourth mold halves form a second mold. Each of the first and second molds having a hot runner leading thereto and an injection unit is provided for delivering melt to the hot runners of the first and second molds. The machine further includes tie bars extending between and connecting the stationary platen and the movable platens. At least one of the first and, if used, the second movable platen and stationary platen includes a mechanism for securing at least one of the tie bars. The mechanism for securing comprises an engagement mechanism for placing the mechanism for securing into and out of locking engagement with at least one of the tie bars such that when the engagement mechanism is out of locking engagement with the at least one tie bar, the mechanism for securing and the at least one tie bar are relatively movable

[0005] U.S. Pat. No. 5,753,153 (Choi) discloses a system and process for controlling mold activity of a molding machine that includes a clamping device for positioning a movable mold platen on a carrier device and relative another platen, for forcefully engaging the movable mold platen with the another platen and on the carrier device, for sustaining forceful engagement of the movable mold platen with the another platen and the carrier device, and for breaking the movable platen from the another platen and the carrying device. The movable mold platen includes a movable mold half and the another platen includes

another mold half. The system also includes a manner for determining an adjustable starting position of the clamping device and movable mold platen. A manner for adjusting the adjustable starting position for achieving greater accuracy of the adjustable starting position for the clamping device and the movable platen is provided. The manner for adjusting includes a mechanism for actuating the clamping device. A device for monitoring and controlling the position of the clamping device and movable platen is provided as well as a mechanism for sustaining the clamp-up force at a prescribed level.

[0006] U.S. Pat. No. 7,404,920 (Nogueira) discloses a molding-system clamp assembly of a molding system, which includes a clamp piston, and a clamp ram, the clamp ram and the clamp piston each including inter-meshable structures to selectively inter-mesh the clamp piston to the clamp ram. In the unmeshed position the clamp piston and the clamp ram do not inter-mesh relative to each other. The assembly includes inter-abuttable structures to selectively inter-abut the clamp piston relative to the clams ram, the inter-abuttable structures having an interposing body abuttable against the clamp ram and the clamp piston, the inter-abuttable structures to abut with each other so that the clamp piston makes contact with the interposing body. The inter-abuttable structures are configured to transfer a mold-break force so that the mold-break force is applied from the clamp piston against the interposing body, and in response the mold-break force is transferred from the clamp piston through the interposing body and to the clamp ram, and once mold break has occurred, the clamp piston is deactivated so that the mold may be opened.

[0007] U.S. Published Pat. Appn. 2008/0187771 (Schad et al.) discloses (i) a clamp of a molding system, (ii) a molding system having a clamp, (iii) a method of a clamp of a molding system, (iv) a molded article manufactured by usage of a clamp of a molding system, (v) a molded article manufactured by usage of a molding system including a clamp, and (vi) a molded article manufactured by usage of a method of a clamp of a molding system. A

disclosed embodiment of a clamp assembly includes a pressure chamber for moving a piston to exert a clamping force on a mold, and a spring acting on a rest plate in a direction opposite the clamping force to position the piston in a home position when the force exerted by pressurized fluid in the clamping chamber is less than the spring force.

SUMMARY

[0008] The following summary is intended to introduce the reader to various aspects of the applicant's teaching, but not to define any invention. In general, disclosed herein are one or more methods or apparatuses related to injection molding, and to positioning, locking, and clamping molds in injection molding machines.

[0009] According to some aspects, an injection molding machine comprises: a) a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions; b) a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens; c) at least a first locking device mounted to the first platen and associated with a first one of the tie bars, the first locking device and first tie bar comprising respective locking elements moveable from an unlocked position to a locked position when the tie bar is moved axially relative to the locking device to one of a plurality of axially spaced apart meshing positions, the first locking device locking together the first tie bar and the first platen when in the locked position, and the first locking device moveable from the locked position to the unlocked position to release the first platen from the first tie bar; d) at least a first clamping mechanism mounted to the second platen and associated with the first tie bar, the first clamping mechanism comprising a piston member affixed to the first tie bar and movable between clamp and unclamp positions within a cylinder housing affixed to the second platen, the piston and cylinder housing defining a clamp chamber and an unclamp chamber on opposite

sides of the piston, for moving the piston towards the clamp and unclamp positions and exerting a clamping force and a mold break force, respectively, when pressurized, the clamping force being less than or equal to a maximum rated load associated with the machine; and e) a traverse actuator comprising one or more linear actuators coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and closed positions, the one or more linear actuators together being free of provision for applying a mold break force to the platens.

[0010] In some examples of such a machine, the one or more linear actuators of the traverse actuator together apply a net axial opening force on the at least one platen in a direction opposite the clamping force and at a vertical and/or horizontal location that is substantially offset from the center of the at least one platen as viewed in a plane orthogonal to the axial direction. The one or more linear actuators of the traverse actuator together can be sized to exert a maximum opening force on the at least one platen in a direction opposite the clamping force that is less than about 3% of the maximum rated load.

[0011] In some examples, the injection molding machine can further comprise a positioning member movable relative to the piston and the cylinder housing and moveable between an advanced position and a retracted position, the positioning member when in the advanced position providing a mechanical stop for the piston when the piston is moved to a datum position intermediate the clamp and unclamp positions. The positioning member can be releasably retainable in the advanced position. When retained in the advanced position, the positioning member can interfere with sliding of the piston within the cylinder housing when moving from the clamp position in at least one direction, for example, from the clamp position towards the unclamp position. When the positioning member is released from the advanced position and displaced towards the retracted position, the positioning member can be free of interfering

with the piston when the piston slides from the clamped position towards the unclamped position.

[0012] In some examples, the clamp chamber is be disposed on a clamp side of the piston, and the positioning member is disposed in the cylinder housing on the clamp side of the piston. The positioning member can comprise an annular sleeve coupled to the piston and axially displaceable relative to the piston. An inner surface of the annular sleeve can slide along an outer surface of the piston. A pushing member can be provided adjacent the annular sleeve to move the annular sleeve to the advanced position. The pushing member can comprises a positioning chamber disposed between the piston and the positioning member, the positioning chamber urging the annular sleeve to the advanced position when pressurized. In some examples, the pushing member can comprise one or a plurality of springs, for example, compressions springs, and the springs can be preloaded to provide a positioning force (urging the positioning member to the advanced position) that is greater than a datum force (urging the piston to the datum position).

[0013] The traverse actuator may comprise a motor. The motor may be mounted beneath at least one of the first platen and the second platen. The motor may be axially aligned with one of the first platen and the second platen. Alternately, the motor may be axially inboard of one of the first platen and the second platen.

[0014] According to another aspect, an injection molding machine is provided. The injection molding machine comprises: a) a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions; b) a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens; c) at least a first locking device mounted to the first platen and associated with a first one of the tie bars, the first locking device and first tie bar comprising respective locking elements moveable from an unlocked position to a

locked position when the tie bar is moved axially relative to the locking device to one of a plurality of axially spaced apart meshing positions, the first locking device locking together the first tie bar and the first platen when in the locked position, and the first locking device moveable from the locked position to the unlocked position to release the first platen from the first tie bar; and d) at least a first clamping mechanism mounted to the second platen and associated with the first tie bar, the first clamping mechanism comprising a piston member affixed to the first tie bar and movable between clamp and unclamp positions within a cylinder housing affixed to the second platen, the piston and cylinder housing defining a clamp chamber and an unclamp chamber on opposite sides of the piston, for moving the piston towards the clamp and unclamp positions and exerting a clamping force and a mold break force, respectively, when pressurized, the clamping force being less than or equal to a maximum rated load associated with the machine; and d) a traverse actuator comprising one or more linear actuators coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and closed positions, wherein the one or more linear actuators of the traverse actuator together apply a net axial opening force on the at least one platen in a direction opposite the clamping force and at a vertical and/or horizontal location that is substantially offset from the center of the at least one platen as viewed in a plane orthogonal to the axial direction.

[0015] The one or more linear actuators of the traverse actuator together may be sized to exert a maximum opening force on the at least one platen in a direction opposite the clamping force that is less than about 3% of the maximum rated load.

[0016] The traverse actuator may comprise a motor, and the motor may be mounted beneath at least one of the first platen and the second platen. The motor may be axially aligned with one of the first platen and the second platen.

Alternately, the motor may be axially inboard of one of the first platen and the second platen.

[0017] According to another aspect, an injection molding machine comprises: a) a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions; b) a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens; c) at least a first locking device mounted to the first platen and associated with a first one of the tie bars, the first locking device and first tie bar comprising respective locking elements moveable from an unlocked position to a locked position when the tie bar is moved axially relative to the locking device to one of a plurality of axially spaced apart meshing positions, the first locking device locking together the first tie bar and the first platen when in the locked position, and the first locking device moveable from the locked position to the unlocked position to release the first platen from the first tie bar; d) at least a first clamping mechanism mounted to the second platen and associated with the first tie bar, the first clamping mechanism comprising a piston member affixed to the first tie bar and movable between clamp and unclamp positions within a cylinder housing affixed to the second platen, the piston and cylinder housing defining a clamp chamber and an unclamp chamber on opposite sides of the piston, for moving the piston towards the clamp and unclamp positions and exerting a clamping force and a mold break force, respectively, when pressurized, the clamping force being less than or equal to a maximum rated load associated with the machine; and e) a traverse actuator comprising one or more linear actuators coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and closed positions, the one or more linear actuators together being free of provision for applying a mold break force to the platens.

[0018] In some examples, the one or more linear actuators of the traverse actuator together apply a net axial opening force on the at least one platen in a

direction opposite the clamping force and at a vertical and/or horizontal location that is substantially offset from the center of the at least one platen as viewed in a plane orthogonal to the axial direction. The one or more linear actuators of the traverse actuator together can be sized to exert a maximum opening force on the at least one platen in a direction opposite the clamping force that is less than about 3 percent of the maximum rated load. The machine can further comprise a stop member movable relative to the piston and the cylinder housing and moveable between an advanced position and a retracted position, the stop member when in the advanced position providing a mechanical stop for the piston when the piston is moved to a datum position intermediate the clamp and unclamp positions.

[0019] The traverse actuator can comprise a motor, and the motor can be mounted beneath at least one of the first platen and the second platen. Alternately, the motor can be positioned at an axial position generally equal to that of one of the first platen and the second platen, or the motor can be axially inboard of one of the first platen and the second platen.

[0020] In some examples, the traverse actuator comprises a ball screw coupled to the motor and a ball nut fixed to the other of the first and second platens and in engagement with the ball screw. In some examples, the traverse actuator comprises a toothed belt driven by the motor and affixed to the other of the first and second platens.

[0021] The injection molding machine can further comprise four tie bars extending between respective corners of the first and second platens, and the traverse actuator can be positioned outside of a space bounded by the tie bars. One of the first and second platens can be a stationary platen remaining in a fixed axial position during use, and the single linear actuator can have a proximate end axially positioned generally at the fixed axial position of the stationary platen.

[0022] According to some aspects, an injection molding machine comprises: a) a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions; b) a sprue bushing mounted in one of the first and second platens generally at a geometrically central position thereof, the sprue bushing receiving melt from an injection nozzle therethrough, the machine having a machine axis parallel to the axial direction and passing through the sprue bushing; c) a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens; d) at least a first locking device mounted to the first platen and associated with a first one of the tie bars, the first locking device and first tie bar comprising respective locking elements moveable from an unlocked position to a locked position when the tie bar is moved axially relative to the locking device to one of a plurality of axially spaced apart meshing positions, the first locking device locking together the first tie bar and the first platen when in the locked position, and the first locking device moveable from the locked position to the unlocked position to release the first platen from the first tie bar; e) at least a first clamping mechanism mounted to the second platen and associated with the first tie bar, the first clamping mechanism comprising a piston member affixed to the first tie bar and movable between clamp and unclamp positions within a cylinder housing affixed to the second platen, the piston and cylinder housing defining a clamp chamber and an unclamp chamber on opposite sides of the piston, for moving the piston towards the clamp and unclamp positions and exerting a clamping force and a mold break force, respectively, when pressurized, the clamping force being less than or equal to a maximum rated load associated with the machine; and f) a traverse actuator comprising a single linear actuator coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and closed positions, wherein the single linear actuator of the traverse actuator extends along an actuator axis that is generally parallel to the machine

axis and offset in at least one of a horizontal and vertical direction from the machine axis.

[0023] The single linear actuator can be sized to exert a maximum opening force on the at least one platen in a direction opposite the clamping force that is less than about 3 percent of the maximum rated load. The injection molding machine can comprise four tie bars extending between respective corners of the first and second platens, and the single linear actuator can be positioned outside of a space bounded by the tie bars. One of the first and second platens can be a stationary platen remaining in a fixed axial position during use, and the single linear actuator can have a proximate end axially positioned generally at the fixed axial position of the stationary platen. The traverse actuator can comprise a motor coupled to the single linear actuator, and the motor can be mounted beneath at least one of the first platen and the second platen. Alternately, the motor can be positioned axially between, and laterally aside, the first platen and the second platen.

[0024] Other aspects and features of the present specification will become apparent, to those ordinarily skilled in the art, upon review of the following description of the specific examples of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The drawings included herewith are for illustrating various examples of articles, methods, and apparatuses of the present specification and are not intended to limit the scope of what is taught in any way. In the drawings:

[0026] Figure 1a is a schematic elevation view of a portion of an injection molding machine showing mold halves spaced apart by a positioning gap;

[0027] Figure 1b shows the machine of Figure 1a with the positioning gap closed;

[0028] Figure 1c shows the machine of Figure 1b with a clamping force exerted across the mold halves;

[0029] Figure 2 is an elevation view of an injection molding machine according to some aspects of the Applicant's teaching;

[0030] Figure 3 is an end view of an upper portion of the machine of Figure 1;

[0031] Figure 4 is a cross-sectional view of a portion of the machine of Figure 3, taken along the lines 4-4;

[0032] Figure 5 is an enlarged view of a first portion of the structure shown in Figure 4;

[0033] Figure 6 is a perspective view of the structure of Figure 4, shown in an unlocked position;

[0034] Figure 7 is an enlarged view of a second portion of the structure shown in Figure 4;

[0035] Figure 8 is an exploded view of the structure of Figure 7;

[0036] Figures 9, 10, and 11 show the clamping device of Figure 7 in a clamped, unclamped, and datum position, respectively;

[0037] Figure 12 is a cross-sectional view similar to that of Figure 7 showing an alternate embodiment of a clamp mechanism;

[0038] Figure 13 is a perspective view showing further details of the moving platen traverse actuator of the injection molding machine of Figure 2;

[0039] Figure 14 is a cross section taken along line 14-14 in Figure 13;

[0040] Figure 15 is a perspective illustration of another example of a traverse actuator for a moving platen; and

[0041] Figure 16 is a perspective illustration of another example of a traverse actuator for a moving platen.

DETAILED DESCRIPTION

[0042] Various apparatuses or processes will be described below to provide an example of an embodiment of each claimed invention. No embodiment described below limits any claimed invention and any claimed invention may cover processes or apparatuses that are not described below. The claimed inventions are not limited to apparatuses or processes having all of the features of any one apparatus or process described below or to features common to multiple or all of the apparatuses described below. It is possible that an apparatus or process described below is not an embodiment of any claimed invention. Any invention disclosed in an apparatus or process described below that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicants, inventors or owners do not intend to abandon, disclaim or dedicate to the public any such invention by its disclosure in this document.

