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(71) Applicant (for all designated States except US): **NESS INVENTIONS** [US/US]; 10229 North 67th Lane, Stillwater, MN 55082 (US).

(71) Applicants and

(72) Inventors (for all designated States except US): **NESS, John, T.** [US/US]; 10229 North 67th Lane, Stillwater, MN 55082 (US). **NESS, Jeffrey, A.** [US/US]; 5775 Newbury Avenue North, Oak Park Heights, MN (US).

(74) Agent: **DICKE, Steven, E.**; Suite 2250 Fifth Street Towers, 100 South Fifth Street, Minneapolis, Minnesota 55402 (US).

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(54) Title: BLOCK MOLD HAVING MOVEABLE LINER

(57) Abstract: A mold assembly for manufacturing concrete blocks and which is adapted for use in a concrete block machine. The mold assembly includes a plurality of liner plates forming at least a first mold cavity, wherein at least a first liner plate is moveable, and a drive assembly. The drive assembly includes a first drive element having a first end and coupled to the first moveable liner plate proximate to a second end, and an actuator assembly. The actuator assembly includes a second drive element selectively coupled to the first drive element proximate to the first end, wherein the actuator assembly is configured to drive the second drive element along a first axis so as to cause at least the second end of the first drive element to move along a second axis and cause the first moveable liner plate to move toward and away from an interior of the first mold cavity.

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BLOCK MOLD HAVING MOVEABLE LINER**Cross-Reference to Related Applications**

10 The subject matter of this application is related to the subject matter of U.S. Provisional Patent Application No. 60/679,464, filed May 10, 2005, priority to which is claimed under 35 U.S.C. § 119(e) and which is incorporated herein by reference.

 This application is related to U.S. Patent Application Serial Number
15 10/629,460, Attorney Docket Number H295.101.101, entitled "CONCRETE BLOCK MOLD WITH MOVEABLE LINER," filed July 29, 2003; U.S. Patent Application Serial Number 10/879,381, Attorney Docket Number H295.104.101, entitled "CONCRETE BLOCK MOLD WITH MOVEABLE LINER," filed June 29, 2004; and U.S. Patent Application Serial Number
20 11/036,147, Attorney Docket Number H295.107.101, entitled "BLOCK MOLD HAVING MOVEABLE LINER," filed January 13, 2005; all of which are incorporated herein by reference.

The Field of the Invention

25 The present invention relates to block molds, and more particularly to a concrete block mold adapted for use with a concrete block machine and having at least one moveable liner.

Background of the Invention

30 Concrete blocks, also referred to as concrete masonry units (CMUs), are typically manufactured by forming them into various shapes using a concrete block machine employing a mold frame assembled so as to form a mold box. A mold cavity having a negative of a desired shape of the block to be formed is provided within the mold box. A support board, or pallet, is moved via a
35 conveyor system onto a pallet table. The pallet table is moved upward until the

5 pallet contacts and forms a bottom of the mold box. The cavity is then filled with concrete by a moveable feedbox drawer.

As soon as the mold is filled with concrete, the feedbox drawer is moved back to a storage position and a plunger, or head shoe assembly, descends to form a top of the mold. The head shoe assembly is typically matched to the top
10 outside surface of the mold cavity and is hydraulically or mechanically pressed down on the concrete. The head shoe assembly compresses the concrete to a desired pounds-per-square-inch (psi) rating and block dimension while simultaneously vibrating the mold along with the vibrating table, resulting in substantial compression and optimal distribution of the concrete throughout the
15 mold cavity.

Because of the compression, the concrete reaches a level of hardness that permits immediate stripping of the finished block from the mold. To remove the finished block from the mold, the mold remains stationary while the shoe and pallet table, along with the corresponding pallet, are moved downward and force
20 the block from the mold onto the pallet. As soon as the bottom edge of the head shoe assembly clears the bottom edge of the mold, the conveyor system moves the pallet with the finished block forward, and another pallet takes its place under the mold. The pallet table then raises the next pallet to form a bottom of the mold box for the next block, and the process is repeated.

25 For many types of CMU's (e.g., pavers, patio blocks, light weight blocks, cinder blocks, etc.), but for retaining wall blocks and architectural units in particular, it is desirable for at least one surface of the block to have a desired texture, such as a stone-like texture. One technique for creating a desired texture on the block surface is to provide a negative of a desired pattern or texture on the
30 side walls of the mold. However, because of the way finished blocks are vertically ejected from the mold, any such pattern or texture would be stripped from the side walls unless they are moved away from the mold interior prior to the block being ejected.

One technique employed for moving the sidewalls of a mold involves the
35 use of a cam mechanism to move the sidewalls of the mold inward and an

5 opposing spring to push the sidewalls outward from the center of the mold.
However, this technique applies an "active" force to the sidewall only when the
sidewall is being moved inward and relies on the energy stored in the spring to
move the sidewall outward. The energy stored in the spring may potentially be
insufficient to retract the sidewall if the sidewall sticks to the concrete.
10 Additionally, the cam mechanism can potentially be difficult to utilize within the
limited confines of a concrete block machine.

A second technique involves using a piston to extend and retract the
sidewall. However, a shaft of the piston shaft is coupled directly to the
moveable sidewall and moves in-line with the direction of movement of the
15 moveable sidewall. Thus, during compression of the concrete by the head shoe
assembly, an enormous amount of pressure is exerted directly on the piston via
the piston shaft. Consequently, a piston having a high psi rating is required to
hold the sidewall in place during compression and vibration of the concrete.
Additionally, the direct pressure on the piston shaft can potentially cause
20 increased wear and shorten the expected life of the piston.

Summary of the Invention

One embodiment of the present invention provides a mold assembly for
manufacturing concrete blocks and which is adapted for use in a concrete block
25 machine. The mold assembly includes a plurality of liner plates forming at least
a first mold cavity, wherein at least a first liner plate is moveable, and a drive
assembly. The drive assembly includes a first drive element having a first end
and coupled to the first moveable liner plate proximate to a second end, and an
actuator assembly. The actuator assembly includes a second drive element
30 selectively coupled to the first drive element proximate to the first end, wherein
the actuator assembly is configured to drive the second drive element along a
first axis so as to cause at least the second end of the first drive element to move
along a second axis and cause the first moveable liner plate to move toward and
away from an interior of the first mold cavity.

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Brief Description of the Drawings

Figure 1 is a perspective view of one exemplary embodiment of a mold assembly having moveable liner plates according to the present invention.

Figure 2 is a perspective view of one exemplary embodiment of a gear drive assembly and moveable liner plate according to the present invention.

10 Figure 3A is a top view of gear drive assembly and moveable liner plate as illustrated in Figure 2.

Figure 3B is a side view of gear drive assembly and moveable liner plate as illustrated in Figure 2.

15 Figure 4A is a top view of the mold assembly of Figure 1 having the liner plates retracted.

Figure 4B is a top view of the mold assembly of Figure 1 having the liner plates extended.

Figure 5A illustrates a top view of one exemplary embodiment of a gear plate according to the present invention.

20 Figure 5B illustrates an end view of the gear plate illustrated by Figure 5A.

Figure 5C illustrates a bottom view of one exemplary embodiment of a gear head according to the present invention.

Figure 5D illustrates an end view of the gear head of Figure 5C.

25 Figure 6A is a top view of one exemplary embodiment of a gear track according to the present invention.

Figure 6B is a side view of the gear track of Figure 6A.

Figure 6C is an end view of the gear track of Figure 6A.

30 Figure 7 is a diagram illustrating the relationship between a gear track and gear plate according to the present invention.

Figure 8A is a top view illustrating the relationship between one exemplary embodiment of a gear head, gear plate, and gear track according to the present invention.

Figure 8B is a side view of the illustration of Figure 8A.

35 Figure 8C is an end view of the illustration of Figure 8A.

5 Figure 9A is a top view illustrating one exemplary embodiment of a gear plate being in a retracted position within a gear track according to the present invention.

 Figure 9B is a top view illustrating one exemplary embodiment of a gear plate being in an extended position from a gear track according to the present
10 invention.

 Figure 10A is a diagram illustrating one exemplary embodiment of drive unit according to the present invention.

 Figure 10B is a partial top view of the drive unit of the illustration of Figure 10A.

15 Figure 11A is a top view illustrating one exemplary embodiment of a mold assembly according to the present invention.

 Figure 11B is a diagram illustrating one exemplary embodiment of a gear drive assembly according to the present invention.

 Figure 12 is a perspective view illustrating a portion of one exemplary
20 embodiment of a mold assembly according to the present invention.

 Figure 13 is a perspective view illustrating one exemplary embodiment of a gear drive assembly according to the present invention.

 Figure 14 is a top view illustrating a portion of one exemplary embodiment of a mold assembly and gear drive assembly according to the
25 present invention.

 Figure 15A is a top view illustrating a portion of one exemplary embodiment of a gear drive assembly employing a stabilizer assembly.

 Figure 15B is a cross-sectional view of the gear drive assembly of Figure 15A.

30 Figure 15C is a cross-sectional view of the gear drive assembly of Figure 15A.

 Figure 16 is a side view illustrating a portion of one exemplary embodiment of a gear drive assembly and moveable liner plate according to the present invention.

5 Figure 17 is a block diagram illustrating one exemplary embodiment of a mold assembly employing a control system according to the present invention.

 Figure 18A is a top view illustrating a portion of one exemplary embodiment of gear drive assembly employing a screw drive system according to the present invention.

10 Figure 18B is a lateral cross-sectional view of the gear drive assembly of Figure 18A.

 Figure 18C is a longitudinal cross-sectional view of the gear drive assembly of Figure 18A.

15 Figure 19A is a perspective view of one embodiment of a drive assembly according to the present invention.

 Figure 19B is a top view of the drive assembly of Figure 19A.

 Figure 20 is a perspective view of one embodiment of a drive assembly according to the present invention.

20 Figure 21 is a top view of one embodiment of a drive assembly according to the present invention.

 Figure 22 is a top view of one embodiment of a drive assembly according to the present invention.

 Figure 23 is a perspective view of one embodiment of a drive assembly according to the present invention.

25

Description of the Preferred Embodiments

 In the following Detailed Description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be
30 practiced. In this regard, directional terminology, such as “top,” “bottom,” “front,” “back,” “leading,” “trailing,” etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and
35 is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from

5 the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

Figure 1 is a perspective view of one exemplary embodiment of a mold assembly 30 having moveable liner plates 32a, 32b, 32c and 32d according to the present invention. Mold assembly 30 includes a drive system assembly 31
10 having side-members 34a and 34b and cross-members 36a and 36b, respectively having an inner wall 38a, 38b, 40a, and 40b, and coupled to one another such that the inner surfaces form a mold box 42. In the illustrated embodiment, cross members 36a and 36b are bolted to side members 34a and 34b with bolts 37.

15 Moveable liner plates 32a, 32b, 32c, and 32d, respectively have a front surface 44a, 44b, 44c, and 44d configured so as to form a mold cavity 46. In the illustrated embodiment, each liner plate has an associated gear drive assembly located internally to an adjacent mold frame member. A portion of a gear drive assembly 50 corresponding to liner plate 32a and located internally to cross-
20 member 36a is shown extending through side-member 34a. Each gear drive assembly is selectively coupled to its associated liner plate and configured to move the liner plate toward the interior of mold cavity 46 by applying a first force in a first direction parallel to the associated cross-member, and to move the liner plate away from the interior of mold cavity 46 by applying a second force
25 in a direction opposite the first direction. Side members 34a and 34b and cross-members 36a and 36b each have a corresponding lubrication port that extends into the member and provides lubrication to the corresponds gear elements. For example, lubrication ports 48a and 48b. The gear drive assembly and moveable liner plates according to the present invention are discussed in greater detail
30 below.

In operation, mold assembly 30 is selectively coupled to a concrete block machine. For ease of illustrative purposes, however, the concrete block machine is not shown in Figure 1. In one embodiment, mold assembly 30 is mounted to the concrete block machine by bolting side members 34a and 34b of drive
35 system assembly 31 to the concrete block machine. In one embodiment, mold

5 assembly 30 further includes a head shoe assembly 52 having dimensions substantially equal to those of mold cavity 46. Head shoe assembly 52 is also configured to selectively couple to the concrete block machine.

Liner plates 32a through 32d are first extended a desired distance toward the interior of mold box 42 to form the desired mold cavity 46. A vibrating table
10 on which a pallet 56 is positioned is then raised (as indicated by directional arrow 58) such that pallet 56 contacts and forms a bottom to mold cavity 46. In one embodiment, a core bar assembly (not shown) is positioned within mold cavity 46 to create voids within the finished block in accordance with design requirements of a particular block.

15 Mold cavity 46 is then filled with concrete from a moveable feedbox drawer. Head shoe assembly 52 is then lowered (as indicated by directional arrow 54) onto mold 46 and hydraulically or mechanically presses the concrete. Head shoe assembly 52 along with the vibrating table then simultaneously vibrate mold assembly 30, resulting in a high compression of the concrete within
20 mold cavity 46. The high level of compression fills any voids within mold cavity 46 and causes the concrete to quickly reach a level of hardness that permits immediate removal of the finished block from mold cavity 46.

The finished block is removed by first retracting liner plates 32a through 32d. Head shoe assembly 52 and the vibrating table, along with pallet 56, are
25 then lowered (in a direction opposite to that indicated by arrow 58), while mold assembly 30 remains stationary so that head shoe assembly 56 pushes the finished block out of mold cavity 46 onto pallet 52. When a lower edge of head shoe assembly 52 drops below a lower edge of mold assembly 30, the conveyer system moves pallet 56 carrying the finished block away and a new pallet takes
30 its place. The above process is repeated to create additional blocks.

