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(54) Title: PART HANDLING APPARATUS FOR AN INJECTION MOLDING MACHINE

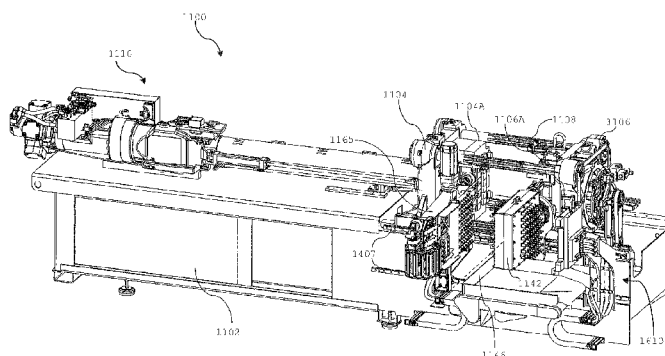


FIG. 1

(57) Abstract: A part handling apparatus has a first locating member and a first cooling plate mounted to a first plate support column that has a target axial position relative to the first locating member. A first plate actuator is connected to the first locating member and moves the first locating member in a first actuating direction from a first axial position to a second axial position. A first force accommodating apparatus mechanically links the first locating member to the first plate support column and is connected to the first locating member at a first connection and to the first plate support column at a second connection. In response to an external displacement force acting opposite the first actuating direction, the first plate support column moves away from the target axial position and the force accommodating apparatus length changes from an unactivated length to an activated length.



TITLE: PART HANDLING APPARATUS FOR AN INJECTION MOLDING  
MACHINE

5 FIELD

[0001] The disclosure relates to injection molding machines, and to part handling apparatuses for handling and/or for post-mold cooling injection molded articles.

BACKGROUND

10 [0002] U.S. Pat. No. 4,836,767 (Schad) relates to an apparatus for producing molded plastic articles which is capable of simultaneously producing and cooling the plastic articles. The apparatus has a stationary mold half having at least one cavity, at least two mating mold portions, each having at least one core element, mounted to a movable carrier plate which  
15 aligns a first one of the mating mold portions with the stationary mold half and positions a second of the mating mold portions in a cooling position, a device for cooling the molded plastic article(s) when in the cooling position, and a device for moving the carrier plate along a first axis so that the aligned mold portion abuts the stationary mold half and the second mating mold portion  
20 simultaneously brings each plastic article(s) thereon into contact with the cooling device. The carrier plate is also rotatable about an axis parallel to the first axis to permit different ones of the mating mold portions to assume the aligned position during different molding cycles.

[0003] U.S. Pat. No. 6,299,431 (Neter) discloses a rotary cooling  
25 station to be used in conjunction with a high output injection molding machine and a robot having a take-out plate. A high speed robot transfers warm preforms onto a separate rotary cooling station where they are retained and internally cooled by specialized cores. The preforms may also be simultaneously cooled from the outside to speed up the cooling rate and thus  
30 avoid the formation of crystallinity zones. Solutions for the retention and ejection of the cooled preforms are described. The rotary cooling station of the

present invention may be used to cool molded articles made of a single material or multiple materials.

[0004] U.S. Pat. No. 6,391,244 (Chen) discloses a take-out device for use with a machine for injection molding plastic articles such as PET preforms. The take-out device has a plurality of cooling tubes that receive hot preforms from the molding machine, carry them to a position remote from the molds of the machine for cooling, and then eject the cooled preforms onto a conveyor or other handling apparatus. The preforms are retained within the cooling tubes by vacuum pressure, but are then ejected by positive air pressure. A retaining plate spaced slightly outwardly beyond the outer ends of the cooling tubes is shiftable into a closed position in which it momentarily blocks ejection of the preforms during the application positive air pressure, yet allows them to be dislodged slightly axially outwardly from the tubes. Such slight dislodging movement is inadequate to vent the air system to atmosphere such that sufficient dislodging air pressure remains in tubes where the preforms might otherwise tend to stick and resist ejection. After the momentary delay, the plate is shifted to an open position in which all of the dislodged preforms are freed to be pushed out of the tubes by the air pressure. Preferably, the retaining plate is provided with specially shaped holes having pass-through portions that become aligned with the tubes when the plate is in its open position, and smaller diameter blocking portions that become aligned with the tubes when the plate is in its closed position. The smaller diameter blocking portions exceed the diameter of the neck of the preforms but are smaller in diameter than the flanges of the preforms such that surface areas around the blocking portions overlie the flanges to block ejection of the preforms as they undergo their dislodging movement.

[0005] EP Pat. No. 1,515,829 (Unterlander) relates to a method and apparatus for cooling molded plastic articles after molding is finished. In particular, the disclosed invention relates to method and apparatus for a post mold cooling ("PMC") device having at least two opposed faces. The method and apparatus are, according to the inventors, particularly well suited for

cooling injection molded thermoplastic polyester polymer materials such as polyethylene terephthalate ("PET") preforms.

#### SUMMARY

[0006] 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 cooling injection molded articles outside the mold area of an injection molding machine.

[0007] According to one broad aspect of the teachings described herein, a part handling apparatus for an injection molding machine includes a first locating member and at least a first cooling plate. The first locating member may be positionable along a part transfer axis relative to a base of the injection molding machine. The a first cooling plate may be mounted to a first plate support column. The first cooling plate may have a plurality of transfer tubes for transferring a first set of molded articles. The first plate support column may be configured to be moveable relative to the base of the injection molding machine and may have a target axial position relative to the first locating member. A first plate actuator may be connected to the first locating member and may be operable to exert an axial driving force to move the first locating member in a first actuating direction from a first axial position to a second axial position relative to the base of the injection molding machine. A first force accommodating apparatus may mechanically link the first locating member to the first plate support column. The first plate support column may be moveable with the first locating member. The first force accommodating apparatus may be connected to the first locating member at a first connection and may be connected to the first plate support column at a second connection. An axial distance between the first connection and the second connection may define a first force accommodating apparatus length. When the first plate support column is in the target axial position relative to the first locating member the first force accommodating apparatus length may define an unactivated length. In response to an external displacement force

acting on the first plate support column opposite the first actuating direction, the first plate support column may move away from the target axial position and the force accommodating apparatus length may change from the unactivated length to an activated length to accommodate at least a portion of  
5 the external displacement force.

[0008] The first force accommodating apparatus may resist changing from the unactivated length to the activated length.

[0009] In the absence of the external displacement force the first force accommodating apparatus may hold the first plate support column in the  
10 target axial position relative to the first locating member when the first locating member is moved in the first actuating direction from the first axial position to the second axial position, and the first plate support column may move in unison with the first locating member.

[0010] In some examples, the first force accommodating apparatus  
15 may be the only axial-load bearing connection between the first locating member and the first plate support column.

[0011] When the first locating member is in the second axial position and the first support column is in the target axial position relative to the first locating member the first cooling plate may be located in an engagement  
20 position for transferring the first set of molded articles between the transfer tubes and another apparatus.

[0012] The first plate actuator may include a drive belt, the first locating member may include a clamp member attached to the belt, and the first force accommodating member may include a shoe member connected to the clamp  
25 member. The shoe member may be moveably mounted to the first plate support column. A force accommodating actuator may be connected between the shoe member and a surface of the first plate support column.

[0013] At least one secondary rail member may be provided on the first plate support column. The shoe member may be coupled to the secondary

rail member and may be axially translatable relative to the first plate support column.

[0014] The at least one secondary rail member may extend substantially parallel to the part transfer axis.

5 [0015] The force accommodating actuator may be a fluidly powered actuator having a cylinder and a piston slidably received within the cylinder. One of the piston and the cylinder may be coupled to the shoe member and the other of the piston and the cylinder may be coupled to the first plate support column.

10 [0016] When the force accommodating apparatus changes from the unactivated length to the activated length the piston may translate a stroke distance relative to the cylinder housing that is between about 2mm and about 50mm.

[0017] The first plate support column may be laterally spaced apart  
15 from the base of the injection molding machine and the first force accommodating apparatus may be disposed laterally intermediate the first support column and the base of the injection molding machine.

[0018] The first locating member and the first plate support column may be laterally spaced apart from each other and may at least partially overlap  
20 each other in the axial direction.

[0019] A transfer shell may be mounted to a shell support column. The transfer shell may be spaced away from a mold area of the injection molding machine and may have at least one shell side. The shell support column may be mountable to the base of the injection molding machine and may be  
25 positionable in a shell transfer position for the at least one shell side to receive the first set of molded articles from the first cooling plate.

[0020] The at least one shell side may include a plurality of transfer pins for receiving the first set of molded articles. The transfer shell may be rotatable about a shell axis for moving the at least one shell side among a

load position and at least one of a supplemental cooling position and an unload position.

[0021] When the first locating member is in the first axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate may be axially spaced apart from the transfer shell. When the first locating member is in the second axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate may be in a plate transfer position in which the first cooling plate engages the at least one shell side.

10 [0022] The first force accommodating apparatus may bias the first plate support column toward the target axial position relative to the first locating member.

[0023] The first force accommodating may be is operable to absorb energy from the movement of the first plate support column away from the target axial position and to use at least a portion of the absorbed energy to urge the first plate support column toward the target axial position relative to the first locating member.

[0024] The part handling apparatus may also include a second locating member. The second locating member may be positionable along a second transfer axis relative to the base of the injection molding machine. A second cooling plate may be mounted to a second plate support column. The second cooling plate may have a plurality of transfer tubes for transferring the first set of molded articles. The second plate support column may be configured to be moveable relative to the base of the injection molding machine and may have a second target axial position relative to the second locating member. A second plate actuator may be connected to the second locating member and may be operable to exert a driving force to axially translate the second locating member in a second actuating direction from a third position to fourth position relative to the base of the injection molding machine. A second force accommodating apparatus may mechanically link the second locating member to the second plate support column. The second plate support

column may be moveable with the second locating member. The second force accommodating apparatus may be connected to the second locating member at a third connection and connected to the second plate support column at a fourth connection. An axial distance between the third connection and the  
5 fourth connection may define a second force accommodating apparatus length. When the second plate support column is in the second target axial position relative to the second locating member the second force accommodating apparatus length may define a second unactivated length. In response to a second external displacement force acting on the second plate  
10 support column opposite the second actuating direction, the second plate support column may move away from the second target axial position and the second force accommodating apparatus length may change from the second unactivated length to a second activated length to accommodate at least a portion of the second external displacement force.

15 [0025] The second transfer axis may be parallel to the part transfer axis.

[0026] The fourth position may be axially intermediate the third position and the second axial position.

[0027] A displacement sensor may be operable to sense a magnitude  
20 change of length of the first force accommodating apparatus and to generate an output signal when the magnitude exceeds an output threshold value.

[0028] A controller may be operable to control at least one machine parameter based on the output signal from the displacement sensor. The controller may be operable to control the first plate actuator.

25 [0029] The activated length may be longer or shorter than the unactivated length.

[0030] According to another broad aspect of the teachings described herein, which may be used in combination with any other aspect described herein, an injection molding machine can include, a machine base, an  
30 injection unit mounted to the base, a stationary platen mounted to the base for

supporting a stationary mold half and a moving platen slidably supported by the base for supporting a moving mold half. The stationary and moving mold halves may define a mold area therebetween and the moving platen may be translatable along a machine axis between advanced and retracted positions.

- 5 A first locating member may be positionable along a part transfer axis relative to the machine base. A first cooling plate may be mounted to a first plate support column. The first cooling plate may have a plurality of transfer tubes for transferring a first set of molded articles. The first plate support column may be translatable relative to the machine base and may have a target axial
- 10 position relative to the first locating member. A first plate actuator may be connected to the first locating member and may be operable to exert an axial driving force to move the first locating member in a first actuating direction from a first axial position to a second axial position relative to the base of the injection molding machine. A first force accommodating apparatus may
- 15 mechanically link the first locating member to the first plate support column. The first plate support column may be moveable with the first locating member. The first force accommodating apparatus may be connected to the first locating member at a first connection and connected to the first plate support column at a second connection. An axial distance between the first
- 20 connection and the second connection defining a first force accommodating apparatus length. When the first plate support column is in the target axial position relative to the first locating member the first force accommodating apparatus length may define an unactivated length. In response to an external displacement force acting on the first plate support column opposite
- 25 the first actuating direction, the first plate support column may move away from the target axial position and the force accommodating apparatus may length change from the unactivated length to an activated length to accommodate at least a portion of the external displacement force.

- [0031] A transfer shell may be mounted to a shell support column. The
- 30 transfer shell may be paced away from the mold area of the injection molding machine and may have at least one shell side. The shell support column may

be positionable in a shell transfer position for the at least one shell side to receive the first set of molded articles from the first cooling plate.

[0032] The at least one shell side may include a plurality of transfer pins for receiving the molded articles from the injection molded machine. The transfer shell may be rotatable about a shell axis for moving the at least one shell side among a load position and at least one of a supplemental cooling position and an unload position.

[0033] The first locating member may be in the first axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate is axially spaced apart from the transfer shell, and when the first locating member is in the second axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate is in a plate transfer position in which the first cooling plate engages the at least one shell side.

[0034] The injection molding machine may also include a second locating member. The second locating member may be positionable along a second transfer axis relative to the machine base. A second cooling plate may be mounted to a second plate support column. The second cooling plate may have having a plurality of transfer tubes for transferring the first set of molded articles. The second plate support column may be moveable relative to the machine base and may have a second target axial position relative to the second locating member. A second plate actuator may be connected to the second locating member and may be operable to exert a driving force to axially translate the second locating member relative to the machine base in a second actuating direction from a third position spaced apart from the transfer shell to a fourth position to engage the transfer shell. A second force accommodating apparatus may mechanically link the second locating member to the second plate support column. The second plate support column may be moveable with the second locating member. The second force accommodating apparatus may be connected to the second locating member at a third connection and may be connected to the second plate

support column at a fourth connection. An axial distance between the third connection and the fourth connection may define a second force accommodating apparatus length. When the second plate support column is in the second target axial position relative to the second locating member the  
5 second force accommodating apparatus length may define a second unactivated length. In response to a second external displacement force acting on the second plate support column opposite the second actuating direction, the second plate support column moves away from the second target axial position and the second force accommodating apparatus length  
10 changes from the second unactivated length to a second activated length to accommodate at least a portion of the second external displacement force.

[0035] The second transfer axis may be parallel to the part transfer axis.

[0036] The first force accommodating apparatus may bias the first plate  
15 support column toward the target axial position relative to the first locating member.

[0037] The first force accommodating apparatus may be operable to absorb energy from the movement of the first plate support column away from the target axial position and to use at least a portion of the absorbed energy to  
20 urge the first plate support column toward target axial position relative to the first locating member.

[0038] The part transfer axis may be generally parallel to and offset from the machine axis.

[0039] The force accommodating apparatus may be positioned laterally  
25 intermediate the at least one of the shell support column and the plate support column and the machine base.

[0040] According to another broad aspect of the teachings described herein, which may be used in combination or sub-combination with any other aspects described herein, a part handling apparatus for an injection molding  
30 machine can include a transfer shell mounted to a shell support column. The

transfer shell may be spaced away from a mold area of the injection molding machine and having at least one shell side with transfer pins. The shell support column being may be mountable to a base of the injection molding machine and may be translatable relative to the base along a part transfer

5 axis. A first cooling plate may be mounted to a first plate support column. The first cooling plate may have a plurality of transfer tubes for transferring a first set of molded articles to the at least one shell side. The first plate support column may be configured to be moveable relative to the base of the injection molding machine. A first locating member may be positionable along the part

10 transfer axis relative to the base of the injection molding machine and may have a target axial position relative to at least one of the shell support column and the first plate support column. A first force accommodating apparatus may mechanically link the first locating member to the at least one of the shell support column and the first plate support column. The at least one of the

15 shell support column and the first plate support column may be moveable with the first locating member. The first force accommodating apparatus may be connected to the first locating member at a first connection and may be connected to the at least one of the shell support column and the first plate support column at a second connection. An axial distance between the first

20 connection and the second connection may define a first force accommodating apparatus length. When the at least one of the shell support column and the first plate support column is in the target axial position relative to the first locating member the first force accommodating apparatus length may define an unactivated length. In response to an external displacement

25 force acting on the at least one of the shell support column and the first plate support column, the at least one of the shell support column and the first plate support column may move away from the target axial position and the force accommodating apparatus length may change from the unactivated length to an activated length to accommodate at least a portion of the external

30 displacement force.

[0041] A first plate actuator may be connected to the first locating member and may be operable to exert an axial driving force to move the first

locating member in a first actuating direction from a first axial position to a second axial position relative to the base of the injection molding machine, and wherein the external displacement forces acts in a direction opposite the first actuating direction.

5 [0042] The force accommodating apparatus may provide substantially the only axial-load bearing mechanical link between the at least one of the shell support column and the first plate support column and the first locating member.

[0043] The first force accommodating apparatus ay bias the at least  
10 one of the shell support column and the first plate support column toward the target axial position relative to the first locating member.

[0044] The first force accommodating apparatus may be operable to absorb energy from the movement of the at least one of the shell support column and the first plate support column away from the target axial position  
15 and to use at least a portion of the absorbed energy to urge the at least one of the shell support column and the first plate support column toward the target axial position relative to the first locating member.

[0045] The first locating member and the at least one of the shell support column and the first plate support column may be laterally offset from  
20 each other and at least partially overlap each other in the axial direction.

[0046] The first locating member may be fixed or moveable relative to the base of the injection molding machine.

[0047] The transfer shell may be rotatable about a shell axis for moving the at least one shell side among a load position and at least one of a  
25 supplemental cooling position and an unload position.

[0048] The first cooling plate may be moveable toward and away from the transfer shell for presenting the molded articles in the transfer tubes to the at least one shell side. The first plate support column may be translatable along the part transfer axis to move the first cooling plate between a retracted  
30 position in which the first cooling plate is axially spaced apart from the at least

one shell side and a plate transfer position in which the first cooling plate engages the at least one shell side.

[0049] The part handling apparatus may also include a second locating member. The second locating member may be positionable along a second transfer axis relative to the base of the injection molding machine. A second cooling plate may be mounted to a second plate support column. The second cooling plate may have a plurality of transfer tubes for transferring the first set of molded articles. The second plate support column may be configured to be moveable relative to the base of the injection molding machine and may have a second target axial position relative to the second locating member. A second plate actuator may be connected to the second locating member and may be operable to exert a driving force to axially translate the second locating member in a second actuating direction from a third position to fourth position relative to the base of the injection molding machine.

[0050] A second force accommodating apparatus may mechanically link the second locating member to the second plate support column. The second plate support column may be moveable with the second locating member. The second force accommodating apparatus may be connected to the second locating member at a third connection and connected to the second plate support column at a fourth connection. An axial distance between the third connection and the fourth connection may define a second force accommodating apparatus length. When the second plate support column is in the second target axial position relative to the second locating member the second force accommodating apparatus length may define a second unactivated length. In response to a second external displacement force acting on the second plate support column opposite the second actuating direction, the second plate support column may move away from the second target axial position and the second force accommodating apparatus length changes from the second unactivated length to a second activated length to accommodate at least a portion of the second external displacement force.

[0051] The first force accommodating apparatus may include a first actuator extending between the shell support column and the base of the injection molding machine.

[0052] The first actuator may include a cylinder and a piston slidably received within the cylinder. One of the piston and the cylinder may be coupled to the shell support column and the other one of the piston and the cylinder may be coupled to the machine base.

[0053] The one of the piston and the cylinder that is coupled to the machine base may provide the first locating member.

10 [0054] The one of the piston and the cylinder that is coupled to the machine base may be fixedly connected to the machine base.

[0055] The first actuator may be operable to move the shell support column to a maintenance position in which the shell support column is axially spaced apart from the first plate support column.

15 [0056] 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

[0057] The drawings included herewith are for illustrating various examples of articles, methods, and apparatuses of the teaching of the present specification and are not intended to limit the scope of what is taught in any way. In the drawings:

[0058] Figure 1 is a back perspective view of an injection molding machine in accordance with or more aspects of the teaching disclosed herein;

25 [0059] Figure 2 is a front view of an exemplary article formed by the machine of Figure 1;

[0060] Figure 2A is a top view of the article of Figure 2;

[0061] Figure 2B is a cross-sectional view of the article of Figure 2A, taken along the lines 2B-2B;

- [0062] Figure 3 is a perspective view of a portion of the machine of Figure 1, showing part handling features in greater detail;
- [0063] Figure 4 is a cross-sectional view of a shell portion of the machine of Figure 3;
- 5 [0064] Figure 5 shows a similar view as Figure 3, with the shell moved to another position;
- [0065] Figure 6 is an enlarged view showing a portion of the take-out plate and shell in spaced apart relation;
- [0066] Figure 7 shows the structure of Figure 6 in an engaged position;
- 10 [0067] Figure 8 is a perspective view of another portion of the part handling apparatus of Figure 1;
- [0068] Figure 9 is an enlarged cross-sectional view of a shell portion of the machine;
- [0069] Figure 10 is an exploded perspective view of a portion of the structure of Figure 9;
- 15 [0070] Figures 11A-11C are schematic view showing the shell moving to an unload position;
- [0071] Figure 12a is a perspective view of another portion of the part handling apparatus of Figure 1;
- 20 [0072] Figure 12b is a different perspective view of the portion of the part handling apparatus of Figure 12a;
- [0073] Figure 13 is a perspective view of the structure of Figure 3, showing both sides of the shell engaged by cooling tubes;
- [0074] Figure 14 is an enlarged cross-sectional view of the shell when engaged by both the take-out plate and supplemental cooling device;
- 25 [0075] Figure 15a is a side view of a portion of the part handling apparatus;
- [0076] Figure 15b is an enlarged portion of Figure 15a;

[0077] Figure 16a is a side view of a portion of the part handling apparatus;

[0078] Figure 16b is an enlarged view of a portion of Figure 16a showing a force accommodating apparatus at its unactivated length;

5 [0079] Figure 16c is a schematic representation of the portion of the part handling apparatus of Figure 16a;

[0080] Figure 17a is a side view of a portion of the part handling apparatus of Figure 1;

[0081] Figure 17b is an enlarged view of a portion of Figure 17a, with a  
10 force accommodating apparatus at its activated length;

[0082] Figure 17c is a schematic representation of the portion of the part handling apparatus of Figure 17a;

[0083] Figure 18 is a rear (non-operator side) elevation view of an injection molding, with a cooling shell in a first position;

15 [0084] Figure 19 is a side elevation view of the machine of Figure 18, with the cooling shell in a second position;

[0085] Figure 20 is a rear perspective view of a portion of the another example of an injection molding machine;

[0086] Figure 21a is a schematic representation of a portion the  
20 machine of Figure 20, with a cooling shell in a first position;

[0087] Figure 21b is similar to Figure 21a, showing the cooling shell in a second position;

[0088] Figure 21c is similar to Figure 21a, showing the cooling shell in a third position;

25 [0089] Figure 22a is a schematic representation of a portion of an another example of an injection molding machine, with a cooling shell in a first position;

[0090] Figure 22b is similar to Figure 22a, showing the cooling shell in a second position; and

[0091] Figure 22c is similar to Figure 22a, showing the cooling shell in a third position.

## 5 DETAILED DESCRIPTION

[0092] 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 differ from those 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.

20 [0093] Referring to Figure 1, an example of an injection molding machine 1100 includes a base 1102, with a stationary platen 1104 and a moving platen 1106 mounted to the base 1102 and coupled together via tie bars 1108. The moving platen 1106 can translate towards and away from the stationary platen 1104 along a machine axis 1105. A mold 1107 is formed  
25 between the platens 1104, 1106, the mold 1107 defined at least in part by a first mold half 1104a mounted to the stationary platen 1104, and a second mold half 1106a mounted to the moving platen 1106. An injection unit 1110 is mounted to the base 1102 for injecting resin or other mold material into the mold 1107 to form a molded article.

[0094] In the example illustrated, the injection molding machine 1100 is shown set up for molding preforms that can be used as input material for subsequent processing, for example, a blow molding operation to produce beverage containers. With reference to Figure 2, an exemplary preform 112  
5 comprises a generally elongate tubular article extending along a preform axis 114, and having opposing open and closed ends 116, 118. A threaded portion 120 for receiving a closure may be provided adjacent the open end 116. A radially outwardly extending annular flange 122 may be disposed adjacent the threaded portion 120, with the threaded portion 120 disposed  
10 axially between the open end 116 and the flange 122. The preforms have an inner surface 124 that can include a generally cylindrical inner wall portion 124a along the axial extent of the preform (between the open and closed ends), and a generally concave inner end portion 124b at the closed end. The preforms 112 have an outer surface 126 spaced apart from the inner  
15 surface 124 that can include a generally cylindrical outer wall portion 126a along the axial extent of the preform and a convex outer end portion 126b at the closed end. The spacing between the inner and outer surfaces 124, 126 generally defines a preform wall thickness 128.

[0095] With reference again to Figure 1, in the example illustrated for  
20 producing the preforms, the first mold half 1104a (attached to the stationary platen 1104) can comprise a cavity side of the mold 1107 having recesses (or mold cavities) 1130 for forming the outer surface 1126 of the preforms 112. The second mold half 1106a can comprise a core side of the mold 1107 having mold core pins 1132 for insertion into the mold cavities 1130 and  
25 forming the inner surface 124 of the preforms 112. In the example illustrated, the machine 1100 has an equal quantity of mold cavities 130 and mold pins 132, this quantity defining the cavitation number of the mold 1107. Typical mold cavitation numbers include 16, 32, 48, 96 or more. In the example illustrated, the mold cavitation number is 16, and the mold has 16 mold  
30 cavities 1130 and 16 mold pins 1132.