[0043] Referring first to Figure 1a, an injection molding machine 10 is shown having a base 12 upon which first and second platens 14, 16 are mounted. In the example illustrated, the injection molding machine 10 is a two-platen type injection molding machine. The first platen 14 can slide in an axial direction along the base 12, towards and away from the second platen 16 which is stationary in the example illustrated. A traverse actuator 24 can be provided to facilitate moving the moving platen 14 between open and closed positions relative to the stationary platen 16. The platens 14, 16 support respective mold portions 14a, 16a (also referred to as mold halves 14a, 16a). Tie bars 20 extend axially between the platens for clamping the platens together during operation of the machine. A locking device 26 is, in the example illustrated, affixed to the moving platen 14 for releasably locking the moving platen 14 to a respective one of the tie bars 20. Clamping mechanisms 36 can be provided for exerting a clamping force across the mold halves 14a, 16a during an injection cycle. In the example illustrated, the clamping mechanisms 36 include a cylinder housing 38

affixed to the stationary platen 16, and a piston 40 affixed to a respective tie bar and slidable within the cylinder housing 38.

[0044] In use of the apparatus 10, the traverse actuator 24 can be energized to advance the moving platen 14 towards a closed position relative to the stationary platen 16. The clamp piston 40 can be moved to a known position, for example, a fully unclamped position as shown in Figure 1a. The locking device 26 can be moved to the locked position to lock the moving platen 14 to a respective tie bar 20.

[0045] Prior to pressurizing the clamp chamber 60 of the clamping mechanism 36, the clamp piston 40 can be pre-positioned within the cylinder housing 38 to a datum position that is axially intermediate the clamping position and the unclamped position (Figure 1b).

[0046] Once the locking devices 26 have been moved to the locked position, the clamp chamber 60 can be pressurized so as to exert a clamping force urging the mold halves 14a, 16a together. The piston 40 would be urged further in the clamping direction (i.e. further to the right as shown in Figure 1c), stretching the tie bars 20 (within their elastic deformation limit) and pulling the mold halves 14a, 16b tightly together. At an appropriate clamping force, the resin (or melt) can be injected into the mold.

[0047] After the molded article has hardened sufficiently to allow ejection, the pressure in the clamp chamber 60 can be relieved. The unclamp chamber 62 can be pressurized so as to exert a mold break force urging the mold halves 14a, 16a apart and moving the piston 40 to the unclamped position (as shown, for example, in Figure 1a). The mold break force exerted by the pressure in the unclamp chamber can be, for example, from about 5 percent to about 10 percent (or more) of the clamping force. Such a mold break force may be required only in certain cases in which factors such as the geometry of the article to be molded, the material, and or specific process factors cause, for example, a

substantial residual clamping force to remain across the platens even after pressure in the clamp chamber has been relieved. In such cases, pressurizing the unclamp chamber can provide the necessary mold break force to urge the mold portions apart. In other cases, such a mold break force may not be requires, so that pressurizing the unclamp chamber (prior to shuttling the moving platen to the open position) may not be necessary.

[0048] Once pressure in the clamp chamber has been relieved (and after the optional mold break force has been applied, if desired), the locking devices 26 can be moved to the unlocked position so as to unlock the moving platen 14 from the tie bars 20. The traverse actuator 24 can then be energized to retract the moving platen 14 to an open position spaced away from the stationary platen 16. An ejection mechanism 25 can be energized to facilitate ejecting the molded article from the mold.

[0049] Pre-positioning the piston 40 to a datum position intermediate the clamp and unclamp positions can facilitate breaking open the mold after an injection cycle, by ensuring that the piston 40 has room to travel back towards the unclamped position after having been moved towards the clamping position. In some cases, the axial travel of the piston 40 in the clamping direction can be minimal (particularly where the machine has been tuned for maximum speed i.e. minimum cycle time). Additionally or alternatively, in some cases the mold can flash (resin squeezing out between the mold halves 14a, 16a) during injection, which can push the clamp piston 40 back towards the unclamp position (clamping force—and tie bar stretch—can remain generally unchanged during mold flash, but the piston can be displaced within the cylinder housing in response to displacement of the moving platen 14 as a result of the resin forcing its way out between the mold halves). This could, in cases where pre-positioning is not provided or not satisfactorily provided, cause the piston to bottom out in the cylinder in the unclamp direction (i.e. piston bears against back wall or other

structural element that physically inhibits further travel of the piston in the unclamp direction).

[0050] If such bottoming out occurs while the tie bars are still loaded (i.e. bottoming out resulting from mold flash), then moving the locking devices 26 to the unlocked position can be very difficult or impossible. Destructive methods may then be required to open the mold and reset the machine for a new injection cycle. The teaching of the present invention can avoid this and/or other possible drawbacks by pre-positioning the piston 40 at an intermediate position within its range of travel in the housing 38 prior to clamping the mold halves together, so that ample travel in the unclamp direction is available after an injection cycle, even in cases where the mold may flash, and also providing sufficient forward travel in the clamping direction for applying a desired clamping force.

[0051] In some examples, the maximum stroke length of the piston in the cylinder housing can be in the range of about 15 to about 20mm. The datum position of the piston can correspond to a position of about 6mm to about 10mm forward (in the clamp direction) of the fully back (unclamped) position, leaving, in the example illustrated, at least about 5mm backward travel of the piston available for mold break. About 10mm forward travel of the piston can be provided for clamping the mold halves together.

[0052] A variety of methods in accordance with the present teaching can be employed to accomplish the pre-positioning of the piston 40. In one example, when moving the platen 14 from an open position towards the closed position, the platen 14 can stop short of the stationary platen 16 so as to leave a positioning gap 77 between the mold portion 14a (secured to moving platen 14) and the mold portion 16a (secured to stationary platen 16) (see Figure 1a). With the mold portions spaced apart by the positioning gap 77, the locking devices can be moved to the locked position to secure together the moving platen 14 and the tie bars 20. The traverse actuator can then be energized to further advance the moving platen 14 to substantially close the positioning gap 77. During

closing of the gap 77, the tie bars 20 are also advanced by the same amount as the platen 14, since the moving platen 14 and tie bars 20 are locked together. This moves the piston 40 from, for example, the unclamped position (Fig. 1a) to the datum position (Fig. 1b).

[0053] In some examples, when the mold portions 14a, 16a secured to the moving platen 14 and the stationary platen 16 are spaced apart by the positioning gap 77, and the moving platen 14 is locked to the tie bars 20, the clamp chamber 60 can be pressurized to urge the piston 40 (and tie bar 20) towards the clamping direction. This carries the moving platen 14 along to close the positioning gap 77. The pressure in the clamping chamber during closing the gap 77 can be lower than the pressure in the clamping chamber during injection of the resin. The traverse actuator 24 can be energized to work in cooperation with the clamp piston 40, or can, for example, be placed in neutral mode so as not interfere with, or be damaged by, the force exerted by the piston 40 during closing of the positioning gap 77.

[0054] In some examples, moving the clamp piston 40 to the datum position can include moving a stop member to an advanced position relative to the clamp piston 40 and cylinder housing 38, and urging the clamp piston 40 to bear against the stop member. An example of such a stop member is described subsequently herein, for example, at positioning member 182 in the apparatus 110. In the examples including a stop member, moving the clamp piston to the datum position can include pressurizing the unclamp chamber, and venting the clamp chamber to tank. Furthermore, a positioning chamber in communication with the stop member can be pressurized for urging the stop member to the advanced position. The stop member can be movably disposed between the clamp chamber and the piston, such that moving the stop member from the retracted to the advanced positions reduces the volume of the clamp chamber. In these examples, when advancing the moving platen from the open position towards the stationary platen, the traverse actuator can bring the mold portion

14a (of the moving platen 14) almost right up against the mold portion 16a (of the stationary platen 16) (i.e. no or zero positioning gap 77) prior to locking the moving platen to the tie bars. In the examples including a stop member, the known position of the piston at which the locking devices can be moved to the locked position can be the datum position.

[0055] Referring now to Figure 2, another two-platen injection molding machine 110 includes a base 112 and a first platen 114 and a second platen 116 each mounted on the base 112. The first platen 114 is movable relative to the second platen 116 between open and closed positions. In the example illustrated, the second platen 116 is generally stationary relative to the base 112 during operation of the machine 110, and is also referred herein as stationary platen 116. The first platen 114, in the example illustrated, moves relative to the base 112 during operation of the machine 110 and is also referred herein as moving platen 114.

[0056] When in the closed position, the platens 114, 116 are drawn together. When in the open position, the platens 114, 116 are separated to facilitate removal of a molded article from a mold formed at least in part by first and second mold halves (mold portions) 114a, 116a affixed to the platens 114, 116, respectively.

[0057] The machine 110 includes at least two tie bars 120 extending between the first and second platens 114, 116 for coupling the platens 114, 116 together. In the example illustrated, four tie bars 120 are provided. Each of the four tie bars 120 are positioned generally at (and extend between) respective corners of the two platens 114, 116 (Figure 3). The tie bars 120 generally comprise elongate members aligned in parallel with a machine axis 122 along which the moving platen 114 translates (each tie bar 120 having a tie bar axis 123 parallel to the machine axis 122). The machine axis 122 passes through the center of a sprue bushing 109 mounted in the stationary platen for receiving melt from an injection nozzle 107.

[0058] A traverse actuator 124 can be coupled to the moving platen 116 to move the platen 116 between the open and closed positions. In the example illustrated, the traverse actuator 124 comprises a single linear actuator in the form of a ball screw driven by a motor and in engagement with a ball nut that is fixed, for example, to the moving platen 114. The tie bars 120 can define a tie bar envelope or space 199, and the traverse actuator 124 can be positioned outside the space 199. In other examples, a belt drive system could be used as a linear actuator to move the moving platen 114 between the open and closed positions. One or more relatively long stroke, small diameter fluid cylinders could also be used as the traverse actuator.

[0059] Referring to Figures 4 and 5, the machine 110 further includes at least one locking device 126 to selectively lock one of the platens 114, 116 to one of the tie bars 120. In the example illustrated, a first one of the locking devices 126 (identified as first locking device 126a) is mounted to the first platen 114 and associated with a first one of the tie bars 120 (identified as first tie bar 120a). The first locking device 126a selectively secures the first platen 114 to, and releases the first platen 114 from, the first tie bar 120a.

[0060] With reference also to Figure 6, the first locking device 126a can comprise, for example, a lock nut element 128 of generally annular construction rotatably disposed in a housing 129 affixed to the moving platen 114. In the example illustrated, the lock nut 128 is provided with an inner bore with first teeth 130 arranged in axial rows, the rows spaced circumferentially apart by first axial grooves 131. The first tie bar 120a (having a first tie bar axis 123a parallel to the machine axis 122) can be provided with second teeth 132 that are similarly arranged in axial rows, spaced apart circumferentially by second axial grooves 133.

[0061] When in the locked position (as shown in Figure 5), the first and second teeth 130, 132 are oriented to be in circumferential registration with each other, so that the first and second teeth inter-engage, thereby inhibiting relative

axial motion between the first platen 114 and tie bar 120a. The lock nut 128 can be rotated relative to the tie bar 120 to an unlocked position (Figure 6) in which the first teeth 130 are aligned with the second axial grooves 133 provided on the tie bar 120, and the second teeth 132 are aligned with the first axial grooves 131 of the lock nut 128, thereby allowing axial movement of the tie bar 120 through the lock nut 128.

[0062] Before moving the locking device 128 from the unlocked to the locked position, the tie bar 120 can be moved axially relative to the lock nut 128 to any one of a plurality of meshing positions in which the peaks of one set of teeth are in axial registration with the valleys between adjacent ones of the other set of teeth. Adjacent meshing positions are spaced apart axially by an amount generally equal to the pitch of the teeth. Providing a plurality of meshing positions can facilitate accommodating molds with different axial extents (different mold heights).

[0063] In one or more other examples, the locking device can comprise two half nuts, each having first engagement elements to engage teeth on the tie bar 120 when in the locked position, and which can be moved away from the tie bar 120 generally perpendicular to the length thereof to be clear of the tie bar when in the unlocked position.

[0064] Referring to Figures 4 and 7, the machine 110 further includes at least one clamping mechanism 136 mounted to one of the platens 114, 116 and associated with one of the tie bars 120 for exerting a clamping force on the platens 114, 116 during the injection mold cycle. In the example illustrated, the machine 110 includes a first clamping mechanism 136a mounted to the second platen 116 and associated with the first tie bar 120a. The first clamping mechanism 136a can selectively exert a first force (clamping force) urging the first and second platens 114, 116 together, and an optional second force (mold break force) urging the first and second platens 114, 116 apart. The first force (clamping force) can have a magnitude of, for example, 80, 120, or 200 tons or

more, and generally defines a maximum rated load for the machine. The second force can typically have a magnitude of about 5 percent to about 10 percent of the first force (i.e. clamping force can be about 10 to about 20 times or more greater than the mold break force).

[0065] The clamping mechanism 136a includes a cylinder housing 138 affixed to the second platen 116, and a piston 140 affixed to the first tie bar 120a and slidable within the cylinder housing 138. The language "affixed to" includes configurations in which the corresponding elements are separately joined together, or are made of integral, one-piece construction. In some examples, the cylinder housing 138 may include an insert or barrel separately attached to the platen. The piston 140 can, in some examples, be partially or entirely formed integrally with the tie bar.

[0066] With reference also to Figure 8, in the example illustrated, the cylinder housing 138 comprises a pocket 139 machined in the stationary platen 116, the cylinder housing 138 being integral with the platen 116. The piston 140, in the example illustrated, comprises a piston head 142 separately attached to the tie bar 120a. The piston head 142 includes an axial bore 144 that has internal threads 146, for engagement with external threads 148 provided along an end portion of the tie bar 120a. A keeper 149 can be positioned across the distal end face of the tie bar 120 and bolted to the end face of the piston head 142 to facilitate locking the piston head 142 in position relative to the tie bar 120.

[0067] The piston 140 further includes, in the example illustrated, a seal journal 150 fitted with a piston seal 151 having a radially outer surface 152 in sealed engagement with an inner surface 154 of the cylinder housing 138. The cylinder housing 138 has a proximal end wall 156 axially nearest the second mold half 116a, and a distal end wall 157 spaced axially apart from the proximal end wall 156. In the example illustrated, the distal end wall 157 comprises a cylinder cap 158 bolted to the platen 116 and having a bore 159 therethrough, an end portion of the piston 140 slidably received through the bore 159.

[0068] As seen in Figure 7, the piston 140 and cylinder housing 138 cooperate to form a first chamber (also called a clamping chamber) 160 on one side (clamp side 161) of the seal journal 150, and a second chamber (also called an unclamp chamber) 162 on a second side (unclamp side 163) of the seal journal 150 of the piston 140, axially opposite the first (clamp) side 161. Fluid can be fed into the clamp and unclamp chambers 160, 162 via a clamping port 164 and unclamp port 166, respectively. In the example illustrated, the clamp and unclamp ports 164, 166 open to an exterior side of the cylinder housing 138.