By retracting liner plates 32a through 32b prior to removing the finished block from mold cavity 46, liner plates 32a through 32d experience less wear and, thus, have an increased operating life expectancy. Furthermore, moveable liner plates 32a through 32d also enables a concrete block to be molded in a
35 vertical position relative to pallet 56, in lieu of the standard horizontal position,

5 such that head shoe assembly 52 contacts what will be a “face” of the finished concrete block. A “face” is a surface of the block that will be potentially be exposed for viewing after installation in a wall or other structure.

Figure 2 is a perspective view 70 illustrating a moveable liner plate and corresponding gear drive assembly according to the present invention, such as
10 moveable liner plate 32a and corresponding gear drive assembly 50. For illustrative purposes, side member 34a and cross-member 36 are not shown. Gear drive assembly 50 includes a first gear element 72 selectively coupled to liner plate 32a, a second gear element 74, a single rod-end double-acting pneumatic cylinder (cylinder) 76 coupled to second gear element 74 via a piston
15 rod 78, and a gear track 80. Cylinder 76 includes an aperture 82 for accepting a pneumatic fitting. In one embodiment, cylinder 76 comprises a hydraulic cylinder. In one embodiment, cylinder 76 comprises a double rod-end dual-acting cylinder. In one embodiment, piston rod 78 is threadably coupled to second gear element 74.

20 In the embodiment of Figure 2, first gear element 72 and second gear element 74 are illustrated and hereinafter referred to as a gear plate 72 and second gear element 74, respectively. However, while illustrated as a gear plate and a cylindrical gear head, first gear element 72 and second gear element 74 can be of any suitable shape and dimension.

25 Gear plate 72 includes a plurality of angled channels on a first major surface 84 and is configured to slide in gear track 80. Gear track 80 slidably inserts into a gear slot (not shown) extending into cross member 36a from inner wall 40a. Cylindrical gear head 74 includes a plurality of angled channels on a surface 86 adjacent to first major surface 84 of female gear plate 72, wherein the
30 angled channels are tangential to a radius of cylindrical gear head 74 and configured to slidably mate and interlock with the angled channels of gear plate 72. Liner plate 32a includes guide posts 88a, 88b, 88c, and 88d extending from a rear surface 90. Each of the guide posts is configured to slidably insert into a corresponding guide hole (not shown) extending into cross member 36a from

5 inner wall 40a. The gear slot and guide holes are discussed in greater detail below.

When cylinder 76 extends piston rod 78, cylindrical gear head 74 moves in a direction indicated by arrow 92 and, due to the interlocking angled channels, causes gear plate 72 and, thus, liner plate 32a to move toward the interior of
10 mold 46 as indicated by arrow 94. It should be noted that, as illustrated, Figure 2 depicts piston rod 78 and cylindrical gear head 74 in an extended position. When cylinder 76 retracts piston rod 78, cylindrical gear head 74 moves in a direction indicated by arrow 96 causing gear plate 72 and liner plate 32 to move away from the interior of the mold as indicated by arrow 98. As liner plate 32a
15 moves, either toward or away from the center of the mold, gear plate 72 slides in guide track 80 and guide posts 88a through 88d slide within their corresponding guide holes.

In one embodiment, a removable liner face 100 is selectively coupled to front surface 44a via fasteners 102a, 102b, 102c, and 102d extending through
20 liner plate 32a. Removable liner face 100 is configured to provide a desired shape and/or provide a desired imprinted pattern, including text, on a block made in mold 46. In this regard, removable liner face 100 comprises a negative of the desired shape or pattern. In one embodiment, removable liner face 100 comprises a polyurethane material. In one embodiment, removable liner face
25 100 comprises a rubber material. In one embodiment, removable liner plate comprises a metal or metal alloy, such as steel or aluminum. In one embodiment, liner plate 32 further includes a heater mounted in a recess 104 on rear surface 90, wherein the heater aids in curing concrete within mold 46 to reduce the occurrence of concrete sticking to front surface 44a and removable
30 liner face 100.

Figure 3A is a top view 120 of gear drive assembly 50 and liner plate 32a, as indicated by directional arrow 106 in Figure 2. In the illustration, side members 34a and 34b, and cross member 36a are indicated dashed lines. Guide posts 88c and 88d are slidably inserted into guide holes 122c and 122d,
35 respectively, which extend into cross member 36a from interior surface 40a.

5 Guide holes 122a and 122b, corresponding respectively to guide posts 88a and 88b, are not shown but are located below and in-line with guide holes 122c and 122d. In one embodiment, guide hole bushings 124c and 124d are inserted into guide holes 122c and 122d, respectively, and slidably receive guide posts 88c and 88d. Guide hole bushings 124a and 124b are not shown, but are located
10 below and in-line with guide hole bushings 124c and 124d. Gear track 80 is shown as being slidably inserted in a gear slot 126 extending through cross member 36a with gear plate 72 sliding in gear track 80. Gear plate 72 is indicated as being coupled to liner plate 32a by a plurality of fasteners 128 extending through liner plate 32a from front surface 44a.

15 A cylindrical gear shaft is indicated by dashed lines 134 as extending through side member 34a and into cross member 36a and intersecting, at least partially with gear slot 126. Cylindrical gear head 74, cylinder 76, and piston rod 78 are slidably inserted into gear shaft 134 with cylindrical gear head 74 being positioned over gear plate 72. The angled channels of cylindrical gear
20 head 74 are shown as dashed lines 130 and are interlocking with the angled channels of gear plate 72 as indicated at 132.

Figure 3B is a side view 140 of gear drive assembly 50 and liner plate 32a, as indicated by directional arrow 108 in Figure 2. Liner plate 32a is indicated as being extended, at least partially, from cross member 36a.

25 Correspondingly, guide posts 88a and 88d are indicated as partially extending from guide hole bushings 124a and 124d, respectively. In one embodiment, a pair of limit rings 142a and 142d are selectively coupled to guide posts 88a and 88, respectively, to limit an extension distance that liner plate 32a can be extended from cross member 36a toward the interior of mold cavity 46. Limit
30 rings 142b and 142c corresponding respectively to guide posts 88b and 88c are not shown, but are located behind and in-line with limit rings 142a and 142d. In the illustrated embodiment, the limit rings are indicated as being substantially at an end of the guide posts, thus allowing a substantially maximum extension distance from cross member 36a. However, the limit rings can be placed at other

5 locations along the guide posts to thereby adjust the allowable extension distance.

Figure 4A and Figure 4B are top views 150 and 160, respectively, of mold assembly 30. Figure 4A illustrates liner plates 32a, 32b, 32c, and 32d in a retracted positions. Liner faces 152, 154, and 154 correspond respectively to
10 liner plates 32b, 32c, and 32d. Figure 4B illustrates liner plates 32a, 32b, 32c, and 32d, along with their corresponding liner faces 100, 152, 154, and 156 in an extended position.

Figure 5A is a top view 170 of gear plate 72. Gear plate 72 includes a plurality of angled channels 172 running across a top surface 174 of gear plate
15 72. Angled channels 172 form a corresponding plurality of linear "teeth" 176 having as a surface the top surface 174. Each angled channel 172 and each tooth 176 has a respective width 178 and 180. The angled channels run at an angle (©) 182 from 0°, indicated at 186, across gear plate 72.

Figure 5B is an end view ("A") 185 of gear plate 72, as indicated by
20 directional arrow 184 in Figure 5A, further illustrating the plurality of angled channels 172 and linear teeth 176. Each angled channel 172 has a depth 192.

Figure 5C illustrates a view 200 of a flat surface 202 of cylindrical gear head 76. Cylindrical gear head 76 includes a plurality of angled channels 204 running across surface 202. Angled channels 204 form a corresponding plurality
25 of linear teeth 206. The angled channels 204 and linear teeth 206 have widths 180 and 178, respectively, such that the width of linear teeth 206 substantially matches the width of angled channels 172 and the width of angled channels 204 substantially match the width of linear teeth 176. Angled channels 204 and teeth 206 run at angle (©) 182 from 0°, indicated at 186, across surface 202.

30 Figure 5D is an end view 210 of cylindrical gear head 76, as indicated by directional arrow 208 in Figure 5C, further illustrating the plurality of angled channels 204 and linear teeth 206. Surface 202 is a flat surface tangential to a radius of cylindrical gear head 76. Each angled channel has a depth 192 from flat surface 202.

5 When cylindrical gear head 76 is “turned over” and placed across surface
174 of gear plate 72, linear teeth 206 of gear head 76 mate and interlock with
angled channels 172 of gear plate 72, and linear teeth 176 of gear plate 72 mate
and interlock with angled channels 204 of gear head 76 (See also Figure 2).
When gear head 76 is forced in direction 92, linear teeth 206 of gear head 76
10 push against linear teeth 176 of gear plate 72 and force gear plate 72 to move in
direction 94. Conversely, when gear head 76 is forced in direction 96, linear
teeth 206 of gear head 76 push against linear teeth 176 of gear plate 72 and force
gear plate 72 to move in direction 98.

 In order for cylindrical gear head 76 to force gear plate 72 in directions
15 94 and 98, angle (Θ) 182 must be greater than 0° and less than 90° . However, it
is preferable that Θ 182 be at least greater than 45° . When Θ 182 is 45° or less,
it takes more force for cylindrical gear head 74 moving in direction 92 to push
gear plate 72 in direction 94 than it does for gear plate 72 being forced in
direction 98 to push cylindrical gear head 74 in direction 96, such as when
20 concrete in mold 46 is being compressed. The more Θ 182 is increased above
 45° , the greater the force that is required in direction 98 on gear plate 72 to move
cylindrical gear head 74 in direction 96. In fact, at 90° gear plate 72 would be
unable to move cylindrical gear head 74 in either direction 92 or 96, regardless
of how much force was applied to gear plate 72 in direction 98. In effect, angle
25 (Θ) acts as a multiplier to a force provided to cylindrical gear head 74 by
cylinder 76 via piston rod 78. When Θ 182 is greater than 45° , an amount of
force required to be applied to gear plate 72 in direction 98 in order to move
cylindrical gear head 74 in direction 96 is greater than an amount of force
required to be applied to cylindrical gear head 74 in direction 92 via piston rod
30 78 in order to “hold” gear plate 72 in position (i.e., when concrete is being
compressed in mold 46).

 However, the more Θ 182 is increased above 45° , the less distance gear
plate 72, and thus corresponding liner plate 32a, will move in direction 94 when
cylindrical gear head 74 is forced in direction 92. A preferred operational angle
35 for Θ 182 is approximately 70° . This angle represents roughly a balance, or

5 compromise, between the length of travel of gear plate 72 and an increase in the level of force required to be applied in direction 98 on gear plate 72 to force gear head 74 in direction 96. Gear plate 72 and cylindrical gear head 74 and their corresponding angled channels 176 and 206 reduce the required psi rating of cylinder 76 necessary to maintain the position of liner plate 32a when concrete is
10 being compressed in mold cavity 46 and also reduces the wear experienced by cylinder 76. Additionally, from the above discussion, it is evident that one method for controlling the travel distance of liner plate 32a is to control the angle (Θ) 182 of the angled channels 176 and 206 respectively of gear plate 72 and cylindrical gear head 74.

15 Figure 6A is a top view 220 of gear track 80. Gear track 80 has a top surface 220, a first end surface 224, and a second end surface 226. A rectangular gear channel, indicated by dashed lines 228, having a first opening 230 and a second opening 232 extends through gear track 80. An arcuate channel 234, having a radius required to accommodate cylindrical gear head 76 extends across
20 top surface 220 and forms a gear window 236 extending through top surface 222 into gear channel 228. Gear track 80 has a width 238 incrementally less than a width of gear opening 126 in side member 36a (see also Figure 3A).

Figure 6B is an end view 250 of gear track 80, as indicated by direction arrow 240 in Figure 6A, further illustrating gear channel 228 and arcuate channel
25 234. Gear track 80 has a depth 252 incrementally less than height of gear opening 126 in side member 36a (see Figure 3A). Figure 6B is a side view 260 of gear track 80 as indicated by directional arrow 242 in Figure 6A.

Figure 7 is a top view 270 illustrating the relationship between gear track 80 and gear plate 72. Gear plate 72 has a width 272 incrementally less than a
30 width 274 of gear track 80, such that gear plate 72 can be slidably inserted into gear channel 228 via first opening 230. When gear plate 72 is inserted within gear track 80, angled channels 172 and linear teeth 176 are exposed via gear window 236.

Figure 8A is a top view 280 illustrating the relationship between gear
35 plate 72, cylindrical gear head 74, and gear track 80. Gear plate 72 is indicated

5 as being slidably inserted within guide track 80. Cylindrical gear head 74 is indicated as being positioned within arcuate channel 234, with the angled channels and linear teeth of cylindrical gear head 74 being slidably mated and interlocked with the angled channels 172 and linear teeth 176 of gear plate 72. When cylindrical gear head 74 is moved in direction 92 by extending piston rod
10 78, gear plate 72 extends outward from gear track 80 in direction 94 (See also Figure 9B below). When cylindrical gear head 74 is moved in direction 96 by retracting piston rod 78, gear plate 72 retracts into gear track 80 in direction 98 (See also Figure 9A below).

Figure 8B is a side view 290 of gear plate 72, cylindrical gear head 74,
15 and guide track 80 as indicated by directional arrow 282 in Figure 8A.

Cylindrical gear head 74 is positioned such that surface 202 is located within arcuate channel 234. Angled channels 204 and teeth 206 of cylindrical gear head 74 extend through gear window 236 and interlock with angled channels 172 and linear teeth 176 of gear plate 72 located within gear channel 228.

20 Figure 8C is an end view 300 as indicated by directional arrow 284 in Figure 8A, and further illustrates the relationship between gear plate 72, cylindrical gear head 74, and guide track 80.