[0096] Referring also to Figure 3, the injection molding machine 1100 is, in the example illustrated, provided with a part-handling apparatus 1140 for moving and/or treating articles formed in the mold 1107 of the machine. The part-handling apparatus 1140 comprises a rotary transfer shell for receiving  
5 and transferring molded articles. Optionally, the transfer shell can be configured to provide and/or facilitate at least some secondary or supplemental cooling of the preforms received thereon, and can be configured as a cooling shell 1142. In the illustrated example the cooling shell 1142 having a plurality of sides 1144, each side 1144 rotatable together with the  
10 cooling shell 1142 about a shell axis 1146. In the example illustrated, the shell axis 1146 is generally horizontal and perpendicular to the machine axis 1105. The cooling shell 1142 has (in the example illustrated) two generally planar sides including a first side 1144a and a second side 1144b (Fig. 4), the two sides generally parallel and on opposed sides of the axis 1146.  
15 Alternatively, the transfer shell need not perform any cooling functions.

[0097] With reference to Figure 4, the shell 1142 has a plurality of interior shell side chambers 1149 associated with respective ones of the sides 1144 of the shell 1142. In the example illustrated, the shell side chambers 1149 include a first shell side chamber 1149a adjacent (and/or bounded at  
20 least in part by) an inner surface of the first side 1144a. The shell 1142 further includes a second shell side chamber 1149b adjacent (and/or bounded at least partially by) an inner surface of the second side 1144b. The shell includes an interior wall 1151 generally separating the interior of the shell into the two shell side chambers 1149a and 1149b.

25 [0098] Rotation of the cooling shell 1142 about the shell axis 1146 can move the sides 1144 between various stations 1150. The stations 1150 can comprise four stations, namely, 1150a-1150d (Figure 3) spaced apart by 90 degree increments about the shell axis 1146. One of the stations (e.g. first station 1150a) can comprise a load station for loading articles onto the shell  
30 1142, and another station (e.g. fourth station 1150d) can comprise an unload station 1150d for unloading articles from the shell 1142. At least one optional

supplemental treatment station can be provided between the load and unload stations 1150a, 1150d.

[0099] In the example illustrated, a side of the shell 1142 is in the load station 1150a when it is in a vertical orientation and nearest (along the machine axis) to the mold 1107. In Figure 3, the first side 1144a of the shell is in the load station 1150a. A side of the shell 1142 is, in the example illustrated, in the unload station 1150d when it is oriented in a generally horizontal plane beneath the shell axis 1146. In Figure 5, the second side 1144b of the shell is in the unload station 1150d.

10 [00100] At least one of the second and third stations 1150b, 1150c can comprise an optional supplemental treatment station. In the example illustrated, the third station 1150c comprises a supplemental treatment station, opposite the load station 1150a. The second station 1150b can comprises an optional second supplemental treatment station provided opposite the unload station 1150d. The supplemental cooling stations may repeat a portion or all of the same cooling treatment as provided at the load and/or unload station. Optionally, the supplemental cooling stations may provide additional cooling treatment, such as, for example, cooling fluid along exterior surfaces of the preforms.

20 [00101] In the example illustrated, the shell rotates in a clock-wise direction about the shell axis when viewed from the front of the shell (i.e. when facing the non-operator side of the machine 1100) as shown in Figure 4. Indexing the shell (i.e. rotating the shell 90 degrees) moves the first side 1144a from the load position 1150a to the position at 1150b, and simultaneously moves the second side 1144b from the supplemental treatment position 150c to the unload position 150d (see Fig. 5). Indexing the cooling shell another 90 degrees moves the first side 1144a (in the example illustrated) to the supplemental treatment station 1150c, positioned opposite the load station 1150a. A further 90 degree index (i.e. a total of 270 degrees from the load position 1150a) moves the first side 1144a to the unload position 150d (Fig. 0). In alternate examples, the shell can rotate clockwise, or

30

can alternate between clockwise and counter clockwise rotation during various points of the machine cycle.

[00102] With reference to Figures 4 and 7, in the example illustrated, the part-handling apparatus 1140 further comprises a plurality of shell receivers in the form of retaining cooling pins 1154 (including a first receiver set of retaining cooling pins 1154a and at least a second receiver set of retaining cooling pins 1154b) disposed on each side 1144 of the shell 1142. The retaining cooling pins 1154 are, in the example illustrated, configured to provide cooling to interior surfaces of the preforms, and to have preforms retained on the pins as the cooling shell indexes the sides 1144 among the various stations 1150.

[00103] Each one of the receiver sets may have an equal quantity of individual receivers (e.g. individual retaining cooling pins 1154), and the quantity of retaining cooling pins 1154 in each set may be equal to the cavitation number of the mold 1107. In the example illustrated, there are three receiver sets each receiver set has 16 receivers (first receiver set has 16 first retaining cooling pins 1154a, second receiver set has 16 second retaining cooling pins 1154b, and a third receiver set has 16 third retaining cooling pins 1154c--see Figs. 4 and 9). There are three receiver sets per side 1144 providing a total of 48 receivers (i.e. 48 retaining cooling pins 1154) per side of the cooling shell 1142 and a total of six receiver sets on the shell 1142 (a total of 96 retaining cooling pins 1154 on the shell).

[00104] The pins 1154a of the first pin set are spaced apart from each other in a pin pattern. In the example illustrated, the pin pattern is defined by two columns spaced apart from each other horizontally by a column spacing. The pin pattern further includes eight rows spaced apart from each other in a vertical direction that, in the example illustrated, is not equal between each pair of adjacent rows. The second set pins 1154b and third set pins 1154c are arranged relative to each other in the same pin pattern as the first set pins 1154a.

[00105] With reference to Figure 7, in the example illustrated, each one of the retaining cooling pins 1154 extends lengthwise along a first pin axis 1155 and comprises a first pin base 1158 fixed to the respective side of the shell, and a first pin tip 1160 spaced away from the base 1158 (along the receiver axis 1155), with a first pin sidewall 1159 extending between the base 1158 and the tip 1160. A first pin fluid channel 1162 can be provided through each cooling pin 1154, each fluid channel 1162 having one or more proximal openings 1162a adjacent the base 1158 for fluid communication between the channel 1162 and a respective one of the side shell chambers 1149 to which the retaining cooling pin 1154 is attached, and one or more distal openings 1162b through the pin sidewall 1159 for fluid communication between the fluid channel 1162 and an intermediary space 150, between the external surface of the retaining cooling pin 1154 and the internal surface of a preform 112 in which the pin has been inserted.

[00106] Referring to Figures 1 and 8, a take-out plate 1164 is movable between the mold 1107 and the cooling shell 1142 for transferring articles therebetween. The take-out plate generally transfers articles from the mold to a position outside the mold for engagement by the pins 1154 of a side 1144 of the cooling shell positioned in the load station. When the first side 1144a is in the load position 1150a, articles are transferred to one of the first, second, or third set retaining cooling pins 1154a, 1154b, 1154c of the first side 1144a of the cooling shell 1142 during one (a first) injection cycle, and articles may be transferred from the mold to another, different one of the first, second, and third set retaining cooling pins 1154a, 1154b, 1154c of the first side 144a during another (a second) injection cycle. In this specification, numbering of injection cycles is used to identify distinct injection cycles, and incremental numbering does not necessarily define a particular order or succession of cycles (incremental numbering may define a particular order in some parts of the discussion where such ordering is expressly specified).

[00107] In the example illustrated, the take-out plate 1164 is joined to a linear robot 1165 that can translate the take-out plate 1164 along a first robot

axis 1166 between at least one advanced position in which the take-out plate is disposed between the mold halves 1104a, 1106a, and at least one retracted position in which the take-out plate 1164 is clear of the mold 1107 (Figure 3). Referring to Figure 8, in the illustrated example, the robot 1165  
5 includes an upright support column 1163 and a generally horizontal arm portion 1167. The support column 1163 is, in the example illustrated, adjustably supported by a rail 1407 fixed to the machine base 1102 and oriented parallel to the machine axis 1105. The rail 1407 can be engaged by bearing shoes 1172 fixed to the support column 1163, which can be  
10 configured to carry substantially all of the weight of the robot 1165.

[00108] In the example illustrated, the first robot axis (z-axis) 1166 is parallel to the shell axis 1146. Furthermore, the take-out plate 1164 is, in the example illustrated, optionally translatable along a second robot axis (x-axis) 1168 that is parallel to the machine axis 1105.

15 [00109] The take-out plate 1164 has a quantity of transfer tubes 1170 for receiving molded articles from the mold core pins 1132. The quantity of transfer tubes 1170 can be equal to or greater than the cavitation number of the mold 1107 and can be equal to or greater than the quantity of individual retaining cooling pins 1154 in each receiver set. In the example illustrated,  
20 the quantity of transfer tubes 1170 provided on the take-out plate 1164 comprises three sets of 16 tubes each—first set tubes 1170a, second set tubes 1170b, and third set tubes 1170c, for a total of 48 transfer tubes. The first set transfer tubes 1170a of the take-out plate 1164 are, in the example illustrated, spaced apart from each other in a tube pattern of eight rows and  
25 two columns that matches the pin pattern. The tubes of the second and third transfer tube sets are similarly spaced apart from each other in the same tube pattern of eight rows and tubes columns, and in the example illustrated, are interlaced with first set tubes 1170a.

[00110] In the example illustrated, the take-out plate 1164 can be moved  
30 to a first x-axis advanced position (along the first robot axis 166) in which the first set tubes 1170a are aligned with the mold core pins 1132 to receive

preforms 112 therefrom. The take-out plate 1164 can also be moved to a second z-axis advanced position (along the first robot axis 1166) in which the second set tubes 170b are aligned with the mold core pins 1132, and to a third z-axis advanced position in which the third set tubes 1170c are aligned  
5 with the mold core pins 1132.

[00111] The take-out plate 1164 can also be moved to at least one z-axis retracted position (along the first robot axis 1166) for selectively aligning the transfer tubes 1170 with pins 1154 on the side 1144 of side of the shell in the load station 1150a. In the example illustrated, the take-out plate 1164 is  
10 movable relative to the cooling shell to one z-axis retracted position in which the 48 transfer tubes 1170 are each simultaneously aligned with respective ones of the 48 cooling pins 1154 of the shell side in the load position. The first set tubes 1170a are aligned with the first set cooling pins 1154a, the second set tubes are aligned with the second set cooling pins 1154b, and the  
15 third set tubes 1170c are aligned with the third set cooling pins 1154c.

[00112] Referring to Figure 9, the shell 1142 can be rotatably mounted to a support column 1462. The support column 1462 is, in the example illustrated, adjustably supported by a rail 1407 fixed to the machine base 1102 and oriented parallel to the machine axis 105. The rail 1407 can be engaged  
20 by bearing shoes 1409 fixed to the support column 1462. This can facilitate adjusting the axial position of the cooling shell in response to the axial length of a particular pre-form being produced. For example, when producing shorter preforms, the cooling shell can be moved along the rail towards the stationary platen 1104 (and then locked in place), which can reduce the length of x-axis  
25 travel that the take-out plate must traverse when moving parts from the mold to the shell. Furthermore, in the example illustrated, the rail 1407 used to support the support column 1462 is the same rail used to support the robot to which the take-out plate is attached. This can facilitate providing correct and accurate relative alignment between the take-out plate and the cooling shell.

30 [00113] Referring also to Figure 10, the support column 1462 includes a header 1411 having a header housing 1412 and a header interior for fluid

communication with the fluid pressurization device 1401. In the example illustrated, the cooling shell 1142 is joined to the support column 1462 by a rotary mount 1413 that is rotatably supported within the header housing 1412, permitting rotation of the cooling shell 1142 relative to the support column 1462. The rotary mount 1413 comprises at least one mount aperture 1417 that provides fluid communication between the header of the support column 1462 and the cooling shell 1142 when mounted to the support column 1462. In the example illustrated, the rotary mount 1413 has two apertures 1417a, and 1417b which provide fluid communication between the header and the respective shell side chambers 1149a, 1149b.

[00114] In the example illustrated, the header 1411 has a first header chamber 1421 in the housing 1412, in fluid communication with the shell side chamber 1149 of the respective side when in and moving between the load position 1150a and the supplemental station 1150c (see Figure 11A) The header 1411 also has a second chamber 1423 separate from the first chamber 1421 and in fluid communication with the shell side chamber 1149 of the side 1144 in the unload station 1150d (see Figure 11C).

[00115] In the example illustrated, the rotary mount 1413 has a generally cylindrical outer surface and one interior mount chamber in fluid communication with, and forming axial extensions of, each shell side chamber. The apertures 1417, 1417b are provided in the outer sidewall of the rotary mount, on opposite sides thereof (180 degrees apart) and opening to respective ones of the interior mount chambers. As the rotary mount rotates, the apertures move between communication with the first chamber 1421 and the second chamber 1423. A dividing wall 1427 having opposed first and second side surfaces (1427a, 1427b) extends across a portion of the header interior.

[00116] The first header chamber 1421 has a first header port 1431 in fluid communication with the fluid pressurization device 1401. The fluid communication can be provided via a first conduit having one end connected to first header port 1431, and another end connected to the fluid pressurization

device 1401. The first conduit can be free of valves or other flow blocking elements, to provide continuous fluid communication between the fluid pressurization device 1401 and the first header chamber 1421. In the example illustrated, the first conduit is connected to the inlet of a fluid  
5 pressurization device 1401, generating a vacuum in the first header chamber 1421.

[00117] The second header chamber 1423 has a second header port 1437 in fluid communication with a fluid pressurization device. In the example illustrated, the port 1437 is connected to a positive pressure source, such as a  
10 source of compressed air or the outlet of a blower, and provides continuous positive pressure to the second chamber 1423.

[00118] Referring to Figure 14, a retaining force may be exerted on the preforms after (and optionally before and/or during) transfer of the preforms from the respective set of tubes 1170 or 1170b of the take-out plate to the  
15 respective set of retaining cooling pins 1154 of the cooling shell. The retaining force can help hold the preforms 1112 on the retaining cooling pins 1154. In the example illustrated, the retaining force is at least partially generated by a negative pressure (vacuum) provided in an intermediate space 1501 between an outer surface of the cooling pins 1154 and an inner  
20 surface of the preforms. The negative pressure can generate a suction force to facilitate holding the preform on the pin, when desired.

[00119] The pin can be provided with slots 1503 or similar flow gates at its base, providing a total cross-sectional inlet area (for admitting ambient air into the intermediate space) that is less than the cross-sectional outlet area  
25 (for withdrawing air from the intermediate space to the shell side chamber 1149 via channel 1162). A flow of cooling fluid (identified at arrows 1505) can be maintained while simultaneously providing negative pressure in the intermediate space 1501 for holding the preform 1112 on the pin 1154. A similar second intermediate space 1502 is provided between the inner surface  
30 of the preforms 112 and the exterior of the load station cooling pins 1354, but in the example illustrated, no flow gates are provided to balance the rate of air

flow with the pressure differential between the intermediate space 1502 and ambient. This can facilitate providing a more vigorous flow of cooling fluid in the intermediate space 1502.

[00120] In the example illustrated, continuous vacuum/cooling fluid flow  
5 1505 is provided from at least the time the respective shell side chamber is in the load station to at least the time the respective shell side chamber arrives at the unload station. In example illustrated, the fluid flow 1505 is also provided at least until the preforms at the unload station are ejected. The duration of the fluid flow 1505 while at the unload station prior to ejection can  
10 be at least 50 percent, and in some examples more than 75 percent of the total time that the respective side of the shell is at the unload station. In the example illustrated, the fluid flow 1505 is provided for more than about 90 percent of the total time that the respective side is at the unload station.

[00121] Referring to Figure 8, the take-out plate 1164 generally includes  
15 a carrier body to which a plurality of take-out receivers can be secured, the take-out receivers shaped and arranged to interact with molded articles in one half of the mold (i.e. core half or cavity half). In the example illustrated the carrier body is in the form of a plate portion 1511 and the take-out receivers correspond to the transfer tubes 1170 configured to interact with preforms  
20 presented on the mold pins of the mold core half.

[00122] Referring also to Figure 6, in the example illustrated, the plate portion 1511 has a front face 1513 and the transfer tubes 1170 project from the front face 1513 of the plate portion 1511. Each tube has an interior nest 1519 for accommodating a preform, the nest 1519 having an open outer end  
25 1521 and a generally closed bottom end 1523. The nest 1519 can be configured to generally match the outer profile of the preform 112 received therein, with at least portions of the outer surface of the preform that are targeted for cooling bearing against the inner surface of the transfer tube. In the example illustrated, the closed bottom end 1523 is configured to engage  
30 the outer surface 126b of the closed convex end (dome portion) of the preform.

[00123] With reference now to Figure 12, the supplemental cooling device 1610 comprises features that are similar in many respects to the take-out plate 1164. The supplemental cooling device includes a plurality of supplemental tubes 1612 affixed to a carrier plate 1614 that is mounted to a supplemental support column 1615. The supplemental tubes include at least a first supplemental tube set of first supplemental tubes 1612a, of equal quantity and spatial arrangement as the first pins 1154a of the first pin set. In the example illustrated, the supplemental cooling device 1610 further includes a second supplemental tube set of second supplemental tubes 1612b, and a third supplemental tubes set of third supplemental tubes 1612c. The tubes 1612b, 1612c, are also arranged to match the quantity and spatial arrangement of the pin pattern of the second set pins 1154b and third set pins 1154c, respectively.

[00124] The supplemental cooling device 1610 is, in the example illustrated, moveable relative to the cooling shell 1142 between a supplemental engaged position (Fig. 13) and a supplemental disengaged position (Fig. 3). In the supplemental engaged position, the carrier plate 1614 and the shell side 1144 positioned at the supplemental cooling station 1150c are drawn together, with the pins 1154a of the first pin set entering the supplemental tubes 1612a of the first supplemental tube set. Likewise when in the supplemental engaged position, in the example illustrated, the second pins 1154b and third pins 1154c enter the respective second supplemental tubes 1612b and third supplemental tubes 1612c, respectively. When in the supplemental disengaged position, the supplemental tubes 1612 are generally clear of the cooling pins 1154, allowing, in the example illustrated, unobstructed rotation of the shell 1142.

[00125] In the example illustrated, the carrier plate 1614 (and supplemental tubes 1612 affixed thereto) is moved between the supplemental engaged and disengaged positions by (x-axis) translation along a first supplemental axis 1616, parallel to the machine axis 1105. In some

examples, the carrier plate 1614 may be moveable in other directions or along other axes, including multiple axes.

[00126] In use, one set of articles ("Set A") is produced in a first injection cycle. Once the articles have partially cooled enough to allow removal from the mold without damaging or distorting the shape of the article, the mold is  
5 the mold without damaging or distorting the shape of the article, the mold is opened, and the first set of articles are transferred from the mold to retained engagement on the take-out plate.

[00127] In the example illustrated, the molded articles are preforms that are still warm when removed from the mold. The preforms have exterior  
10 surfaces and interior surfaces that are targeted for post-mold cooling. When in retained engagement on the take-out plate, the exterior surfaces of the preforms are conductively cooled by, in the example illustrated, bearing against inner surfaces of the transfer tubes 1170. The preforms can nest closely within the transfer tubes, and a first suction applied to the interior of  
15 the tubes can hold the preforms securely in the tubes. A stripper plate or similar structure can be provided at the mold to help release the preforms from the mold core pins.

[00128] Once the articles have been loaded into the transfer tubes, the take-out plate can shuttle out of the mold area (i.e. to the z-axis retracted  
20 position) so that the mold can reclose to produce a subsequent set of articles in the mold.

[00129] Outside the mold, the take-out plate and the cooling shell can be drawn together. In the example illustrated, the take-out plate is advanced to the x-axis advanced position (load engagement position), at which point the  
25 pins 1154 of the shell side in the load position 1150a are positioned axially within the respective transfer tubes 1170.

[00130] Robot 1165, including the take-out plate 1164 and supplemental cooling device 1610 can be driven in the x-direction by any suitable actuator or combination of two or more actuators. When driven by their respective  
30 actuators, the direction of motion of the robot 1165 and supplemental cooling

device 1610 can be referred to as the actuating direction. For example, if the robot 1165 is moved from a position in which is spaced apart from the cooling shell 1140 to a position in which it is adjacent or engaged with the cooling shell 1140, the actuating direction is toward the cooling shell 1140.

5 [00131] Optionally, the take-out plate 1164 and supplemental cooling device 1610 can be driven by separate actuators. This may allow the take-out plate 1164 and supplemental cooling device 1610 to be independently controlled. In such a configuration the robot 1165 carrying take-out plate 1164 and supplemental cooling device 1610 may be moved at different times  
10 and/or at different speeds. Alternatively, the actuators can be controlled, for example using any suitable machine controller (not shown), so that the take-out plate 1164 and supplemental cooling device 1610 are moved in unison. When moved in unison, the take-out plate 1164 and supplemental cooling device 1610 may engage and/or disengage the cooling shell 1140  
15 simultaneously.

[00132] Alternatively, the take-out plate 1164 and supplemental cooling device 1610 may be driven by the same actuator. Driving both the take-out plate 1164 and supplemental cooling device 1610 may help facilitate coordinated and/or synchronized movement between the take-out plate 1164  
20 and supplemental cooling device 1610.

[00133] Referring to Figure 8, in the illustrated example, the support column 1163 of robot 1165, and take-out plate 1164 thereon, is driven in the x-direction 1168 using a drive actuator 1650a that includes a motor 1652a and a drive belt 1654a suspended on two pulleys 1656a that can be attached to  
25 the base 1102.

[00134] The motor 1652a is operable to drive one of the pulleys 1656a, which results in a corresponding movement of the belt 1654a. Preferably, the motor 1652a is an electric motor and more preferably an electric servo motor. Alternatively, any suitable type of motor or driving actuator may be used.

[00135] Referring to Figure 17b, the robot 1165 is connected to the belt 1654a via a clamp member 1658a that includes a first end that is coupled to the support column 1163 of the robot 1165, and a second end that clamps onto the belt 1654a. Similarly, clamp member 1658b is used to connect the supplemental upright column 1615 to belt 1654b (Figure 12a and 17a). In this configuration, the clamp member 1658a acts as a positioning or locating member for the support column 1163 of robot 1165.

[00136] To accurately move the upright support column 1163 of the robot 1165 along the x-axis, for example from an unengaged position (Figures 16a and 16b) to an engaged position (Figures 17a and 17b), the actuator 1650a can be controlled to move the belt 1654a, and clamp member 1158a fastened thereto, to a desired axial position relative to the machine base 1102. The support column 1163 is connected to the clamp member 1658a and positioned in a target or desired axial position relative to the clamp member 1658a. In this configuration, the support column 1163 can be moved to or between its desired operating position(s) by positioning the locating member, the clamp member 1158a, in a desired position and maintaining the target axial position between the clamp member 1158a and the support column 1163 during the move. Because the support column 1163 is connected to the clamp member 1158a, when the clamp member 1158a is moved the support column 1163 will generally follow.

[00137] For example, when the axial position of the support column 1163 is maintained in the target position relative to the clamp member 1654a, positioning the clamp member 1654a in a first predetermined axial position will position the support column 1163, and the take-out plate 1164 carried thereon, in its retracted position (along the first robot axis 1166), and positioning the clamp member 1654a in a second predetermined axial position will position the support column 1163, and the take-out plate 1164 carried thereon, in position to engage the cooling shell 1142.

[00138] Optionally, the connection between the support column 1163 and the locating member, i.e. the clamp member 1658a, can be substantially

rigid to preserve the target relative axial positions between the clamp member 1658a and the support column 1163. Alternatively, as explained in greater detail herein, the connection between the support column 1163 and the belt 1654a can incorporate one or more force accommodating members that may  
5 to help, dampened, absorb, dissipate or otherwise accommodate forces acting on the take-out plate 1164 (or other portions of the robot 1165) by allowing a desired amount of relative movement between support column 1163 and the locating member 1658a under certain machine operating conditions.

10 [00139] Referring to Figure 12, in the illustrated example, the support column 1615 of the supplemental cooling device 1610, and the cooling plate 1614 mounted thereto, are driven in the x-direction 1168 using a drive actuator 1650b. In the illustrated example, actuator 1650b is similar to actuator 1650a, and like features are identified using like reference characters  
15 with a "b" suffix.

[00140] Like the support column of robot 1165, the support column 1615 is coupled to the locating member, i.e. clamp member 1658b that is fastened to the drive belt 1654b so that motion of the belt 1654b to place the locating member 1658b in a desired location results in corresponding motion of the  
20 support column 1615.

[00141] In the illustrated example the locating members (clamps 1658a,b) coupled to the support columns 1163 and 1615 are selectably moveable relative to the machine base 102, and their positions can be controlled by the position of their respective belts 1654a and 1654b. By  
25 holding the belts in position, for example by applying a holding torque with respective motors 1652a,b, the position of the locating members 1658a and 1658b can be held steady. In this configuration, both the locating members 1658a and 1658b and the respective support columns 1163 and 1615 are independently moveable relative to the base 102. Alternatively, as explained  
30 in greater detail herein, the locating member may be fixedly or non-moveably connected to the machine base.

[00142] While belts are used in the example illustrated, any other suitable power transfer member may be used, including, for example a pneumatic or hydraulic cylinder, a chain and sprocket and a ball screw.

[00143] During steady state operation, in the example illustrated, the  
5 take-out plate will be completely loaded with preforms when moving towards the load engagement position. The first set of articles may, in the example illustrated, be loaded in the first set tubes 1170a of the take-out plate 1164. A previous set of articles ("Set Z") produced in the previous injection cycle may have been loaded in the third set tubes 1170c, and a set of articles produced  
10 in a cycle previous to that ("Set Y" articles) may have been loaded in the second set transfer tubes 1170b. Each of the tubes 1170 provide conductive cooling to the exterior surfaces of the preforms that are in retained engagement within the tubes 1170.