[0069] In the example illustrated, the clamp side 161 and clamping chamber 160 are disposed proximal the second mold half 116a (relative to the seal journal 150), and the unclamp side 163 and unclamp chamber 162 are disposed axially distal the second mold half 116a. Pressurizing the clamping chamber 160 can exert a force (axially in a clamp direction 168) on a clamp face 170 of the piston 140, the clamp face 170 directed toward the second mold half 116a. Pressurizing the unclamp chamber 162 can exert an axial force (in an unclamp direction 169) on an unclamp face 172 of the piston, opposite the clamp face 170.

[0070] Each of the clamp and unclamp faces 170, 172 can comprise a single face, or a plurality of face sections spaced apart axially and/or radially along the piston head 142. In the example illustrated, the clamp face 170 includes a clamp end face portion 170a (generally defined by the surface area of the retaining ring 204 directed towards the proximal end wall 156—described further in relation to Fig. 8), and a clamp stepped face portion 170b generally defined by the surface area of the annular orthogonal wall portion of the seal journal 150 facing towards the proximal end wall 156. The unclamp face 172 is, in the example illustrated, generally defined by the surface area of the annular orthogonal wall portion of the seal journal 150 facing away from the proximal end wall 156 (i.e. the face of the seal journal 150 directed towards the unclamp side 163). The surface of the unclamp face 172 can be stepped or notched at an

outer radial edge thereof, for example, to facilitate fluid flow into (or out of) the unclamp chamber 162 (via port 166) even when the piston 140 is advanced to its maximum travel position in the clamping direction (right-most position relative to the cylinder housing 138).

[0071] The piston 140 is axially slidable within the cylinder housing among a clamping position 176 (Fig. 9), an unclamped position 178 (Fig. 10), and a datum position 180 (Fig. 11). The maximum axial spacing between the clamping position 176 and the unclamped position 178 can generally be defined by axially opposed end walls (e.g. end walls 156, 157), and/or radially inwardly protruding step walls (e.g. step wall 206), between which the piston 140 is confined to travel. The datum position 180 is, in the example illustrated, located axially intermediate the clamping and unclamped positions 176, 178.

[0072] The piston 140 can be moved to, and selectively released from, the datum position 180. In the example illustrated, the locking device 126 can be moved from the unlocked to the locked position when the piston 140 is in the datum position (i.e. axial position of the tie bar and its teeth relative to the stationary platen and its teeth can be accurately computed via the machine coordinate system). In some examples, the datum position 180 can define the position of the piston 140 at which clamping together of the platens 114, 116 is initiated (i.e. delivery of pressurized fluid to the clamping chamber 160 for generating the clamp force is initiated when the piston 140 is in the datum position 180). Initiating clamp-up at an axially intermediate position (i.e. at the datum position 180) can ensure that sufficient axial piston travel is available in both the clamp direction 168 (to apply the required clamp force), and in the unclamp direction 169 (to effect separation of the mold halves 114a, 116a after an injection cycle). Sufficient travel in the unclamp direction 169 can be particularly advantageous in cases where the machine 110 is set up such that minimal axial displacement of the moving platen 114 occurs during clamp-up, and/or in cases of mold flash during the injection cycle.

[0073] The datum position 180 can be defined by a mechanical stop member configured to inter-engage with the piston 140 and the cylinder housing 138 when the piston 140 is in the datum position 180. In the example illustrated, the clamping mechanism 136 includes (as an example of a stop member) a positioning member 182 moveable between advanced and retracted positions 192, 194. The positioning member 182 is moveable relative to the piston 140 and relative to the cylinder housing 138, and can be selectively retained in, and released from, the advanced position 194.

[0074] In the example illustrated, the positioning member 182 comprises an annular body or sleeve 190 (Fig. 8) slidably coupled to the piston 140, and coaxial therewith. The positioning member 182 is axially displaceable relative to the piston 140 between the advanced and retracted positions 192, 194. The positioning member comprises a proximal end face 196 having a radially inner portion defining a first contact surface 198, and a radially outer portion defining a second contact surface 200. The contact surfaces 198, 200 cooperate with other elements to provide a positive mechanical stop for the positioning member 182. In the example illustrated, the first and second contact surfaces 198, 200 are generally coplanar, and are disposed adjacent an axial end (proximal end 196) of the positioning member nearest the second mold half 116a.

[0075] The piston 140 has a first abutment surface 202 for engagement with the first contact surface 198 of the positioning member 182 when the positioning member 182 is in the advanced position 194. The first abutment surface 202 is fixed to, and moves with, the piston 140 during operation of the machine 110. In the example illustrated, the first abutment surface 202 comprises a radially outwardly protruding shoulder portion of a retaining ring 204 mounted to the proximal end of the piston head 142. The first abutment surface 202 is spaced apart from the seal journal 150 on the clamping side 161 of the piston 140. The positioning member 182 can generally move axially between the first abutment surface 202 and the seal journal 150. Displacement of the

positioning member 182 towards the seal journal 150 generally corresponds to the retracted position 194 of the positioning member 182 relative to the piston 140. In the example illustrated, the positioning member 182 is disposed on the clamp side 161 of the seal journal 150 of the piston 140.

[0076] A second abutment surface 206 is affixed to the cylinder housing 138 for engagement with the second contact surface 200 of the positioning member 182 when the piston 140 is in the datum position 180 and the positioning member 182 is in the advanced position 194. The second abutment surface 206 is in an axially fixed position relative to the stationary platen 116 during operation of the machine 110. In the example illustrated, the second abutment surface 206 comprises an annular radially inwardly protruding step 208 extending from the inner surface 154 of the cylinder housing 138.

[0077] A pushing member 211 can be provided for exerting a positioning force on the positioning member 182 to move and/or releasably retain the positioning member 182 to/in the advanced position. In the example illustrated, the pushing member 211 comprises a positioning fluid chamber 212. The positioning force is generated by pressurizing the positioning fluid chamber 212 which is adjacent to, and in fluid contact with, a distal end face 214 of the positioning member 182. The distal end face 214 of the positioning member is generally defined by a radially extending end wall of the annular body 192, disposed axially opposite the proximal end face 196. Fluid can be supplied to or evacuated from the positioning fluid chamber 212 via a positioning port 216, which, in the example illustrated, extends radially through the cylinder housing 138, at a position axially between the clamping port 164 and the unclamp port 166. The distal end face 214 can be stepped or notched at its radially outer edge to help ensure satisfactory fluid communication between the positioning fluid chamber 212 and the positioning port 216, even when the positioning member 182 is at its maximum rightward travel position relative to the positioning port 212

(i.e. when the positioning member is in the fully retracted position 194 and the piston 140 is in the clamp position176).

[0078] In the example illustrated, the positioning fluid chamber 212 is disposed (axially) on the clamping side 161 of the piston 140 (i.e. on the clamping side 161 of the seal journal 150), between the positioning member 182 and the seal journal 150 of the piston 140. The positioning chamber 212 extends radially between an outer surface of the piston 140 and the inner surface 154 of the housing 138 (Fig. 7). One end (i.e. proximal axial end) of the positioning chamber 212 is, in the example illustrated, sealed by the seal journal 150 (with seal 151). The opposite end (distal axial end) can be sealed by radially inner and outer positioning member seals 218a, 218b, respectively. The radially inner positioning member seal 218a can be disposed between the inner surface of the positioning member 182 and an outer surface of the piston 140. The radially outer positioning member seal 218b can be disposed between an outer surface of the positioning member 182 and the inner surface 154 of the cylinder housing 138.

[0079] In use, an example is considered where new mold halves 114a, 116a are installed on the platens 114, 116, and wherein the shut-height of the new mold is not known. Once the mold halves have been attached to the platens, and with the locking devices 126 in the unlocked position, the traverse actuator 124 can be energized to jog the moving platen 114 (e.g. in set-up mode) towards the stationary platen 116 until the mold is closed (mold halves 114a, 116a just or nearly touch).

[0080] Prior to completing the step of closing the mold, the clamping mechanisms 136 (and pistons 140 thereof) can be moved to the datum position 180, by pressurizing the positioning fluid chamber 212 and the unclamp chamber 162 with, for example, hydraulic fluid, and opening the clamping port 164 to tank to evacuate fluid from the clamp chamber 160. The positioning force exerted by the pressurized positioning fluid chamber 212 urges the positioning member 182

left (in the unclamp direction 169 in Fig. 10) relative to the piston 140 (in other words, urges the piston 140 right relative to the positioning member 182), so that the first contact surface 198 bears against the first abutment surface 202 (Fig. 11). The pressure in the unclamp chamber 162 exerts a datum force on the piston, urging the piston 140 (with the positioning member 182 coupled thereto) towards the left in Figure 11, so that the second contact surface 200 engages the second abutment surface 206. The datum force on the piston 140 urging the piston left relative to the positioning member 182 (so as to urge the positioning member towards the retracted position) is less than the positioning force urging the piston right relative to the positioning member (urging the positioning member to the advanced position), so the positioning member 182 remains in the advanced position 192 relative to the piston 140 and the piston is retained in the datum position 180 (in the position as shown in Figure 11).

[0081] To provide a datum force (exerted by the pressurized unclamp chamber 162) that is less than the positioning force (exerted by the pressurized positioning fluid chamber 212), the pressure of the fluid can be lower in the unclamp chamber 162 than in the positioning fluid chamber 212. Alternatively or additionally, the effective relative surface areas against which the fluid in the respective chambers 162, 212 bears can be configured to ensure the desired differential in axial forces is achieved. In the example illustrated, the surface area of the unclamp face 172 of the piston (having a radial extent 219) is less than the surface area of the distal face 214 of the positioning member 182 (having a radial extent 221, which subsumes and extends beyond the radial extent 219). Having differently sized surface areas of the faces on which pressurized fluid in the chambers 212, 162 act can provide the desired difference in force magnitudes while having equal fluid pressure in the chambers 212, 162, which can reduce the number of pressure control valves (or similar) required in the machine 110.

[0082] The machine 110 can include a controller in communication with an encoder, linear transducer, or the like for accurately reading the axial position of the moving platen 114 relative to a machine coordinate system, and so the position of the moving platen 114 corresponding to the mold closed position can be recorded in the machine controller. When the piston 140 is in the datum position 180, the precise axial position of the tie bar 120 (and its teeth 132) relative to the stationary platen 116 (and hence relative to the machine coordinate system) is known. This can facilitate accurate movement of the platen 114 (with lock nut 128) to a meshing position relative to the tie bar 120.

[0083] The recorded "mold closed" position of the moving platen 114 can be compared to the nearest previous meshing position for the locking device 126 (i.e. relative axial position in which the peaks of one set of teeth are axially aligned with the valleys of the other set of teeth). The moving platen 114 can then be moved back (in the unclamp direction) to that nearest meshing position (by an axial distance defined as an offset amount), and this new position of the moving platen can be recorded in the controller as the "rapid advance" position for future injection cycles with the given mold halves 114a, 116a. In other words, the axial position of the rapid advance position to which the moving platen is shuttled by the traverse actuator corresponds to a meshing position (position of the moving platen 114 relative to tie bar 120 in which the locking device 126 can be moved to the locked position) and to a near mold closed position (or mold closed position if offset is about zero) position of moving platen 114 relative to stationary platen 116 in which

[0084] The offset amount need generally not be more than the pitch of teeth of the locking device 126, and can range, for example, from near or equal 0mm to about 4mm or about 12mm. The magnitude of the offset amount can be minimized (and can in some cases be reduced to about zero) by loosening the keepers 149 and rotating the piston head 142 relative to the tie bars 120 to adjust the relative axial position of the tie bar 120 (and its teeth 132) when the piston

140 is in the datum position. This can adjust the axial position of the meshing positions with respect to the stationary platen 116.

[0085] Once the offset and the rapid advance positions have been established, the machine can be returned to a home state (locking devices unlocked, mold fully opened). Normal run mode can then be initiated.

[0086] In run mode, the traverse actuator 124 can shuttle the moving platen 114 to the rapid advance position (i.e, towards the closed position). Generally prior to completing this shuttling step, the pistons 140 of the clamping mechanisms 136 can each be moved to the datum position, so that the tie bars 120 are in a meshing position when the traverse actuator 124 completes shuttling the moving platen to the rapid advance position. The locking devices 126 can then be moved to the locked position.

[0087] With the moving platen 116 locked to the tie bars 120, and the piston 140 already in the datum position 180 (from the previous step), the machine 110 is ready for the clamp force to be applied (Figure 11). For each of the clamping mechanisms 136, pressurized fluid can be fed into the clamping chamber 160 (via clamping port 164), and the unclamp port 166 can be opened to tank, relieving any pressure in the unclamp chamber 162 (Fig. 9). In the example illustrated, the clamp force exerted by the pressurized fluid in the clamp chamber 160 is greater then the unclamp (mold break) force, and can be from about 10 times to about 20 times (or a higher factor) greater than the unclamp force. The effective surface area of the face on which the pressure in the clamp chamber 160 acts (i.e. directly acting on surfaces 170a and 196 as seen in Fig. 7) can be greater than the surface area of the unclamp face 172 by a corresponding proportional amount. The clamp chamber 160 can be pressurized (during clamp up) with fluid at the same pressure as that provided to the unclamp chamber 162 (during mold break, where a mold break force is desired), and the desired difference in force magnitude can be provided as a result of the difference in effective surface areas on which the pressurized fluid acts.

[0088] During clamping together of the mold halves 114a, 116a, the positioning chamber 212 can be, but need not be, maintained in a pressurized state. Maintaining pressurized fluid in the positioning chamber 212 can reduce the oil consumption required for filling the clamping chamber 160 upon clamp-up, by keeping the positioning member 182 in or near the advanced position 192 and so reducing the volume of the clamping chamber 160 to be filled upon clamp-up. In the example illustrated, the effective surface areas of the axially opposite faces of the positioning member exposed to the clamping chamber 160 and the positioning chamber 212 are about equal (i.e. the effective surface are of distal end face 196 is generally equal to the effective surface area of proximal end face 214. During mold clamping, fluid at about the same pressure setting is fed into each of the clamping chamber 160 and the positioning chamber 212. The positioning member 182 is in the advanced position when clamping is initiated, and remains in that position since the left and right axial forces acting on the respective end faces are generally balanced. The force exerted by the pressure of the fluid in the clamping chamber 160 is transmitted through the positioning member 182 and through the pressurized fluid in the positioning chamber 212, and ultimately against the clamp side 161 of the seal journal (face 170b) (Fig. 9).

[0089] Once the piston 140 has moved to the clamping position (to the right as shown, for example, in Figure 9) and the desired clamping pressure is achieved, the melt can be injected into the mold halves 114a, 116a.

[0090] Upon completion of injection and after waiting a period of time as may be required for sufficient solidification of the molded articles, clamp pressure can be released (opening the clamp valve 164 to tank). Where a mold break force is optionally provided, the unclamp force can be applied by the clamping mechanisms 136 (pressurizing the unclamp chamber 162 via the unclamp port 166). The positioning chamber 212 can be depressurized (opening port 216 to tank), so that as the piston moves in the unclamp direction 169 (to the left in Figure 9), the piston can move past the datum position without interference with

the positioning member 182 that would otherwise stop the piston in the datum position (i.e. positioning member 182 can move towards the retracted position 194; see Fig. 10). Accordingly, even with minimal forward travel of the piston 140 for clamp-up, or in cases of mold flash, sufficient travel of the piston (and hence the moving platen 114) in the unclamp direction 169 is available by urging the piston axially (in the unclamp direction) past the datum position.