Figure 9A is top view 310 illustrating gear plate 72 being in a fully retracted position within gear track 80, with liner plate 32a being retracted
25 against cross member 36a. For purposes of clarity, cylindrical gear head 74 is not shown. Angled channels 172 and linear teeth 176 are visible through gear window 236. Liner plate 32a is indicated as being coupled to gear plate 72 with a plurality of fasteners 128 extending through liner plate 32a into gear plate 72. In one embodiment, fasteners 128 threadably couple liner plate 32a to gear plate
30 72.

Figure 9B is a top view 320 illustrating gear plate 72 being extended, at least partially from gear track 80, with liner plate 32a being separated from cross member 36a. Again, cylindrical gear head 74 is not shown and angled channels 172 and linear teeth 176 are visible through gear window 236.

5 Figure 10A is a diagram 330 illustrating one exemplary embodiment of a gear drive assembly 332 according to the present invention. Gear drive assembly 332 includes cylindrical gear head 74, cylinder 76, piston rod 78, and a cylindrical sleeve 334. Cylindrical gear head 74 and piston rod 78 are configured to slidably insert into cylindrical sleeve 334. Cylinder 76 is
10 threadably coupled to cylindrical sleeve 334 with an O-ring 336 making a seal. A window 338 along an axis of cylindrical sleeve 334 partially exposes angled channels 204 and linear teeth 206. A fitting 342, such as a pneumatic or hydraulic fitting, is indicated as being threadably coupled to aperture 82. Cylinder 76 further includes an aperture 344, which is accessible through cross
15 member 36a.

 Gear drive assembly 332 is configured to slidably insert into cylindrical gear shaft 134 (indicated by dashed lines) so that window 338 intersects with gear slot 126 so that angled channels 204 and linear teeth 206 are exposed within
20 gear slot 126. Gear track 80 and gear plate 72 (not shown) are first slidably inserted into gear slot 126, such that when gear drive assembly 332 is slidably inserted into cylindrical gear shaft 134 the angled channels 204 and linear teeth 206 of cylindrical gear head 74 slidably mate and interlock with the angled channels 172 and linear teeth 176 of gear plate 72.

 In one embodiment, a key 340 is coupled to cylindrical gear head 74 and
25 rides in a key slot 342 in cylindrical sleeve 334. Key 340 prevents cylindrical gear head 74 from rotating within cylindrical sleeve 334. Key 340 and key slot 342 together also control the maximum extension and retraction of cylindrical gear head 74 within cylindrical sleeve 334. Thus, in one embodiment, key 340 can be adjusted to control the extension distance of liner plate 32a toward the
30 interior of mold cavity 46. Figure 10A is a top view 350 of cylindrical shaft 334 as illustrated in Figure 10B, and further illustrates key 340 and key slot 342.

 Figure 11A is a top view illustrating one exemplary embodiment of a mold assembly 360 according to the present invention for forming two concrete blocks. Mold assembly 360 includes a mold frame 361 having side members
35 34a and 34b and cross members 36a through 36c coupled to one another so as to

5 form a pair of mold boxes 42a and 42b. Mold box 42a includes moveable liner plates 32a through 32d and corresponding removable liner faces 33a through 33d configured to form a mold cavity 46a. Mold box 42b includes moveable liner plates 32e through 32h and corresponding removable liner faces 33e through 33h configured to form a mold cavity 46b.

10 Each moveable liner plate has an associated gear drive assembly located internally to an adjacent mold frame member as indicated by 50a through 50h. Each moveable liner plate is illustrated in an extended position with a corresponding gear plate indicated by 72a through 72h. As described below, moveable liner plates 32c and 32e share gear drive assembly 50c/e, with gear
15 plate 72e having its corresponding plurality of angled channels facing upward and gear plate 72c having its corresponding plurality of angled channels facing downward.

Figure 11B is diagram illustrating a gear drive assembly according to the present invention, such as gear drive assembly 50c/e. Figure 11B illustrates a
20 view of gear drive assembly 50c/e as viewed from section A-A through cross-member 36c of Figure 11A. Gear drive assembly 50c/e includes a single cylindrical gear head 76c/e having angled channels 204c and 204e on opposing surfaces. Cylindrical gear head 76c/e fits into arcuate channels 234c and 234e of gear tracks 80c and 80d, such that angled channels 204c and 204e slidably
25 interlock with angled channels 172c and 172e of gear plates 72c and 72e respectively.

Angled channels 172c and 204c, and 172e and 204e oppose one another and are configured such that when cylindrical gear head 76c/e is extended (e.g. out from Figure 11B) gear plate 72c moves in a direction 372 toward the interior
30 of mold cavity 46a and gear plate 72e moves in a direction 374 toward the interior of mold cavity 46b. Similarly, when cylindrical gear head 76c/e is retracted (e.g. into Figure 11B) gear plate 72c moves in a direction 376 away from the interior of mold cavity 46a and gear plate 72e moves in a direction 378 away from the interior of mold cavity 378. Again, cylindrical gear head 76c/e
35 and gear plates 72c and 72c could be of any suitable shape.

5 Figure 12 is a perspective view illustrating a portion of one exemplary embodiment of a mold assembly 430 according to the present invention. Mold assembly includes moveable liner plates 432a through 432l for simultaneously molding multiple concrete blocks. Mold assembly 430 includes a drive system assembly 431 having a side members 434a and 434b, and cross members 436a
10 and 436b. For illustrative purposes, side member 434a is indicated by dashed lines. Mold assembly 430 further includes division plates 437a through 437g.

 Together, moveable liner plates 432a through 432l and division plates 437a through 437g form mold cavities 446a through 446f, with each mold cavity configured to form a concrete block. Thus, in the illustrated embodiment, mold
15 assembly 430 is configured to simultaneously form six blocks. However, it should be apparent from the illustration that mold assembly 430 can be easily modified for simultaneously forming quantities of concrete blocks other than six.

 In the illustrated embodiment, side members 434a and 434b each have a corresponding gear drive assembly for moving moveable liner plates 432a
20 through 432f and 432g through 432l, respectively. For illustrative purposes, only gear drive assembly 450 associated with side member 434a and corresponding moveable liner plates 432a through 432g is shown. Gear drive assembly 450 includes first gear elements 472a through 472f selectively coupled to corresponding moveable liner plates 432a through 432f, respectively, and a
25 second gear element 474. In the illustrated embodiment, first gear elements 472a through 472f and second gear element 474 are shown as being cylindrical in shape. However, any suitable shape can be employed.

 Second gear element 474 is selectively coupled to a cylinder-piston (not shown) via a piston rod 478. In one embodiment, which is described in greater
30 detail below (see Figure 12), second gear element 474 is integral with the cylinder-piston so as to form a single component.

 In the illustrated embodiment, each first gear element 472a through 472b further includes a plurality of substantially parallel angled channels 484 that slidably mesh and interlock with a plurality of substantially parallel angled
35 channels 486 on second gear element 474. When second gear element 474 is

5 moved in a direction indicated by arrow 492, each of the moveable liner plates 432a through 432f moves in a direction indicated by arrow 494. Similarly, when second gear element 474 is move in a direction indicated by arrow 496, each of the moveable liner plates 432a through 432f moves in a direction indicated by arrow 498.

10 In the illustrated embodiment, the angled channels 484 on each of the first gear elements 432a through 432f and the angled channels 486 are at a same angle. Thus, when second gear element 474 moves in direction 492 and 496, each moveable liner plate 432a through 432f moves a same distance in direction 494 and 498, respectively. In one embodiment, second gear element 474
15 includes a plurality of groups of substantially parallel angled channels with each group corresponding to a different one of the first gear elements 472a through 472f. In one embodiment, the angled channels of each group and its corresponding first gear element have a different angle such that each moveable liner plate 432a through 432f move a different distance in directions 494 and 498
20 in response to second gear element 474 being moved in direction 492 and 496, respectively.

Figure 13 is a perspective view illustrating a gear drive assembly 500 according to the present invention, and a corresponding moveable liner plate 502 and removable liner face 504. For illustrative purposes, a frame assembly
25 including side members and cross members is not shown. Gear drive assembly 500 includes double rod-end, dual-acting pneumatic cylinder-piston 506 having a cylinder body 507, and a hollow piston rod 508 with a first rod-end 510 and a second rod-end 512. Gear drive assembly 500 further includes a pair of first gear elements 514a and 514b selectively coupled to moveable liner plate 502,
30 with each first gear element 514a and 514b having a plurality of substantially parallel angled channels 516a and 516b.

In the illustrated embodiment, cylinder body 507 of cylinder-piston 506 includes a plurality of substantially parallel angled channels 518 configured to mesh and slidably interlock with angled channels 516a and 516b. In one

5 embodiment, cylinder body 507 is configured to slidably insert into and couple to a cylinder sleeve having angled channels 518.

In one embodiment, cylinder-piston 506 and piston rod 508 are located within a drive shaft of a frame member, such as drive shaft 134 of cross-member 36a, with rod-end 510 coupled to and extending through a frame member, such as side member 34b, and second rod-end 512 coupled to and extending through a frame member, such a side member 34a. First rod-end 510 and second rod-end 512 are configured to receive and provide compressed air to drive dual-acting cylinder-piston 506. With piston rod 508 being fixed to side members 34a and 34b via first and second rod-ends 512 and 510, cylinder-piston 506 travels along the axis of piston rod 508 in the directions as indicated by arrows 520 and 522 in response to compressed air received via first and second rod-ends 510 and 512.

When compressed air is received via second rod-end 512 and expelled via first rod-end 510, cylinder-piston 506 moves within a drive shaft, such as drive shaft 134, in direction 522 and causes first gear elements 514a and 516b and corresponding liner plate 502 and liner face 504 to move in a direction indicated by arrow 524. Conversely, when compressed air is received via first rod-end 510 and expelled via second rod-end 512, cylinder-piston 506 moves within a gear shaft, such as gear shaft 134, in direction 520 and causes first gear elements 514a and 516b and corresponding liner plate 502 and liner face 504 to move in a direction indicated by arrow 526.

In the illustrated embodiment, cylinder-piston 506 and first gear elements 514a and 514b are shown as being substantially cylindrical in shape. However, any suitable shape can be employed. Furthermore, in the illustrated embodiment, cylinder-piston 506 is a double rod-end dual-acting cylinder. In one embodiment, cylinder piston 506 is a single rod-end dual acting cylinder having only a single rod-end 510 coupled to a frame member, such as side member 34b. In such an embodiment, compressed air is provided to cylinder-piston via single rod-end 510 and a flexible pneumatic connection made to cylinder-piston 506 through side member 34a via gear shaft 134. Additionally, cylinder-piston 506 comprises a hydraulic cylinder.

5 Figure 14 is a top view of a portion of mold assembly 430 (as illustrated by Figure 12) having a drive assembly 550 according to one embodiment of the present invention. Drive assembly 550 includes first drive elements 572a to 572f that are selectively coupled to corresponding liner plates 432a to 432f via openings, such as opening 433, in side member 434a. Each of the first drive
10 elements 572a to 572f is further coupled to a master bar 573. Drive assembly 550 further includes a double-rod-end hydraulic piston assembly 606 having a dual-acting cylinder 607 and a hollow piston rod 608 having a first rod-end 610 and a second rod-end 612. First and second rod-ends 610, 612 are stationary and are coupled to and extend through a removable housing 560 that is coupled to side
15 member 434a and encloses drive assembly 550. First and second rod ends 610, 612 are each coupled to hydraulic fittings 620 that are configured to connect via lines 622a and 622b to an external hydraulic system 624 and to transfer hydraulic fluid to and from dual-acting cylinder 607 via hollow piston rod 608.

 In one embodiment, as illustrated, first drive elements 572b and 572e
20 include a plurality of substantially parallel angled channels 616 that slideably interlock with a plurality of substantially parallel angled channels 618 that form a second drive element. In one embodiment, as illustrated above by Figure 12, angled channels 618 are formed on dual-acting cylinder 607 of hydraulic piston assembly 606, such that dual-acting cylinder 607 forms the second drive
25 element. In other embodiments, as will be described by Figures 15A – 15C below, the second drive element is separate from and operatively coupled to dual-acting cylinder 607.

 When hydraulic fluid is transmitted into dual-acting cylinder 607 from second rod-end 612 via fitting 620 and hollow piston rod 608, hydraulic fluid is
30 expelled from first rod-end 610, causing dual-acting cylinder 607 and angled channels 618 to move along piston rod 608 toward second rod-end 612. As dual-acting cylinder 607 moves toward second rod-end 612, angled channels 618 interact with angled channels 616 and drive first drive elements 572b and 572e, and thus corresponding liner plates 432b and 432e, toward the interior of mold
35 cavities 446b and 446e, respectively. Furthermore, since each of the first drive

5 elements 572a through 572f is coupled to master bar 573, driving first gear elements 572b and 572e toward the interiors of mold cavities 446b and 446e also moves first drive elements 572a, 572c, 572d, and 572f and corresponding liner plates 432a, 432c, 432d, and 432e toward the interiors of mold cavities 446a, 446c, 446d, and 446f, respectively. Conversely, transmitting hydraulic fluid into
10 dual-acting cylinder 607 from first rod-end 610 via fitting 620 and hollow-piston rod 608 causes dual-acting cylinder 607 to move toward first rod-end 610, and causes liner plates 432 to move away from the interiors of corresponding mold cavities 446.

In one embodiment, drive assembly 550 further includes support shafts
15 626, such as support shafts 626a and 626b, which are coupled between removable housing 560 and side member 434a and extend through master bar 573. As dual-acting cylinder 607 is moved by transmitting/expelling hydraulic fluid from first and second rod-ends 610, 612, master bar 573 moves back and forth along support shafts 626. Because they are coupled to static elements of
20 mold assembly 430, support shafts 626a and 626b provide support and rigidity to liner plates 432, drive elements 572, and master bar 573 as they move toward and away from mold cavities 446.