[00144] When in the load engagement position, respective pins 1154a,  
15 1154b, and 1154c enter the preforms retained in the respective tubes 1170a, 1170b, and 1170c and, in the example illustrated, provide convective cooling to the interior surfaces of the preforms. The convective cooling is, in the example illustrated, provided by a suction air stream drawing air into the open end of the preform, through the intermediate space 1501 between the pin and  
20 the inner surface of the preform, then through the distal openings of the channel in the pin, and then into the shell side chamber. In the example illustrated, the suction force holding the preform in the tube is greater than the suction force generated in the intermediate space 1501 by the pin's cooling airflow, so the preform remains in retained engagement in the tube while the  
25 tube suction force is applied.

[00145] At the load engaged position, before withdrawing the take-out plate from the cooling shell, at least one set of preforms can be released from retained engagement on the take-out plate and transferred to retained engagement on the cooling shell. To facilitate the release of retained  
30 engagement from the tubes and transfer to retained engagement on the shell, the tube suction force can be terminated, and can be reversed to urge the

preform out of the tube. The suction force exerted by the pin can pull the preform into retained engagement on the pin. In the example illustrated, the preform is pulled against a seat located near the base of the pin, with vent or gate apertures remaining open to allow continued air flow into and through the  
5 intermediate space 1501. In some examples, the base of the pin may have a seal surface, and the edge of the open end of the preform may bear against the seal surface when the preform is in retained engagement on the shell. Engaging the seal surface can increase the suction force in the intermediate space 1501, which can increase the force holding the preform on the pin  
10 when transferred thereto.

[00146] The pin may have a resilient tip biased away from the base that contacts the dome portion when the take-out plate is in the load engaged position, both before and after transfer of the preforms from the take-out plate to the shell. In the example illustrated, a spring is provided to urge the tip  
15 away from the base.

[00147] In the example illustrated, the coldest set of the three sets of preforms in the take-out plate (i.e. the preforms that have been retained on the take-out plate for the longest period of time, the "Set Y" articles in this example), are transferred from the take-out plate to the cooling shell (e.g.  
20 from the second set tubes 1170b to the second set pins 1154b).

[00148] After transferring the set of preforms to the shell, the take out plate can retract from the shell and the shell can rotate 180 degrees to move the first shell side to the supplemental cooling station. In the example illustrated, the shell is rotated 180 degrees in a clockwise direction (as viewed  
25 from the non-operator side of the machine), moving through the station 1150b at 90 degrees of rotation, in which the first shell side is generally vertical and positioned above the shell axis, and then 90 degrees further to the supplemental cooling device at station 150c.

[00149] At the supplemental cooling station, the supplemental cooling device and the cooling shell can be drawn together to a supplemental  
30 engaged position in which the cooling pins are axially inside at least a portion

of the length of the supplemental cooling tubes. When at the supplemental engaged position, the preforms retained on the cooling pins are inserted into the interiors of the supplemental tubes. The preforms may then be released from the cooling shell and transferred to retained engagement on the supplemental cooling device. In the example illustrated, prior to part transfer, a slight gap is provide between outer surface of the preforms retained on the shell and the inner surface of the supplemental tubes. Transfer is facilitated by applying a vacuum to the interiors of the supplemental tubes, the tube vacuum being greater than the cooling pin vacuum, so that the preforms are pulled axially off the pins and seated snugly within the supplemental tubes.

[00150] In the example illustrated, the preforms are transferred from the shell to the supplemental device generally immediately after the device is in the supplemental engaged position. The supplemental device can then hold that position for a cooling pause until the injection cycle requires that the shell rotate to receive the next set of parts from the take-out plate. The supplemental tubes provide conductive cooling to the exterior surfaces of the preforms held in retained engagement therein (similar to the conductive cooling provided by the take-out tubes). During the cooling pause, the interior surfaces of the preforms can be simultaneously cooled via convective cooling provided by the airflow through the pins. Furthermore, in the example illustrated, simultaneous interior and exterior cooling is provided to the preforms on both sides of the shell at the same time (see Figures 13 and 14).

[00151] During steady state operation, in the example illustrated, the supplemental cooling device will have only a single empty set of supplemental tubes. The empty set of tubes corresponds, each cycle, to the lone set of cooling pins of the shell side that have preforms loaded thereon. In the example illustrated, the other two sets of supplemental tubes carry preforms loaded therein from previous injection cycles. For example, the set of preforms (set Y) loaded on the second set pins 1154b can be loaded into the empty second set supplemental tubes 1612b. The third set of supplemental tubes 1612c can be loaded with a set of preforms (set W) from a previous

injection cycle, and the first set of supplemental tubes 1612a can be loaded with a set of preforms formed in a further previous injection cycle. The coldest preform (from the earliest injection cycle) can, before the supplemental device disengages the shell, be transferred back to the shell. The vacuum to the  
5 respective tube set can be terminated and a positive pressure can be applied to facilitate transfer of the preforms out of the supplemental tubes and into the shell. As the shell side rotates through the unload position, the vacuum in the shell side chamber switches to positive pressure to facilitate dropping the preforms.

10 [00152] Looking at the progression of the first set of articles in the example illustrated, upon withdrawal from the mold, the first set preforms are retained in the transfer tubes 1170a and engage the first set cooling pins 1154a of the shell during a first subsequent cycle, carried away from the shell back into the mold and then again to the shell for a second cycle, carried back  
15 to the mold and again to the shell for a third cycle, after which the first preforms are transferred to the shell. The shell rotates and the first set of preforms are then transferred to the first set supplemental tubes 1612a with subsequent pin engagement during a fourth cycle, then moved away from the pins (while retained in the supplemental tubes) and moved back into  
20 engagement with the pins during a fifth cycle, and then moved away from, and back into engagement with, the pins during a sixth cycle, following which the first set of preforms are transferred back to the shell.

[00153] When the injection molding machine 1100 is in use, the robot 1165, transfer shell 1142 and/or the supplemental cooling device 1610 may  
25 be subjected to external forces, in addition to the driving forces exerted by their respective actuators.

[00154] For example, expected engagement between the take-out plate 1164 and cooling shell 1142 can generate engagement or reactionary forces that act on both members. Engagement between the supplemental cooling  
30 device 1610 and the cooling shell 1142 may generate similar reactionary forces. In the illustrated example, when approaching the cooling shell 1142

the take-out plate 1164 is moving linearly along the x-axis. In this configuration the engagement force, represented using arrow 1714a in Figure 13, may be a substantially axial force acting in the x-direction. Similarly, an engagement force 1714b may be exerted between the supplemental cooling  
5 device 1610 and the cooling shell 1142 when the supplemental cooling device 1610 is engaged with the cooling shell 1142. Engagement force 1714b may also be a substantially axial force acting in the x-direction, and may act in the same direction as force 1714a or in the generally opposite direction, depending on machine conditions.

10 [00155] The magnitudes of engagement forces 1714a and 1714b may be generally the same, or may be different. Under normal operating conditions, for example when the take-out plate 1164 and cooling plate 1614 on supplemental cooling device 1610 are moved in unison toward the cooling shell 1142, the magnitudes of engagement forces 1714a and 1714b may be  
15 generally the same and they may be acting in generally opposite directions. In this configuration the forces acting on the cooling shell 1142 may be balanced, and the net force exerted on the cooling shell 1142 may be relatively low. In some configurations, the forces exerted on opposing sides of the cooling shell 1142 may substantially cancel each other out and the  
20 magnitude of the net force may be approximately zero.

[00156] In the illustrate example, while the net force acting on the cooling shell 1142 may be balanced and/or relatively low, the take-out plate 1164 and/or the supplemental cooling device 1610 may be subjected to substantially the full magnitude of forces 1714a and 1714b, respectively,  
25 which may act away from the cooling shell 1142 in the x-direction.

[00157] Once source of the engagement forces 1714a and 1714b can be pneumatic forces generated during the blow off phase of the molding cycle, in which preforms are blown out of their cooling tubes and transferred to the cooling shell 1142. In some configurations, the force of the air flow  
30 used to eject the preforms can exert a relatively high external forces on the part handling components.

[00158] If the magnitude of these external forces 1714a and 1714b is above intended levels, it may result in unwanted stress and/or damage to the take-out plate 1164 or the supplemental cooling device 1610 if they are rigidly or fixedly held in place, for example by their respective actuators. In this configuration the take-out plate 1164 and supplemental cooling device 1610 may be stationary when the blow off force is exerted, but the direction of the blow off force may be generally opposite the direction of travel that brought the take-out plate 1164 and supplemental cooling device 1610 into engagement with the cooling shell 1142

10 [00159] Another source of external forces may be as a result of operating the injection molding machine 1100 outside its intended operating specifications, or if an error, fault or overload condition occurs. For example, misalignment between one or more pairs of transfer tubes 1170 and cooling pins 1354 may result in jamming as the take-out plate 1164 is moved toward the transfer shell 1142 and may produce a strong external force acting against the direction of motion of the take-out plate 1164 (i.e. against its actuating direction), and a corresponding opposing force acting on the transfer shell 1142. Misalignment between the cooling shell 1142 and the supplemental cooling device 1610 may result in similar forces.

20 [00160] An overload condition may also occur if there is a collision between the take-out plate 1164 or supplemental cooling device 1610 and the cooling shell 1142. For example, one or more preforms may be unintentionally retained in any one or more of the take-out plate 1164, supplemental cooling device 1610 or the cooling shell 1142 during the wrong phase in the molding cycle. If, for example, a preform were retained on a given pin on the cooling shell 1142 after it was supposed to be ejected, it may cause interference with the next preform that is to be received on the same pin on the cooling shell 1142 when the take-out plate 1164 is moving toward its engaged position with the cooling shell 1142. Such impacts may generate relatively high external forces on the components involved.

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[00161] High magnitude external forces may cause bending or other damage to the take-out plate 1164 or cooling device 1610, the transfer tubes 1170, the cooling pins 1354, the cooling shell 1142 and other components. At the time of transfer, the preforms carried by the take-out plate 2164 may not  
5 be fully cooled and may be vulnerable to deformation or distortion as a result of unintended contact or mishandling. Safeguarding against excess force on the machine components and/or preforms can help to avoid these problems.

[00162] In this regard, the injection molding machine can optionally include a one or more force accommodating apparatus to help absorb,  
10 dissipate or otherwise accommodate the external forces acting between the take-out plate 1164, supplemental cooling device 1610 and the cooling shell 1142. Optionally, the force accommodating apparatus may be configured to exert a biasing force on a component of the machine, for example to urge the component in a given direction or toward a particular axial position.  
15 Alternatively, the force accommodating apparatus may be configured to merely resist motion and/or to provide a dampening or dissipating function, without otherwise exerting a biasing force in the absence of an applied external force and/or motion.

[00163] In some examples, the force accommodating apparatus can be  
20 configured to accommodate engagement forces by allowing a controlled axial displacement of at least one the cooling shell 1142, the take-out plate 1164, supplemental cooling device 1610 or other machine component. This may be achieved using an suitable components or combination of components, including a dampening component, a biasing component and/or a  
25 combination thereof This may allow the two components between which high external forces are exerted to axially separate or move away from each other to reduce the magnitude of the forces acting on the components. External forces that are strong enough to displace one or more machine components may be generally referred to as displacement forces to distinguish them from  
30 forces which are applied to the machine components but are not strong

enough to activate the force accommodating apparatus to cause displacement.

[00164] Referring to Figure 16a, in the illustrated example a force accommodating apparatus 1700 serves as the mechanical link between the upright support column 1163 supporting the take-out plate 1164 and the locating member, i.e. clamp 1658a that is fastened to the belt 1654a to drive the robot 1165 in the x-direction. Similarly, another force accommodating apparatus 1700 is positioned to provide the mechanical link between the support column 1615 and its corresponding locating member, i.e. clamp member 1658b. Figures 16c and 18c are schematic representations of portions of the machine 1100 and the force accommodating apparatuses 1700.

[00165] In the illustrated example, the force accommodating apparatuses 1700 used in conjunction with support column 1163 and support column 1615 are generally similar. While the force accommodating apparatus 1700 coupled to the support column 1163 is described in detail below, the force accommodating apparatus coupled to support column 1615 includes analogous components and operates in an analogous manner, but in an opposite direction as illustrated. Alternatively, the force accommodating apparatuses connected to columns 1163 and 1615 need not be the same, and may be of any suitable configuration.

[00166] The force accommodating apparatus 1700 includes a first joint or connection coupled to the upright support column 1163 and a second joint or connection coupled to the clamp member 1658a. Optionally, at least one of the first and second connections can be a moveable or pivotable connection.

[00167] In the illustrated example, the force accommodating apparatus 1700 includes a pneumatic actuator 1702 having a cylinder 1704 and a piston 1706 that is slidably received within the cylinder 1704. The force accommodating apparatus 1700 also includes a secondary rail member 1740 that is mounted to the inner surface 1742 of the support column 1163 and a

shoe 1744 that is slidably mounted thereon. The shoe member 1744 is fixedly coupled to the clamp member 1658a and, in the example illustrated, is not axially moveable relative thereto. The actuator 1702 may be configured in any suitable manner, including , for example, to be operable to selectably  
5 exert a driving force on the support column 1163, to be operable as a generally resiliently compressible air-spring type member and to be operable in a dampening or energy dissipating configuration.

[00168] In this configuration, if an external displacement force is exerted on the take-out plate 1164 as it is being driven toward the cooling shell 1142  
10 by its actuator (i.e. a jamming or overload force), the force accommodating apparatus 1700 can enable limited axial movement of the clamp member 1658a relative to the support column 1163 (i.e. the support column 1163 is effectively held static and the clamp member 1658a is allowed to continue with the drive belt 1654 for a limited distance) to help prevent damage to robot  
15 1163. Alternatively, if the displacement force is exerted on the take-out plate 1164 while it is static and the clamp member 1658a is being held in a fixed position by its actuator (e.g. a blow off force), activation of the force accommodating apparatus 1700 can allow the support column 1163 to translate axially toward the clamp member 1658a to help absorb the energy  
20 from the blow off force.

[00169] Providing the secondary rail 1740, or any other suitable type of linear bearing member, to support and guide the shoe 1744 may help limit the motion of the shoe 1744 relative to the support column 1163 to the x-axial direction, and may help reduce twisting of the belt 1654a during operation of  
25 the force accommodating apparatus 1700.

[00170] In the illustrated example the force accommodating apparatus 1700 is provided on the inside 1742 (i.e. the side facing the base of the machine) of the upright support column 1163. In this configuration, the force accommodating apparatus 1700 is laterally intermediate the support column  
30 1163 and the base 1102. This may help reduce the overall size of the machine 1100. Alternatively, the force accommodating apparatus 1700 may

be positioned in any other suitable location, including, for example, the outside of the support column 1163.

[00171] Optionally, the force accommodating apparatus 1700 may at least partially axially overlap the support column 1163. This may help reduce the axial length of the combination of the force accommodating apparatus 1700 and the support column 1163. Covering the force accommodating apparatus 1700 with the support column 1163 may also help shield or protect the force accommodation apparatus 1700. Referring to Figure 16a, in the illustrated example the force accommodating apparatus 1700 has a shorter axial length than the support column 1163 and is completely covered or overlapped by the support column 1163. Alternatively, some or all of the force accommodating apparatus may not be axially overlapped by the support column 1163 (see for example the force accommodating apparatus 3700 described herein).

[00172] Referring to Figure 16b, in the illustrated example the cylinder 1704 is fixedly connected to the support column 1163 and the piston 1706 has a free end 1746 (or an extension member attached thereto) that is coupled to a shoe member 1744. In this configuration, movement of the shoe 1744 relative to the support column 1163 will result in corresponding movement of the piston 1706 within the cylinder 1704, and vice versa.

[00173] When the locating member, i.e. the clamp member 1658a, is in its target axial position relative to the support column 1163 the force accommodating apparatus 1700 defines an unactivated or target length 1748 (Figure 16c). The force accommodating apparatus length, in both its activated and unactivated states, can be measured as the distance separating the first and second connections of the force accommodating apparatus – e.g. the connection between the force accommodating apparatus and the locating member, and the connection between the force accommodating apparatus and the support column.

[00174] In the illustrated example, the target length is represented by the axial distance 1748 between the cylinder 1704 and the shoe member 1744

(which is axially fixed relative to the clamp 1658a) when the column 1163 is in its desired axial position relative to the clamp member 1658a, which can also be represented as the length of the exposed portion of the piston.

[00175]        Optionally, the force accommodating apparatus 1700 can be  
5   configured to resist displacement of the support column 1163 away from its target axial position. The resistance of the actuator 1702, e.g. the amount of force required to move the extend or retract the piston 1706 relative to the cylinder 1704, can be selected so that forces generated by normal or routine movements of the support column 1163 while the machine is in use (for  
10   example moving the take-out plate 1164 towards and away from the cooling shell 1142, and/or the blow off force exerted during part transfer) are not sufficient to move the piston 1706 to alter the relative axial positions of the support column 1163 and the clamp member 1658a. That is, the actuator 1702 (or other suitable dampening member, etc.) can be selected so that it  
15   has a stiffness that is greater than the axial driving forces (e.g. forces exerted by the actuator 1650a, momentum of the robot 1163, etc.) exerted on the actuator 1702 during normal use of the machine 1100.

[00176]        In the illustrated example, during normal operation of the machine 1100 the piston 1706 is held in a generally retracted position (Figure  
20   16c) and the support column 1163 travels axially in unison with the clamp member 1658a.

[00177]        The sensitivity or resistivity of the force accommodating apparatus 1700 may also be based on the size of the machine (e.g. size and weight of take-out plate 1164, number of preforms carried in the take-out plate  
25   1164, etc.) and the magnitude of the axial forces expected during normal operation.

[00178]        In the illustrated example, the resistance of the force accommodating apparatus 1700 is selected (for example by controlling the air pressure within the pneumatic actuator) so that when the support column  
30   1163, or take-out plate 1164 mounted thereto, are subjected to an external force as described herein, the force accommodating apparatus 1700 changes

length to an activated length 1750 (Figures 17b and 17c), (in the example illustrated the piston 1706 further extends) to allow the support column 1163 to move axially relative to the locating member 1658a.

[00179] Referring to Figures 17b and 17c, increasing the distance  
5 between the shoe 1744 and the cylinder 1704 allows the shoe 1744 to remain axially fixed relative to the clamp 1658a, while allowing the rest of the support column 1163 to translate relative to the clamp member 1658a. In the illustrated example, changes between the activated and unactivated lengths 1748 and 1750 (Figures 16c and 17c) can be measured by the stroke of the  
10 piston. In the illustrated example, the stroke of the piston may be much shorter than the amount of translation of the axial support column relative to the base during normal operation of the machine, and may be between about 2mm and about 100mm or more, and may be between about 2-50mm, between about 10-35mm and may be about 25mm.

15 [00180] Optionally, the force accommodating apparatus 1700 can be configured so that axial movement between the locating member 1658a and the support column 1163 will occur in the presence of an elevated, displacement force and not under normal operating conditions and/or so that the support columns can axially shift during normal operation of the machine,  
20 for example to accommodate normal blow off forces during the transfer of molded articles from the take-out plate 1164 and/or cooling plate 1614 to the cooling shell 1142, as well as in response to elevated overload or displacement forces.

[00181] Allowing relative movement between the support column 1163  
25 and the clamp member 1658a may help absorb and/or dissipate the high magnitude engagement forces acting on the take-out plate 1164. While in the illustrated example the force accommodating apparatus 1700 accommodates for the external force by increasing in length (e.g. the activated length 1750 is greater than the unactivated length 1748), the force accommodating  
30 apparatus may also be configured so that the activated length is less than the unactivated length.

[00182] Optionally, the actuator used in the force accommodating apparatus 1700 may be any suitable actuator, including, for example a hydraulic cylinder, a solenoid, a mechanical actuator, a spring or other biasing member. The actuator may be configured in any suitable manner, including,  
5 for example the cylinder being mounted on the moveable shoe and the free end of the piston being connected to the support column.

[00183] Optionally, the actuator 1702 may also be configured to bias the support column 1163 back to its target axial position relative to the clamp member 1658a when the external force has been removed. For example, the  
10 actuator 1702 may be configured to absorb energy from the movement or displacement of the support column 1163 away from its target axial position and then to use at least a portion of the absorbed energy to urge the support column 1163 toward its target axial position. In this configuration the actuator 1702 may operate as a resilient member that is capable of converting kinetic  
15 energy into potential energy for temporary storage, and then re-converting the stored potential energy into kinetic energy. Alternatively, the actuator 1702 need not store energy from the movement of the support column 1163, and can be configured to dissipate the energy in other ways. Optionally, to return the support column 1163 to its target axial position, the actuator 1702 can be  
20 selectably controllable, using any suitable controller (including the machine controller) to drive the support column 1163 toward to its target axial position (e.g. its intended or calibrated position relative to the clamp member).

[00184] In this configuration, the force accommodating apparatus 1700 is configured to allow the upright support column 1163, and the take-out plate  
25 1164 supported thereon, to axially translate away from the cooling shell 1142 if the take-out plate 1164 is subjected to a sufficiently high external force.

[00185] Optionally, the force accommodating apparatus 1700 may also include one or more sensors to monitor the configuration of the force accommodating apparatus and/or the axial position of the support column  
30 relative to the locating member. For example, in the illustrated example the actuator 1702 may include any type of sensor, such as position sensor that

can be used to determine the position of the piston 1706 relative to the cylinder 1704 and/or a limit switch to detect when the piston 1706 and/or the support column 1163 has shifted outside a pre-determined acceptable axial position range with respect to the locating member 1658a.

- 5 [00186] The sensor can be coupled to any suitable controller. Optionally, if the piston 1706 extends beyond a pre-set threshold position an alarm output can be produced by controller. This output may be used to warn an operator that the support column 1163 has shifted too far from its target axial position and/or to control one or more additional machine components.
- 10 For example, if the support column 1163 has been forced too far beyond its target axial position the controller may be configured to stop the actuator 1650a and/or to release all torques or other forces acting on the belt 1654a, and clamp member 1658a attached thereto. In this configuration, the force accommodating apparatus 1700 in this manner may serve also as a collision
- 15 protection apparatus, reducing the force applied by the actuator 1702 in response to an axial displacement of the support column 1163 relative to the locating member 1658a.

- [00187] While illustrated as be connected between the plate support column 1163 and the clamp member 1658a, the force accommodating
- 20 apparatus 1700 may alternatively be positioned to provide the mechanical link between the support column 1163 and any other suitable corresponding locating member attached to the machine, and/or force accommodating apparatuses 1700 may be provided for both the plate support column 1163 and the cooling shell support column 1462.

- 25 [00188] While illustrated with the supplemental cooling device 1610 generally opposing the robot 1163, and translating along a parallel axis, the supplemental cooling device 1610 can be positioned in any other suitable position (including above or below the cooling shell 1142) and may translate along an axis that is not parallel to the robot x-axis.

- 30 [00189] Referring to Figure 18, another example of an injection molding machine 2100 is shown. The machine 2100 has similarities to the machine

1100, and like features are identified by like reference characters incremented by 1000.

[00190] In the example illustrated, the cooling shell 2142 includes a plurality of receivers, in the form of cooling pins 2354, extending from each side 2144a-2144d. The cooling pins 2354 are insertable into the interiors of the molded articles carried by the take-out plate 2621 (as explained in detail below).

[00191] In the illustrated example, the part handling apparatus 2140 includes a fluid pressurization device 2401 for urging a flow of fluid through the some or all of the cooling pins 2354 extending from the cooling shell 2142. The fluid pressurization device can be a blower in fluid communication with the cooling shell 2142. Optionally, the fluid pressurization device 2401 can positively pressurize or negatively pressurize a portion of the interior of the cooling shell 2142 so that air can be blown out by, or sucked in by, the cooling pins 2354, respectively to help facilitate cooling of the interior of the preforms surrounding each cooling pin 2354. Alternatively, the part transfer apparatus need not perform any cooling of the molded articles. In such a configuration, the receivers on the part handling apparatus need not perform any cooling of the interior of the molded articles. Optionally, the part handling apparatus can still use pressurized fluid (for example a vacuum suction) to help with part handling and transfer. Alternatively, the receivers may be other suitable mechanisms (including, for example mechanical grippers) and the part handling apparatus 2140 need not include a fluid pressurization device 2401 (see for example Figures 21a-c).

[00192] Referring to Figure 19, when the moving platen 2106 is translated away from the stationary platen generally as far as possible (at or near its travel limit), the moving platen 2106 is in a mold-change position 2601 (as shown in Figure 20). At this position (i.e. the moving platen in the mold-change position), an inter-platen access space 2603 is provided axially between the stationary and moving platens. The inter-platen access space 2603 is generally defined by the axial distance between the opposed front

faces 2104f and 2106f of the stationary and moving platens, respectively. The inter-platen access space 2603 can generally be reduced by the sum of the heights of the molds halves 2104a, 2106a when mounted to the respective platens 2104, 2106.

5 [00193] The cooling shell 2142 is adjustably coupled to the base by, in the example illustrated, a support column 2462. The support column 2462 has a pair of bearing shoes 2409 slidably coupled to a linear rail 2407 fixed to a sidewall of the base 2102 (Figure 19). In the example illustrated, the linear robot 2165 supporting the take-out plate 2164 is slidably coupled to the same  
10 rail 2407.

[00194] The shell 2142 is slidable along the base between at least one shell working position 2605 (Figure 18) and a shell maintenance position 2607 (Figure 19). When in the shell working position 2605, the shell is engageable by the take-out plate 2164 and positioned axially between the maintenance  
15 position 2607 and the stationary platen 2104. In the working position, the shell 2142 is spaced apart from the stationary platen 2104 by a shell working spacing 2609, measured as the axial distance between the front face 2104f of the stationary platen and the 2104 and the proximal side 2144 of the shell 2142.