[0091] After the pressure in the clamp chamber has been relieved (and after the piston has been moved to the unclamp position in cases where a mold break force is optionally provided), the locking device(s) 126 (which are still in the locked position but are under no load since axial forces on the tie bar 120 have been relieved) can be moved to the unlocked position. The traverse actuator 124 can then be energized to shuttle the moving platen 114 back to an open position, away from the stationary platen 116. The molded articles can be ejected from the mold halves 114a, 116a, and the next cycle can commence. In some examples, the piston 140 can be moved back to the datum position while the traverse actuator shuttles the moving platen 114 to the open position, and/or during ejection of the molded articles. Moving (or at least partially moving) the piston to the datum position during one or both of the advance and return strokes of the traverse actuator 124 can save cycle time.

[0092] Further details of other aspects of the machine 110 will now be described. With reference again to Figure 5, in the example illustrated, the locking device comprises a lock housing 129 having an inner surface affixed to the moving platen 114 and extending coaxially with the tie bar axis 123a. In the example illustrated, the housing 129 is integral with the platen 114 and comprises a bore provided in the platen. The inner surface of the housing 129 can be stepped, providing a first bearing face 222 and a second bearing face 224 each extending generally radially inwardly of the housing 129 at spaced apart locations along the axis of the housing. In the example illustrated, the first and second bearing faces 222, 224 are spaced axially apart by a first housing

spacing 226. The first bearing face 222 is, in the example illustrated, positioned axially away from (or distal) the stationary platen 116. The second bearing face 224 is axially nearest (or proximal) the stationary platen 116.

[0093] The lock nut 128 of the locking device 126 is received within the housing 129 and rotatable within the housing about the axis 123a between the locked and unlocked positions. The lock nut 128 has a generally annular body with axially opposite first and second ends 227, 229. The first end (distal end) 227 is directed away from the stationary platen 116, and the second end (proximal end) 229 is directed towards the stationary platen 116. An inner bore 230 extends coaxially through the nut 128 from the first end to the second end, for receiving the tie bar 120 therethrough. The inner bore 230 defines a radially inner surface having radially inwardly projecting elements (i.e. first teeth 130 in the example illustrated) extending therefrom. The projecting elements 130 engage the tie bar 120 when the lock nut 128 is in the locked position, to transfer the axial clamp load (and unclamp load) from the tie bar 120 to the lock nut 128.

[0094] The body of the lock nut 128 has a radially outer surface 232 opposite the inner surface, the outer surface 232 including first and second step faces 234, 236 for abutting the first and second bearing faces 222, 224, respectively, to cooperatively transfer the axial clamp load from the lock nut 128 to the platen 114. The bearing faces 222, 224 are, in the example illustrated, generally planar surfaces oriented generally perpendicular to the axis 123.

[0095] In the example illustrated, the first (distal) step face 234 abuts the first bearing surface 222 generally continuously during operation of the machine 110. The surfaces 234, 222 are in flush engagement whether or not a clamp load is being applied across the platens 114, 116. An annular retaining plate 238 can be mounted to the platen 114 for engaging the nut 128 and holding the first step face 234 against the first bearing surface 222. The retaining plate 238 can have a radially inwardly protruding wall 239 that bears against a shoulder surface 240 protruding radially outwardly from the nut 128, at an axial position spaced

rearward (distally) of the first step face 234. The contact between the surfaces 222, 234 can serve a locating function, providing a known position of the teeth 130 relative to the moving platen 114 (and hence to the machine coordinate system), at least when the tie bars 120 and lock nut 128 are unloaded (i.e. in relaxed, untensioned state). Engagement between the faces 239 and 240 can also be used, in the illustrated example, to transfer an unclamp force from the nut 128 to the platen 114.

[0096] The second step face 236 can be spaced apart from the second bearing surface 224 when the lock nut 128 is unloaded (for example by a first stretch gap 242), and the second step face 236 can abut the second bearing surface 224 when the axial clamp load is applied to the nut 128. In the example illustrated, the second step face 236 is axially spaced apart from the first step face 234 by a first (proximal) nut spacing 244. The proximal nut spacing 244 is less than the first housing spacing 226 when the nut 128 is unloaded, the difference between the first housing spacing 226 and the first nut spacing 244 being equal to the first stretch gap 242.

[0097] The lock housing 129 can be provided with additional axial load bearing surfaces, such as, for example, a third (intermediate) bearing surface 246 positioned axially intermediate the first and second bearing surfaces 222, 224. The third bearing surface 246 is, in the example illustrated, oriented generally perpendicular to the axis 123, and is spaced apart from the first bearing surface 222 by an intermediate housing spacing 248. The lock nut 128 can include a third step face 250 axially intermediate the fist and second step faces 234, 236, and in adjacent facing relation to the third bearing surface 246 for cooperating with the first and second step faces 234, 236 to transfer the axial clamp load from the nut 128 to the platen 114.

[0098] In the example illustrated, the third step face 250 is spaced axially apart from the third bearing surface 246 (for example by an intermediate stretch gap 252) when the nut 128 is unloaded, and the third step face 250 abuts the

third bearing surface 246 when the axial clamp load is applied to the nut 128. In the example illustrated, the intermediate step face 250 is axially spaced apart from the first step face 234 by a second (intermediate) nut spacing 254. The intermediate nut spacing 254 is less than the intermediate housing spacing 248 when the nut 128 is unloaded, the difference between the intermediate housing spacing 248 and the intermediate nut spacing 254 being equal to the intermediate stretch gap 252.

[0099] The intermediate stretch gap 252 is, in the example illustrated, less than the proximal stretch gap 242. In use, upon initial application of pressurized fluid in the clamping chamber, the tie bar 120 is urged towards the right (in Figure 5), urging the lock nut 128 (through inter-engagement of the teeth 130, 132) also towards the right. Some of the clamp load is immediately transferred to the platen 114 from the nut 128 through the abutment of the first step face 234 against the first bearing surface 222. As the clamp load increases, the tie bar stretches, resulting in maximum rightward displacement of the right-most end of the tie bar, and zero displacement at the left-most end of the tie bar 120. Along the axial extent of the tie bar 120 that is within the bore of the lock nut 128, the same is true (more axial displacement of the tie bar at the right or proximal end than at the left or distal end). The proximal and intermediate stretch gaps can allow the lock nut 128 to stretch axially with the tie bar, so that once full clamping pressure is reached, the load is distributed across the bearing surfaces 222, 246, and 224. The loading on the teeth 130, 132 can also be uniformly distributed across the axial extent of the lock nut 128 by accommodating tie bar stretch through the provision of the plural bearing surfaces 222, 224, 246 and the stretch gaps 242, 252.

[00100] Without provision for stretch gaps as disclosed above, the stepped lock nut 128 can still provide enhanced force distribution across the axial extent of the nut and the engaged teeth 130, 132. However, with the provision of the stretch gaps, the lock nut can stretch with the tie bar, and the stress on the tie

bar and lock nut can be distributed more broadly and more uniformly. Without the steps and/or without the stretch gaps, the stress would generally be more concentrated in a localized axial position, typically near the front (proximal) end of the nut. More localized, concentrated stress loading can reduce the overall machine clamp capacity and/or reduce the service life of the locking device components, including the tie bar in some cases.

[00101] A generally sealed lubrication chamber 260 can be provided between at least a substantial portion of the radially outer surface of the locking nut 128 and the inner surface of the housing 129. Lubrication fluid can be provided in the lubrication chamber 260 to further facilitate rotation of the locking nut 128 between the locked and unlocked positions. A proximal seal 262 (e.g. a radial shaft seal) can be provided between the outer surface of the nut 128 and the housing 129 at a proximal end of the nut to seal off the proximal end of the chamber 260. A distal seal 264 can be provided at the distal end of the locking nut 128 to seal off the chamber 260 at the distal end. The distal seal 264, in the example illustrated, comprises a radially outer seal 266 (mounted between the housing 129 and the retainer 238) and a radially inner seal 268 (mounted between the nut 128 and the retainer 238). A valved fill port 270 can extend between the two seals 266, 268 for filling the chamber 260. A drain port 271 can similarly be provided, at a lower point around the circumference of the chamber 260.

[00102] In the example illustrated, the lubrication fluid can be unpressurized, i.e. maintained at generally atmospheric pressure, since the locking device 126 is free of (or isolated from) any pressure chambers for generating a clamping force or an unclamp force. This can reduce the pressure rating requirements for the seals 262, 264 which can permit use of lower friction seals, which in turn can further reduce the time and energy required to move the locking device 126 between the locked and unlocked positions.

[00103] Referring again to Figure 2, the traverse actuator 124 can be free of provisions for providing an unclamp force (or mold break force) after an injection cycle. Such provisions can be understood with reference to a prior art injection molding machine, wherein the traverse actuator(s) provide an unclamp force of at least about 5% to 10% of the clamp force, and the traverse actuator(s) are arranged so that this force is generally equally balanced about the vertical and horizontal center point of the platen (e.g. a single actuator located generally centrally of the mold, or plural actuators arranged symmetrically about the center point). Even for dedicated machines running a process in which a mold break force is not normally required, the machine can advantageously be equipped with provision for applying a mold break force in case the mold does not open as expected (e.g. as may be caused, for example, by mold flash).

[00104] In the example illustrated, the clamp mechanism 136 of the injection molding machine 110 provides the capability to apply an unclamp (mold break) force to separate the platens 114, 116 after an injection cycle, if necessary. The traverse actuator 124 of the injection molding machine 110 can be sized with a significantly lower maximum force rating than would otherwise be required if it were relied upon to provide the unclamp (mold break) force. In the example illustrated, the maximum force rating of the traverse actuator 124 in the mold open direction is about 3% of the maximum clamp force of the machine. In other examples, the traverse actuator 124 may be only 1% (or less) of the maximum clamp force of the machine 110. Furthermore, the traverse actuator 124 may alternatively or additionally be arranged to exert its opening and closing force at a point that is laterally offset with respect to the center 115 of the moving platen 114. Further details of the traverse actuator 124 are described subsequently herein.

[00105] Referring to Figure 12, an alternative example of a clamping mechanism 336 is shown. The clamping mechanism 336 is similar to the

clamping mechanism 136, with like features identified by like reference characters, incremented by 200.

[00106] The clamping mechanism 336 comprises a pushing member 411 for exerting a positioning force on the positioning member 382 to move and/or releasably retain the positioning member 382 to/in the advanced position. In the example illustrated, the positioning force is generated by springs 511 acting between the distal end face 414 of the positioning member 382 and the piston 140, urging the positioning member away from the clamping side 361 of the seal journal 350.

[00107] In use, the piston 340 is moved to the datum position by relieving pressure in the clamp chamber 360 (e.g. venting port 364 to tank in the example illustrated). The springs 511 can move the positioning member to the advanced position relative to the piston (i.e. with the first contact surface 398 bearing against the first abutment surface 402 of the retainer 404. The unclamp chamber 362 is pressurized so that it exerts a datum force on the piston 340 that is less than the positioning force exerted by the springs 511. Accordingly, the positioning member 382 is retained in the advanced position relative to the piston by the springs 511. The pressure of the clamp chamber moves the piston into position so that the second (radially outer) contact surface 400 of the positioning member 382 remains engaged with the second abutment surface 406 of the cylinder housing.

[00108] During clamping of the platens, the unclamp chamber can be depressurized, and the clamp chamber pressurized. The pressure in the clamp chamber exerts a force on the piston to move the piston towards the clamped position. The springs may or may not compress during the clamping of the platens. Pressurized fluid in the clamping chamber can bear directly against the end face of the piston and/or the clamping shoulder of the piston (face 370b). Fluid may flow around or through the positioning member (e.g. through apertures in the positioning member) to access the clamping shoulder from the clamping

port 364. For certain applications, particular for long running, low-cycle time applications, the machine can be set up so that the total axial travel of the piston from the datum position to full clamping of the platens can be minimized, and can be as short as a few millimeters or less.

[00109] During unclamp (mold break), the clamping chamber 360 can be depressurized (port 364 vented to tank), and the unclamp chamber 362 pressurized (high pressure fluid fed through port 366). The axial force generated by the pressurized unclamp chamber 362 can be greater than the force exerted by the springs 511, so that the springs can compress, allowing the positioning member 382 to be displaced towards the retracted position relative to the piston 340. The ability of the piston 340 to move in an unclamp direction (i.e. left in Fig. 12) past its axial position upon initiating clamp-up (i.e. past the datum position) can help to ensure that sufficient unclamp stroke length is available to separate and relieve the pressure on the clamped mold halves 314a, 316a. This unclamp stroke length is available even in cases where the piston travel from datum to fully clamped platens is minimal, and/or in cases where the mold has flashed.

[00110] Considering again the traverse actuator 124, and with reference now to Figures 13 and 14, traverse actuator 124 of the machine 110 can take the form of a single linear actuator 124a mounted at or near the lower end 117 of the moving platen 114. In the example illustrated, the single linear actuator 124a comprises a motor 113 coupled to a ball screw 119. The motor 113 may be a hollow motor attached to (and moveable with) the moving platen 114, with a ball nut 121 rotatably housed within the motor 113.

[00111] The single linear actuator 124a of the traverse actuator 124 extends along an actuator axis 105 that is generally parallel to the machine axis 122 and offset in at least one of a horizontal and vertical direction from the machine axis 122. In the example illustrated, the actuator axis 105 is vertically offset from the geometrical center of the platens 114, 116 (i.e. spaced vertically beneath the axis 122 by an actuator offset 103). The single actuator 124a

applies a net opening force on the moving platen that acts along the actuator axis 105 in a direction opposite the clamping force. In some examples, the single actuator 124a can additionally or alternatively be positioned horizontally offset from the axis 122. The offset configuration of the single actuator 124a can provide additional space and flexibility with respect to overall packaging of components in the injection molding machine 110.

[00112] Referring to Figure 15, another example of a traverse actuator 1524 configuration for an injection molding machine 1510 is illustrated, having features similar to that of the machine 110 identified with like reference numerals, incremented by 1400. The traverse actuator 1524 is also free of provision for providing an unclamp force after an injection cycle, and the traverse actuator 1524 is arranged to exert its opening and closing force at a point that is laterally offset with respect to the center 1515 of the moving platen 1514. In the example illustrated, the traverse actuator 1524 comprises a first ball screw 1519a and a second ball screw 1519b mounted at or near the lower end 1517 of the moving platen 1514, on horizontally opposed sides of the moving platen 1514 (i.e. on either side of the axis 1522). First and second motors 1513a, 1513b are coupled to the respective ball screws 1519a, 1519b. The motors 1513 are, in the example illustrated, fixed to the machine 1510 at or near a lower surface of the stationary platen 1516. Respective ball nuts 1521a, 1521b are fixed to a lower surface of the moving platen 1514, to receive the respective ball screws 1519a, 1519b therethrough. In this configuration, each ball screw 1519 extends between the fixed and moving platens 1514, 1516, parallel to the tie bars 1520. Each ball screw 119 has a proximal end 101 that is axially positioned at about the same axial position as the stationary platen, and an opposing distal end is directed towards the moving platen. This configuration can reduce outward axial extension of the traverse actuator 1524 (i.e. in a direction extending from one platen away from the other platen), which can further facilitate packaging of machine components and minimizing overall axial length of the machine 1510.