In one embodiment, drive assembly 550 further includes a pneumatic fitting 628 configured to connect via line 630 to an external compressed air
25 system 632 and provide compressed air to housing 560. By receiving compressed air via pneumatic fitting 628 to removable housing 560, the internal air pressure of housing 560 is positive relative to the outside air pressure, such that air is continuously "forced" out of housing 560 through any non-sealed openings, such as openings 433 through which first drive elements 572 extend
30 through side member 434a. By maintaining a positive air pressure and forcing air out through such non-sealed opening, the occurrence of dust and debris and other unwanted contaminants from entering housing 560 and fouling drive assembly 550 is reduced.

First and second rod ends 610, 612 are each coupled to hydraulic fittings
35 620 that are configured to connect via lines 622a and 622b to an external

5 hydraulic system 624 and to transfer hydraulic fluid to and from dual-acting cylinder 607 via hollow piston rod 608.

Figure 15A is a top view illustrating a portion of one embodiment of drive assembly 550 according to the present invention. Drive assembly 550 includes double-rod-end hydraulic piston assembly 606 comprising dual-acting
10 cylinder 607 and a hollow piston rod 608 with first and second rod-ends 610 and 612 being and coupled to and extending through removable housing 560.

As illustrated, dual-acting cylinder 607 is slideably-fitted inside a machined opening 641 within a second gear element 640, with hollow piston rod 608 extending through removable end caps 642. In one embodiment, end caps
15 646 are threadably inserted into machined opening 641 such that end caps 646 butt against and secure dual-acting cylinder 607 so that dual-acting cylinder 607 is held stationary with respect to second drive element 640. Second drive element 640 includes the plurality of substantially parallel angled channels 618, in lieu of angled channels being an integral part of dual-acting cylinder 607.
20 With reference to Figure 14, angled channels 618 of second gear element 640 are configured to slideably interlock with angled channels 616 of first gear elements 572b and 572e.

Second gear element 640 further includes a guide rail 644 that is slideably coupled to linear bearing blocks 646 that are mounted to housing 560.
25 As described above with respect to Figure 14, transmitting and expelling hydraulic fluid to and from dual-acting cylinder 607 via first and second rod-ends 610, 612 causes dual-acting cylinder 607 to move along hollow piston-rod 608. Since dual-acting cylinder 607 is "locked" in place within machined shaft 641 of second gear element 640 by end caps 642, second gear element 640
30 moves along hollow piston-rod 608 together with dual-acting cylinder 607. As second drive element 640 moves along hollow piston-rod 608, linear bearing blocks 646 guide and secure guide rail 644, thereby guiding and securing second drive element 640 and reducing undesirable motion in second drive element 640 that is perpendicular to hollow piston rod 608.

5 Figure 15B is a lateral cross-sectional view A-A of the portion of drive assembly 550 illustrated by Figure 15A. Guide rail 644 is slideably fitted into a linear bearing track 650 and rides on bearings 652 as second drive element 640 is moved along piston rod 608 by dual-acting cylinder 607. In one embodiment, linear bearing block 646b is coupled to housing 560 via bolts 648.

10 Figure 15C is a longitudinal cross-sectional view B-B of the portion of drive assembly 550 of Figure 15A, and illustrates dual-acting cylinder 607 as being secured within shaft 641 of drive element 640 by end caps 642a and 642b. In one embodiment, end caps 642a and 642b are threadably inserted into the ends of second drive element 640 so as to butt against each end of dual-acting
15 cylinder 607. Hollow piston rod 608 extends through end caps 642a and 642b and has first and second rod ends 610 and 612 coupled to and extending through housing 560. A divider 654 is coupled to piston rod 608 and divides dual-acting cylinder 607 into a first chamber 656 and a second chamber 658. A first port 660 and a second port 662 allow hydraulic fluid to be pumped into and expelled
20 from first chamber 656 and second chamber 658 via first and second rod ends 610 and 612 and associated hydraulic fittings 620, respectively.

 When hydraulic fluid is pumped into first chamber 656 via first rod-end 610 and first port 660, dual-acting cylinder 607 moves along hollow piston rod 608 toward first rod-end 610 and hydraulic fluid is expelled from second
25 chamber 658 via second port 662 and second rod-end 612. Since dual-acting cylinder 607 is secured within shaft 641 by end caps 642a and 642b, second drive element 640 and, thus, angled channels 618 move toward first rod-end 610. Similarly, when hydraulic fluid is pumped into second chamber 658 via second rod-end 612 and second port 662, dual-acting cylinder 607 moves along hollow
30 piston rod 608 toward second rod-end 612 and hydraulic fluid is expelled from first chamber 656 via first port 660 and first rod-end 610.

 Figure 16 is a side view of a portion of drive assembly 550 as shown by Figure 14 and illustrates a typical liner plate, such as liner plate 432a, and corresponding removable liner face 400. Liner plate 432a is coupled to second
35 drive element 572a via a bolted connection 670 and, in-turn, drive element 572a

5 is coupled to master bar 573 via a bolted connection 672. A lower portion of
liner face 400 is coupled to liner plate 432a via a bolted connection 674. In one
embodiment, as illustrated, liner plate 432a includes a raised "rib" 676 that runs
the length of and along an upper edge of liner plate 432a. A channel 678 in liner
face 400 overlaps and interlocks with raised rib 676 to form a "boltless"
10 connection between liner plate 432a and an upper portion of liner face 400.
Such an interlocking connection securely couples the upper portion of liner face
400 to liner plate 432 in an area of liner face 400 that would otherwise be too
narrow to allow use of a bolted connection between liner face 400 and liner plate
432a without the bolt being visible on the surface of liner face 400 that faces
15 mold cavity 446a.

In one embodiment, liner plate 432 includes a heater 680 configured to
maintain the temperature of corresponding liner face 400 at a desired
temperature to prevent concrete in corresponding mold cavity 446 sticking to a
surface of liner face 400 during a concrete curing process. In one embodiment,
20 heater 680 comprises an electric heater.

Figure 17 is a block diagram illustrating one embodiment of a mold
assembly according to the present invention, such as mold assembly 430 of
Figure 14, further including a controller 700 configured to coordinate the
movement of moveable liner plates, such as liner plates 432, with operations of
25 concrete block machine 702 by controlling the operation of the drive assembly,
such as drive assembly 550. In one embodiment, as illustrated, controller 700
comprises a programmable logic controller (PLC).

As described above with respect to Figure 1, mold assembly 430 is
selectively coupled, generally via a plurality of bolted connections, to concrete
30 block machine 702. In operation, concrete block machine 702 first places pallet
56 below mold box assembly 430. A concrete feedbox 704 then fills mold
cavities, such as mold cavities 446, of assembly 430 with concrete. Head shoe
assembly 52 is then lowered onto mold assembly 430 and hydraulically or
mechanically compresses the concrete in mold cavities 446 and, together with a
35 vibrating table on which pallet 56 is positioned, simultaneously vibrates mold

5 assembly 430. After the compression and vibration is complete, head shoe
assembly 52 and pallet 56 are lowered relative to mold cavities 446 so that the
formed concrete blocks are expelled from mold cavities 446 onto pallet 56.
Head shoe assembly 52 is then raised and a new pallet 56 is moved into position
below mold cavities 446. The above process is continuously repeated, with each
10 such repetition commonly referred to as a cycle. With specific reference to mold
assembly 430, each such cycle produces six concrete blocks.

PLC 700 is configured to coordinate the extension and retraction of liner
plates 432 into and out of mold cavities 446 with the operations of concrete
block machine 702 as described above. At the start of a cycle, liner plates 432
15 are fully retracted from mold cavities 446. In one embodiment, with reference to
Figure 14, drive assembly 550 includes a pair of sensors, such as proximity
switches 706a and 706b to monitor the position of master bar 573 and, thus, the
positions of corresponding moveable liner plates 432 coupled to master bar 573.
As illustrated in Figure 14, proximity switches 706a and 706b are respectively
20 configured to detect when liner plates 432 are in an extended position and a
retracted position with respect to mold cavities 446.

In one embodiment, after pallet 56 has been positioned beneath mold
assembly 430, PLC 700 receives a signal 708 from concrete block machine 702
indicating that concrete feedbox 704 is ready to deliver concrete to mold cavities
25 446. PLC 700 checks the position of moveable liners 432 based on signals 710a
and 710b received respectively from proximity switches 706a and 706b. With
liner plates 432 in a retracted position, PLC 700 provides a liner extension signal
712 to hydraulic system 624.

In response to liner extension signal 712, hydraulic system 624 begins
30 pumping hydraulic fluid via path 622b to second rod-end 612 of piston assembly
606 and begins receiving hydraulic fluid from first rod-end 610 via path 622a,
thereby causing dual-acting cylinder 607 to begin moving liner plates 432
toward the interiors of mold cavities 446. When proximity switch 706a detects
master bar 573, proximity switch 706a provides signal 710a to PLC 700
35 indicating that liner plates 432 have reached the desired extended position. In

5 response to signal 710a, PLC 700 instructs hydraulic system 624 via signal 712 to stop pumping hydraulic fluid to piston assembly 606 and provides a signal 714 to concrete block machine 702 indicating that liner plates 432 are extended.

In response to signal 714, concrete feedbox 704 fills mold cavities 446 with concrete and head shoe assembly 52 is lowered onto mold assembly 430.

10 After the compression and vibrating of the concrete is complete, concrete block machine 702 provides a signal 716 indicating that the formed concrete blocks are ready to be expelled from mold cavities 446. In response to signal 716, PLC 700 provides a liner retraction signal 718 to hydraulic system 624.

In response to liner retraction signal 718, hydraulic system 624 begins
15 pumping hydraulic fluid via path 622a to first rod-end 610 via path 622 and begins receiving hydraulic fluid via path 622b from second rod-end 612, thereby causing dual-acting cylinder 607 to begin moving liner plates 432 away from the interiors of mold cavities 446. When proximity switch 706b detects master bar 573, proximity switch 706b provides signal 710b to PLC 700 indicating that
20 liner plates 432 have reached a desired retracted position. In response to signal 710b, PLC 700 instructs hydraulic system 624 via signal 718 to stop pumping hydraulic fluid to piston assembly 606 and provides a signal 720 to concrete block machine 702 indicating that liner plates 432 are retracted.

In response to signal 720, head shoe assembly 52 and pallet 56 eject the
25 formed concrete blocks from mold cavities 446. Concrete block machine 702 then retracts head shoe assembly 52 and positions a new pallet 56 below mold assembly 430. The above process is then repeated for the next cycle.

In one embodiment, PLC 700 is further configured to control the supply of compressed air to mold assembly 430. In one embodiment, PLC 700 provides
30 a status signal 722 to compressed air system 630 indicative of when concrete block machine 702 and mold assembly 430 are in operation and forming concrete blocks. When in operation, compressed air system 632 provides compressed air via line 630 and pneumatic fitting 628 to housing 560 of mold assembly 420 to reduce the potential for dirt/dust and other debris from entering

5 drive assembly 550. When not in operation, compressed air system 632 does not provide compressed air to mold assembly 430.

Although the above description of controller 700 is in regard to
controlling a drive assembly employing only a single piston assembly, such as
piston assembly 606 of drive assembly 500, controller 700 can be adapted to
10 control drive assemblies employing multiple piston assemblies and employing
multiple pairs of proximity switches, such as proximity switches 706a and 706b.
In such instances, hydraulic system 624 would be coupled to each piston
assembly via a pair of hydraulic lines, such as lines 622a and 622b.
Additionally, PLC 700 would receive multiple position signals and would
15 respectively allow mold cavities to be filled with concrete and formed blocks to
be ejected only when each applicable proximity switch indicates that all
moveable liner plates are at their extended position and each applicable
proximity switch indicates that all moveable liner plates are at their retracted
position.

20 Figures 18A through 18C illustrate portions of an alternate embodiment
of drive assembly 550 as illustrated by Figures 15A through 15C. Figure 18A is
top view of second gear element 640, wherein second gear element 640 is driven
by a screw drive system 806 in lieu of a piston assembly, such as piston
assembly 606. Screw drive system 806 includes a threaded screw 808, such as
25 an Acme or Ball style screw, and an electric motor 810. Threaded screw 808 is
threaded through a corresponding threaded shaft 812 extending lengthwise
through second gear element 640. Threaded screw 808 is coupled at a first end
to a first bearing assembly 814a and is coupled at a second end to motor 810 via
a second bearing assembly 814b. Motor 810 is selectively coupled via motor
30 mounts 824 to housing 560 and/or to the side/cross members, such as cross
member 434a, of the mold assembly.

In a fashion similar to that described by Figure 15A, second gear element
640 includes the plurality of angled channels 618 which slideably interlock and
mesh with angled channels 616 of first gear elements 572b and 572e, as
35 illustrated by Figure 14. Since second gear element 640 is coupled to linear

5 bearing blocks 646, when motor 810 is driven to rotate threaded screw 808 in a counter-clockwise direction 816, second gear element 640 is driven in a direction 818 along linear bearing track 650. As second gear element 640 moves in direction 818, angled channels 618 interact with angled channels 616 and extend liner plates, such as liner plates 432a through 432f illustrated by Figures
10 12 and 14, toward the interior of mold cavities 446a through 446f.

When motor 810 is driven to rotate threaded screw 808 in a clockwise direction 820, second gear element 640 is driven in a direction 822 along linear bearing track 650. As second gear element 640 moves in direction 822, angled channels 618 interact with angled channels 616 and retract liner plates, such as
15 liner plates 432a through 432f illustrated by Figures 12 and 14, away from the interior of mold cavities 446a through 446f. In one embodiment, the distance the liner plates are extended and retracted toward and away from the interior of the mold cavities is controlled based on the pair of proximity switches 706a and 706b, as illustrated by Figure 14. In an alternate embodiment, travel distance of
20 the liner plates is controlled based on the number of revolutions of threaded screw 808 is driven by motor 810.

Figures 18B and 18C respectively illustrate lateral and longitudinal cross-sectional views A-A and B-B of drive assembly 550 as illustrated by Figure 18A. Although illustrated as being located external to housing 560, in
25 alternate embodiments, motor 810 is mounted within housing 560.