20 [00195] When the shell 2142 is in the shell maintenance position 2607, the shell 2142 is spaced apart from the stationary platen 2104 by a shell maintenance spacing 2611 (measured as the axial distance between the front face 2104f of the platen and the 2104 and the proximal side 2144 of the shell). The shell maintenance spacing 2611 is greater than the shell working spacing  
25 2609, and can provide improved access to the mold area from the non-operator side of the machine. In the example illustrated, the shell is generally clear of the inter-platen space when in the shell maintenance position 2607 (Fig. 20).

[00196] In the example illustrated, the shell has a shell axis 2146 about  
30 which the shell can rotate to move at least one side between a load and an unload position. The shell axis 2146 is, in the example illustrated, positioned

axially rearward of the front face 2106f of the moving platen 2106 when the shell is in the maintenance position 2607 and the moving platen 2106 is in the mold change position.

[00197] The take-out plate 2164 (and robot 2165 to which it is attached)  
5 may also be axially translatable between at least one robot x-axis working position 2615 and a robot x-axis maintenance position 2617. Referring to Figure 18, in the example illustrated, the at least one robot x-axis working position includes a robot x-axis retracted position 2621 (for mold area entry and exit along a z-axis) and a robot x-axis advanced position 2623 (for  
10 engagement with the cooling shell 2142).

[00198] In the robot x-axis retracted position 2621 (shown in solid line in Figure 18), the rear face 2515 of the take-out plate 2164 is spaced axially forward of the front face of the stationary mold half 2104a by a mold clearance spacing 2625. The mold clearance spacing 2625 can typically be minimized  
15 to help minimize the required stroke length that the moving platen 2106 must open to accommodate entry of the take-out plate between the mold halves 2104a, 2106a for (for example) unloading preforms.

[00199] In the robot x-axis advanced position 2623, the take-out plate 2164 (shown in phantom in Figure 18), is sufficiently near the cooling shell  
20 2142 so that the pins 2154, 2354 of the cooling shell are inserted into the transfer tubes 2170 (and preforms loaded therein) to a desired depth. In the example illustrated, the robot x-axis advanced position 2623 is spaced axially forward of the retracted position 2621 by a robot working stroke length 2627.

[00200] In the robot x-axis maintenance position 2617 (Figure 19), the  
25 take-out plate is spaced axially apart (generally as far as possible) from the moving platen 2106. The front face 2513 of the take out plate 2164 is, in the example illustrated, disposed rearward of the front face 2104f of the stationary platen 2104 by a take-out plate maintenance offset 2631 when the robot is in the x-axis maintenance position 2617. The robot x-axis maintenance position  
30 2617 is spaced axially rearward (by spacing 2613) of the x-axis retracted position 2621 by a robot maintenance stroke length 2629 (Fig. 19).

[00201] Referring again to Figure 19, when the shell is in the shell maintenance position and the robot is in the robot maintenance position, the axially inwardly directed tips of the tubes 2170 and opposed pins 2354 are spaced axially apart by a receiver clearance 2633. The magnitude of the receiver clearance 2633 may be at least as large as 50 percent of the inter-platen access space 2603 when the moving platen is in the mold-change position 2601. The receiver clearance 2633 may be greater than 600mm, and in some examples may be greater than 750mm. In the example illustrated, the receiver clearance is about 700mm.

10 [00202] Optionally, the axial position of the cooling shell 2142 may be adjustable between at least two shell working positions. In the example illustrated, the cooling shell 2142 is generally infinitely adjustable to any working position between a proximal shell working position 2637 and a distal shell working position 2639 (each shown in phantom with reference to the support column 2462 in Figure 18). The distal shell working position 2639 can accommodate longer length preforms. The proximal shell working position 2637 can help to increase cooling efficiency for shorter part production. The axial distance between the proximal and distal shell working positions (defined as a shell work position range 2641) can be 25mm, 50mm, or more than 15 100mm. In some examples, the shell work position range 2641 can be 300mm or more. In the example illustrated, the shell work position range 2641 is about 250mm.

[00203] In the example illustrated, a lower end of the support column 2462 is releasably lockable to a keeper rail 2643. When unlocked, the support column 2642 can be manually translated to the shell maintenance position 2607, or to a desired working position between proximal and distal working positions, and then locked in place, to accommodate longer preforms and/or to help reduce or minimize the axial travel required by the take-out plate when moving between the advanced and retracted robot working positions. Reducing this axial travel can help to increase the amount of time that the pins 2354 are fully engaged with the tubes 2170 (i.e. fully inserted into 25 30

the preforms held therein), which can help to increase the amount of cooling provided to the preforms.

[00204] Optionally, an actuator can be provided to help facilitate translation of the part handling apparatus, or portions thereof, relative to the machine base. For example, an actuator can be provided to move the cooling shell between the shell working positions and the maintenance position. The actuator can be positioned to slide the cooling shell in a direction that is substantially parallel to the machine axis, or in another direction. Optionally, the actuator can also form part of a force accommodating apparatus.

10 [00205] Referring to Figure 20 another example of an injection molding machine 3100 is shown. The machine 3100 has similarities to the machine 1100, and like features are identified by like reference characters, incremented by 2000.

[00206] In the example illustrated, the machine base 3102 has a stationary platen 3104 and a moving platen 3106 mounted thereon. The stationary platen 3104 supports a stationary mold half 3104a, and the moving platen supports a moving mold half 3106a. The moving platen 3106 is slidable along the machine axis 3105 towards and away from the stationary platen 3104, to close and open the mold formed by the mold halves. The machine 3100 also includes an actuator 3702 connected between the machine base 3102 and the support column 3462.

[00207] In the illustrated example, the actuator 3702 can be selectably energized to move the support column 3462 between multiple positions, including for example, amongst the shell working positions and the maintenance position (as explained in detail above). The actuator 3702 includes a cylinder 3704 mounted to the base 3102, and a piston assembly 3706 that is slidably received within the cylinder 3704.

[00208] The piston assembly 3706 may optionally include a connecting rod 3708, which may be an extension of the piston assembly 3706, connected to the support column 3462. The actuator 3702 can be a pneumatic actuator,

a hydraulic actuator or any other suitable type of fluid powered actuator, and can be connected to a suitable fluid supply source (not shown). Alternatively, the force accommodating apparatus can include any suitable type of actuator, including, for example, a ball screw assembly, a gear assembly, a rack and  
5 pinion assembly and a belt drive assembly.

[00209] Referring to Figure 21a, a schematic representation of the take-out plate 3162, cooling shell 3142 and the actuator 3702 illustrates the cooling shell 3412 supported by support column 3462, which is slidable along rails 3407 and 3643.

10 [00210] The actuator 3702 can be used to position the cooling shell 3142 in a shell working position 3605 in which the shell is engageable by the take-out plate. In the example, illustrated, when the shell is in the working position 3605, the pins of the cooling shell 3142 can enter the preforms held by the take-out plate to cool the preform interiors, and/or the preforms can be  
15 transferred from the take-out plate 3162 to the cooling shell 3142.

[00211] Optionally, translation of the cooling shell 3142 toward the take-out plate 3162 can be limited by a stop member 3710. The stop member 3710 can be positioned so that when the support column 3462 contacts the stop member 3710 the cooling shell 3142 is in the desired shell working  
20 position 3605. In this configuration the actuator 3702 may be configured to continually exert a relatively small positioning or biasing force on the support column 3462, illustrated using arrow 3712. Exerting a biasing force 3712 on the support column 3462 may help keep the support column 3462 pressed against the stop member 3710 when engaging the take-out plate 3164. This  
25 may help keep the cooling shell 3142 in the desired shell working position 3605.

[00212] Optionally, the biasing force 3712 can be sufficient such that it provides substantially all of the force required to keep the cooling shell 3142 in the working position 3605 while the machine 3100 is in use. This may help  
30 eliminate the need for the use of separate fastening or locking mechanisms to secure the cooling shell 3142 in the desired shell working position 3605.

[00213] Alternatively, the actuator 3702 can be configured to hold the support column 3642 in a desired location in the absence of a stop member 3710. In such a configuration, the actuator 3702 may not exert a net biasing force 3712 on the support column 3642 when the cooling shell 3142 is in the  
5 shell working position 3605. The actuator may exert a holding force that resists displacement of the shell 3142 out of the working position 3605.

[00214] Referring to Figure 21b, to move the cooling shell 3142 into an alternate position, such as, for example, the maintenance position 3607, the actuator 3702 can be moved in a retraction direction.

10 [00215] Alternatively, the actuator could 3702 be provided in another location (for example to the left of the support column as illustrated) such that extension of the piston translates the cooling shell toward the maintenance position and retraction of the piston translates the cooling shell toward the shell working position.

15 [00216] When the take-out plate 3164 engages the cooling shell 3142, for example to transfer preforms to the cooling shell 3142, the take-out plate 3164 may exert an engagement force or other external force (e.g. a blow off force) on the cooling shell 3142, represented by arrow 3714. In the illustrated example, the engagement force exerted on the cooling shell 3142 is a  
20 substantially axial force acting in a direction that is substantially parallel to the machine axis 3105.

[00217] For example, preforms carried in the transfer tubes 3170 may bear against the tips of their respective cooling pins 3354 when in the load station 3150a. Alternatively, or in addition, an ejection force, including for  
25 example, a pneumatic force, may be applied to the preforms to help eject the preforms from the transfer tubes 3170 and transfer the preforms to their respective cooling pins 3354. Such an ejection force may be transmitted to the cooling shell 3142 via the preforms.

[00218] For example, the force accommodating apparatus can be  
30 configured to allow the cooling shell 3142 to be displaced from the shell

working position 3605 when subjected to engagement forces 3714 exerted by the take-out plate on the cooling shell. The force accommodating apparatus may include a dampening member, to soften or retard translation of the cooling shell 3142 and optionally to absorb at least some of the forces  
5 causing the displacement. The force accommodating apparatus can also include a biasing member that is operable to exert a sufficient biasing force on the cooling shell 3142 to return the cooling shell 3142 to the shell working position 3605 after the external engagement force is reduced or removed. Optionally, a single component may serve as both the dampening member  
10 and the biasing member. Alternatively, the force accommodation apparatus may include a dampening member without a biasing member, or vice versa. In the illustrated example, engagement forces of sufficient magnitude to cause displacement of the cooling shell 3142 can be referred to as displacement forces.

15 [00219] In the illustrated example, the injection molding machine 3100 includes a force accommodation apparatus 3700 that includes the actuator 3702. In this configuration, the actuator 3702 is operable to help absorb some or all of the external displacement or engagement force 3174 acting on the cooling shell 3142 by allowing controlled displacement of the cooling shell  
20 3142 away from the take-out plate 3164.

[00220] In this configuration, the cylinder 3704 is fixed to the base 3102 and serves as the locating member. As the position of the cylinder 3704 relative to the base 3102 remains constant, the position of the support column 4462 can be monitored/ controlled based on a target axial position relative to  
25 the cylinder 3704.

[00221] When the cooling shell 3142 is in its intended working position the support column 3462 (Figure 21a) is in its target axial position relative to the cylinder 3704. When the support column is in its target axial position relative the cylinder 3704, the distance between the support column 3462 and  
30 the cylinder 3704 defines the unactivated length of the force accommodating apparatus 3748. When the cooling shell 3142 is displaced by an external

engagement or overload force (Figure 21c), the force accommodating apparatus moves by a corresponding amount and changes from its unactivated length 3748 (Figure 21a) to its activated length 3750 (Figure 21c)

[00222] Referring to Figure 21a, the actuator 3702 is configured to exert  
5 a biasing force, represented by arrow 3712, on the cooling shell 3142 urging the cooling shell 3142 toward a desired position (for example the shell working position 3605). If the magnitude of the engagement force 3714 exceeds the magnitude of the biasing force 3712, the result is a displacement force, represented by arrow 3718, that urges the cooling shell 3142 toward a  
10 displaced position (Figure 21c) spaced apart from the take-out plate 3164 (and from the shell's working position). As the cooling shell 3142 translates, the actuator 3702 can resist the movement of the cooling shell 3142 and can absorb at least a portion of the displacement force 3718.

[00223] Preferably, the actuator 3702 is configured such that the  
15 resistance of the actuator 3702 increases as the cooling shell 3142 is displaced away from the take-out plate 3164. In this configuration, the magnitude of the biasing force 3714 can increase as the cooling shell 3142 slides, until the cooling shell 3142 reaches a position in which the magnitude of the biasing force 3714 equals the magnitude of the displacement force  
20 3718. When the forces 3714 and 3718 reach equilibrium the cooling shell 3142 will settle in a displaced position 3720 (Figure 21c). The distance 3722 between the stationary platen 3104 and the displaced position 3720 can vary based on a variety of factors including for example, the magnitude of the displacement force 3718 and the resistive characteristics of the force  
25 accommodating apparatus. In the illustrated example, the displacement position 3720 is axially intermediate the shell working position 3605 and the shell maintenance position 3607.

[00224] After the displacement force 3718 is removed (e.g. when the magnitude of the engagement force 3176 drops below the magnitude of the  
30 biasing force 3174), for example when the take-out plate 3164 is disengaged from the cooling shell 3142, the biasing force 3174 exerted by the force

accommodating apparatus can urge cooling shell 3142 to return to the shell working position 3605, optionally to receive the next batch of preforms from the take-out plate 3164.

[00225] In the illustrated example, the actuator 3702 acts as both a dampening member and a biasing member. The actuator 3702 is also  
5 controllable to selectably translate the cooling shell 3142 to the maintenance position 3611, as described above. The actuator 3702 is a powered actuator that is operable to move the cooling shell 3142 in at least two directions, and need not rely on an external force, such as the engagement force 3714, to  
10 translate the cooling shell 3142 away from the take-out plate 3164. Optionally, the actuators described in relation to machine 1100 may also be configured in this manner.

[00226] In this configuration, the actuator 3702 can react to compensate and at least partially absorb displacement forces 3718 and can return the  
15 cooling shell 3142 to its intended shell working position when the displacement force is eliminated.

[00227] Optionally, the force accommodating apparatus need not include a powered or controllable actuator that is operable to selectably translate the cooling shell away from the take-out plate.

20 [00228] Referring to Figure 22a, portions of another example of an injection molding machine 4100 are schematically illustrated. The machine 4100 has similarities to the machine 1100, and like features are identified by like reference characters, incremented by 3000. The machine 4100 includes a force accommodating apparatus 4700.

25 [00229] In the illustrated example, the force accommodating apparatus 4700 includes a biasing and dampening member 4724 in the form of a spring 4726 connected between the support column 4462 and machine base. The spring 4726 biases the support column toward 4642 the shell working position 4605, and exerts a net biasing force 4714 pressing the support column 4462  
30 against the stop member 4710.

[00230] In this configuration, the locating member can be provided by the end 4727 of the spring 4726 which is fixedly connected to the base 4102 in a known position. The target axial position of the support column 4462 can then be determine with reference to the location of end 4727 of spring 4726.

- 5 In the illustrated example, changing from the unactivated length 4748 to the activated length 7450 of the force accommodating apparatus 4700 results in a shortening or compressing of the spring 4726. Alternatively, the spring 4726 could be positioned in an alternate position in which changing from the unactivated length 4748 to the activated length 7450 of the force  
10 accommodating apparatus 4700 results in the extension or lengthening of the spring 4726.

- [00231] When subjected to a displacement force the spring 4726 can absorb at least a portion of the displacement force when the cooling shell is displaced from the shell working position to the second position, store this  
15 portion of the displacement force as potential energy, and then release the potential energy and use at least a portion of the absorbed force to urge the cooling shell 4142 toward the shell working position, after the displacement force is removed.

- [00232] Optionally, to help facilitate translation of the cooling shell 4142  
20 to the maintenance position (Figure 22b) the spring 4726 can be compressed using an external compression tool (not shown), and/or can be decoupled from the support column 4462.

- [00233] The resistance of the spring 4726 can be selected so that the cooling shell 4142 can remain in the shell working position 4605 when  
25 subjected to expected engagement forces, but when the cooling shell 4142 is subjected to a displacement force 4718 the spring 4726 can compress to allow the cooling shell 4142 to move away from the take-out plate 4164. After the displacement force dissipates, the spring 4728 can urge the cooling shell 4142 toward the shell working position 4605.

- 30 [00234] The return of the cooling shell 4142 to the shell working position 4605 can occur immediately after the displacement force is removed, or the

force accommodation apparatus can be configured so that there is a delay between the removal of the displacement force and the return of the cooling shell 4142. For example, the spring 4728 can be configured so that its rate of extension does not exceed a predetermined threshold. Similarly, the return  
5 velocity of an actuator or other apparatus can be limited to a desired rate.

[00235] While an actuator and spring are illustrated as examples, the force accommodating apparatus can include any suitable member including, for example, a resilient compression member.

[00236] While the above description provides examples of one or more  
10 processes or apparatuses, it will be appreciated that other processes or apparatuses may be within the scope of the accompanying claims.

## CLAIMS:

1. A part handling apparatus for an injection molding machine, the part handling apparatus comprising:

5 a) a first locating member, the first locating member positionable along a part transfer axis relative to a base of the injection molding machine;

b) a first cooling plate mounted to a first plate support column, the first cooling plate having a plurality of transfer tubes for transferring a first set of molded articles, and the first plate support column configured to be  
10 moveable relative to the base of the injection molding machine and having a target axial position relative to the first locating member;

c) a first plate actuator connected to the first locating member and operable to exert an axial driving force to move the first locating member in a first actuating direction from a first axial position to a second axial position  
15 relative to the base of the injection molding machine;

d) a first force accommodating apparatus mechanically linking the first locating member to the first plate support column, the first plate support column moveable with the first locating member, the first force accommodating apparatus connected to the first locating member at a first  
20 connection and connected to the first plate support column at a second connection, an axial distance between the first connection and the second connection defining a first force accommodating apparatus length;

wherein when the first plate support column is in the target axial position relative to the first locating member the first force accommodating  
25 apparatus length defines an unactivated length, and wherein in response to an external displacement force acting on the first plate support column opposite the first actuating direction, the first plate support column moves away from the target axial position and the force accommodating apparatus length changes from the unactivated length to an activated length to  
30 accommodate at least a portion of the external displacement force.

2. The part handling apparatus of claim 1, wherein the first force accommodating apparatus resists changing from the unactivated length to the activated length.
3. The part handling apparatus of any one of claims 1 to 2, wherein in the  
5 absence of the external displacement force the first force accommodating apparatus holds the first plate support column in the target axial position relative to the first locating member when the first locating member is moved in the first actuating direction from the first axial position to the second axial position, and the first plate support column moves in unison with the first  
10 locating member.
4. The part handling apparatus of any one of claims 1 to 3, wherein the first force accommodating apparatus is the only axial-load bearing connection between the first locating member and the first plate support column.
5. The part handling apparatus of any one of claims 1 to 4, wherein when the  
15 first locating member is in the second axial position and the first support column is in the target axial position relative to the first locating member the first cooling plate is located in an engagement position for transferring the first set of molded articles between the transfer tubes and another apparatus.
6. The part handling apparatus of any one of claims 1 to 5, wherein the first  
20 plate actuator comprises a drive belt, the first locating member comprises a clamp member attached to the belt, and the first force accommodating member comprises a shoe member connected to the clamp member and moveably mounted to the first plate support column, and a force accommodating actuator connected between the shoe member and a surface  
25 of the first plate support column.
7. The part handling apparatus of any one of claims 1 to 6, further comprising at least one secondary rail member on the first plate support column, wherein the shoe member is coupled to the secondary rail member and is axially translatable relative to the first plate support column.

8. The part handling apparatus of claim 7, wherein the at least one secondary rail member extends substantially parallel to the part transfer axis.

9. The part handling apparatus of claim 8, wherein the force accommodating actuator is a fluidly powered actuator comprising a cylinder and a piston  
5 slidably received within the cylinder, one of the piston and the cylinder being coupled to the shoe member and the other of the piston and the cylinder being coupled to the first plate support column.

10. The part handling apparatus of claim 9, wherein when the force accommodating apparatus changes from the unactivated length to the  
10 activated length the piston translates a stroke distance relative to the cylinder housing, and the stroke distance is between about 2mm and about 50mm.

11. The part handling apparatus of any one of claims 1 to 10, wherein the first plate support column is laterally spaced apart from the base of the injection molding machine and the first force accommodating apparatus is disposed  
15 laterally intermediate the first support column and the base of the injection molding machine.

12. The part handling apparatus of any one of claims 1 to 11, wherein the first locating member and the first plate support column are laterally spaced apart from each other and at least partially overlap each other in the axial direction.

20 13. The part handling apparatus of any one of claims 1 to 12, further comprising a transfer shell mounted to a shell support column, the transfer shell spaced away from a mold area of the injection molding machine and having at least one shell side, the shell support column mountable to the base of the injection molding machine and positionable in a shell transfer position  
25 for the at least one shell side to receive the first set of molded articles from the first cooling plate.

14. The part handling apparatus of claim 13, wherein the at least one shell side comprises a plurality of transfer pins for receiving the first set of molded

articles, the transfer shell rotatable about a shell axis for moving the at least one shell side among a load position and at least one of a supplemental cooling position and an unload position.

15. The part handling apparatus of claim 14, wherein when the first locating member is in the first axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate is axially spaced apart from the transfer shell, and when the first locating member is in the second axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate is in a plate transfer position in which the first cooling plate engages the at least one shell side.

16. The part handling apparatus of any one of claims 1 to 15, wherein the first force accommodating apparatus biases the first plate support column toward the target axial position relative to the first locating member.

17. The part handling apparatus of any one of claims 1 to 16, wherein the first force accommodating apparatus is operable to absorb energy from the movement of the first plate support column away from the target axial position and to use at least a portion of the absorbed energy to urge the first plate support column toward the target axial position relative to the first locating member.

18. The part handling apparatus of any one of claims 1 to 17, further comprising:

a) a second locating member, the second locating member positionable along a second transfer axis relative to the base of the injection molding machine;

b) a second cooling plate mounted to a second plate support column, the second cooling plate having a plurality of transfer tubes for transferring the first set of molded articles, and the second plate support column configured to be moveable relative to the base of the injection molding

machine and having a second target axial position relative to the second locating member;

c) a second plate actuator connected to the second locating member and operable to exert a driving force to axially translate the second  
5 locating member in a second actuating direction from a third position to fourth position relative to the base of the injection molding machine;

d) a second force accommodating apparatus mechanically linking the second locating member to the second plate support column, the second plate support column moveable with the second locating member, the  
10 second force accommodating apparatus connected to the second locating member at a third connection and connected to the second plate support column at a fourth connection, an axial distance between the third connection and the fourth connection defining a second force accommodating apparatus length,

15 wherein when the second plate support column is in the second target axial position relative to the second locating member the second force accommodating apparatus length defines a second unactivated length, and wherein in response to a second external displacement force acting on the second plate support column opposite the second actuating direction, the  
20 second plate support column moves away from the second target axial position and the second force accommodating apparatus length changes from the second unactivated length to a second activated length to accommodate at least a portion of the second external displacement force.

19. The part handling apparatus of claim 18, wherein the second transfer axis  
25 is parallel to the part transfer axis.

20. The part handling apparatus of claim 19, wherein the fourth position is axially intermediate the third position and the second axial position.

21. The part handling apparatus of any one of claims 1 to 20, further comprising a displacement sensor operable to sense a magnitude change of

length of the first force accommodating apparatus and to generate an output signal when the magnitude exceeds an output threshold value.

22. The part handling apparatus of claim 21, further comprising a controller operable to control at least one machine parameter based on the output  
5 signal from the displacement sensor.

23. The part handling apparatus of claim 22, wherein the controller is operable to control the first plate actuator.

24. The part handling apparatus of any one of claims 1 to 23, wherein the activated length is longer than the unactivated length.

10 25. The part handling apparatus of any one of claims 1 to 23, wherein the activated length is shorter than the unactivated length.

26. An injection molding machine, comprising:

- a) a machine base;
- b) an injection unit mounted to the base;
- 15 c) a stationary platen mounted to the base for supporting a stationary mold half;
- d) a moving platen slidably supported by the base for supporting a moving mold half, the stationary and moving mold halves defining a mold area therebetween and the moving platen translatable along a  
20 machine axis between advanced and retracted positions;
- e) a first locating member, the first locating member positionable along a part transfer axis relative to the machine base;
- f) a first cooling plate mounted to a first plate support column, the first cooling plate having a plurality of transfer tubes for transferring a first  
25 set of molded articles, and the first plate support column translatable relative to the machine base and having a target axial position relative to the first locating member;
- g) a first plate actuator connected to the first locating member and operable to exert an axial driving force to move the first locating member

in a first actuating direction from a first axial position to a second axial position relative to the base of the injection molding machine;

h) a first force accommodating apparatus mechanically linking the first locating member to the first plate support column, the first plate support column moveable with the first locating member, the first force accommodating apparatus connected to the first locating member at a first connection and connected to the first plate support column at a second connection, an axial distance between the first connection and the second connection defining a first force accommodating apparatus length;

wherein when the first plate support column is in the target axial position relative to the first locating member the first force accommodating apparatus length defines an unactivated length, and wherein in response to an external displacement force acting on the first plate support column opposite the first actuating direction, the first plate support column moves away from the target axial position and the force accommodating apparatus length changes from the unactivated length to an activated length to accommodate at least a portion of the external displacement force.

27. The injection molding machine of claim 26, further comprising a transfer shell mounted to a shell support column, the transfer shell spaced away from the mold area of the injection molding machine and having at least one shell side, the shell support column positionable in a shell transfer position for the at least one shell side to receive the first set of molded articles from the first cooling plate.