[00113] Referring to Figure 16, another example of a traverse actuator 1624 configuration for an injection molding machine 1610 is illustrated, having features similar to that of the machine 1610 identified with like reference numerals, incremented by 1500. The traverse actuator 1624 is also free of provisions for providing an unclamp force after an injection cycle, and the traverse actuator 1624 is arranged to exert its opening and closing force at a point that is laterally offset with respect to the center 1615 of the moving platen 1614. In the example illustrated, the traverse actuator 124 includes a motor 1613 mounted to the machine base at a position generally beneath the moving platen when the moving platen is in the retracted (mold open) position. The motor 1613 rotates a pair of drive pulleys 1635 via a shaft 1637, all of which are mounted to the machine base. A pair of spaced apart idler pulleys 1641 are secured to the stationary platen, and a respective toothed belt 1643 extends between respective ones of the drive pulleys 1635 and idler pulleys 1641. The moving platen is secured to the belts 1635 via belt coupling plates 1645 mounted to an underside surface of the moving platen 1614.

[00114] While the above description provides examples of one or more processes or apparatuses, it will be appreciated that other processes or apparatuses may be within the scope of the accompanying claims.

CLAIMS:

1. An injection molding machine, comprising:

a) a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions;

b) a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens;

c) at least a first locking device mounted to the first platen and associated with a first one of the tie bars, the first locking device and first tie bar comprising respective locking elements moveable from an unlocked position to a locked position when the tie bar is moved axially relative to the locking device to one of a plurality of axially spaced apart meshing positions, the first locking device locking together the first tie bar and the first platen when in the locked position, and the first locking device moveable from the locked position to the unlocked position to release the first platen from the first tie bar; and

d) at least a first clamping mechanism mounted to the second platen and associated with the first tie bar, the first clamping mechanism comprising a piston member affixed to the first tie bar and movable between clamp and unclamp positions within a cylinder housing affixed to the second platen, the piston and cylinder housing defining a clamp chamber and an unclamp chamber on opposite sides of the piston, for moving the piston towards the clamp and unclamp positions and exerting a clamping force and a mold break force, respectively, when pressurized, the clamping force being less than or equal to a maximum rated load associated with the machine; and

e) a traverse actuator comprising one or more linear actuators coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and

closed positions, the one or more linear actuators together being free of provision for applying a mold break force to the platens.

2. The injection molding machine of claim 1, wherein the one or more linear actuators of the traverse actuator together apply a net axial opening force on the at least one platen in a direction opposite the clamping force and at a vertical and/or horizontal location that is substantially offset from the center of the at least one platen as viewed in a plane orthogonal to the axial direction.

3. The injection molding machine of any one of claims 1-2, wherein the one or more linear actuators of the traverse actuator together are sized to exert a maximum opening force on the at least one platen in a direction opposite the clamping force that is less than about 3 percent of the maximum rated load.

4. The injection molding machine of any one of claims 1-3, further comprising a stop member movable relative to the piston and the cylinder housing and moveable between an advanced position and a retracted position, the stop member when in the advanced position providing a mechanical stop for the piston when the piston is moved to a datum position intermediate the clamp and unclamp positions.

5. The injection molding machine of any one of claims 1-4, wherein the traverse actuator comprises a motor, and the motor is mounted beneath at least one of the first platen and the second platen.

6. The injection molding machine of any one of claims 1-4, wherein the traverse actuator comprises a motor, and the motor is positioned at an axial position generally equal to that of one of the first platen and the second platen.

7. The injection molding machine of any one of claims 1-4, wherein the traverse actuator comprises a motor, and the motor is axially inboard of one of the first platen and the second platen.

8. The injection molding machine of any one of claims 1-7, wherein the traverse actuator comprises a ball screw coupled to the motor and a ball nut fixed to the other of the first and second platens and in engagement with the ball screw.

9. The injection molding machine of any one of claims 1-7, wherein the traverse actuator comprises a toothed belt driven by the motor and affixed to the other of the first and second platens.

10. The injection molding machine of any one of claims 1-9, wherein the injection molding machine comprises four tie bars extending between respective corners of the first and second platens, and wherein the traverse actuator is positioned outside of a space bounded by the tie bars.

11. The injection molding machine of any one of claims 1-10, wherein one of the first and second platens is a stationary platen remaining in a fixed axial position during use, and wherein the single linear actuator has a proximate end axially positioned generally at the fixed axial position of the stationary platen.

12. An injection molding machine, comprising:

a) a first platen and a second platen, the first platen movable relative to the second platen in an axial direction between open and closed positions;

b) a sprue bushing mounted in one of the first and second platens generally at a geometrically central position thereof, the sprue bushing receiving melt from an injection nozzle therethrough, the machine having a machine axis parallel to the axial direction and passing through the sprue bushing;

c) a plurality of tie bars extending generally between the first and second platens for coupling together the first and second platens;

d) at least a first locking device mounted to the first platen and associated with a first one of the tie bars, the first locking device and first tie bar comprising respective locking elements moveable from an unlocked position to a locked position when the tie bar is moved axially relative to the locking device to one of a plurality of axially spaced apart meshing positions, the first locking device locking together the first tie bar and the first platen when in the locked position, and the first locking device moveable from the locked position to the unlocked position to release the first platen from the first tie bar;

e) at least a first clamping mechanism mounted to the second platen and associated with the first tie bar, the first clamping mechanism comprising a piston member affixed to the first tie bar and movable between clamp and unclamp positions within a cylinder housing affixed to the second platen, the piston and cylinder housing defining a clamp chamber and an unclamp chamber on opposite sides of the piston, for moving the piston towards the clamp and unclamp positions and exerting a clamping force and a mold break force, respectively, when pressurized, the clamping force being less than or equal to a maximum rated load associated with the machine; and

f) a traverse actuator comprising a single linear actuator coupled to at least one of the first and second platens for effecting said movement of the first platen relative to the second platen between the open and closed positions, wherein the single linear actuator of the traverse actuator extends along an actuator axis that is generally parallel to the machine axis and offset in at least one of a horizontal and vertical direction from the machine axis.

13. The injection molding machine of claim 12, wherein the single linear actuator is sized to exert a maximum opening force on the at least one platen in a direction opposite the clamping force that is less than about 3 percent of the maximum rated load.

14. The injection molding machine of claim 12 or 13, wherein the injection molding machine comprises four tie bars extending between respective corners of the first and second platens, and wherein the single linear actuator is positioned outside of a space bounded by the tie bars.

15. The injection molding machine of any one of claims 12-14, wherein one of the first and second platens is a stationary platen remaining in a fixed axial position during use, and wherein the single linear actuator has a proximate end axially positioned generally at the fixed axial position of the stationary platen.

16. The injection molding machine of any one of claims 12-15, wherein the traverse actuator comprises a motor coupled to the single linear actuator, and the motor is mounted beneath at least one of the first platen and the second platen.

17. The injection molding machine of any one of claims 12-16, wherein the traverse actuator comprises a motor coupled to the single linear actuator, and the motor is positioned axially between, and laterally aside, the first platen and the second platen.