As described above, concrete blocks, also referred to broadly as concrete masonry units (CMUs), encompass a wide variety of types of blocks such as, for example, patio blocks, pavers, light weight blocks, gray blocks, architectural units, and retaining wall blocks. The terms concrete block, masonry block, and
30 concrete masonry unit are employed interchangeably herein, and are intended to include all types of concrete masonry units suitable to be formed by the assemblies, systems, and methods of the present invention. Furthermore, although described herein primarily as comprising and employing concrete, dry-cast concrete, or other concrete mixtures, the systems, methods, and concrete
35 masonry units of the present invention are not limited to such materials, and are

5 intended to encompass the use of any material suitable for the formation of such blocks.

Figures 19A and 19B respectively illustrate perspective and top views of one embodiment of a drive assembly 850 in accordance with the present invention for moving an associated moveable liner plate 852 (indicated by dashed lines and similar to moveable liner plate 32 of Figures 1 and 2). To simplify illustration, side and cross members of a mold assembly of which moveable liner plate 852 is part (similar to side and cross members 34a, 34b and 10 36a, 36b of mold assembly 30 of Figure 1) are not shown.

Drive assembly 850 includes a first drive element 854 and an actuator assembly 856 including a second drive element 858. In one embodiment, second drive element 858 includes a linear rail 860 at a non-zero angle (θ) 862 with x-axis 870. In one embodiment, first drive element 854 includes a channel 864 proximate to a first end 866, with channel 864 also being substantially at the non-zero angle (θ) 862 to moveable liner plate 852 and configured to slideably receive and interlock with linear rail 860 such that first drive element 854 is 20 substantially at a right angle to moveable liner plate 852 and second drive element 858. A second end 868 of first drive element 854 is selectively coupled to moveable liner plate 852.

Actuator assembly 856 is configured to move second drive element 858 25 substantially linearly along an x-axis 870. First drive element 854 is restricted to movement substantially along a y-axis 872. In embodiment, first drive element 854 extends through a guide track through a side or cross member of the mold assembly (not shown) similar to gear track 80 illustrated by Figure 2 above. In one embodiment, moveable liner plate 852 includes one or more guide posts, 30 such as guides posts 870a and 870b (similar to guide posts 88a – 88d of Figure 2) which extend into a side or cross member of the mold assembly (not shown) and guide and limit movement of moveable liner plate 852 along y-axis 872.

In operation, when actuator assembly 856 drives second drive element 858 along x-axis 870 in a first direction 874, channel 864 of first drive element 35 854 travels along linear rail 860, thereby causing first drive element 854 and,

5 thus, moveable liner plate 852 to move along y-axis 872 in a first direction 876. Similarly, when actuator assembly 856 drives second drive element 858 along x-axis 870 in a second direction 878, channel 864 of first drive element 854 travels along linear rail 860 and causes first drive element 854 and, thus, moveable liner plate 852 to move along y-axis 872 in a direction 880. It is noted that the
10 magnitude of movement of first drive element 854 along y-axis 872 is proportional to angle (θ) 862 (i.e. the greater the angle(θ) 862, the greater the ration of movement of first drive element 854 along y-axis 872 to movement of second drive element 858 along x-axis 870).

In one embodiment, as illustrated by Figures 19A – 19B, actuator
15 assembly 856 includes a double-rod-end piston assembly 882 similar to double-rod-end piston assembly 606 illustrated and described above by Figures 15A – 15C. Double rod-end piston assembly 882 includes a hollow piston body 884 selectively coupled within second drive element 854 and having first and second hollow rod-ends 886 and 888. As described above with respect to double-rod
20 end assembly 606 of Figures 15A – 15C, a hydraulic medium is pumped into and out of hollow piston body 884 to drive second drive element 858 in first and second directions 876 and 878 along x-axis 870. In one embodiment, actuator assembly 856 comprises a screw drive system (not illustrated), similar to screw drive system 806 described and illustrated above by Figures 18A – 18C, to drive
25 second drive element 858 in first and second directions 876 and 878 along x-axis 870.

Figure 20 is a perspective view illustrating one embodiment of a drive
assembly 900 in accordance with the present invention. Drive assembly 900 is similar to drive assembly 850 as described and illustrated by Figures 19A – 19B
30 above, except that second drive element 858 includes a curvilinear rail 902 in lieu of linear rail 860 and first gear element 854 includes a pair of roller elements 904a and 904b in lieu of a channel 864. Roller elements 904a and 904b are spaced apart from one another and configured to contact and ride along curvilinear rail 902. In one embodiment, curvilinear rail 902 is “serpentine” in
35 nature and has a portion 906 which is a greater distance away from moveable

5 liner plate 852 than portions 908 and 910 of curvilinear rail 902. As with drive assembly 850, moveable liner plate 852 and first gear element 854 are restricted to movement along y-axis 872 and second gear element 858 is restricted to movement along x-axis 870.

In operation, actuator assembly 856 is configured to drive second drive
10 element 858 back and forth along x-axis 870 which causes first drive element 854 and, thus, moveable liner plate 852 to extend and retract along y-axis 872. For example, when actuator assembly 856 drives second gear element 858 in a first direction 912 along x-axis 870 such that roller elements 904a and 904b travel along curvilinear rail 902 from portion 908 to portion 906, first gear
15 element 854 and, thus, moveable liner plate 852 move along y-axis 872 in a first direction 914 (i.e., "retract" from an associated mold cavity). In a similar fashion, when actuator assembly 856 drives second gear element 858 in first direction 912 along x-axis 870 such that roller elements 904a and 904b travel along curvilinear rail 902 from portion 906 to portion 910, first gear element 854
20 and, thus, moveable liner plate 852 move along y-axis 872 in a second direction 916 (i.e., "extend" into an associated mold cavity).

Similarly, when actuator assembly 856 drives second gear element 858 in a second direction 918 along x-axis 870 such that roller elements 904a and 904b travel along curvilinear rail 902 from portion 910 to portion 906, first gear
25 element 854 and, thus, moveable liner plate 852 move along y-axis 872 in first direction 914 (i.e., "retract" from an associated mold cavity). In a similar fashion, when actuator assembly 856 drives second gear element 858 in second direction 918 along x-axis 870 such that roller elements 904a and 904b travel along curvilinear rail 902 from portion 906 to portion 908, first gear element 854
30 and, thus, moveable liner plate 852 move along y-axis 872 in a second direction 916 (i.e., "extend" into an associated mold cavity).

Figure 21 is a top view illustrating one embodiment of a drive assembly 950 according to the present invention. Drive assembly 950 is similar to drive assembly 850 illustrated and described above by Figures 19A – 19B, except that
35 second drive element 858 does not include a rail element (e.g. liner rail 860 and

5 curvilinear rail 902) and first drive element is pivotally coupled at a first end 952 to moveable liner plate 852 via a first pin 954 and is pivotally coupled at a second end 956 to second gear element 858 via a second pin 958. Second gear element 858 is restricted to movement along y-axis 872 and moveable liner plate 852 is restricted to movement along x-axis 870.

10 As illustrated by Figure 21, solid lines indicate drive assembly 950 when moveable liner plate 852 is in an extended position 960, while dashed lines indicate drive assembly 950 when moveable liner plate 852 is in a retracted position 962. In operation, actuator assembly 856 is configured to drive second drive element 858 back and forth along x-axis 870 so as to cause first drive
15 element 854 to drive moveable liner plate 852 to back and forth along y-axis 872 as first drive element 854 rotates about first and second pins 954 and 958.

For example, when actuator assembly 856 drives second drive element 858 a distance D1 964 in a direction 966 along y-axis 968 from an extended position to a retracted position, first drive element 854 rotates about first and
20 second pins 954 and 958 to a position indicated by the dashed lines and pulls moveable liner plate 852 a distance D2 970 in a direction 972 along x-axis 974 from extended position 960 to retracted position 962. Similarly, when actuator assembly 856 drives second drive element 856 distance D1 964 in a direction 976 along y-axis 968 from the retracted position to the extended position, first
25 drive element 854 rotates about first and second pins 954 and 958 to a position indicated by the solid lines and pushes moveable liner plate 852 the distance D2 970 in a direction 978 along x-axis 974 from retracted position 962 to extended position 960. In one embodiment, a stop element 980 prevents actuator
assembly 856 from moving first drive element 854 beyond a substantially fully
30 extended position.

Figure 22 is a top view of a drive assembly 1000 according to the present invention for simultaneously moving two moveable liner plates. Drive assembly 1000 is similar to drive assembly 950 illustrated and described above by Figure 21, except that actuator assembly 856 includes a pair of first drive elements 854a
35 and 854b each coupled to a corresponding moveable liner plate 852a and 852b of

5 separate mold cavities of a mold assembly (similar to moveable liner plates 32c and 32e of mold cavities 46a and 46b of mold assembly 360 described and illustrated above with respect to Figure 11A). First drive element 854a is pivotally coupled to moveable liner plate 852a via a pin 954a and to second
10 drive element 858 via a pin 958a, and first drive element 854b is pivotally coupled to moveable liner plate 852b via a pin 954b and to second drive element 858 via a pin 958b. Second drive element 858 is restricted to movement along y-axis 872 and moveable liner plates 852a and 852b are restricted to movement along x-axis 870.

As illustrated by Figure 22, solid lines indicate drive assembly 1000
15 when moveable liner plates 852a and 852b are in respective extended positions 960a and 960b, while dashed lines indicated drive assembly 1000 when moveable liner plates 852a and 852b are in respective retracted positions 962a and 962b. In operation, actuator assembly 856 is configured to drive second drive element 858 back and forth along y-axis 872 so as to drive moveable liner
20 plates 852a and 852b back and forth along x-axis 870 via respective first drive elements 854a and 854b.

For example, when actuator assembly 856 drives second drive element 858 distance D1 964 in direction 966 along x-axis 870 from an extended position to a retracted position, first drive element 854a rotates about pins 954a and 958a
25 to a position indicated by the dashed lines and pulls moveable liner plate 852a a distance D2 970a in a direction 972a along y-axis 872 from extended position 960a to retracted position 962a. Simultaneously, first drive element 854b rotates about pins 954b and 958b to a position indicated by the dashed lines and pulls moveable liner plate 852b a distance D2 970b in a direction 972b along y-axis
30 872 from extended position 960b to retracted position 962b.

Conversely, when actuator assembly 856 drives second drive element 858 distance D1 964 in direction 976 along x-axis 870 from an extended position to a retracted position, first drive element 854a rotates about pins 954b and 958b to a position indicated by the solid lines and pushes moveable liner plate 852a a
35 distance D2 970a in a direction 978a along y-axis 872 from retracted position

5 962a to extended position 960a. Simultaneously, first drive element 854b rotates about pins 954b and 958b to a position indicated by the solid lines and pushes moveable liner plate 852b a distance D_2 970b in a direction 978b along y-axis 872 from extended position 962b to retracted position 960b.

Figure 23 is a perspective view of one embodiment of a drive assembly
10 1050 according to the present invention for simultaneously moving two moveable liner plates. Drive assembly 1050 is similar to drive assemblies 850 and 900 illustrated and described above by Figures 19A – 19B and 20, except that actuator assembly 856 includes a pair of third drive elements 1054a and 1054b each coupled to first drive element 854 at first ends and at second ends
15 1055a and 1055b to corresponding moveable liner plates 852a and 852b of separate mold cavities of a mold assembly (similar to moveable liner plates 32c and 32e of mold cavities 46a and 46b of mold assembly 360 described and illustrated above with respect to Figure 11A).

As illustrated, first drive element 854 includes channel 864 configured to
20 slideably interlock with and travel along linear rail 860, each of which is at the same non-zero angle (θ) 862 with x-axis 872. First drive element 854 further includes a first set of angled channels 1056a and a second set of angled channels 1056b on opposing sides of first drive element 854. Third drive elements 1054a and 1054b respectively include sets of angled channels 1058a and 1058b which
25 are respectively configured to slideably interlock with angled channels 1056a and 1056b of first drive element 854. Angled channels 1056a, 1056b, 1058a and 1058b are similar to those described above with respect to Figures 5A through 9B. In one embodiment, as illustrated by Figure 23, first drive element 854 is positioned between moveable liner plates 852a and 852b and the mold cavities to
30 which they correspond (e.g. within cross-member 36c between moveable liners plates 32c and 32e and corresponding mold cavities 46a and 46b as illustrated and described above by Figure 11A).

In operation, when actuator assembly 856 drives second drive element 858 along x-axis 870 in first direction 874, channel 864 of first drive element
35 854 rides along linear rail 860 causing first drive element 854 to move along y-

5 axis 872 in first direction 876. In turn, interaction between angled channels 1056a and 1058a and angled channels 1056b and 1058b respectively causes third gear elements 1054a and 1054b and corresponding moveable liner plates 852a and 852b to move along x-axis 870 in directions 1060a and 1060b toward an interior of their respective mold cavities.

10 Conversely, when actuator assembly 856 drives second drive element 858 along x-axis 870 in second direction 878, channel 864 of first drive element 854 rides along linear rail 860 causing first drive element 854 to move along y-axis 872 in second direction 880. In turn, interaction between angled channels 1056a and 1058a and angled channels 1056b and 1058b respectively causes third
15 gear elements 1054a and 1054b and corresponding moveable liner plates 852a and 852b to move along x-axis 870 in directions 1062a and 1062b away from the interior of their respective mold cavities.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of
20 alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this invention be limited only by the claims and the equivalents
25 thereof.