28. The injection molding machine of claim 27, wherein the at least one shell side comprises a plurality of transfer pins for receiving the molded articles from the injection molded machine, the transfer shell rotatable about a shell axis for moving the at least one shell side among a load position and at least one of a supplemental cooling position and an unload position.

29. The injection molding machine of claim 27, wherein when the first locating member is in the first axial position and the first plate support column is in the

target axial position relative to the first locating member the first cooling plate is axially spaced apart from the transfer shell, and when the first locating member is in the second axial position and the first plate support column is in the target axial position relative to the first locating member the first cooling plate is in a plate transfer position in which the first cooling plate engages the at least one shell side.

30. The injection molding machine of any one of claims 27 to 29, further comprising:

a) a second locating member, the second locating member positionable along a second transfer axis relative to the machine base;

b) a second cooling plate mounted to a second plate support column, the second cooling plate having a plurality of transfer tubes for transferring the first set of molded articles, and the second plate support column moveable relative to the machine base and having a second target axial position relative to the second locating member;

c) a second plate actuator connected to the second locating member and operable to exert a driving force to axially translate the second locating member relative to the machine base in a second actuating direction from a third position spaced apart from the transfer shell to a fourth position to engage the transfer shell;

d) a second force accommodating apparatus mechanically linking the second locating member to the second plate support column, the second plate support column moveable with the second locating member, the second force accommodating apparatus connected to the second locating member at a third connection and connected to the second plate support column at a fourth connection, an axial distance between the third connection and the fourth connection defining a second force accommodating apparatus length,

wherein when the second plate support column is in the second target axial position relative to the second locating member the second force accommodating apparatus length defines a second unactivated length, and

wherein in response to a second external displacement force acting on the second plate support column opposite the second actuating direction, the second plate support column moves away from the second target axial position and the second force accommodating apparatus length changes from  
5 the second unactivated length to a second activated length to accommodate at least a portion of the second external displacement force.

31. The part handling apparatus of claim 30, wherein the second transfer axis is parallel to the part transfer axis.

32. The part handling apparatus of any one of claims 26 to 31, wherein the  
10 first force accommodating apparatus biases the first plate support column toward the target axial position relative to the first locating member.

33. The part handling apparatus of any one of claims 26 to 32, wherein the first force accommodating apparatus is operable to absorb energy from the movement of the first plate support column away from the target axial position  
15 and to use at least a portion of the absorbed energy to urge the first plate support column toward target axial position relative to the first locating member.

34. The part handling apparatus of claim 26, wherein the part transfer axis is generally parallel to and offset from the machine axis.

20 35. The part handling apparatus of claim 26, wherein the force accommodating apparatus is positioned laterally intermediate the at least one of the shell support column and the plate support column and the machine base.

25 36. A part handling apparatus for an injection molding machine, the part handling apparatus comprising:

a) a transfer shell mounted to a shell support column, the transfer shell spaced away from a mold area of the injection molding machine and having at least one shell side with transfer pins, the shell support column

being mountable to a base of the injection molding machine and being translatable relative to the base along a part transfer axis;

b) a first cooling plate mounted to a first plate support column, the first cooling plate having a plurality of transfer tubes for transferring a first set of molded articles to the at least one shell side, and the first plate support column configured to be moveable relative to the base of the injection molding machine;

c) a first locating member, the first locating member positionable along the part transfer axis relative to the base of the injection molding machine and having a target axial position relative to at least one of the shell support column and the first plate support column;

d) a first force accommodating apparatus mechanically linking the first locating member to the at least one of the shell support column and the first plate support column, the at least one of the shell support column and the first plate support column moveable with the first locating member, the first force accommodating apparatus connected to the first locating member at a first connection and connected to the at least one of the shell support column and the first plate support column at a second connection, an axial distance between the first connection and the second connection defining a first force accommodating apparatus length;

wherein when the at least one of the shell support column and the first plate support column is in the target axial position relative to the first locating member the first force accommodating apparatus length defines an unactivated length, and wherein in response to an external displacement force acting on the at least one of the shell support column and the first plate support column, the at least one of the shell support column and the first plate support column moves away from the target axial position and the force accommodating apparatus length changes from the unactivated length to an activated length to accommodate at least a portion of the external displacement force.

37. The part handling apparatus of claim 36, further comprising a first plate actuator connected to the first locating member and operable to exert an axial driving force to move the first locating member in a first actuating direction from a first axial position to a second axial position relative to the base of the injection molding machine, and wherein the external displacement forces acts  
5 in a direction opposite the first actuating direction.

38. The part handling apparatus of claim 36 or 37, wherein the force accommodating apparatus provides substantially the only axial-load bearing mechanical link between the at least one of the shell support column and the  
10 first plate support column and the first locating member.

39. The part handling apparatus of any one of claims 36 to 38, wherein the first force accommodating apparatus biases the at least one of the shell support column and the first plate support column toward the target axial  
15 position relative to the first locating member.

40. The part handling apparatus of any one of claims 36 to 39, wherein the first force accommodating apparatus is operable to absorb energy from the movement of the at least one of the shell support column and the first plate  
20 support column away from the target axial position and to use at least a portion of the absorbed energy to urge the at least one of the shell support column and the first plate support column toward the target axial position relative to the first locating member.

41. The part handling apparatus of any one of claims 36 to 40, wherein the  
25 first locating member and the at least one of the shell support column and the first plate support column are laterally offset from each other and at least partially overlap each other in the axial direction.

42. The part handling apparatus of any one of claims 36 to 41, wherein the first locating member is fixed relative to the base of the injection molding machine.

5 43. The part handling apparatus of any one of claims 36 to 41, wherein the first locating member is moveable relative to the base of the injection molding machine.

44. The part handling apparatus of any one of claims 36 to 43, wherein the  
10 transfer shell is rotatable about a shell axis for moving the at least one shell side among a load position and at least one of a supplemental cooling position and an unload position.

45. The part handling apparatus of any one of claims 36 to 44, wherein the first cooling plate is moveable toward and away from the transfer shell for  
15 presenting the molded articles in the transfer tubes to the at least one shell side, the first plate support column being translatable along the part transfer axis to move the first cooling plate between a retracted position, in which the first cooling plate is axially spaced apart from the at least one shell side and a plate transfer position in which the first cooling plate engages the at least one  
20 shell side.

46. The part handling apparatus of any one of claims 36 to 45, further comprising

a) a second locating member, the second locating member positionable along a second transfer axis relative to the base of the injection  
25 molding machine;

b) a second cooling plate mounted to a second plate support column, the second cooling plate having a plurality of transfer tubes for transferring the first set of molded articles, and the second plate support column configured to be moveable relative to the base of the injection molding

machine and having a second target axial position relative to the second locating member;

c) a second plate actuator connected to the second locating member and operable to exert a driving force to axially translate the second  
5 locating member in a second actuating direction from a third position to fourth position relative to the base of the injection molding machine;

d) a second force accommodating apparatus mechanically linking the second locating member to the second plate support column, the second plate support column moveable with the second locating member, the  
10 second force accommodating apparatus connected to the second locating member at a third connection and connected to the second plate support column at a fourth connection, an axial distance between the third connection and the fourth connection defining a second force accommodating apparatus length,

15 wherein when the second plate support column is in the second target axial position relative to the second locating member the second force accommodating apparatus length defines a second unactivated length, and wherein in response to a second external displacement force acting on the second plate support column opposite the second actuating direction, the  
20 second plate support column moves away from the second target axial position and the second force accommodating apparatus length changes from the second unactivated length to a second activated length to accommodate at least a portion of the second external displacement force.

47. The injection molding machine of claim 36, wherein the first force  
25 accommodating apparatus comprises a first actuator extending between the shell support column and the base of the injection molding machine.

48. The injection molding machine of claim 47, wherein the first actuator comprises a cylinder and a piston slidably received within the cylinder, one of the piston and the cylinder being coupled to the shell support column and the  
30 other one of the piston and the cylinder being coupled to the machine base.

49. The injection molding machine of claim 48, wherein the one of the piston and the cylinder that is coupled to the machine base provides the first locating member.

50. The injection molding machine of claim 48, wherein the one of the piston  
5 and the cylinder that is coupled to the machine base is fixedly connected to the machine base.

51. The injection molding machine of claim 47, wherein the first actuator is operable to move the shell support column to a maintenance position in which the shell support column is axially spaced apart from the first plate support  
10 column.

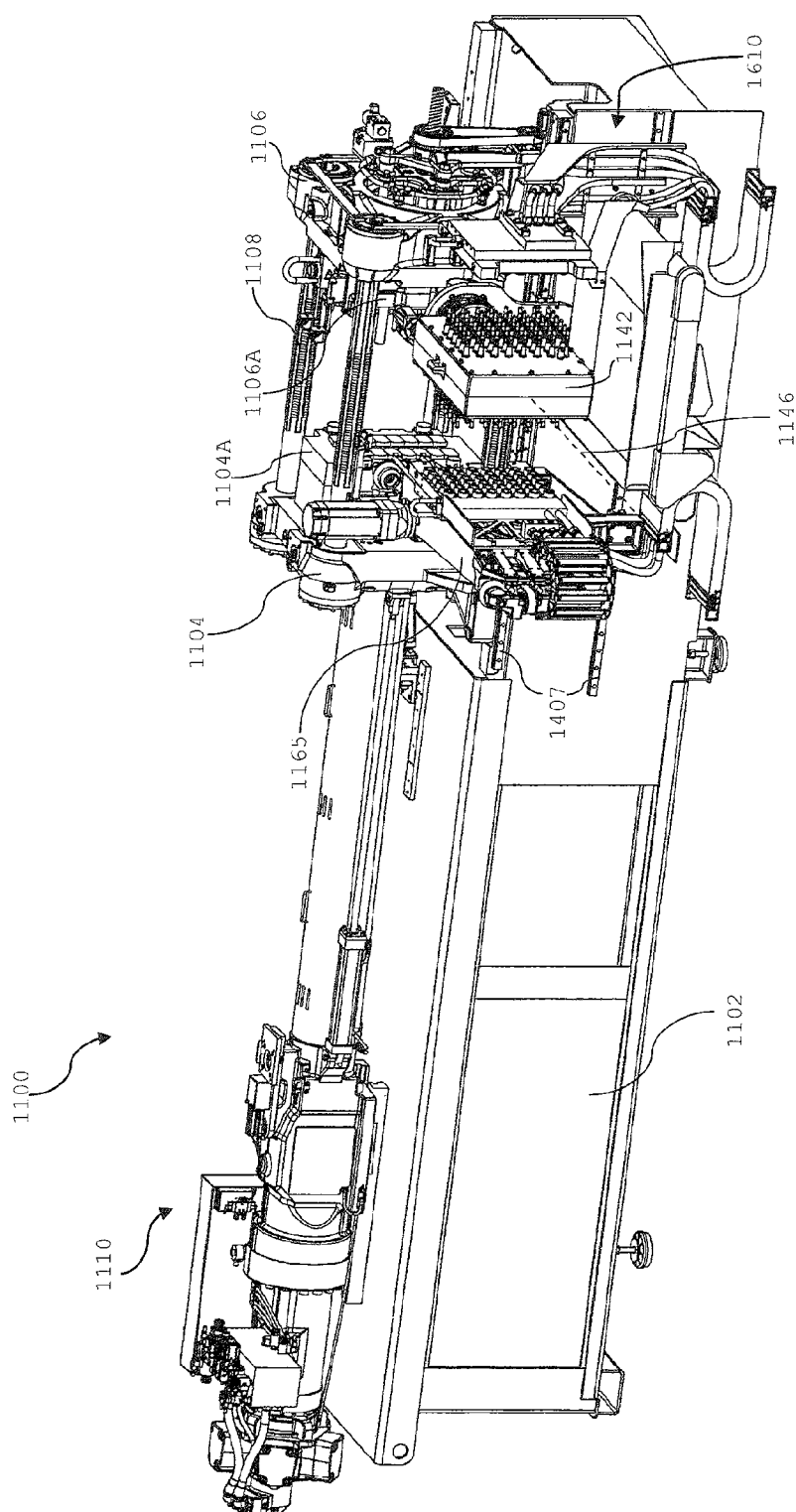


**FIG. 1**

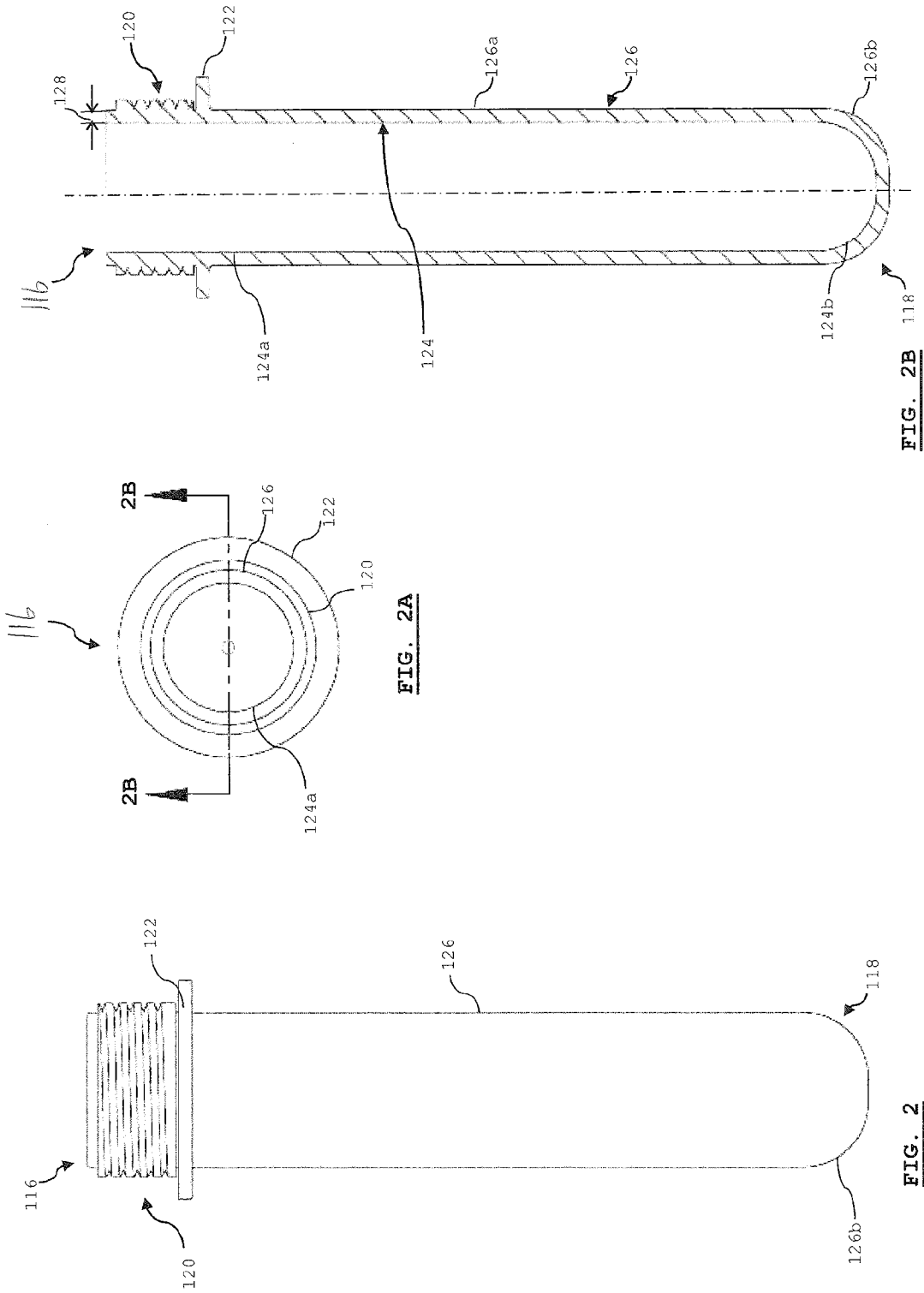
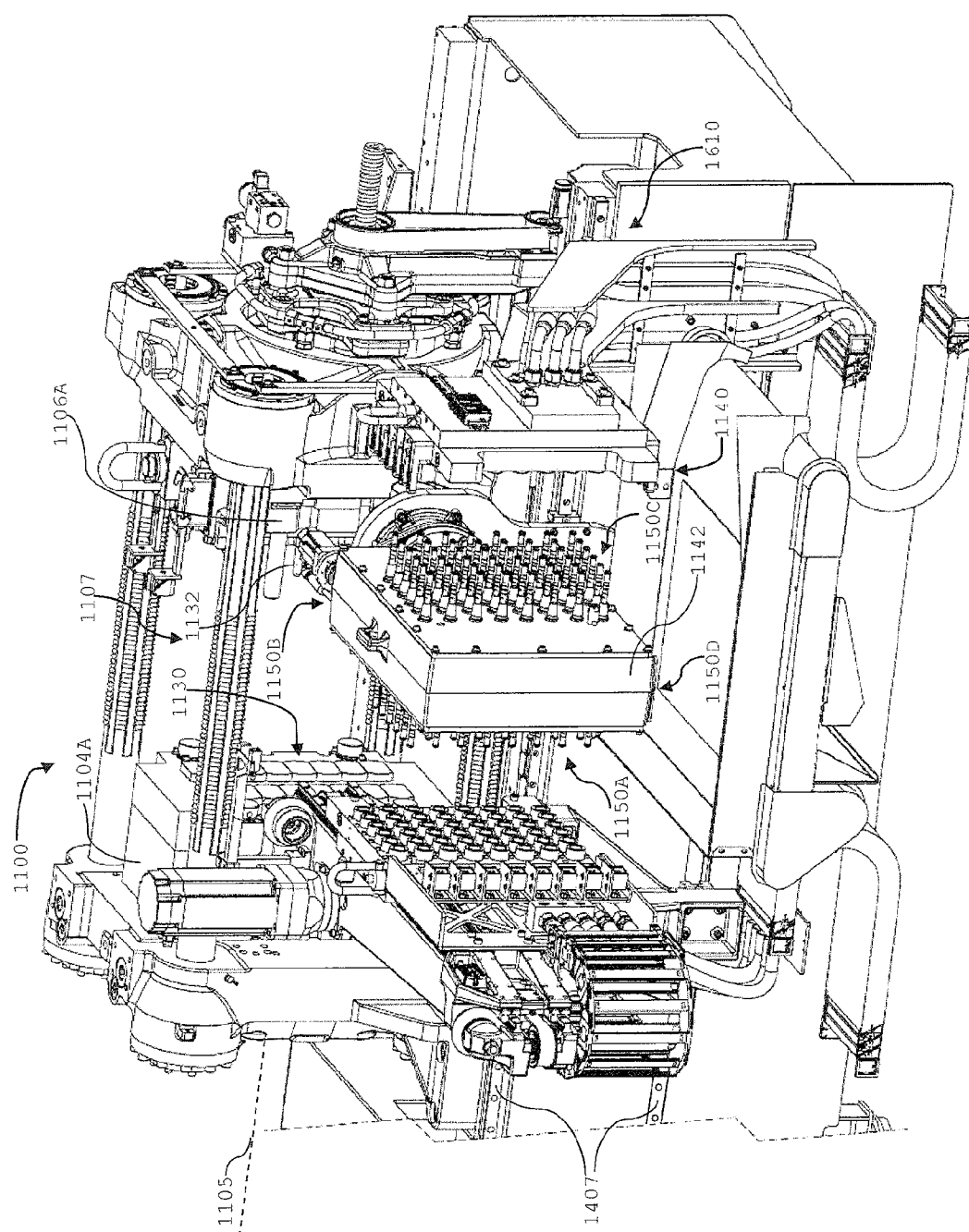
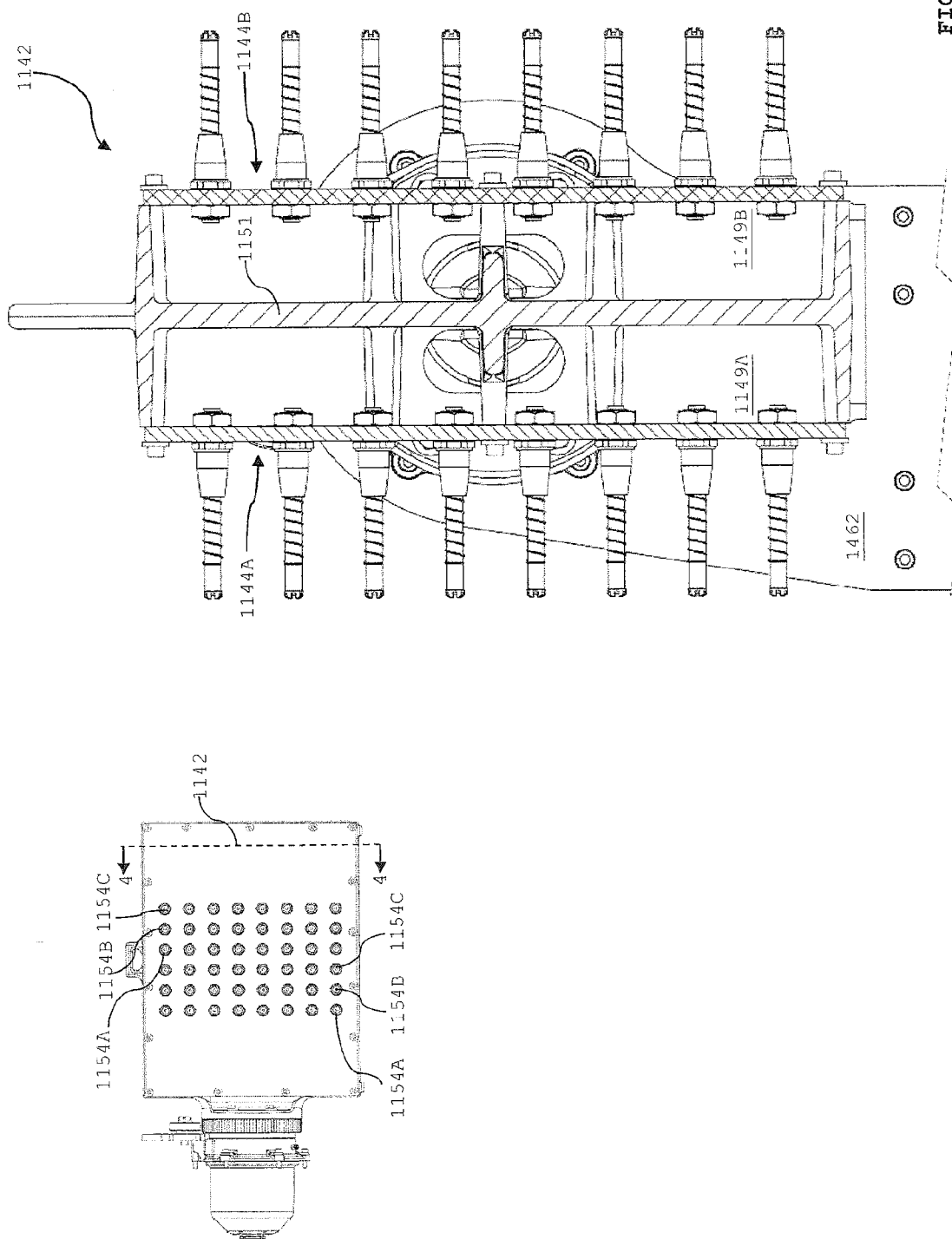