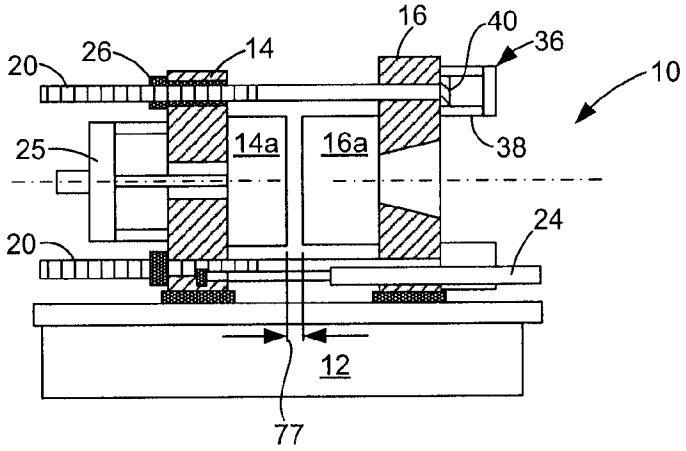


FIG. 1a

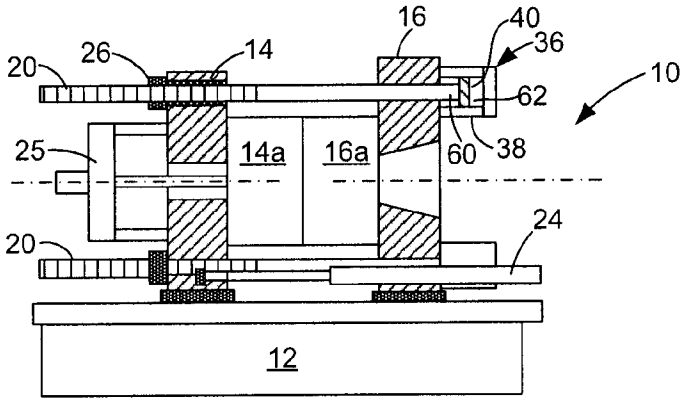


FIG. 1b

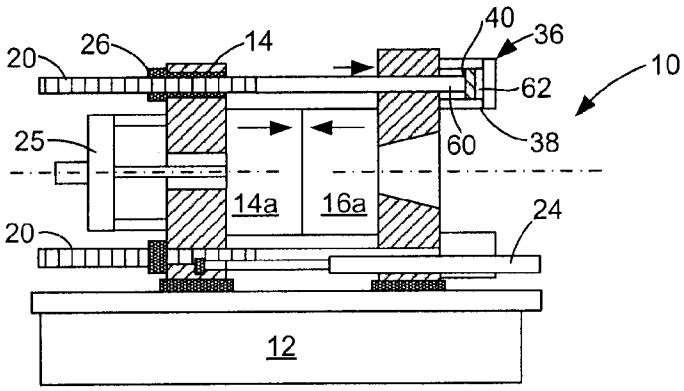


FIG. 1c

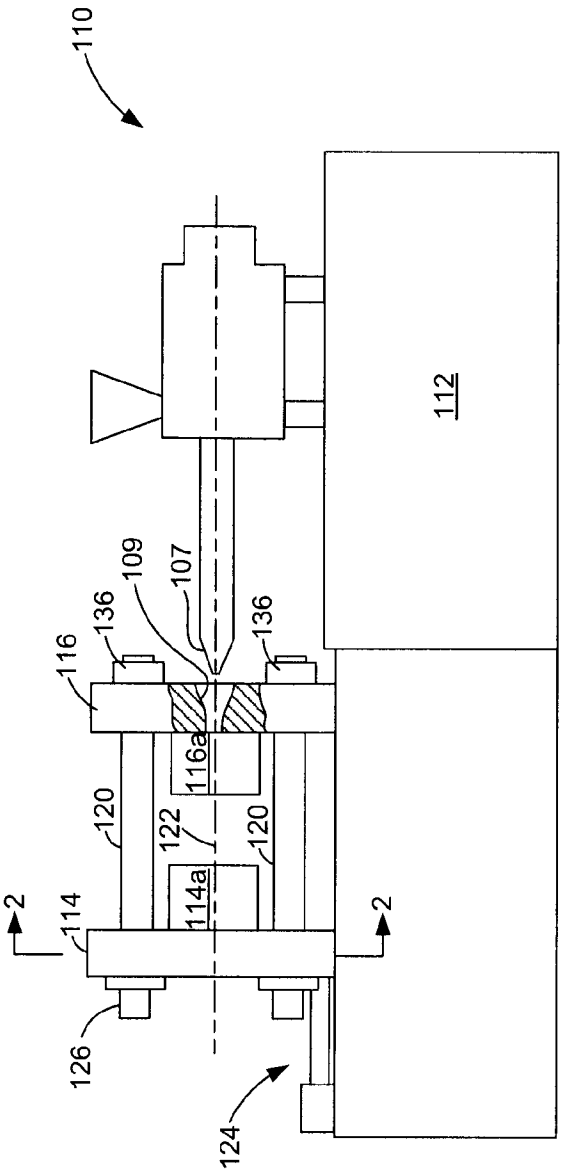


FIG. 2

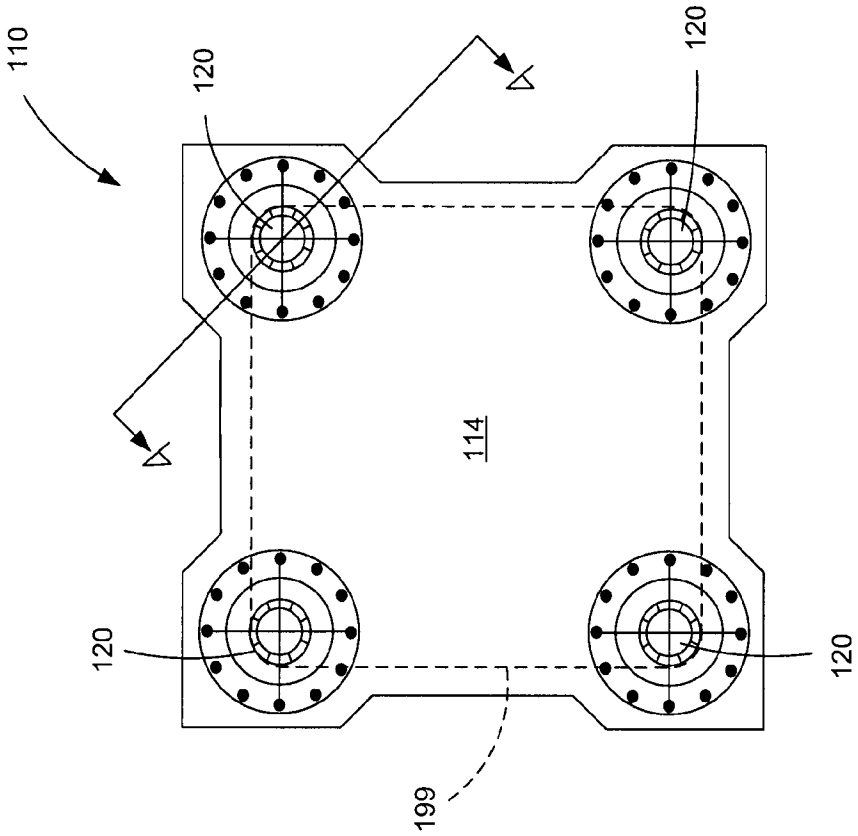


FIG. 3

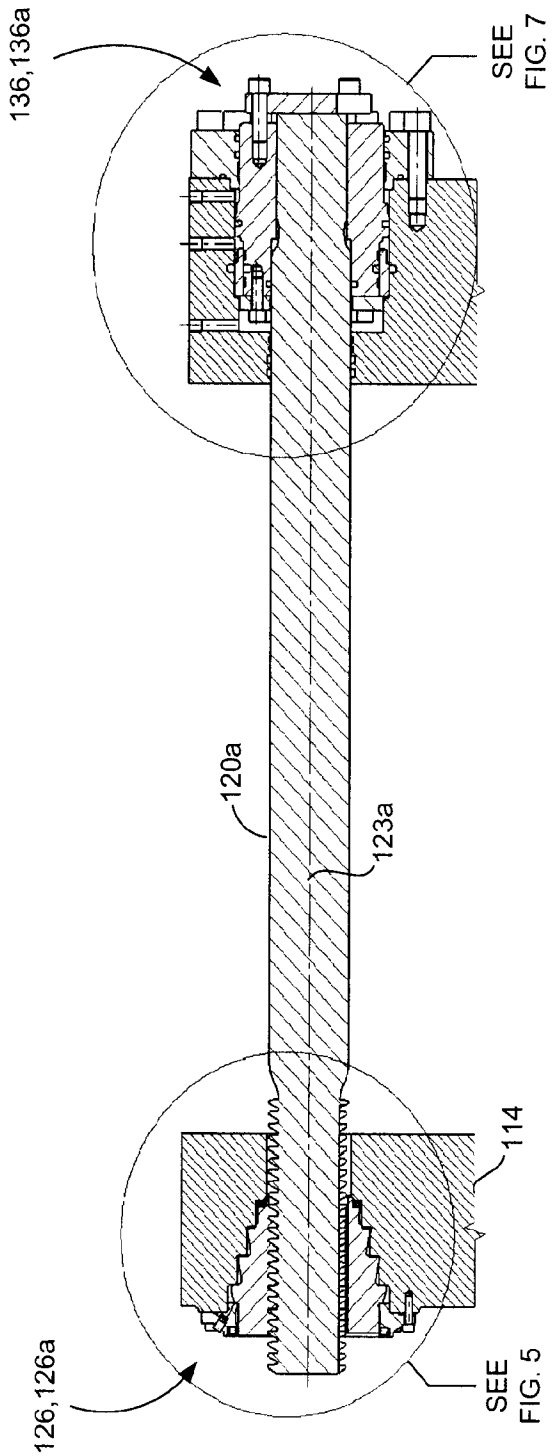


FIG. 4

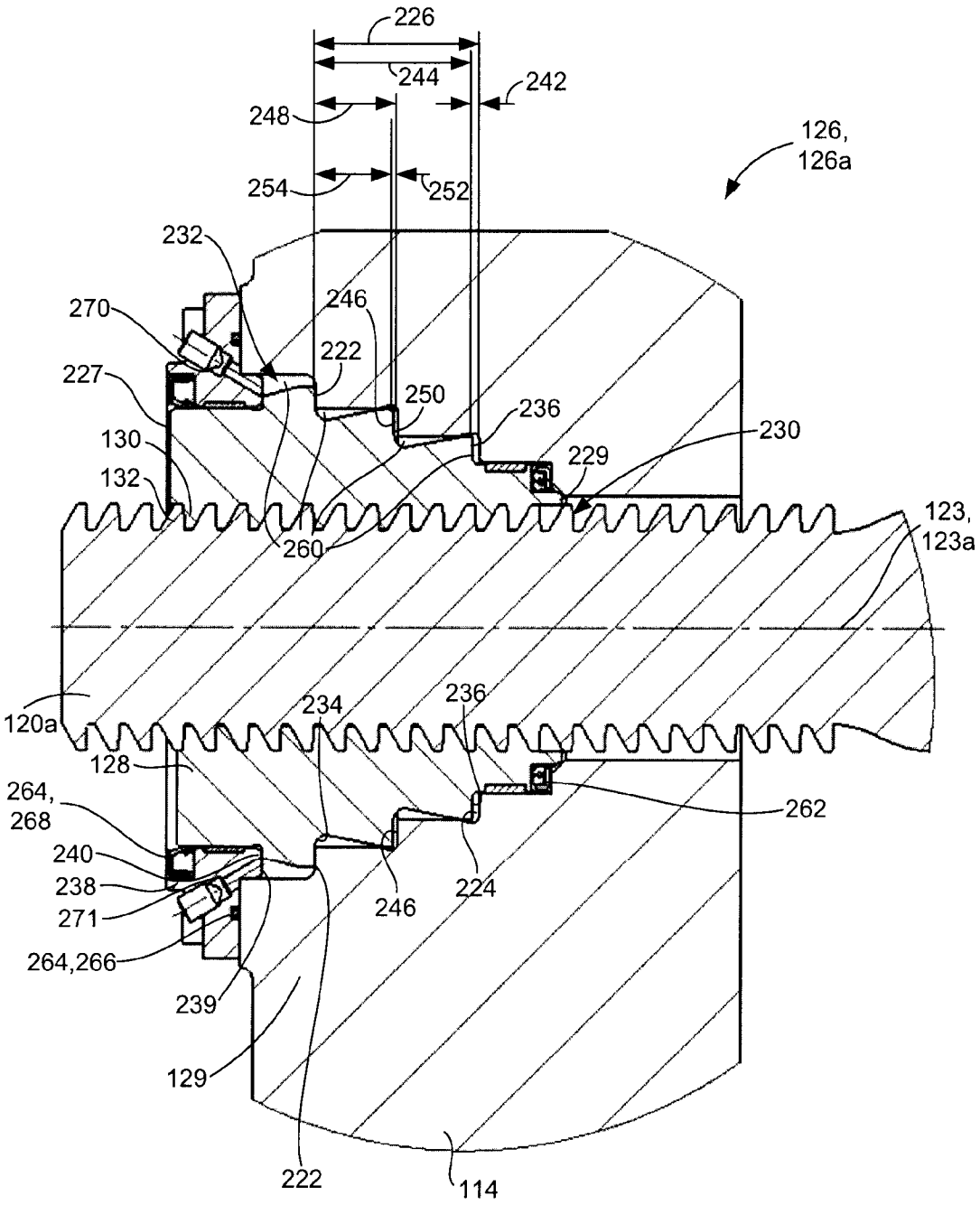

226
244
242
248
254
252
126,
126a
232
270
246
222
227
250
236
230
130
229
132
260
123,
123a
120a
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128
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264,
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264,266
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114

FIG. 5

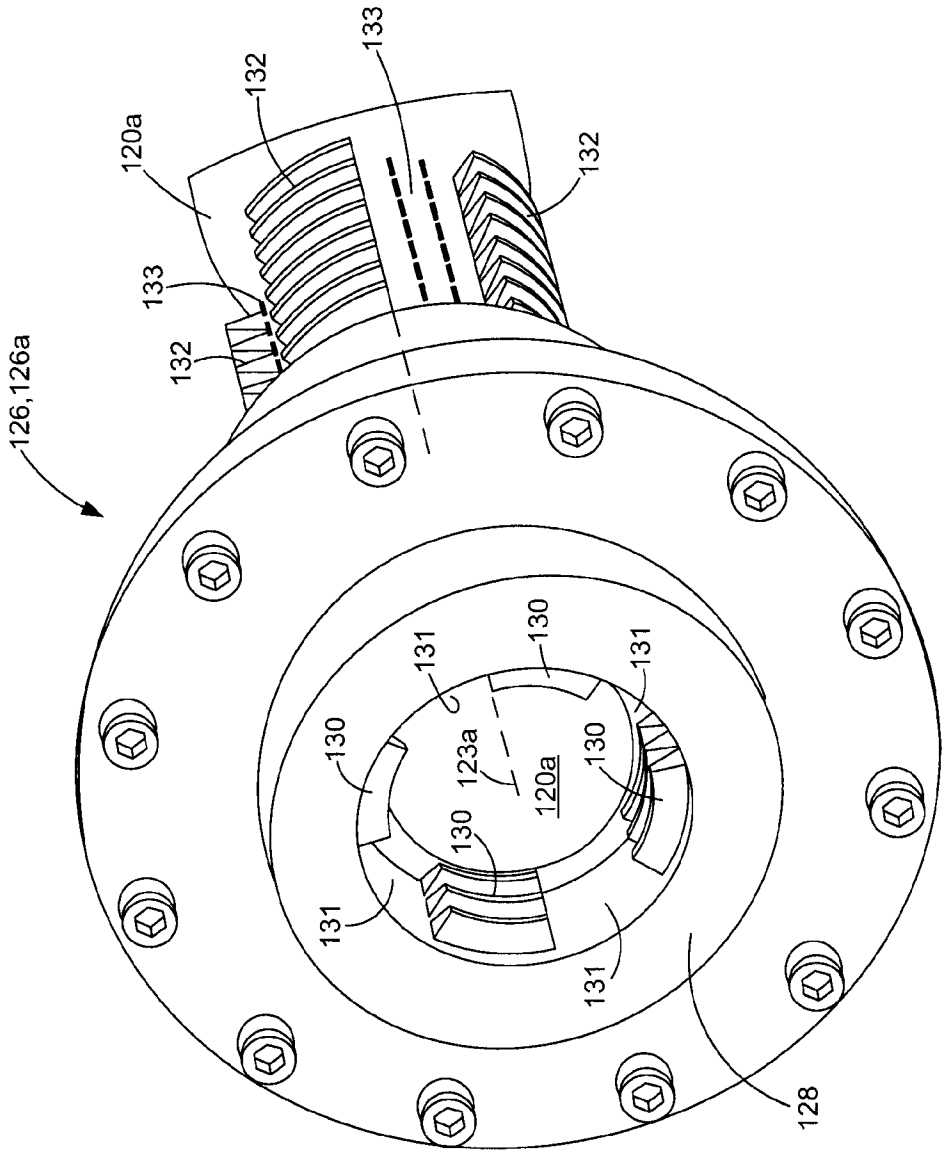

133
132
120a
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126,126a
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123a
120a
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128

FIG. 6

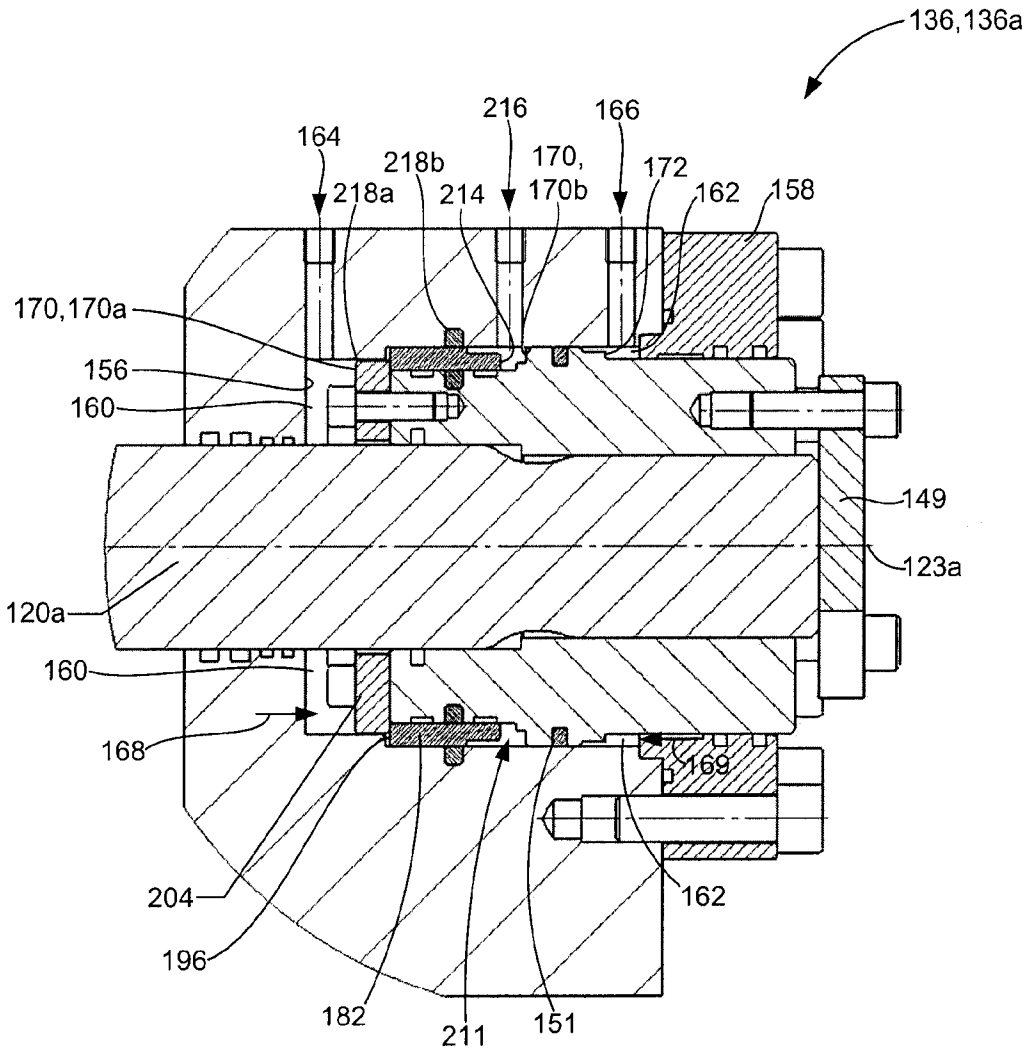

136,136a
164
216
166
218b
170,
172
218a
214
170b
162
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170,170a
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160
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123a
120a
160
168
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204
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151