WHAT IS CLAIMED IS:

1. A mold assembly for manufacturing concrete blocks and adapted for use in a concrete block machine, the mold assembly comprising:
 - a plurality of liner plates forming at least a first mold cavity, wherein at least a first liner plate is moveable; and
 - a drive assembly comprising:
 - a first drive element having a first end and coupled to the first moveable liner plate proximate to a second end; and
 - an actuator assembly including a second drive element selectively coupled to the first drive element proximate to the first end, wherein the actuator assembly is configured to drive the second drive element along a first axis so as to cause at least the second end of the first drive element to move along a second axis and cause the first moveable liner plate to move toward and away from an interior of the first mold cavity.
2. The mold assembly of claim 1, wherein the second axis is substantially perpendicular to the first axis.
3. The mold assembly of claim 1, wherein the second drive element includes a rail element, and wherein the first drive element is slideably coupled to the rail element.
4. The mold assembly of claim 3, wherein the rail element is substantially linear and at a non-zero angle with the first axis.
5. The mold assembly of claim 3, wherein the rail element is curvilinear relative to the first axis.
6. The mold assembly of claim 3, wherein the first drive element includes a channel proximate to the first end which is configured to slideably receive and interlock with the rail element.

7. The mold assembly of claim 3, wherein the first drive element includes a plurality of roller elements spaced to slideably receive and configured to follow the rail element.
8. The mold assembly of claim 1, wherein the first drive element is rotatably coupled to the second drive element proximate to the first end and rotatably coupled to the first moveable liner plate proximate to the second end.
9. The mold assembly of claim 1, further including a third drive element coupled proximate to a first end to the second drive element and coupled proximate to a second end to a second moveable liner plate of a second mold cavity, wherein at least the second end of the third drive element moves along the second axis to cause the second liner plate to move toward and away from an interior of the second mold cavity in response to the actuator assembly driving the second drive element along the first axis.
10. The mold assembly of claim 9, wherein movement of the first and second moveable liner plates is substantially parallel to the second axis.
11. The mold assembly of claim 1, the drive assembly including:
 - a third drive element selectively coupled between the first drive element and the first moveable liner plate; and
 - a fourth drive element selectively coupled between the first drive element and a second moveable liner plate of a second mold cavity, wherein the third drive element moves a third axis and the fourth drive element moves along a fourth axis to respectively move the first and second moveable liner plates toward and away from an interior of the first and second mold cavities, and wherein the third and fourth axes are substantially in parallel with the first axis.

12. The mold assembly of claim 10, wherein movement of the first and second moveable liner plates is in a direction substantially parallel to the first axis.
13. A mold assembly for manufacturing concrete blocks and adapted for use in a concrete block machine, the mold assembly comprising:
a plurality of liner plates forming at least a first mold cavity, wherein at least a first liner plate is moveable; and
a drive assembly comprising:
a first drive element having a first end and a second end, the second end rotatably coupled to the first moveable liner plate; and
an actuator assembly including a second drive element rotatably coupled to the first end of the first drive element, wherein the actuator assembly is configured to drive the second drive element along a first axis such that the first end of the first drive element rotates and moves along the first axis and the second end rotates and moves along a second axis which is substantially perpendicular to the first axis and causes the first moveable liner plate to move toward and away from an interior of the first mold cavity.
14. The mold assembly of claim 13, wherein when the actuator assembly moves the second drive element in a first direction along the first axis the second end of the first drive element moves in a first direction along the second axis and moves the first moveable liner plate away from the interior of the first mold cavity, and wherein when the actuator assembly moves the second drive element in a second direction along the first axis the second end of the first drive element moves in a second direction along the second axis and moves the first moveable liner plate toward the interior of the first mold cavity
15. The mold assembly of claim 14, wherein the drive assembly further includes a third drive element having a first end rotatably coupled to the second

drive element and a second end rotatably coupled to a second moveable liner plate of a second mold cavity, wherein the first end moves along the first axis and the second end of the third drive element moves along the second axis and moves the second moveable liner toward and away from an interior of the second mold cavity when the second drive element moves along the first axis.

16. The mold assembly of claim 15, wherein when the actuator assembly moves the second drive element in the first direction along the first axis the second end of the third drive element moves in the second direction along the second axis and moves the second moveable liner plate away from the interior of the second mold cavity, and wherein when the actuator assembly moves the second drive element in the second direction along the first axis the second end of the third drive element moves in the first direction along the second axis and moves the second moveable liner plate toward the interior of the second mold cavity.

17. A mold assembly for manufacturing concrete blocks and adapted for use in a concrete block machine, the mold assembly comprising:

a plurality of liner plates forming at least a first mold cavity, wherein at least a first liner plate is moveable; and

a drive assembly comprising:

an actuator assembly having a first drive element; and

a second drive element coupled between the first drive element and the first moveable liner plate, wherein the actuator assembly is configured to drive the first drive element along a first axis so as to cause the second drive element to move along a second axis perpendicular to the first axis and cause the first moveable liner plate to move toward and away from an interior of the first mold cavity.

18. The mold assembly of claim 17, wherein the second drive element includes a first of angled channels, and wherein the drive assembly further includes:

a third drive element coupled to the first moveable liner plate and having a plurality of angled channels configured to slideably interlock with the first plurality of angled channels of the second drive element; wherein interaction between the first plurality of angled channels of the second drive element and the plurality of angled channels of the third drive element causes the third drive element to move along a third axis and move the first moveable liner plate toward and away from an interior of the first mold cavity in response to the second drive element moving along the second axis.

19. The mold assembly of claim 18, wherein the second drive element includes a second plurality of angled channels, and wherein the drive assembly further includes:

a fourth drive element coupled to a second moveable liner of a second mold cavity and having a plurality of angled channels configured to slideably interlock with the second plurality of angled channels of the second drive element, wherein interaction between the second plurality of angled channels of the second drive element and the plurality of angled channels of the fourth drive element causes the fourth drive element to move along a further axis and move the second moveable liner plate toward and away from an interior of the first mold cavity in response to the second drive element moving along the second axis.

20. The mold assembly of claim 19, wherein the third and fourth axes are substantially parallel to the first axis, and wherein movement of the first and second moveable liner plates toward and away from the interiors of the first and second mold cavities is substantially parallel to the first axis.

21. The mold assembly of claim 19, wherein movement of the first drive element along the first axis in a first direction causes movement of the second drive element in a first direction along the second axis, causes movement of the third drive element in a first direction along the third axis and movement the first moveable liner plate toward the interior of the first mold cavity, and causes movement of the fourth drive element a first direction along the fourth axis and movement of the second moveable liner plate toward the interior of the second mold cavity, wherein the first direction along the third axis is opposite the first direction along the fourth axis.

22. The mold assembly of claim 21, wherein movement of the first drive element along the first axis in a second direction causes movement of the second drive element in a second direction along the second axis, causes movement of the third drive element in a second direction along the third axis and movement the first moveable liner plate away from the interior of the first mold cavity, and causes movement of the fourth drive element a second direction along the fourth axis and movement of the second moveable liner plate away from the interior of the second mold cavity, wherein the second direction along the third axis is opposite the second direction along the fourth axis.