**FIG. 3**





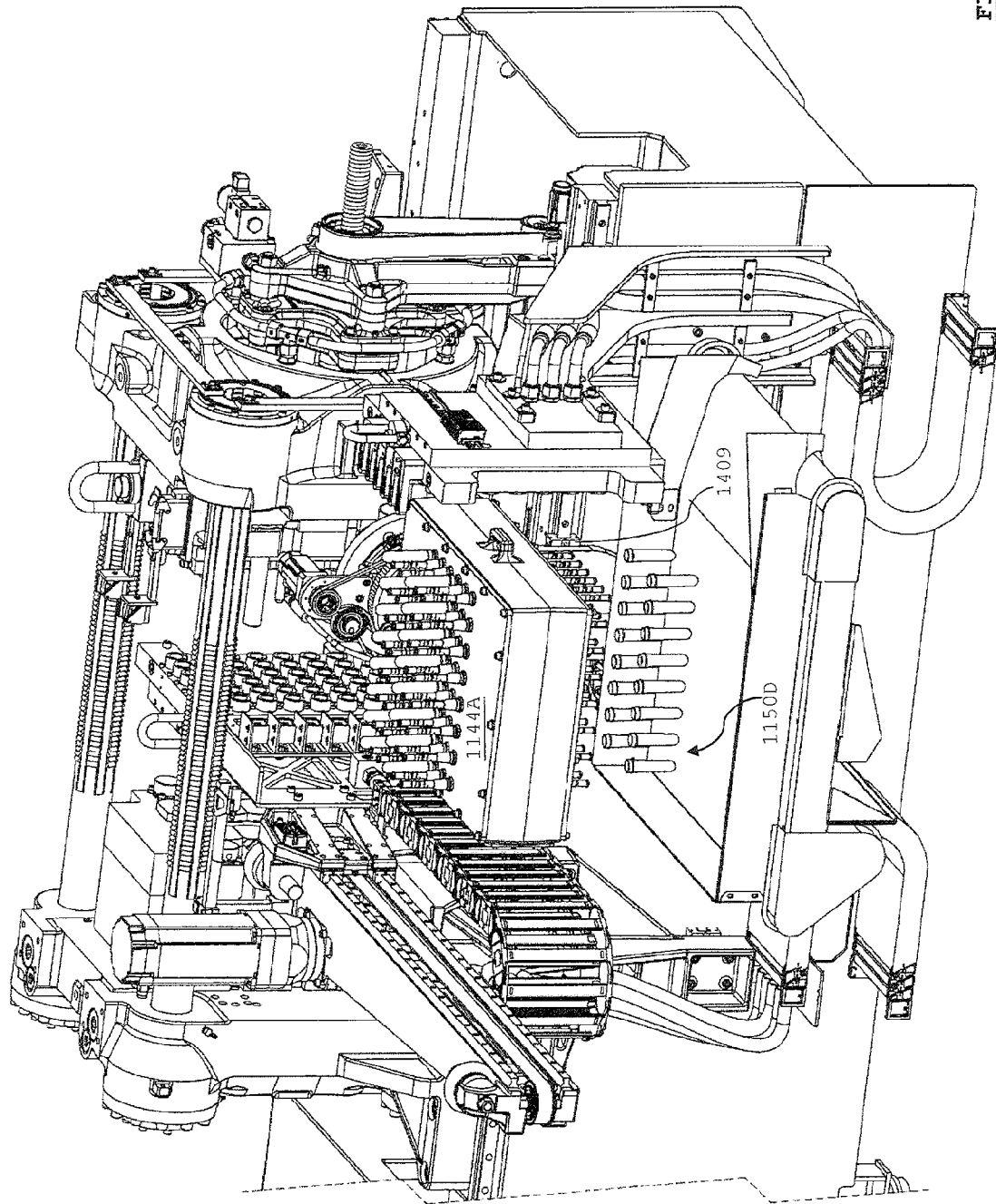
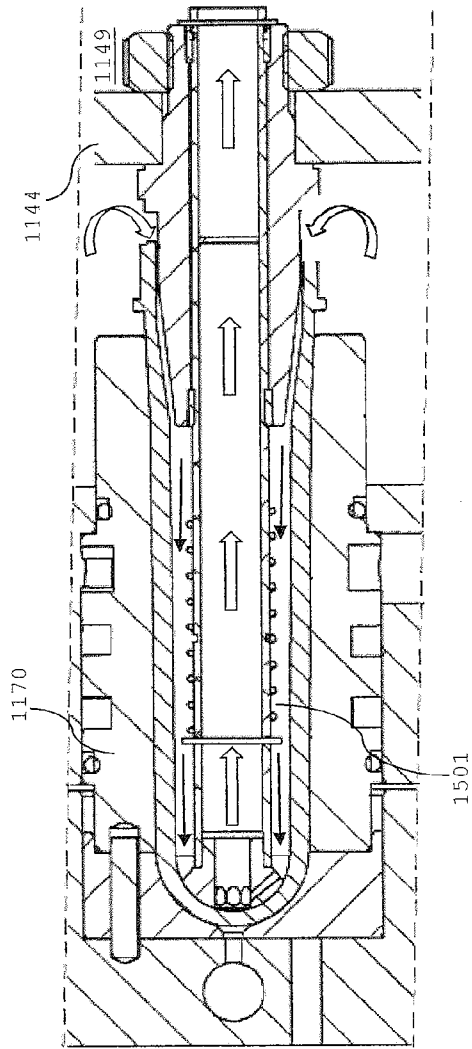
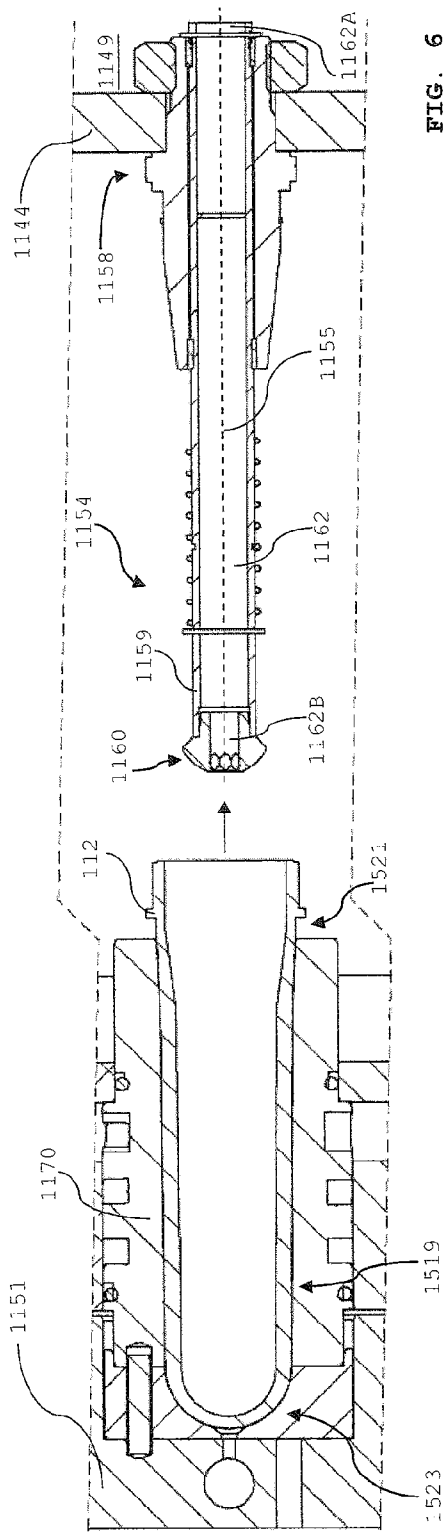


FIG. 5



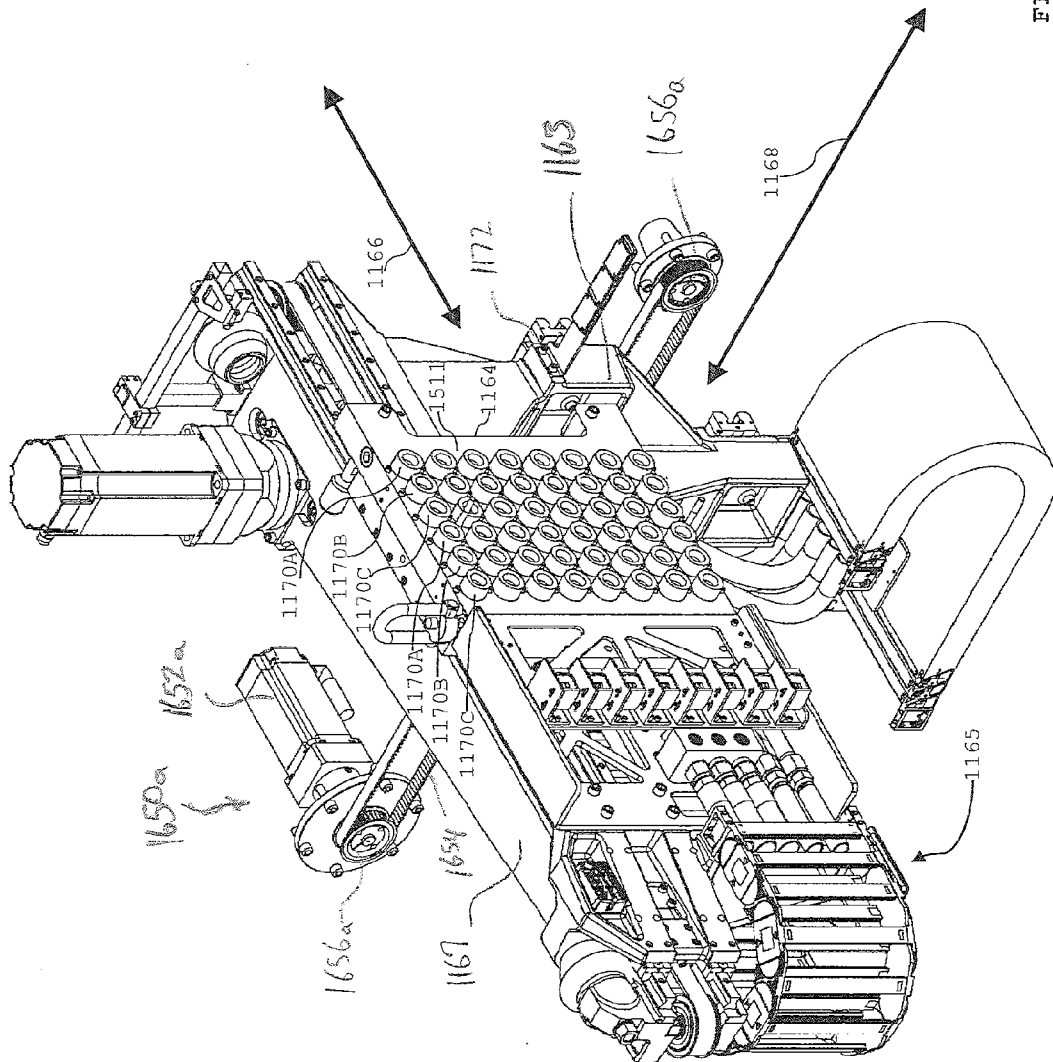


FIG. 8

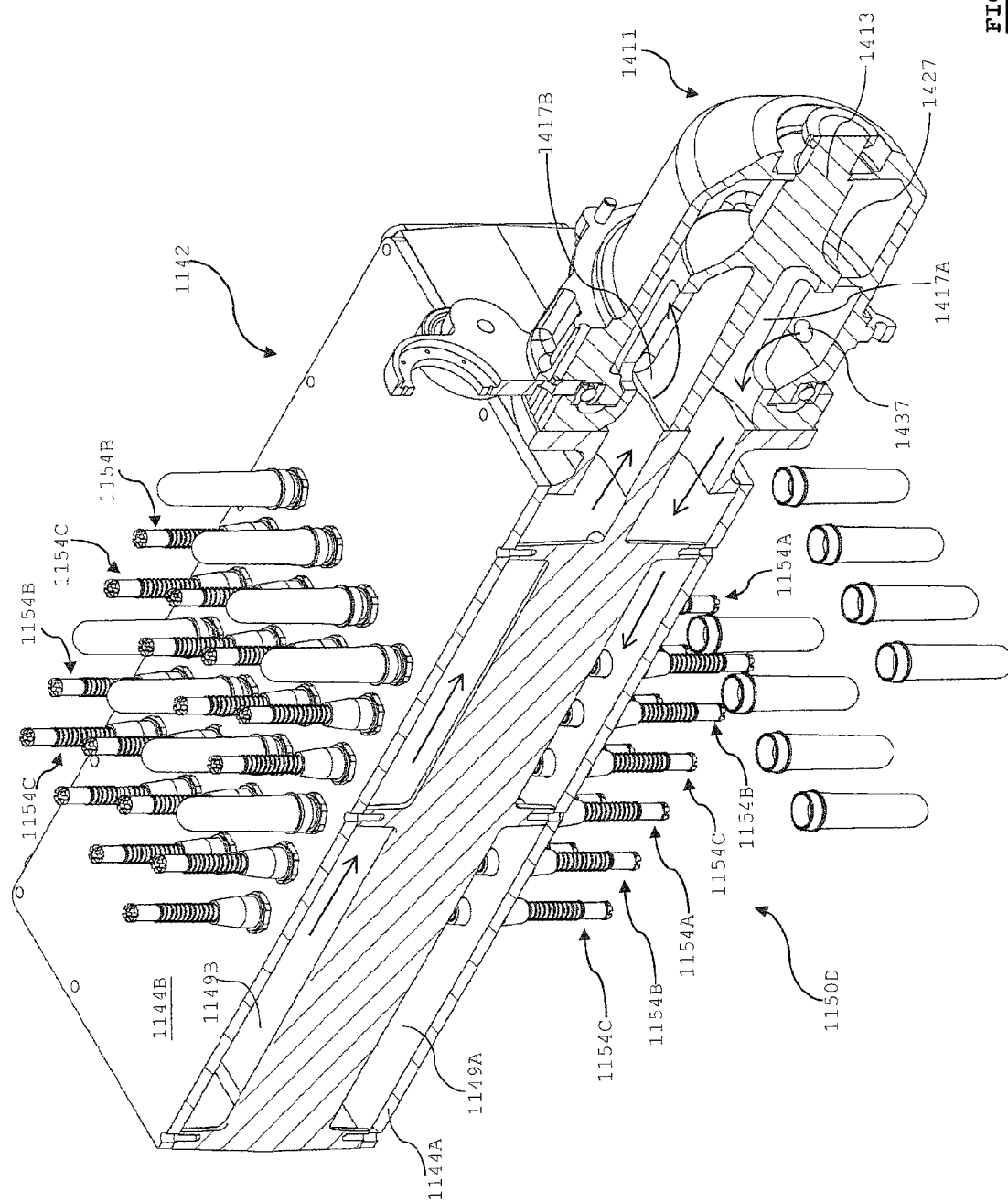


**FIG. 9**

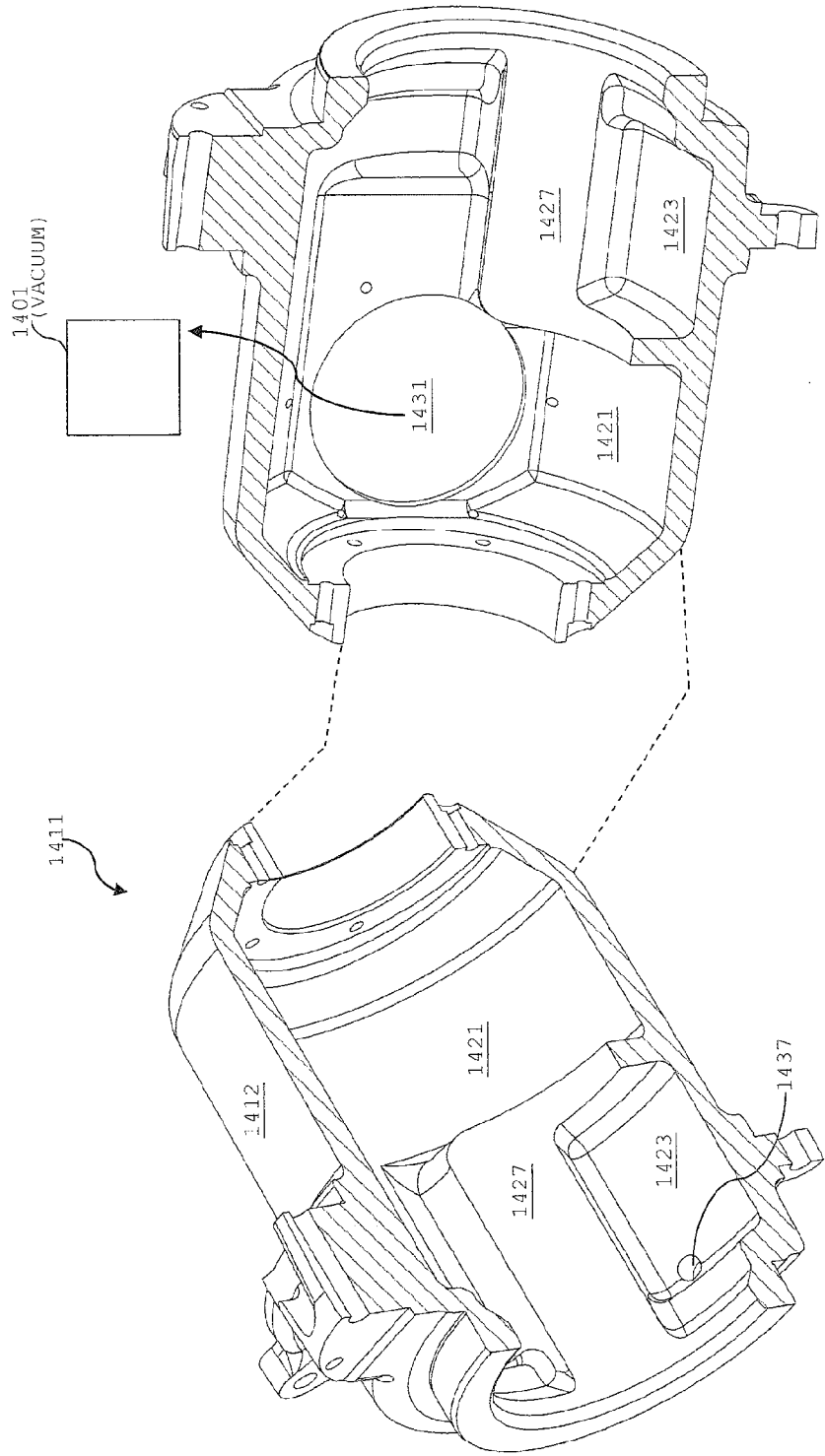


FIG. 10

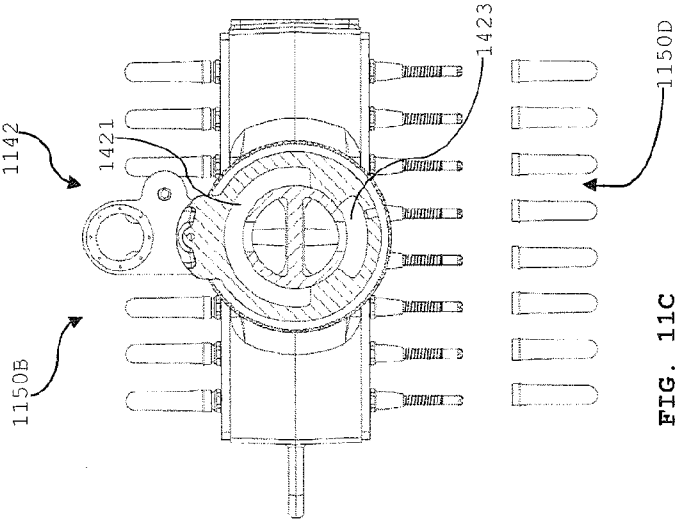


**FIG. 11C**

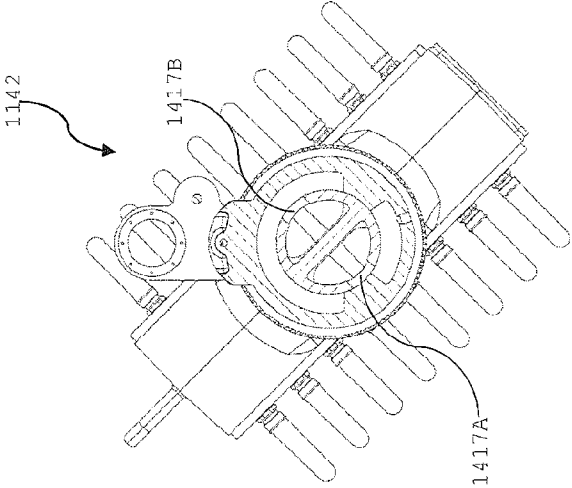


**FIG. 11B**

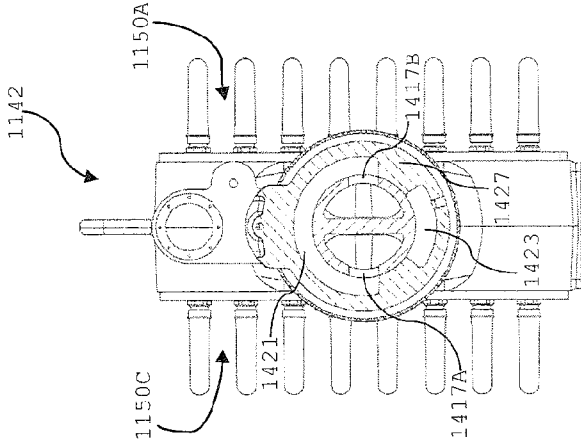
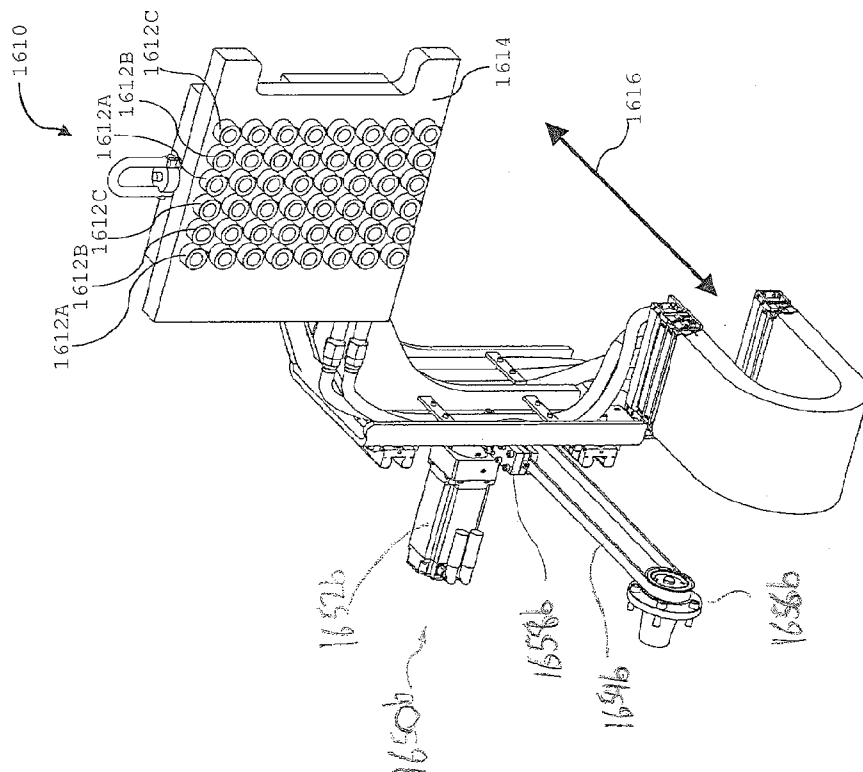
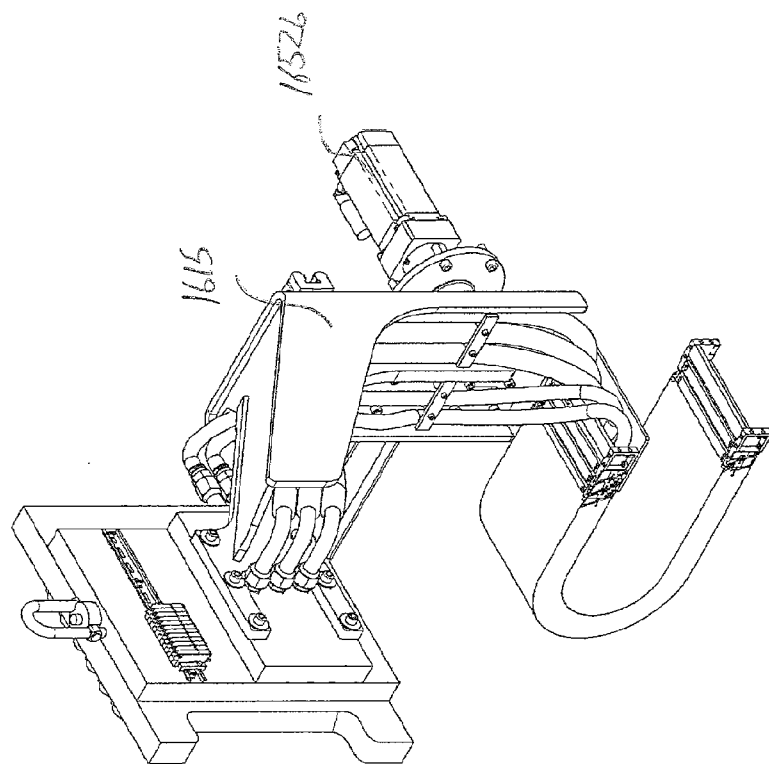