FIG. 7

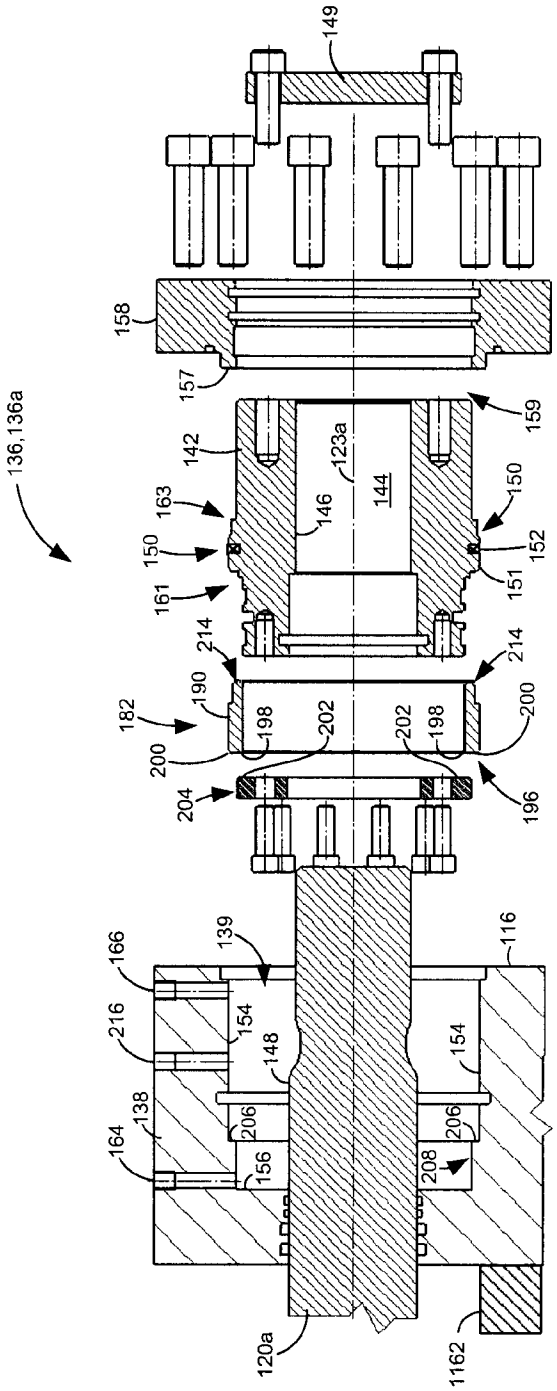

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FIG. 8

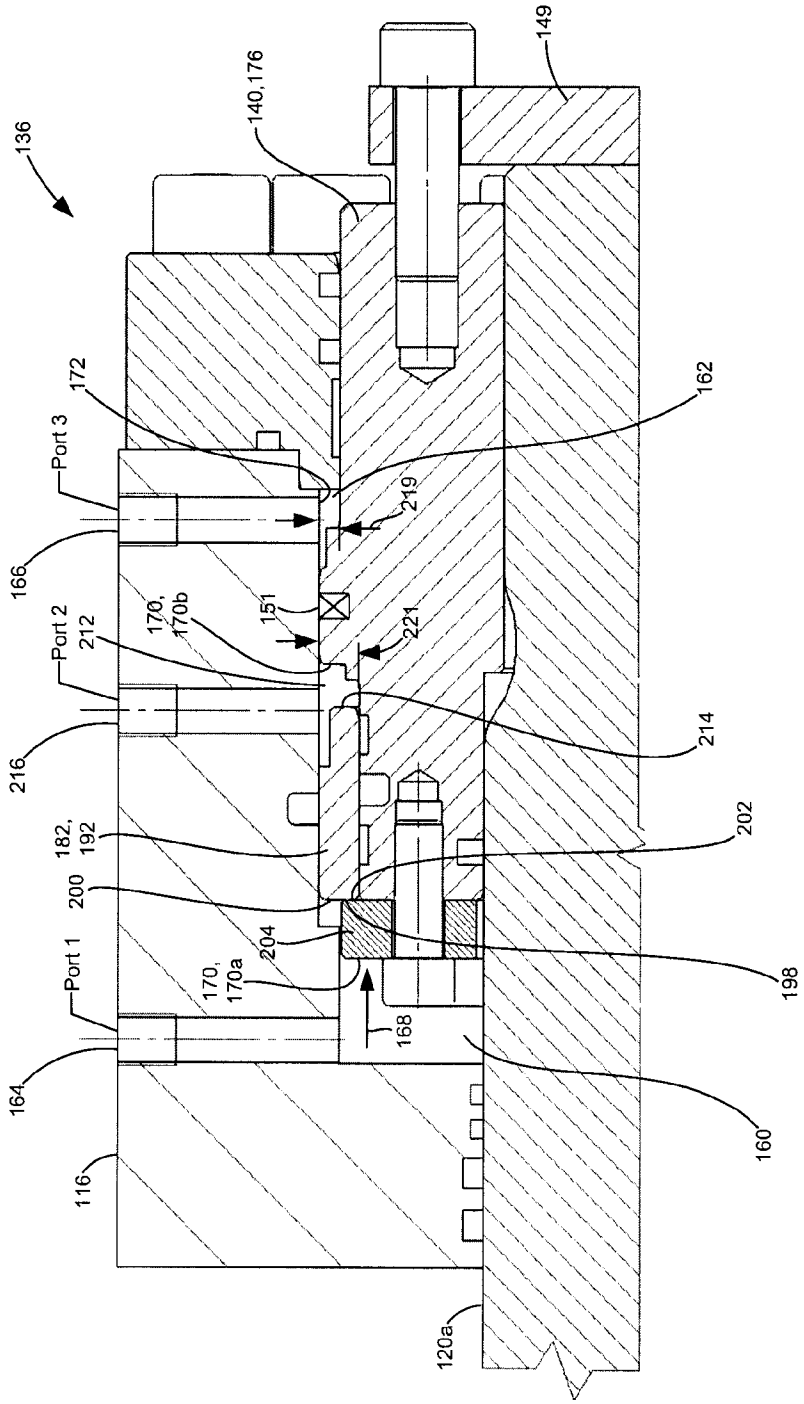

136
140,176
149
172
162
Port 3
166
219
151
170,
170b
221
Port 2
212
216
214
182,
192
202
200
204
198
Port 1
170,
170a
168
164
160
116
120a

FIG. 9

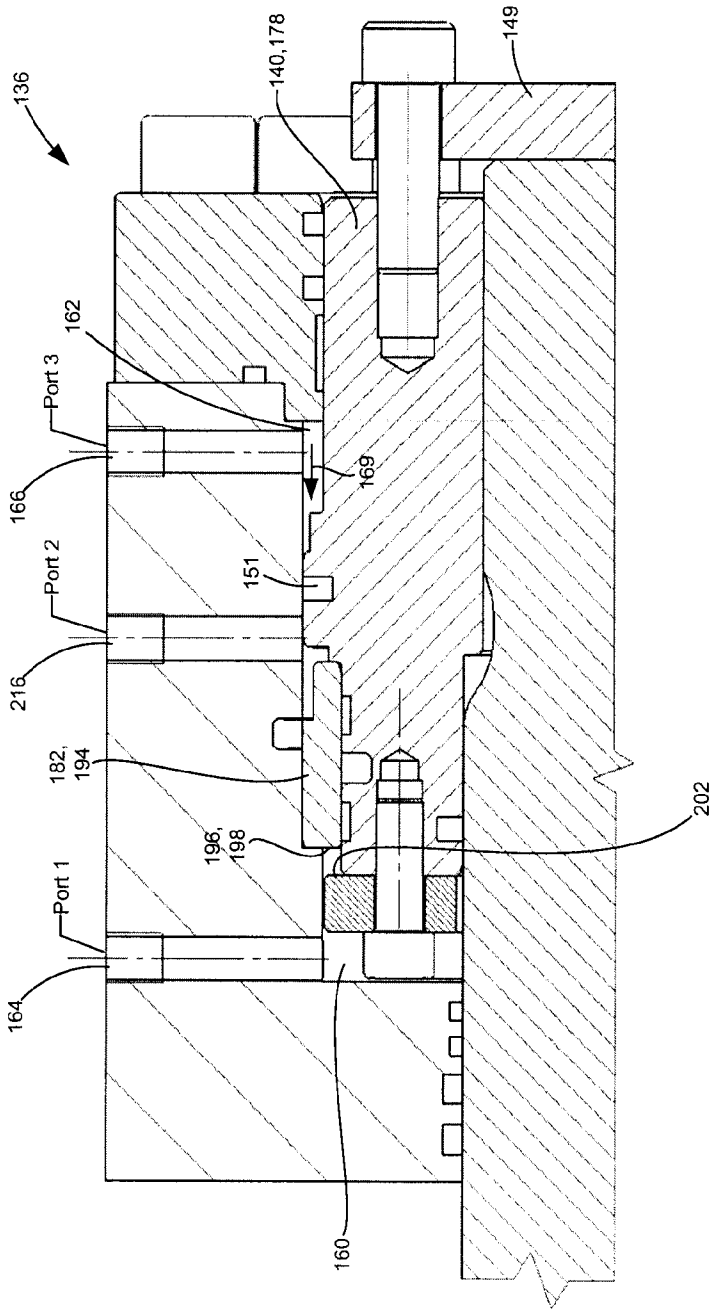

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Port 2
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216
182,
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202
196,
198
Port 1
164
160

FIG. 10

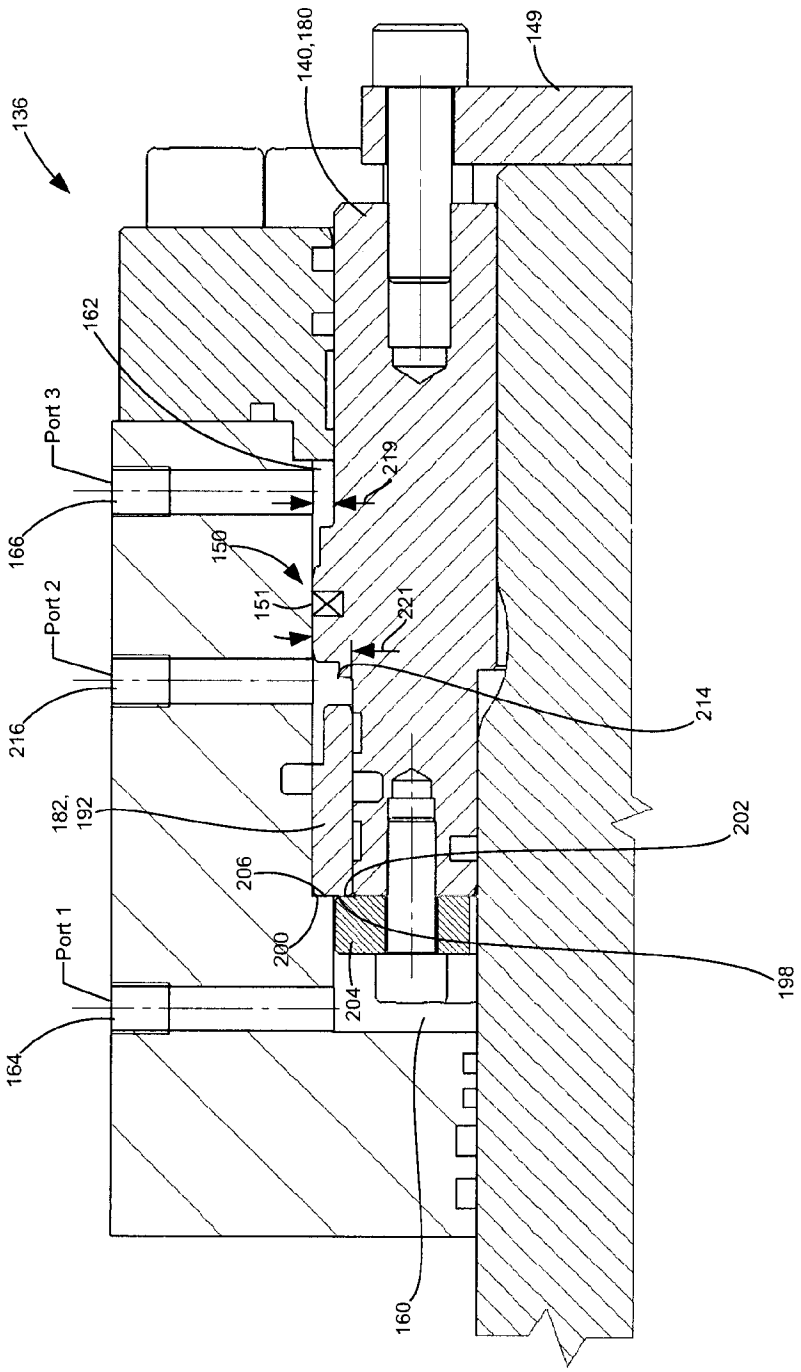

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140,180
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Port 3
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Port 2
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182,
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200
Port 1
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FIG. 11

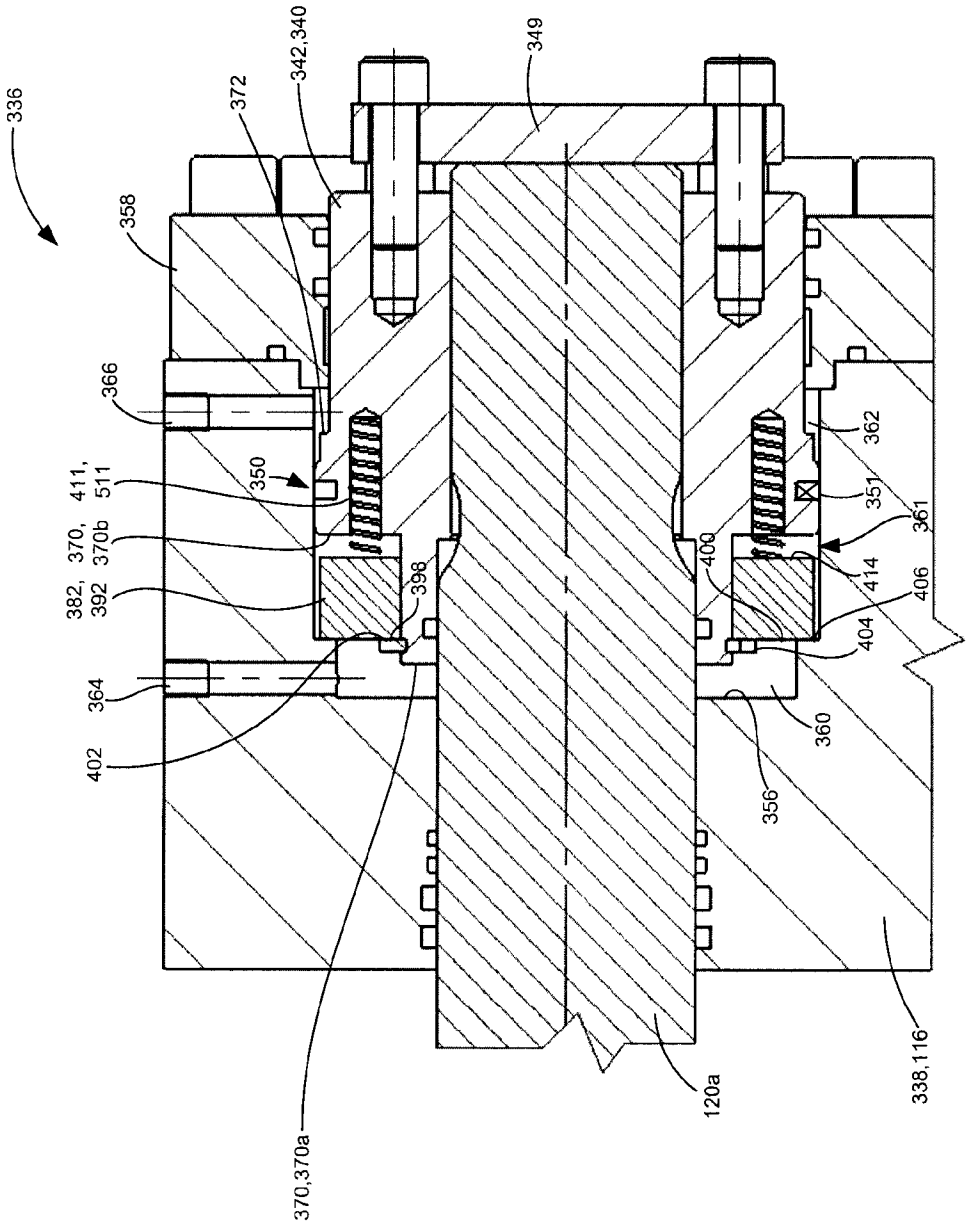

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372
342,340
349
358
366
362
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411,
511
351
361
370,
370b
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382,
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404
364
360
402
356
370,370a
120a
338,116