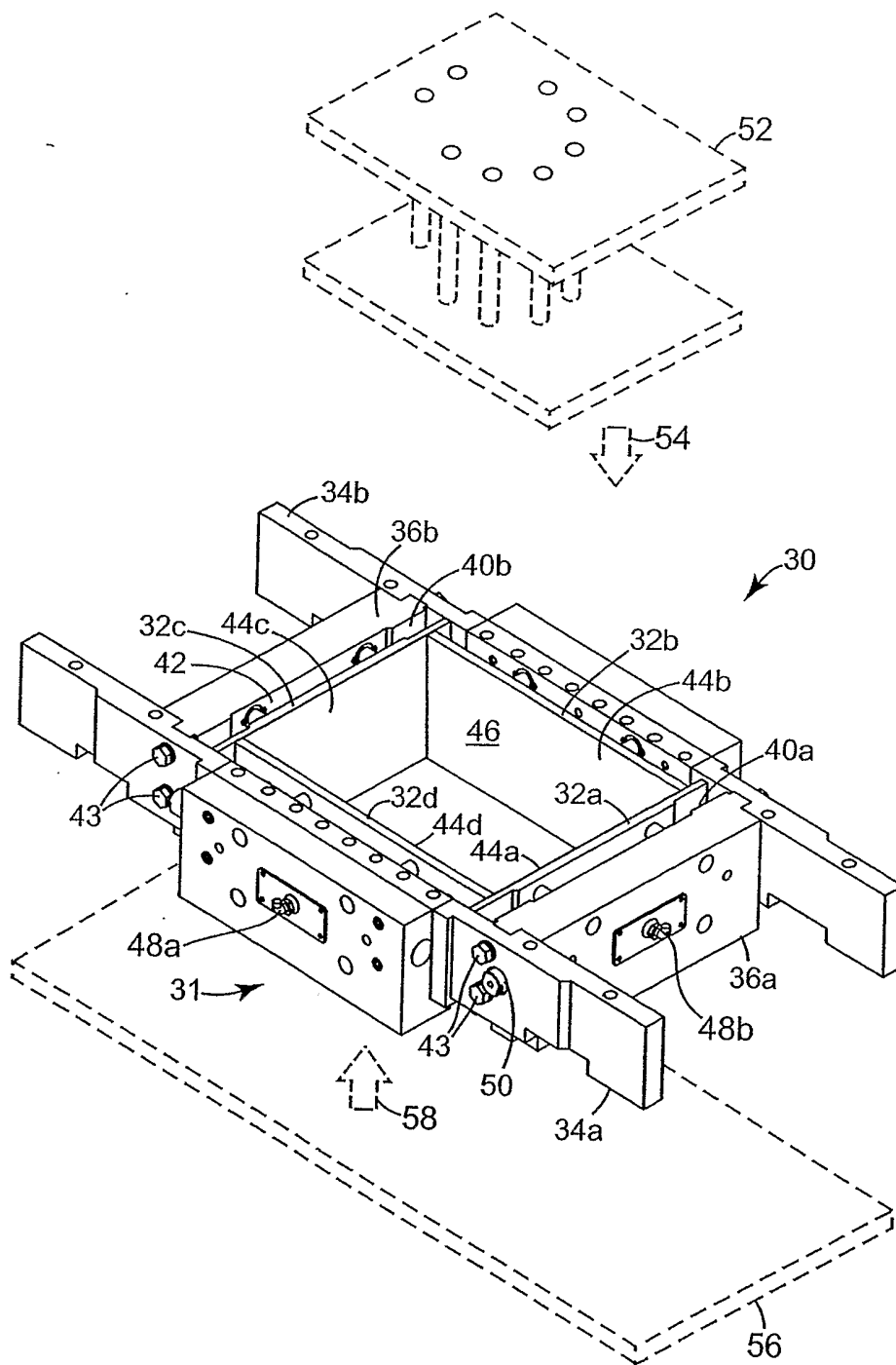


Fig. 1

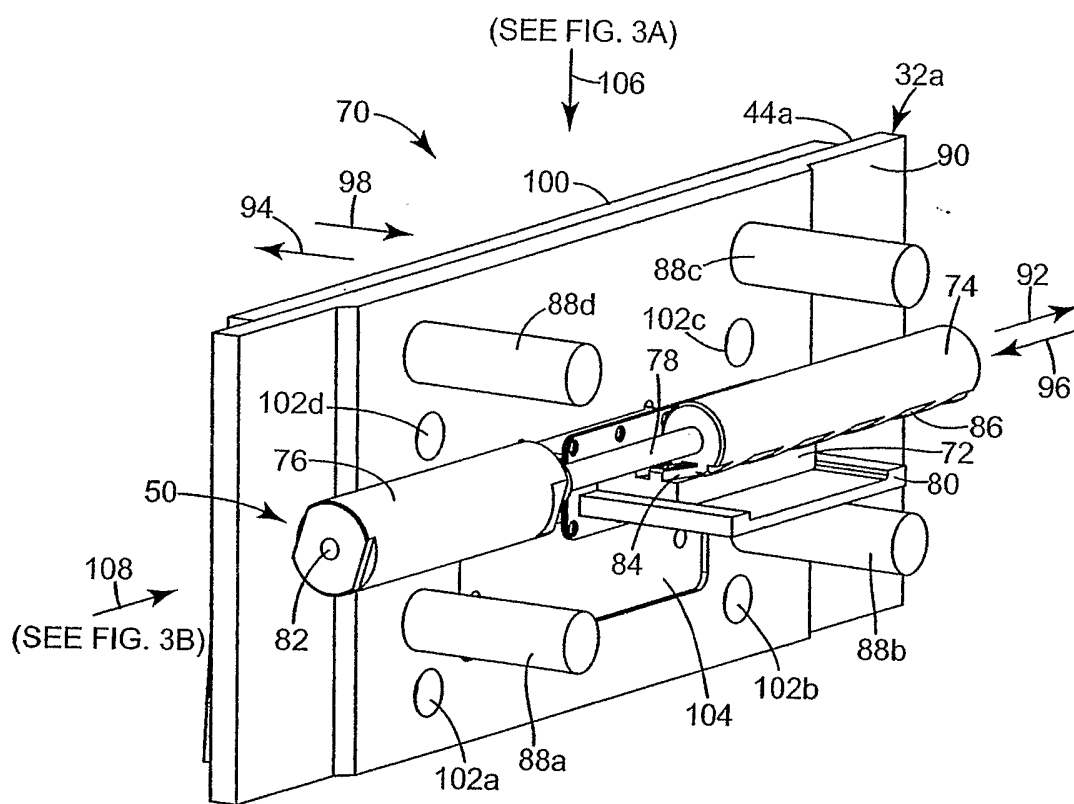


Fig. 2

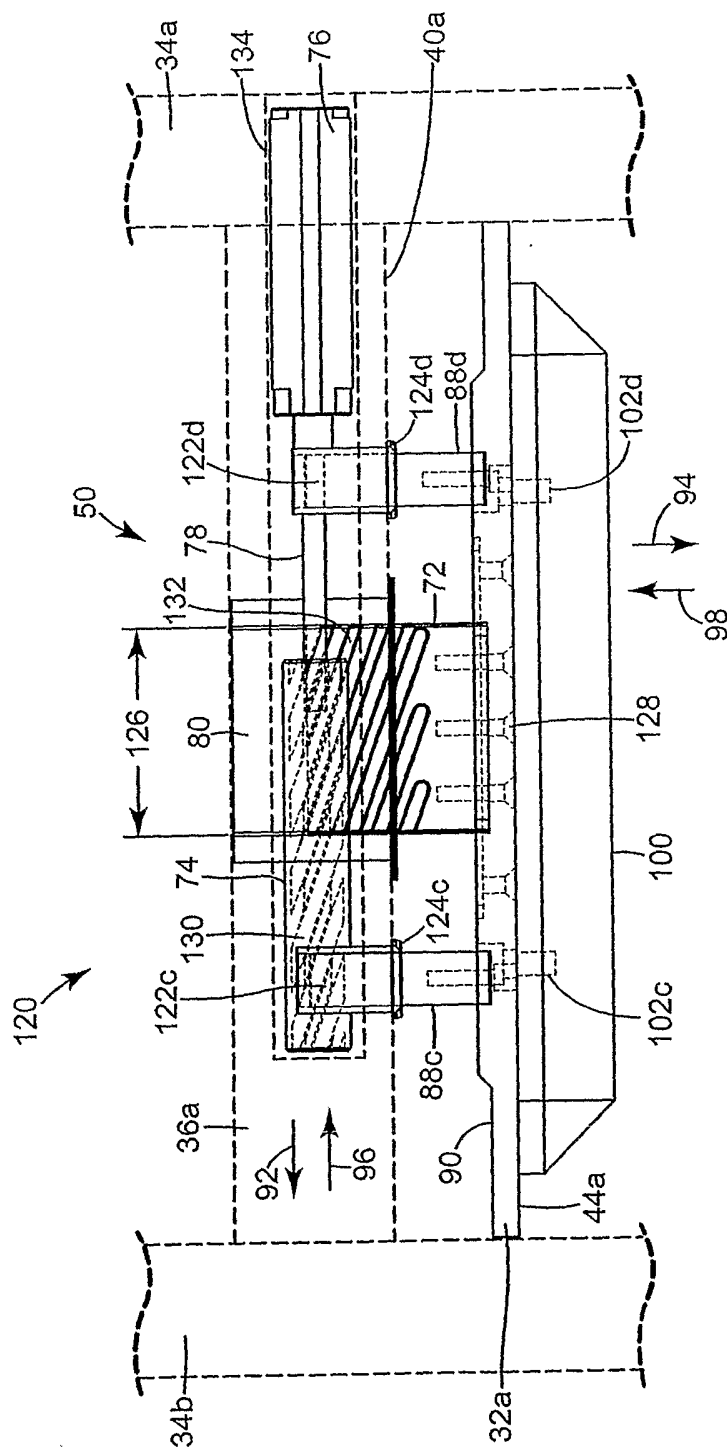


Fig. 3A

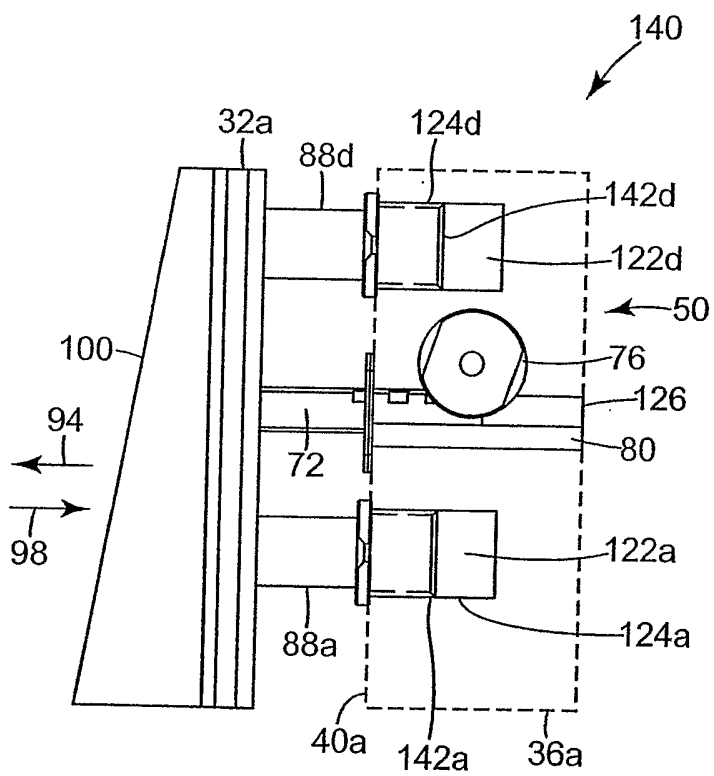


Fig. 3B

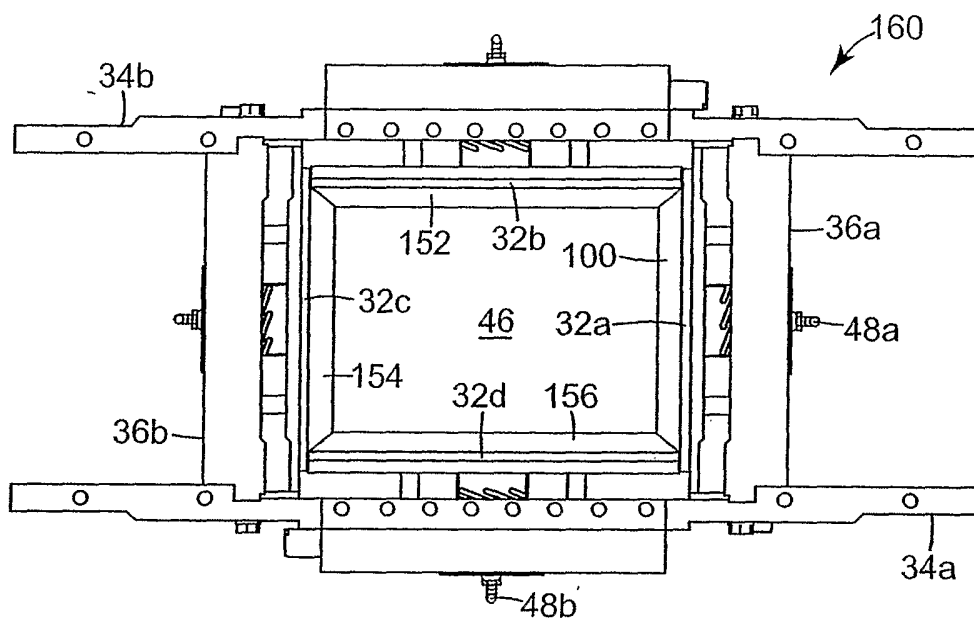


Fig. 4B

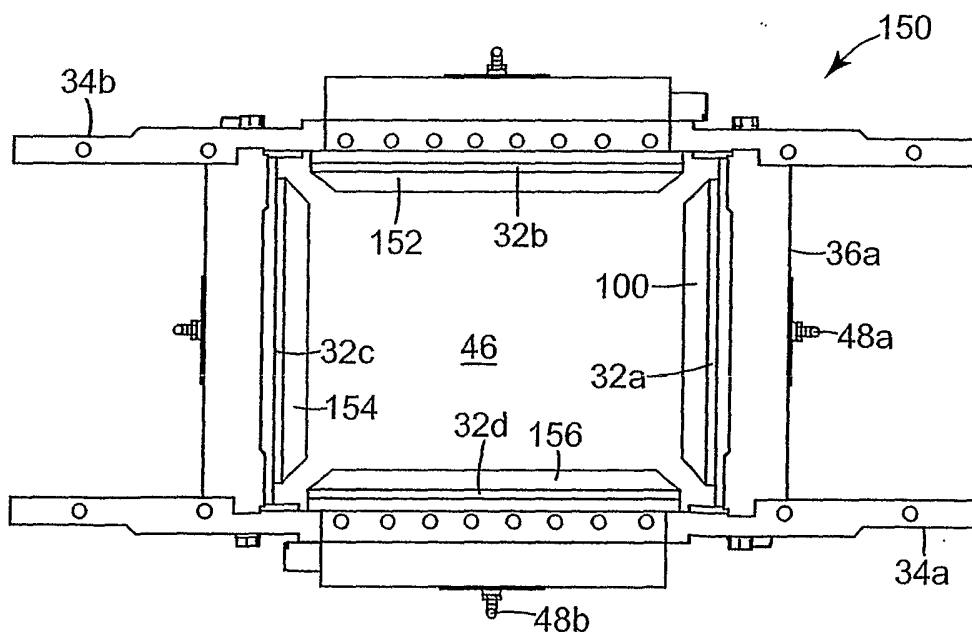


Fig. 4A

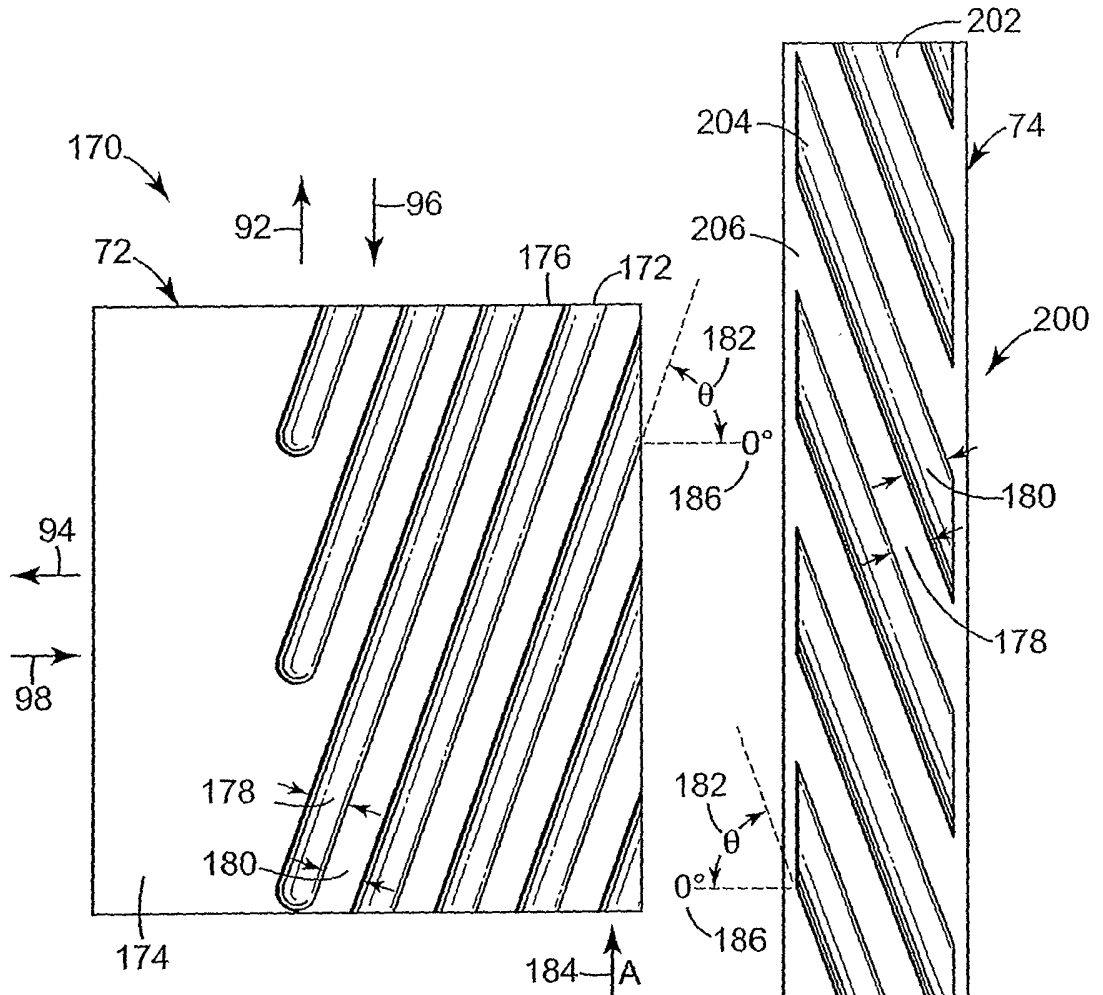


Fig. 5A

Fig. 5C

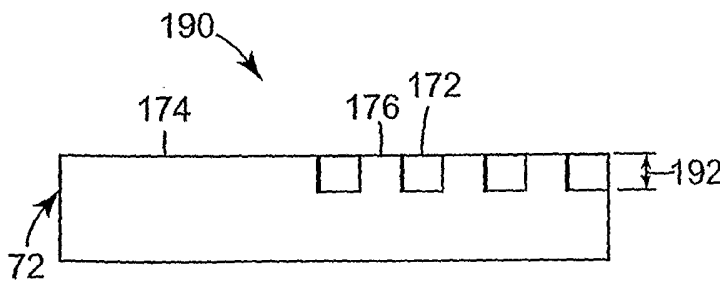


Fig. 5B