**FIG. 11A**



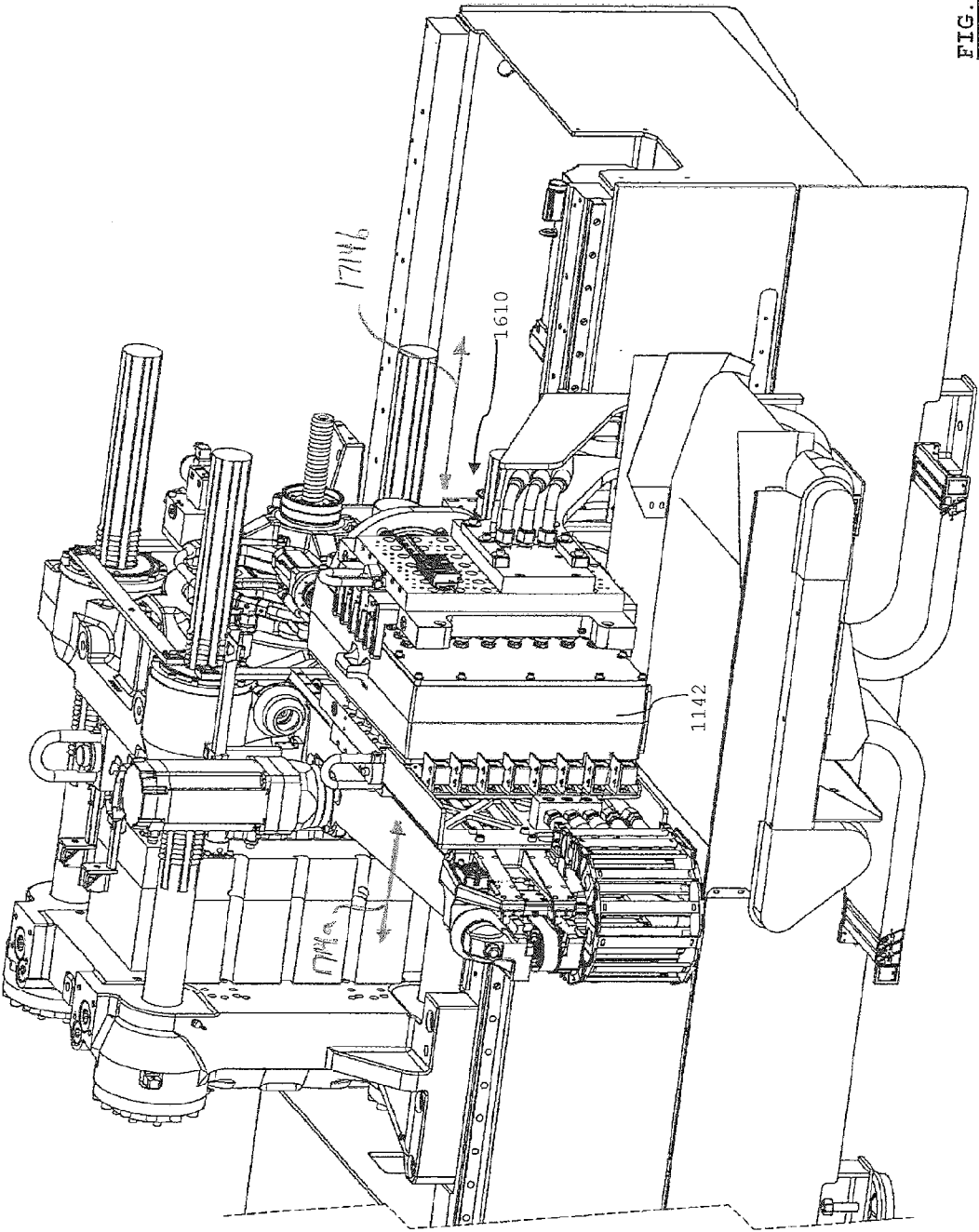


FIG. 13

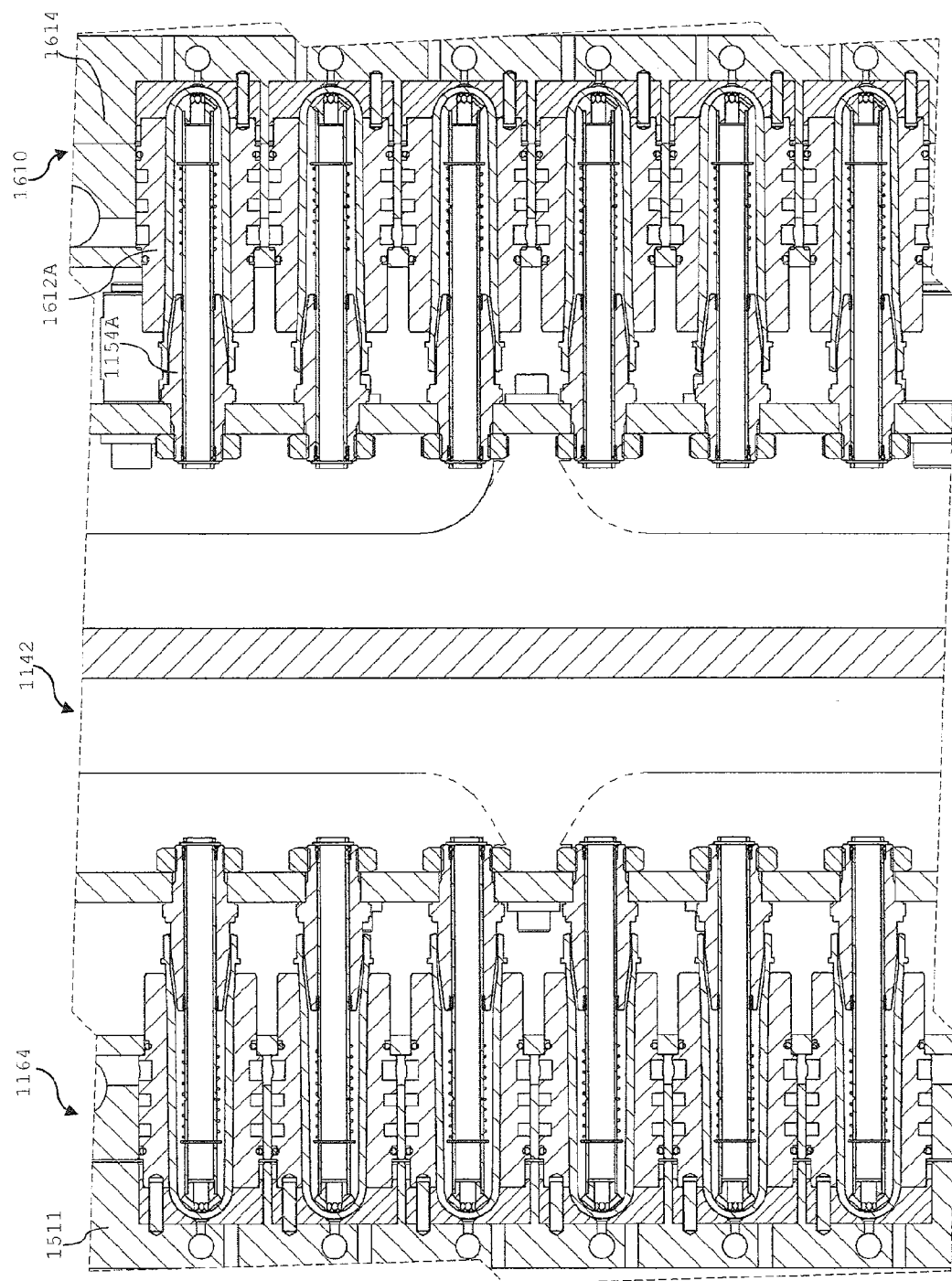
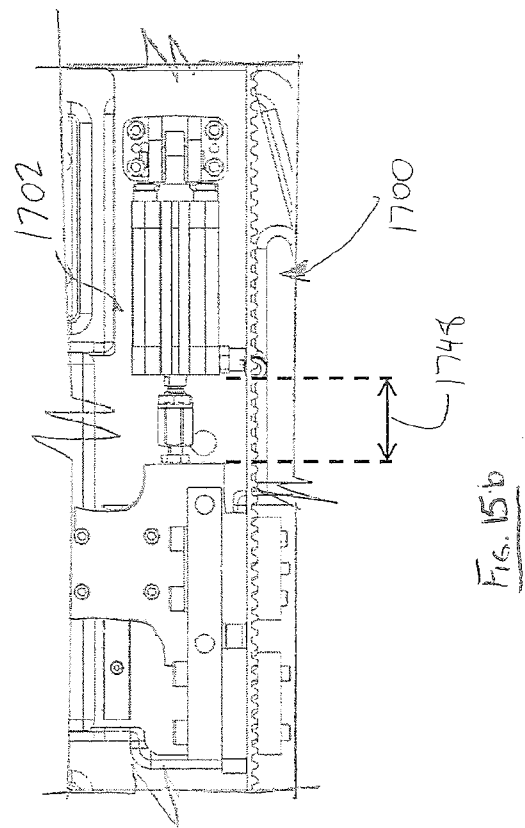
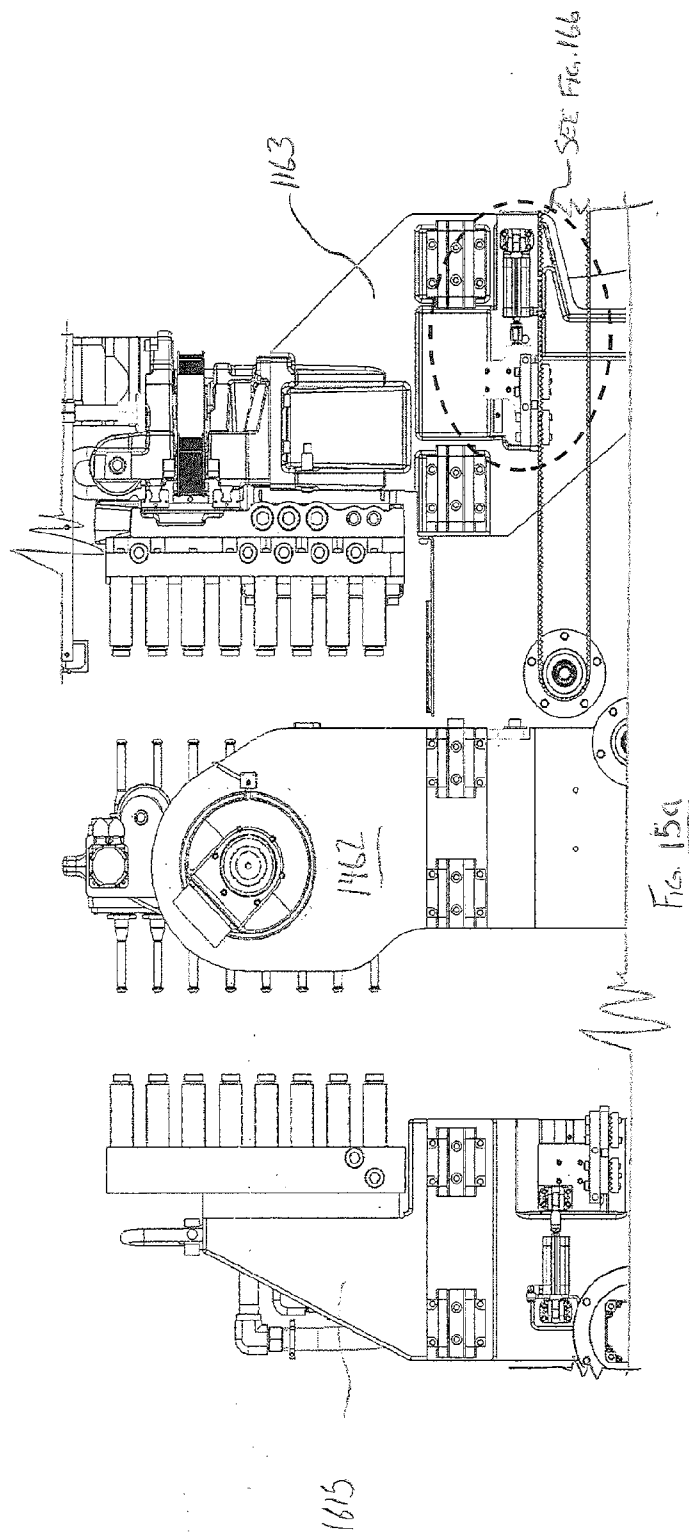
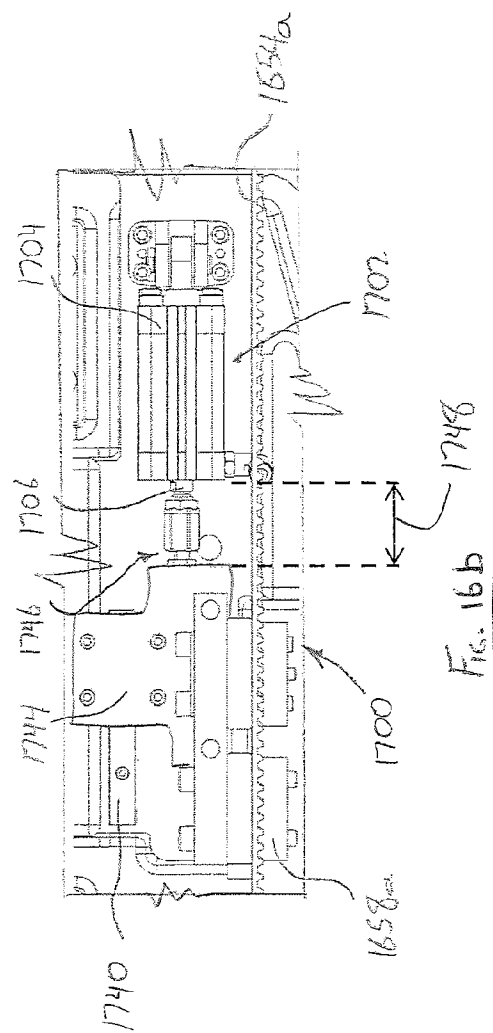
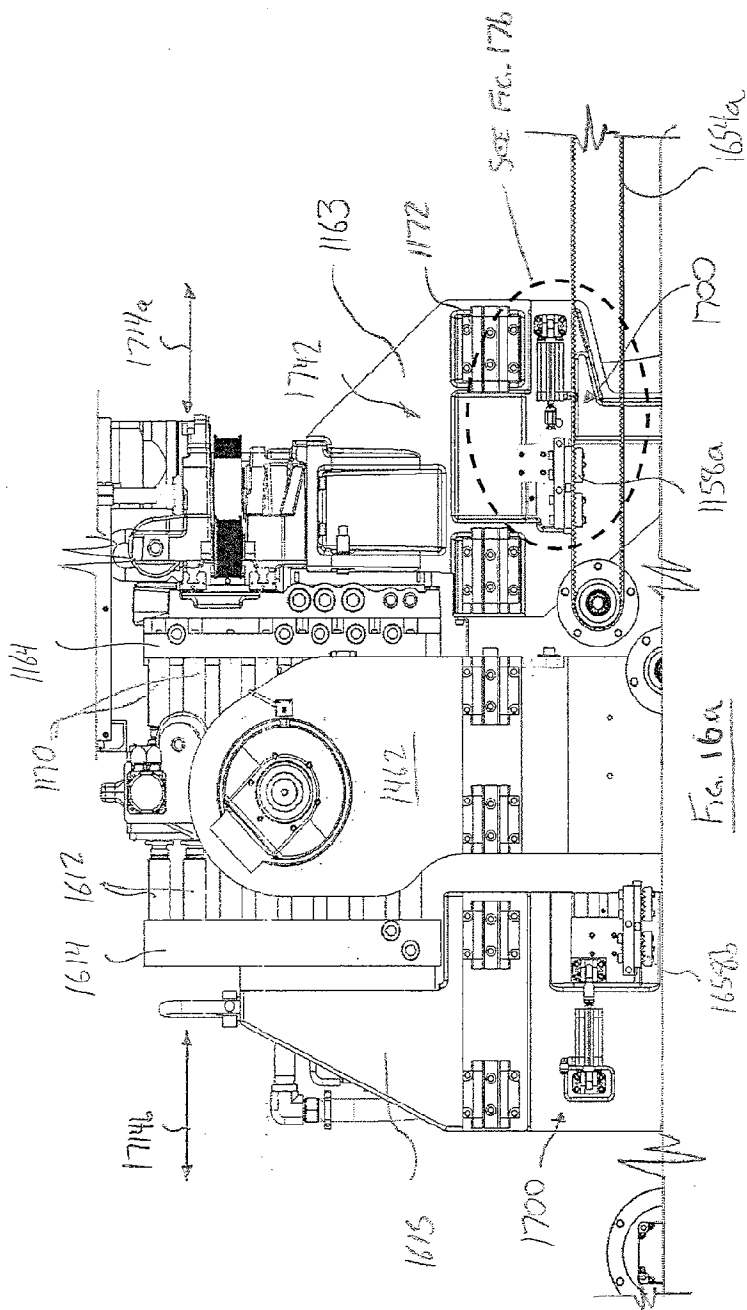


**FIG. 14**

14/23





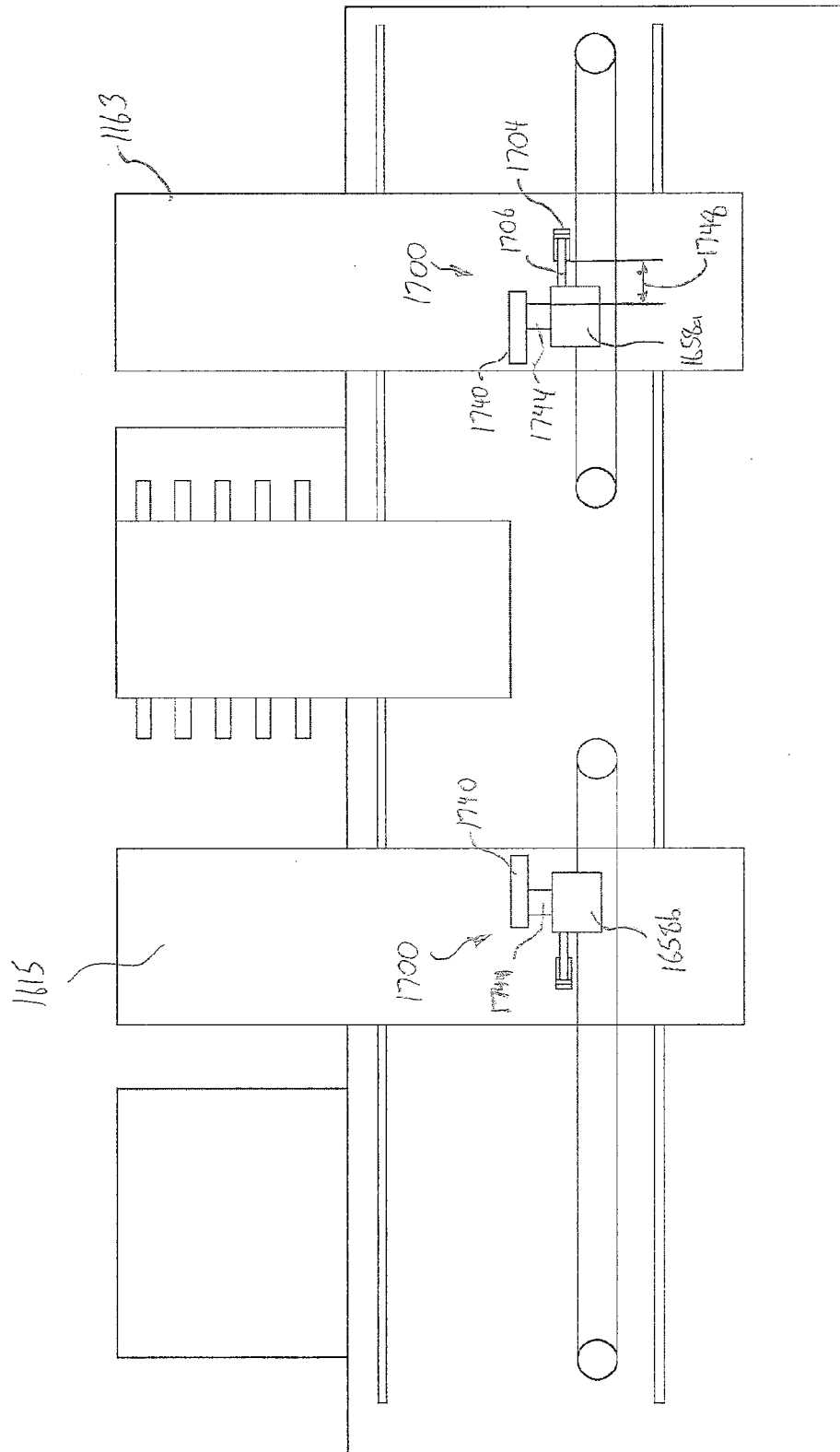
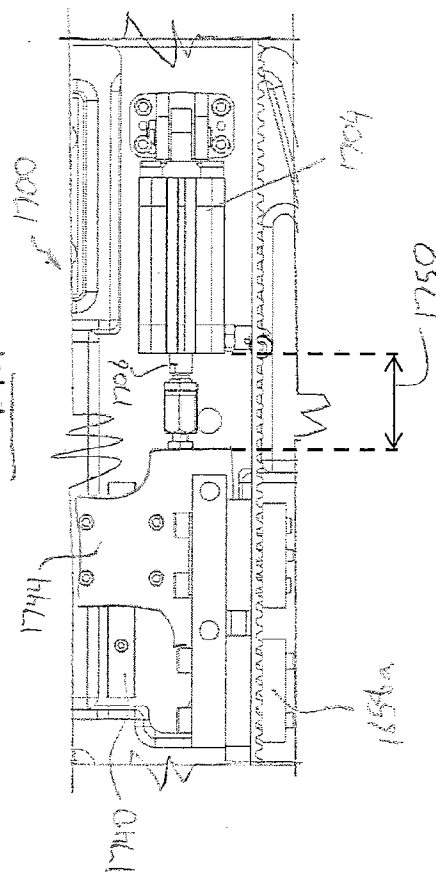
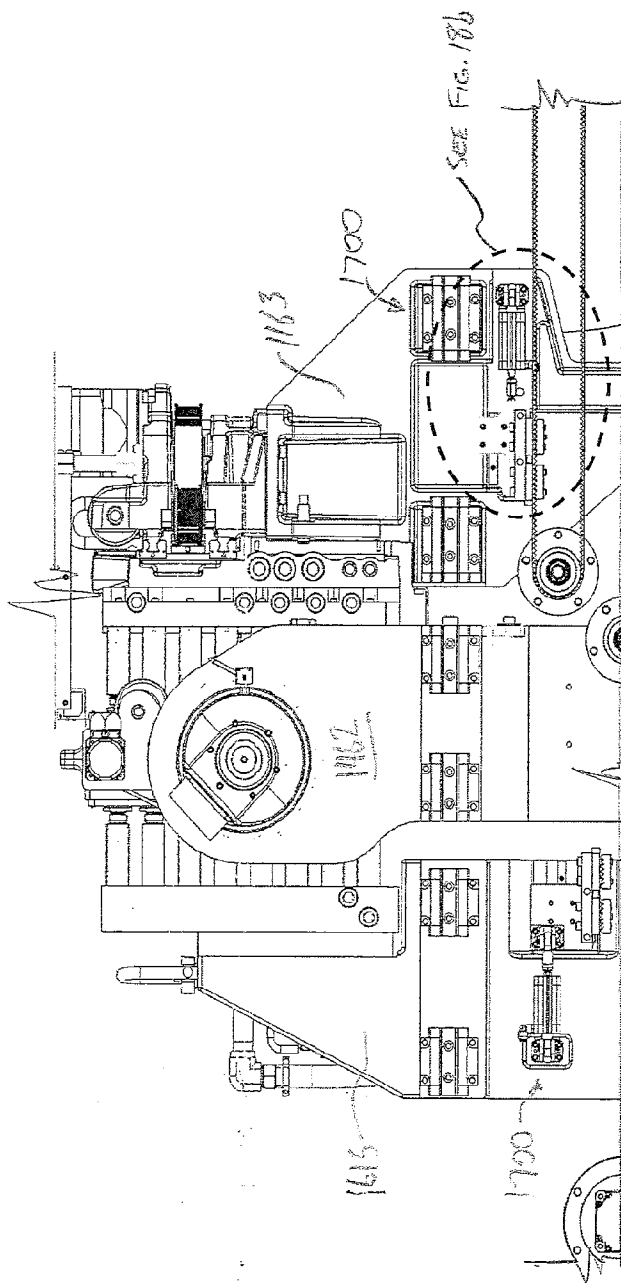