FIG. 12

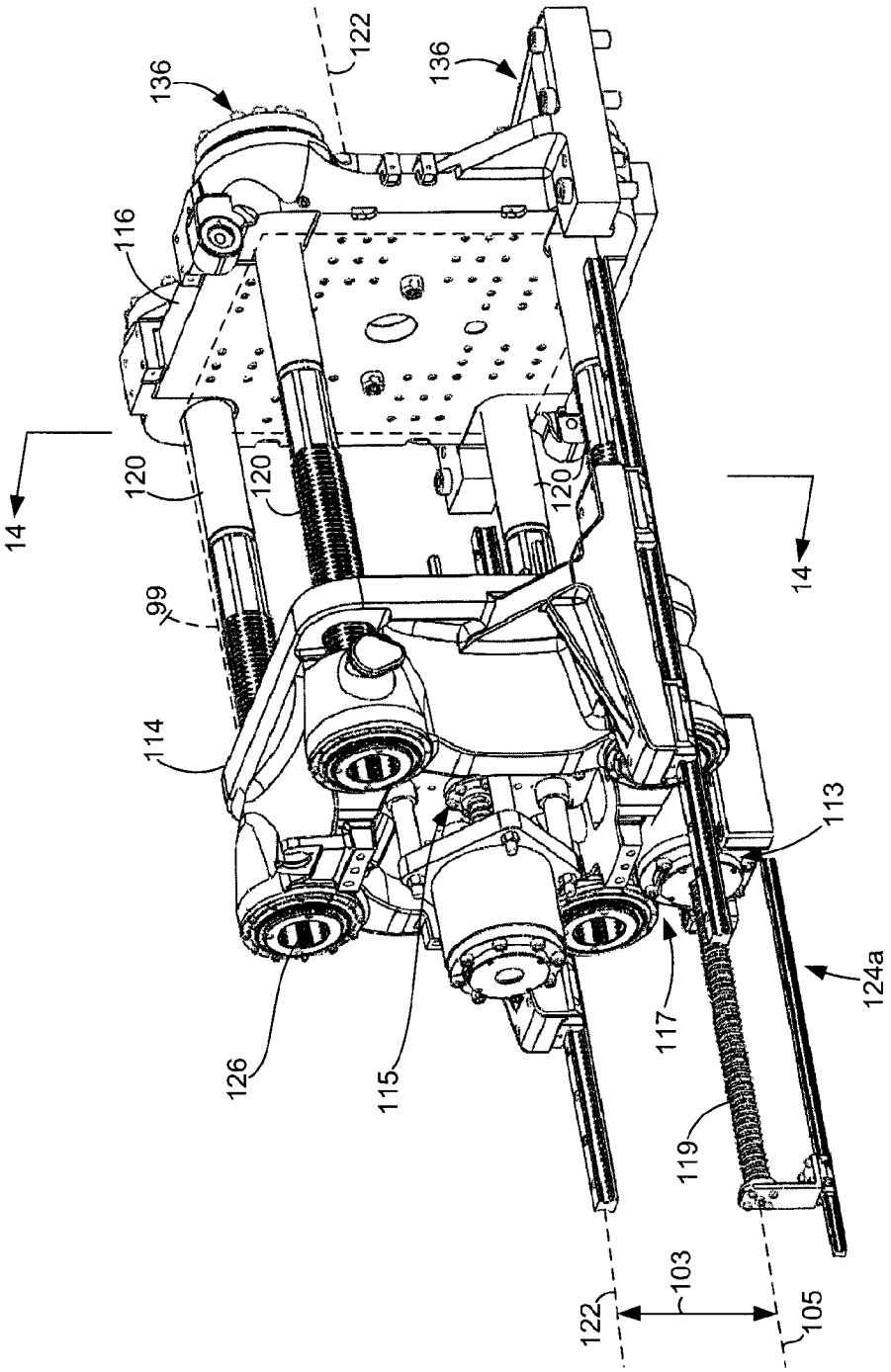

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124a
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FIG. 13

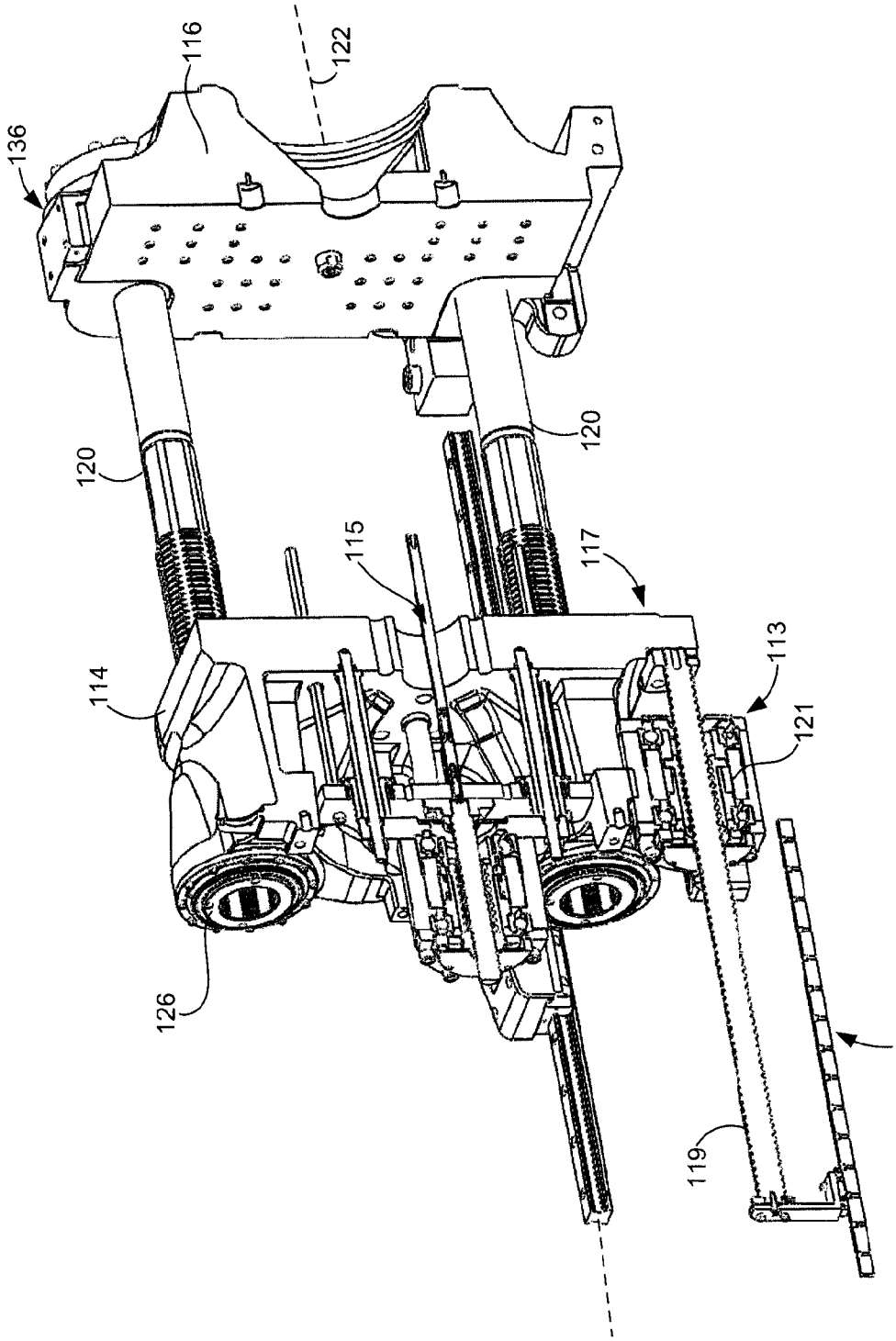


FIG. 14

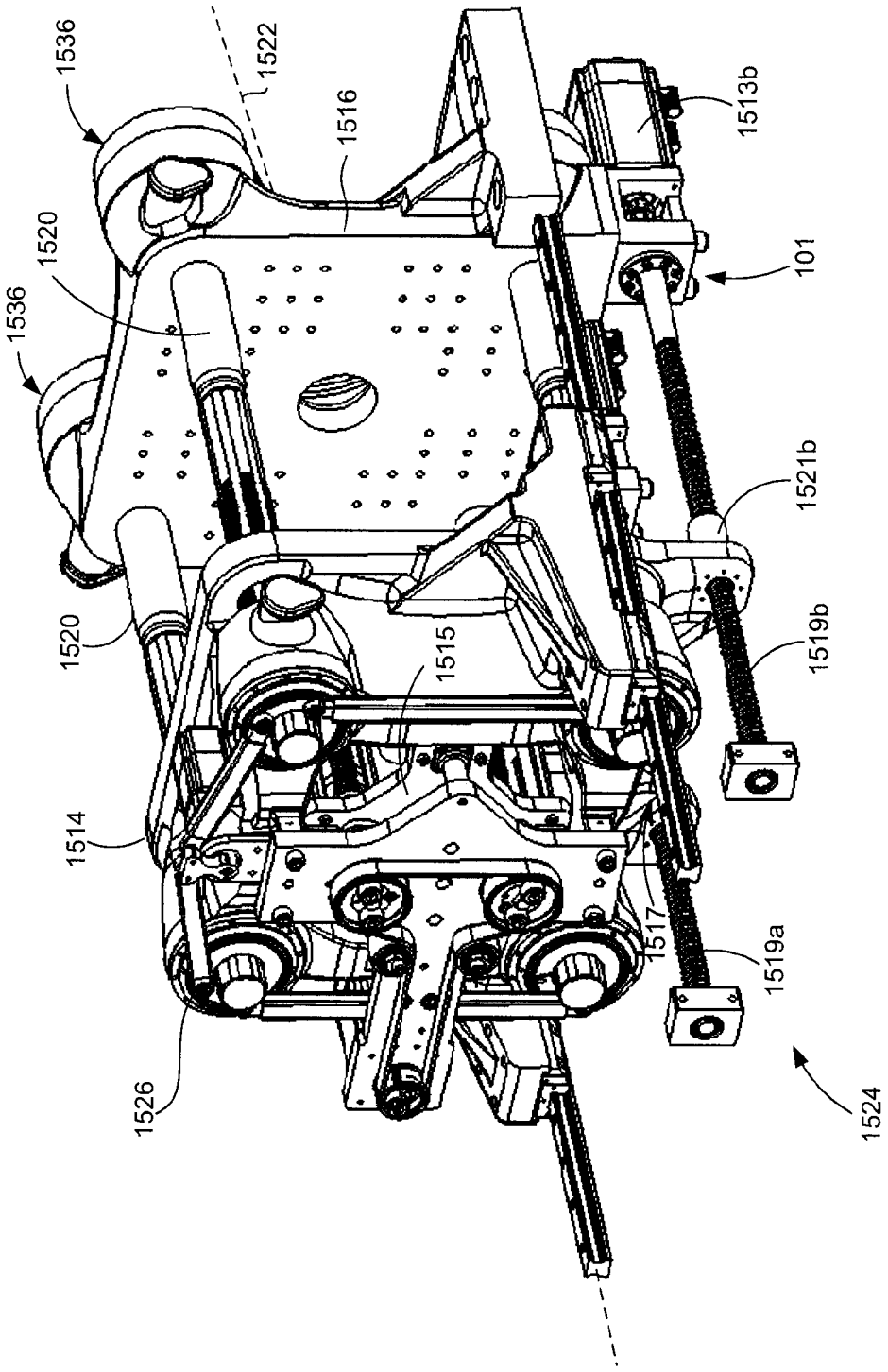

1536
1522
1516
1513b
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1521b
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FIG. 15

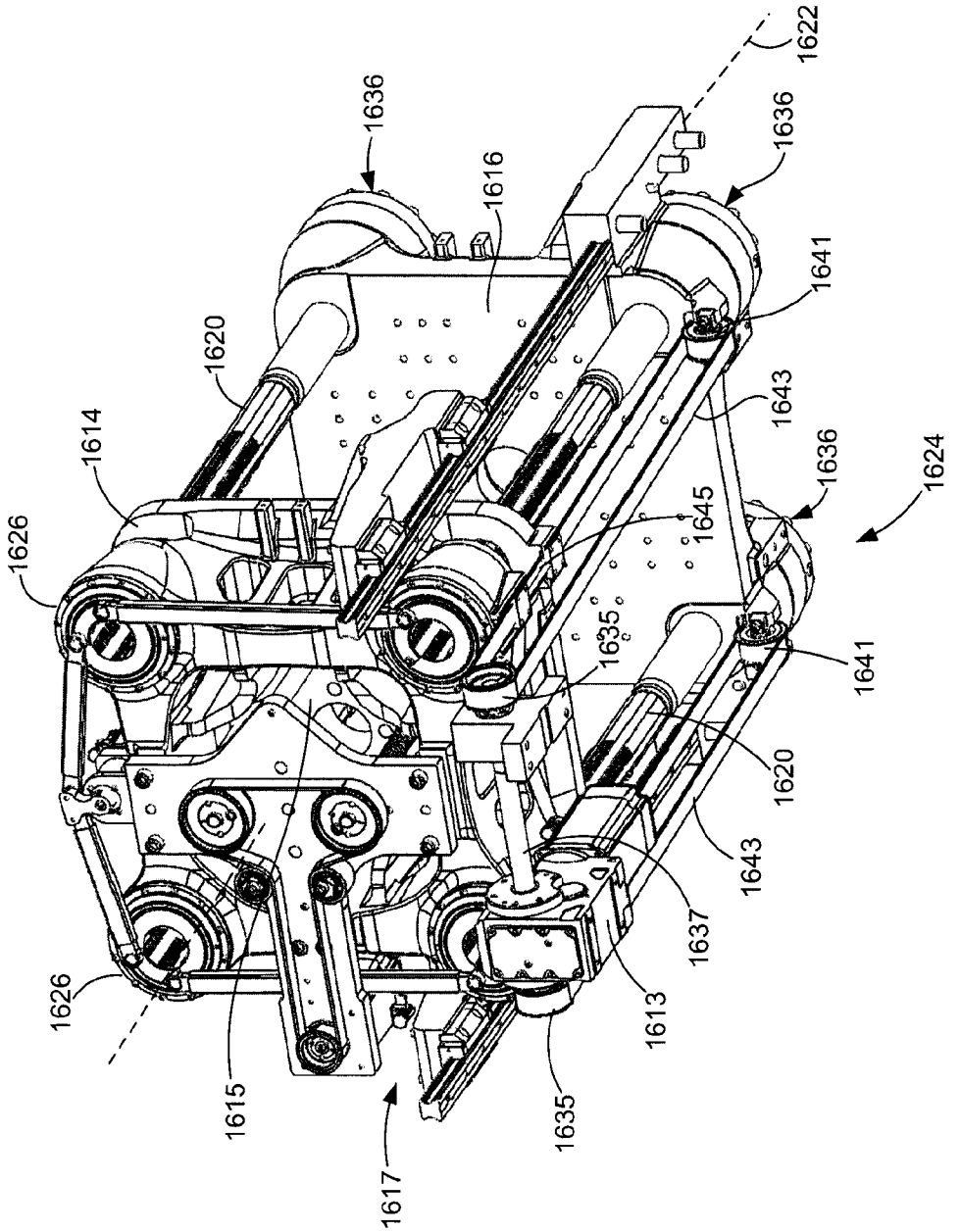

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FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2009/001398

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B29C 45/64*** (2006.01) , ***B29C 45/08*** (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*, B29C 45/*, B29C 45/64/low

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)
Delphion, EPOQUE, Canadian Patent Database, Patent Abstracts of Japan, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA2177950 C (KESTLE et al.) 08 December 1996 (08-12-1996) *whole document*	1-3, 5-7, 10-17
Y		4, 8, 9
Y	US6878317 B2 (KUBOTA) 12 April 1998 (12-04-1998) *Fig. 1, col. 4, lines 52-64*	8, 9
Y	JP2052707 A (KAKIMOTO) 22 February 1990 (22-02-1990) *Abstract, Figs. 1-3*	4
A	US5853773 A (CHOI) 29 December 1998 (29-12-1998) *whole document*	1-17
A	US6805827 B2 (KAMI et al.) 19 October 2004 (19-10-2004) *whole document*	1-17
A	US4017236 A (PENKMAN et al.) 12 April 1977 (12-04-1977) *whole document*	1-17

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

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"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
12 February 2010 (12-02-2010)	16 February 2010 (16-02-2010)

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	Zoran Novakovic (819) 956-0843

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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