Fig. 16C



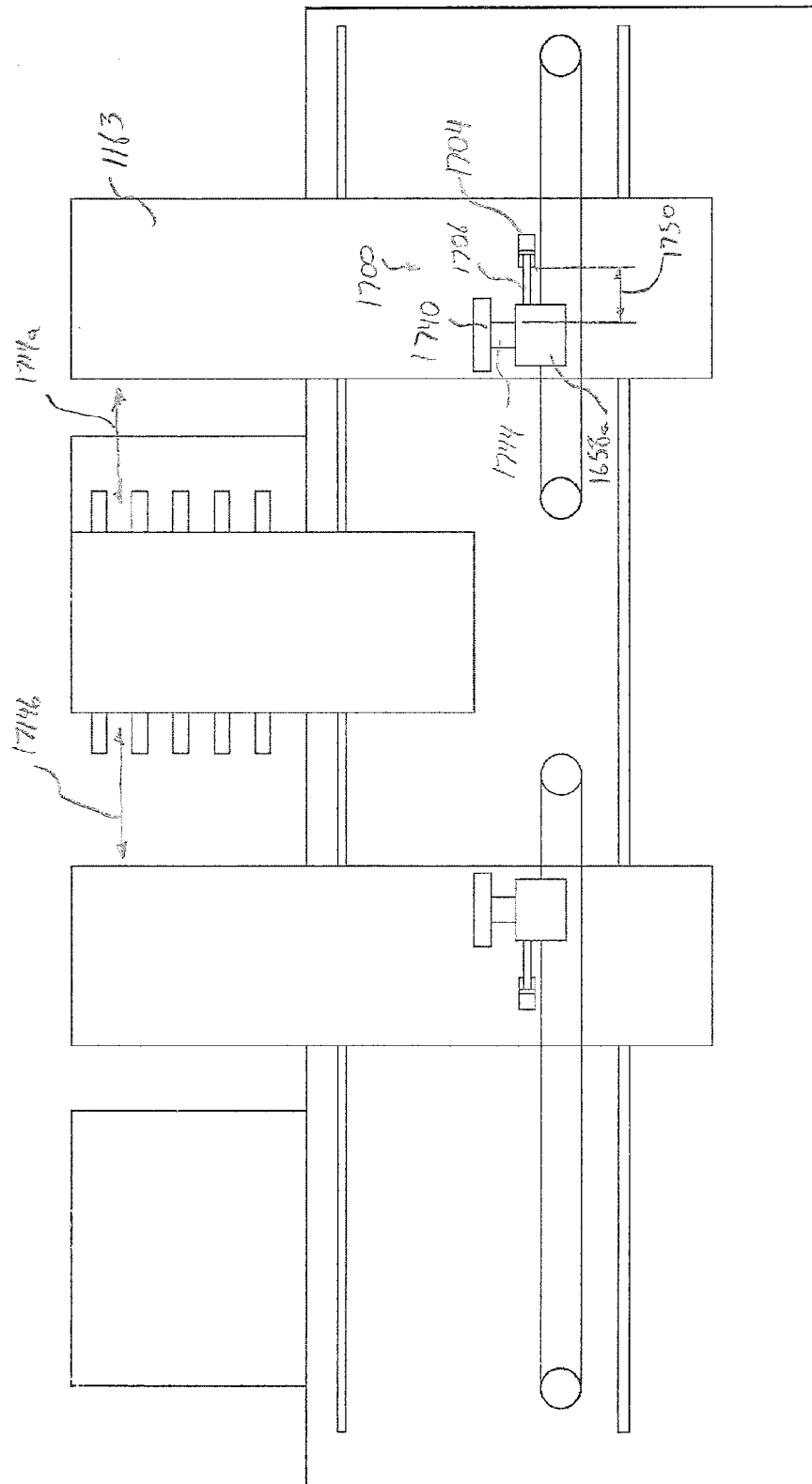
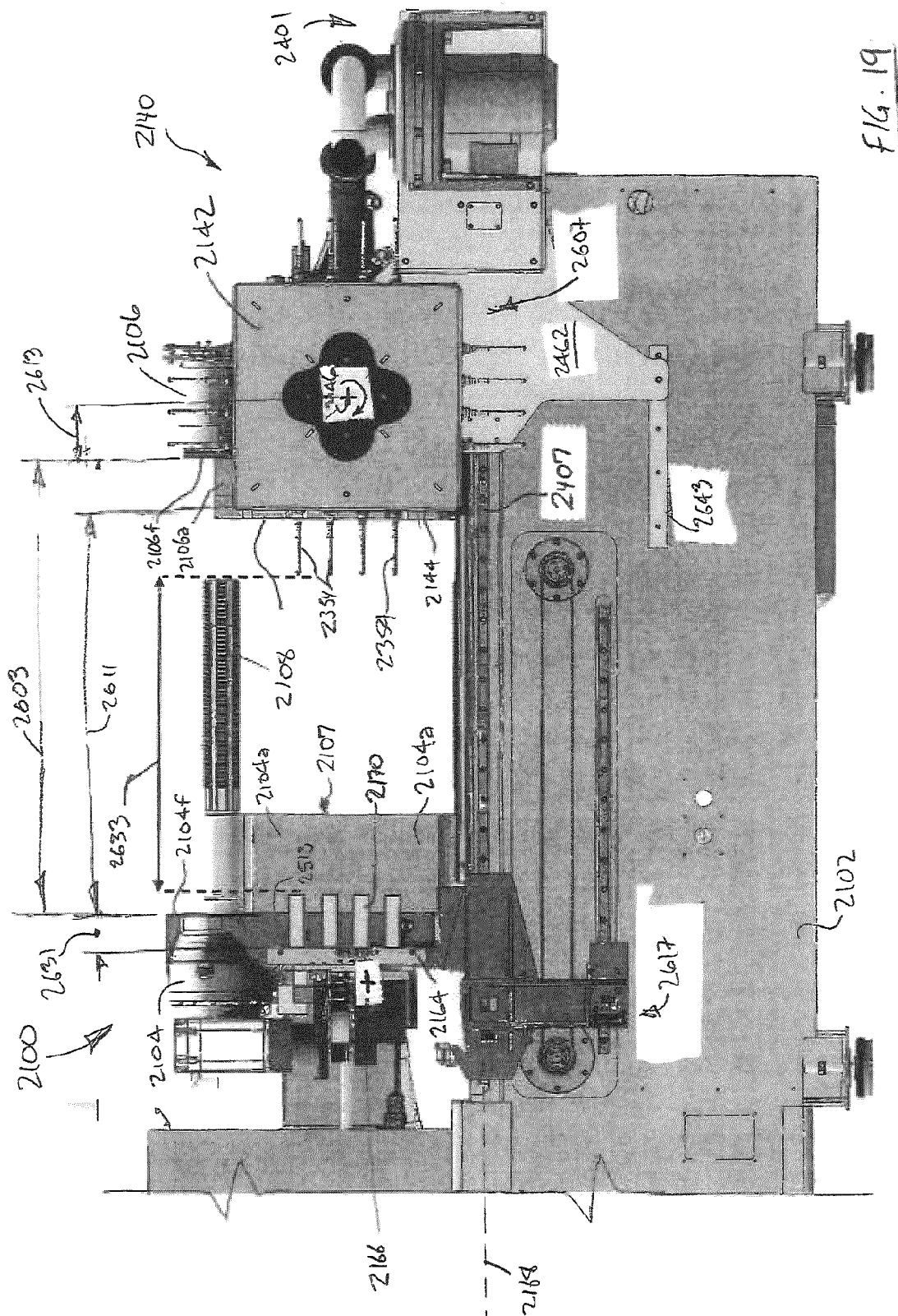
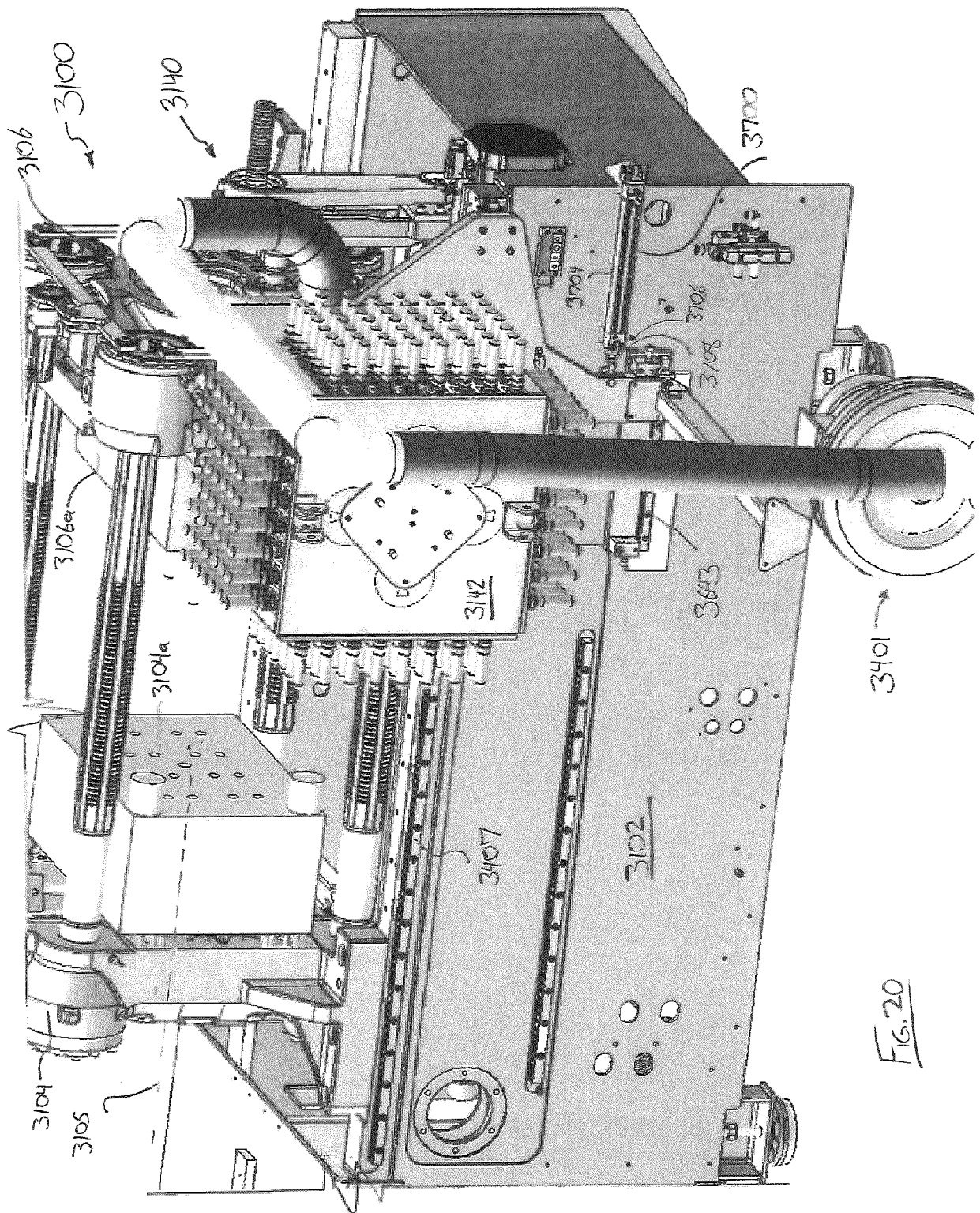
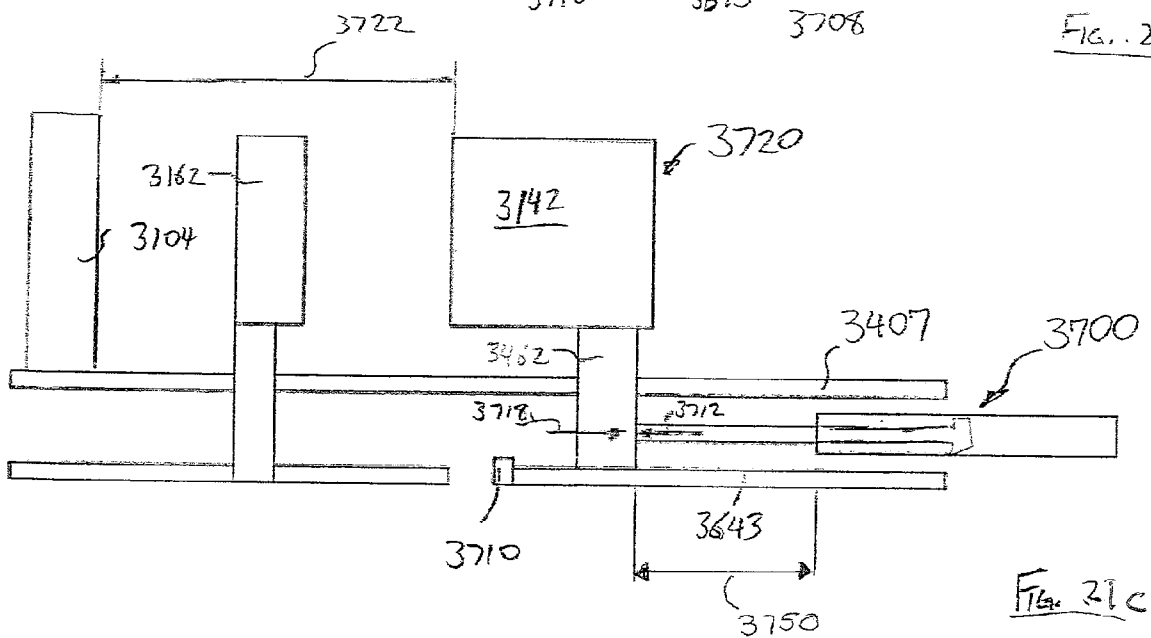
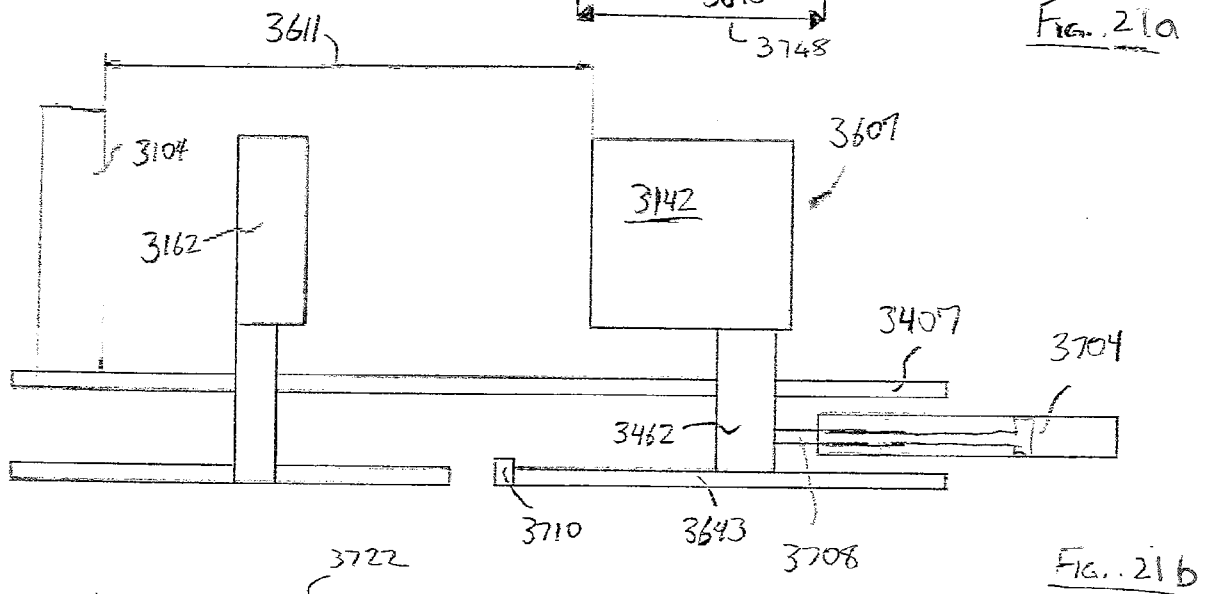
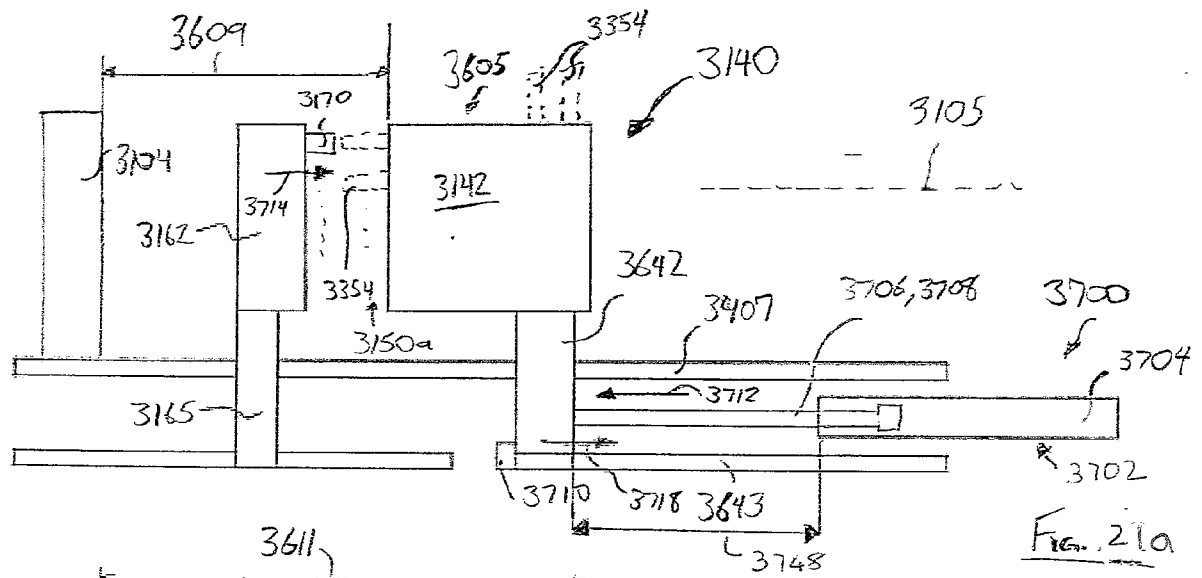


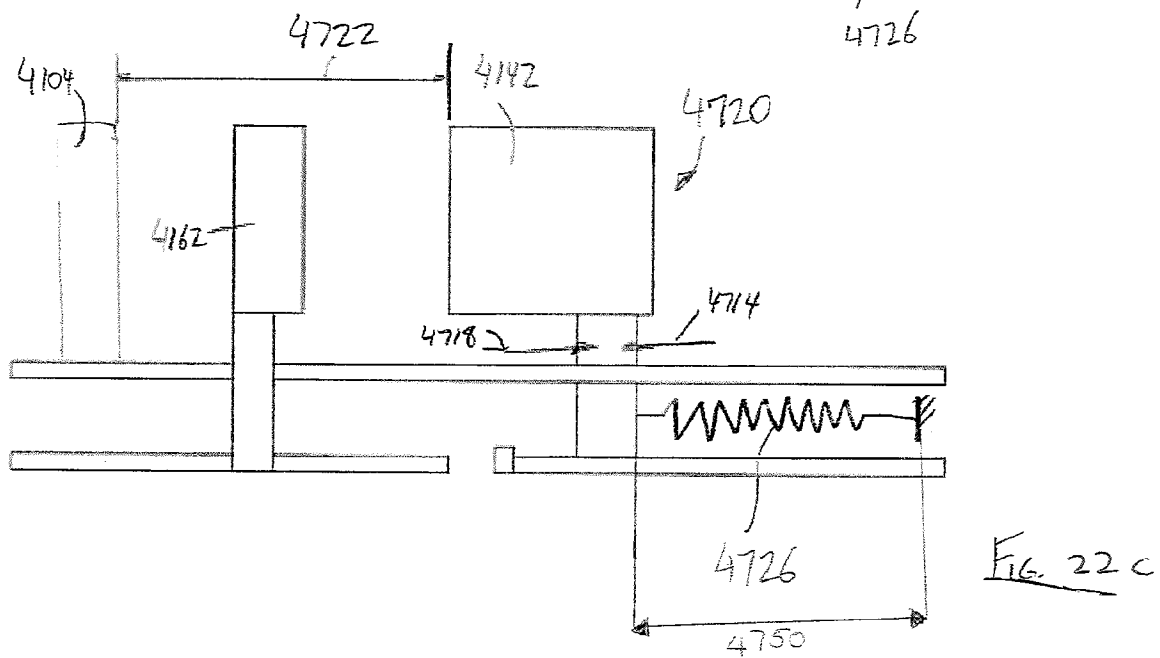
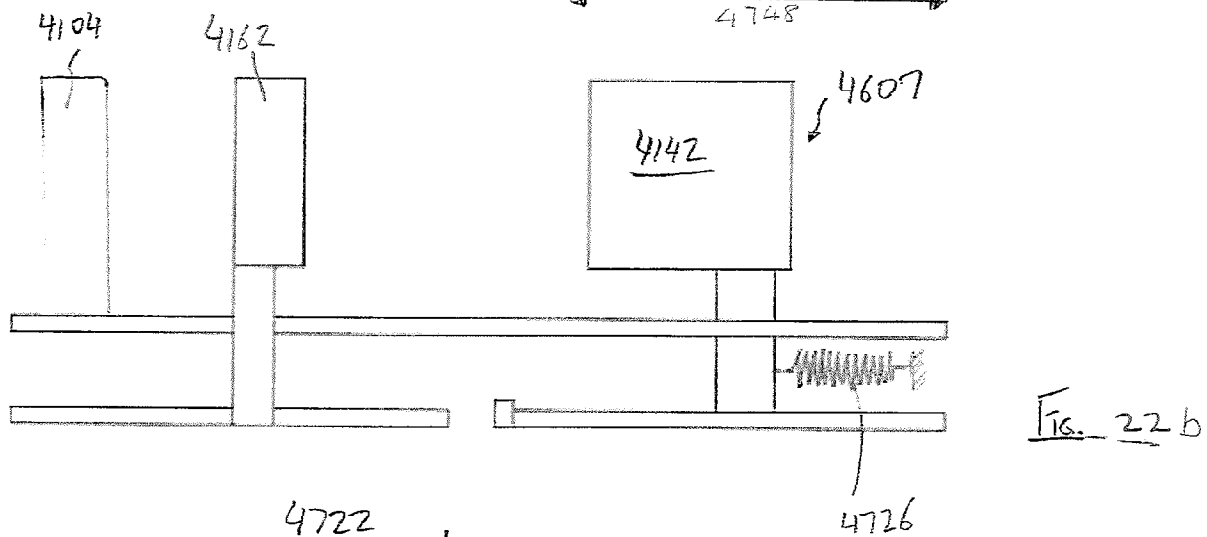
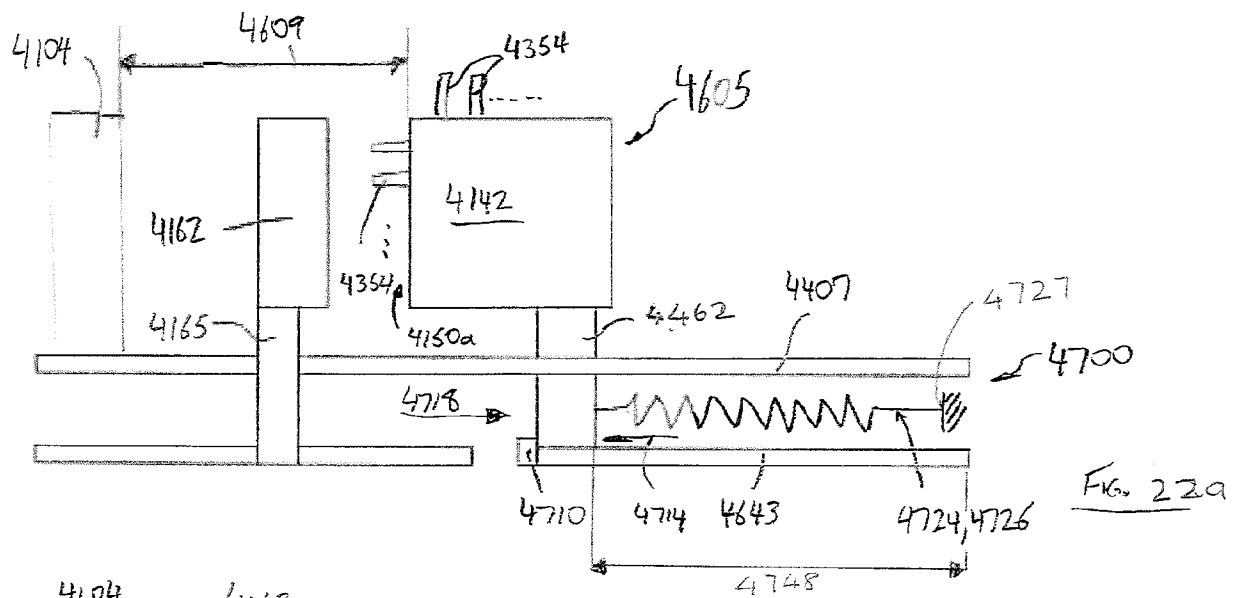
Fig. 17c











# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/CA2013/050024

| <p>A. CLASSIFICATION OF SUBJECT MATTER<br/> IPC: <b>B29C 45/17</b> (2006.01) , <b>B29C 45/80</b> (2006.01)<br/> According to International Patent Classification (IPC) or to both national classification and IPC</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----|----------------------------------------------------------------------------------------|------|---|------------------------------------------------------------------------------------------------|------|
| <p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols)<br/> IPC: <b>B29C 45/*</b> (2006.01)</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)<br/> EPOQUE (EPODOC and X-FULL), CPD with key words, such as: mold/mould machine, part handl+, take-off device, part remov+, article handl+, article remov+, robot and cooling.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
| <p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 60%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 30%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">A,P</td> <td>WO 2012/037686 A1 (SCHAD, R. D. et al.) 29 March 2012 (29-03-2012)<br/>*whole document*</td> <td style="text-align: center; vertical-align: top;">1-51</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">A</td> <td>US 2004/0185136 A1 (DOMODOSSOLA, R. et al.) 23 September 2004 (23-09-2004)<br/>*whole document*</td> <td style="text-align: center; vertical-align: top;">1-51</td> </tr> </tbody> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                             | Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Relevant to claim No. | A,P | WO 2012/037686 A1 (SCHAD, R. D. et al.) 29 March 2012 (29-03-2012)<br>*whole document* | 1-51 | A | US 2004/0185136 A1 (DOMODOSSOLA, R. et al.) 23 September 2004 (23-09-2004)<br>*whole document* | 1-51 |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Relevant to claim No.                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
| A,P                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | WO 2012/037686 A1 (SCHAD, R. D. et al.) 29 March 2012 (29-03-2012)<br>*whole document*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1-51                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | US 2004/0185136 A1 (DOMODOSSOLA, R. et al.) 23 September 2004 (23-09-2004)<br>*whole document*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1-51                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
| <p><input type="checkbox"/> Further documents are listed in the continuation of Box C.      <input checked="" type="checkbox"/> See patent family annex.</p> <table style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 50%; vertical-align: top;"> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> </td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                             | <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> | <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> |                       |     |                                                                                        |      |   |                                                                                                |      |
| <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> |                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
| <p>Date of the actual completion of the international search</p> <p>27 February 2013 (27-02-2013)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <p>Date of mailing of the international search report</p> <p>27 March 2013 (27-03-2013)</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |
| <p>Name and mailing address of the ISA/CA<br/> Canadian Intellectual Property Office<br/> Place du Portage I, C114 - 1st Floor, Box PCT<br/> 50 Victoria Street<br/> Gatineau, Quebec K1A 0C9<br/> Facsimile No.: 001-819-953-2476</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <p>Authorized officer</p> <p><b>Pengfei Zhang (819) 953-0654</b></p>                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |     |                                                                                        |      |   |                                                                                                |      |

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/CA2013/050024**

| Patent Document<br>Cited in Search Report | Publication<br>Date            | Patent Family<br>Member(s)                                                                                                                                                                                                                                                | Publication<br>Date                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WO 2012037686 A1                          | 29 March 2012 (29-03-2012)     | None                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| US 2004185136 A1                          | 23 September 2004 (23-09-2004) | AT465858T<br>CA2516480A1<br>CA2516480C<br>CN1761559A<br>CN100480017C<br>DE602004026842D1<br>EP1608496A1<br>EP1608496B1<br>JP2006520706A<br>JP4339887B2<br>KR20050113656A<br>KR100742923B1<br>TWI232161B<br>US7104780B2<br>US2006263467A1<br>US7264463B2<br>WO2004082922A1 | 15 May 2010 (15-05-2010)<br>30 September 2004 (30-09-2004)<br>28 April 2009 (28-04-2009)<br>19 April 2006 (19-04-2006)<br>22 April 2009 (22-04-2009)<br>10 June 2010 (10-06-2010)<br>28 December 2005 (28-12-2005)<br>28 April 2010 (28-04-2010)<br>14 September 2006 (14-09-2006)<br>07 October 2009 (07-10-2009)<br>02 December 2005 (02-12-2005)<br>25 July 2007 (25-07-2007)<br>11 May 2005 (11-05-2005)<br>12 September 2006 (12-09-2006)<br>23 November 2006 (23-11-2006)<br>04 September 2007 (04-09-2007)<br>30 September 2004 (30-09-2004) |