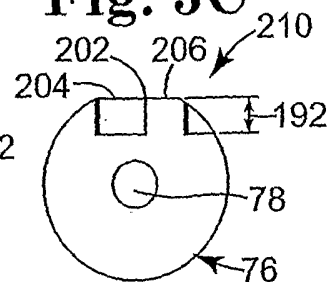


Fig. 5D

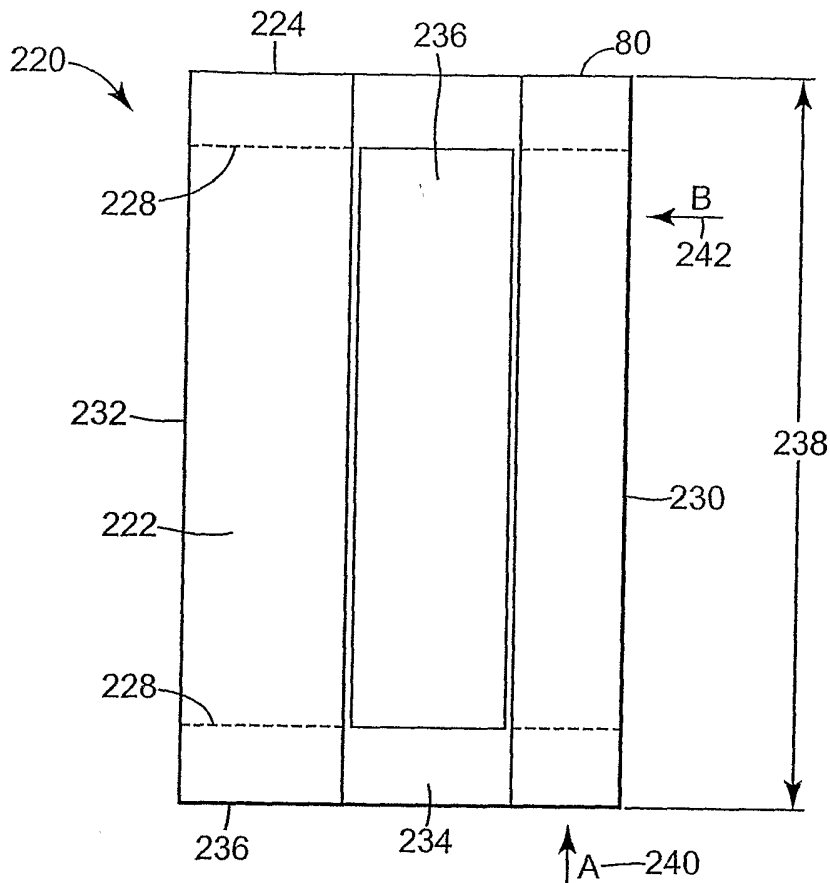


Fig. 6A

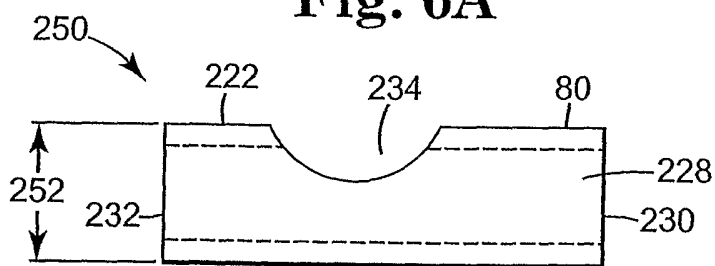


Fig. 6B

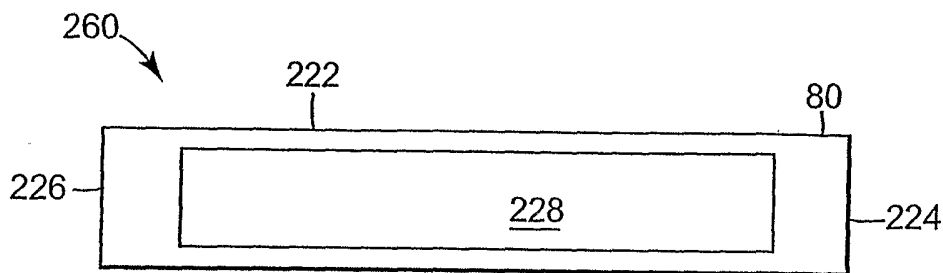


Fig. 6C

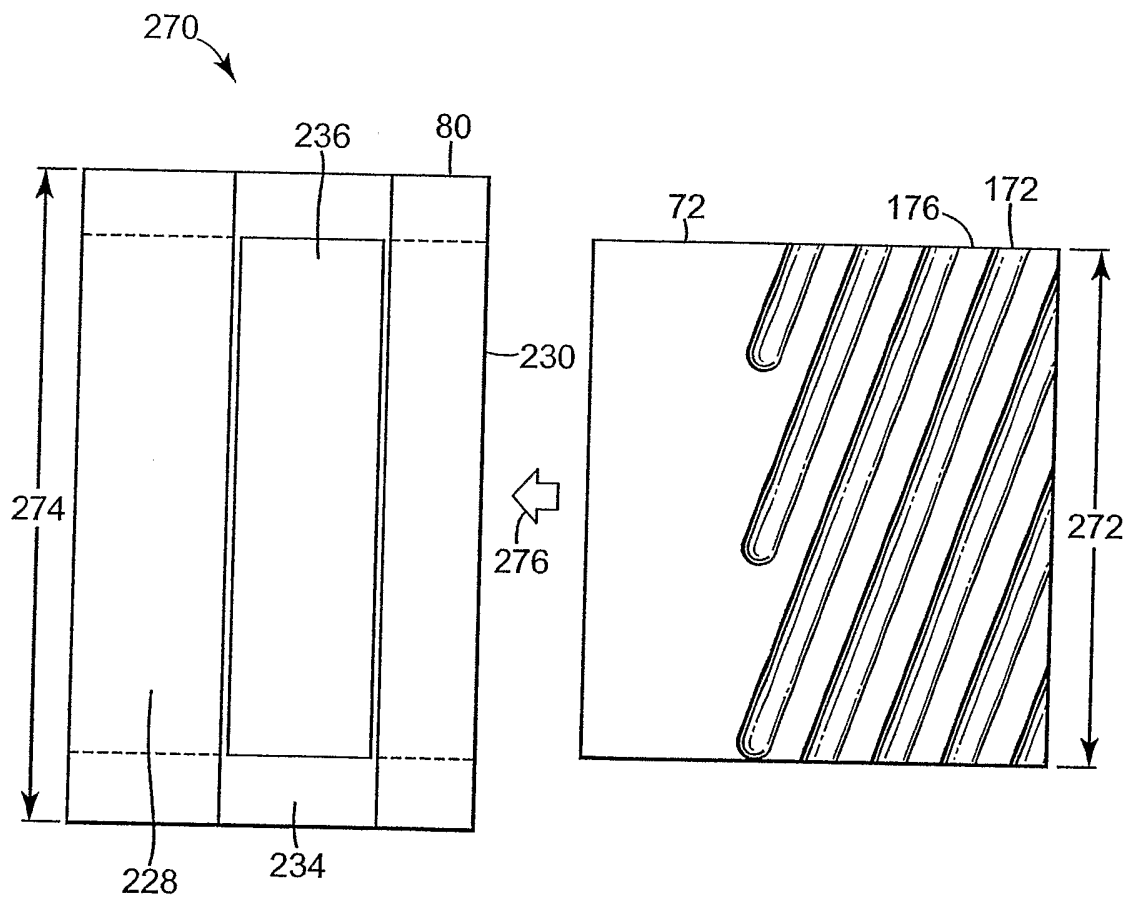


Fig. 7

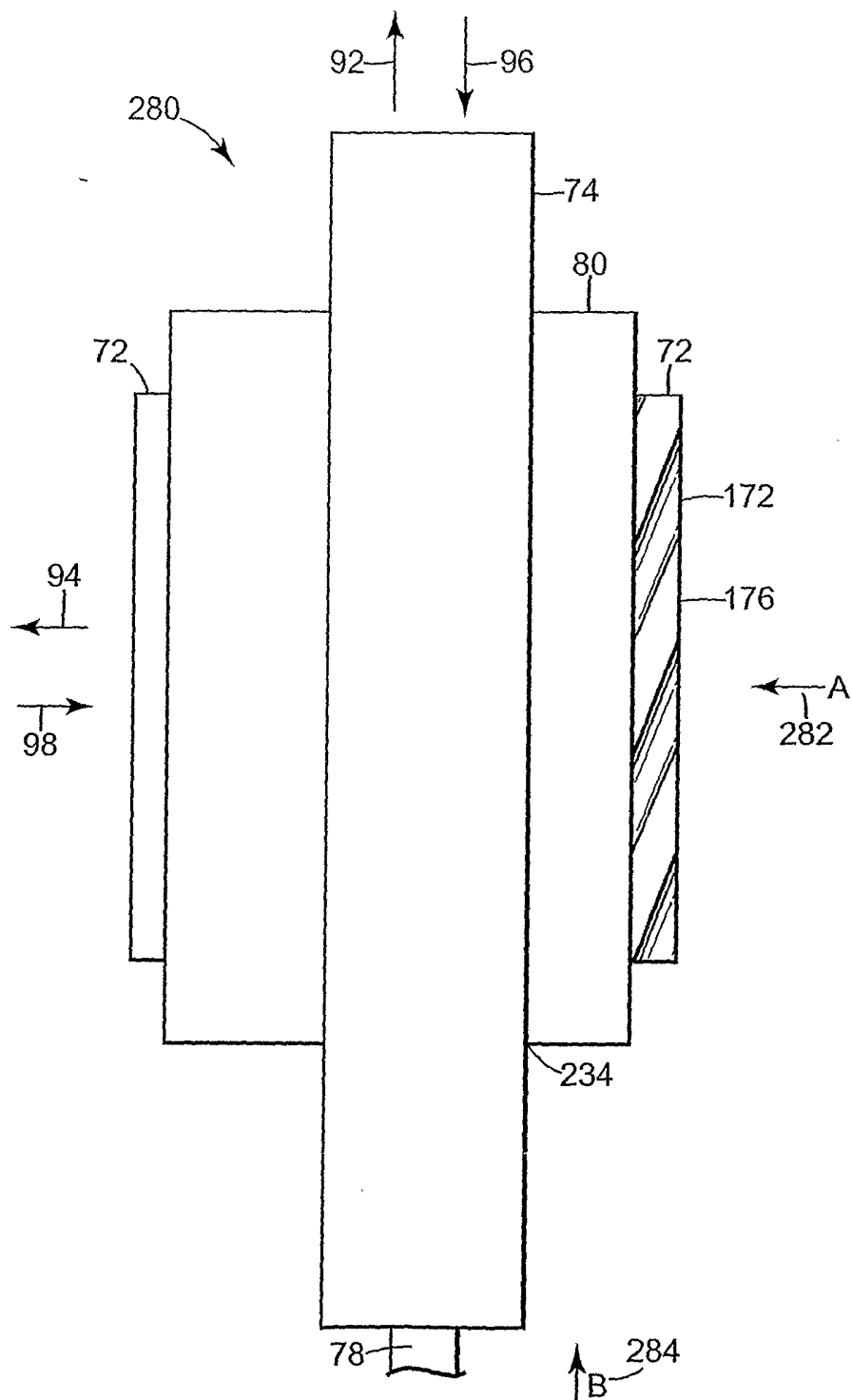


Fig. 8A

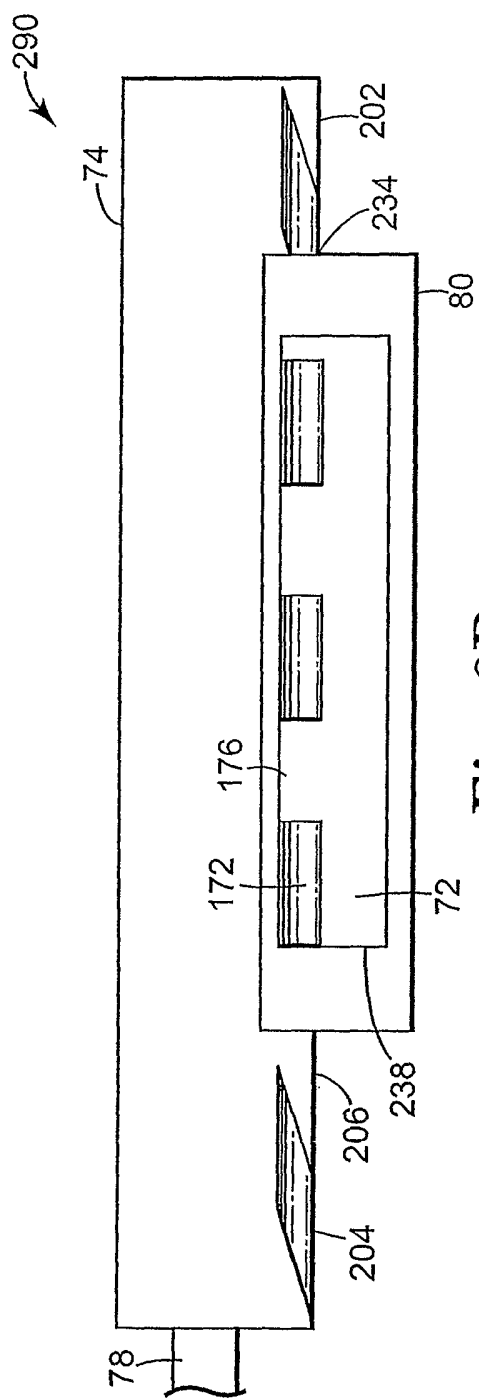


Fig. 8B

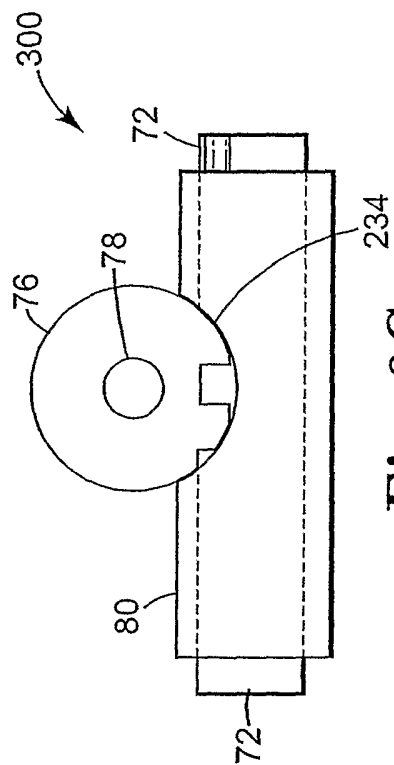


Fig. 8C

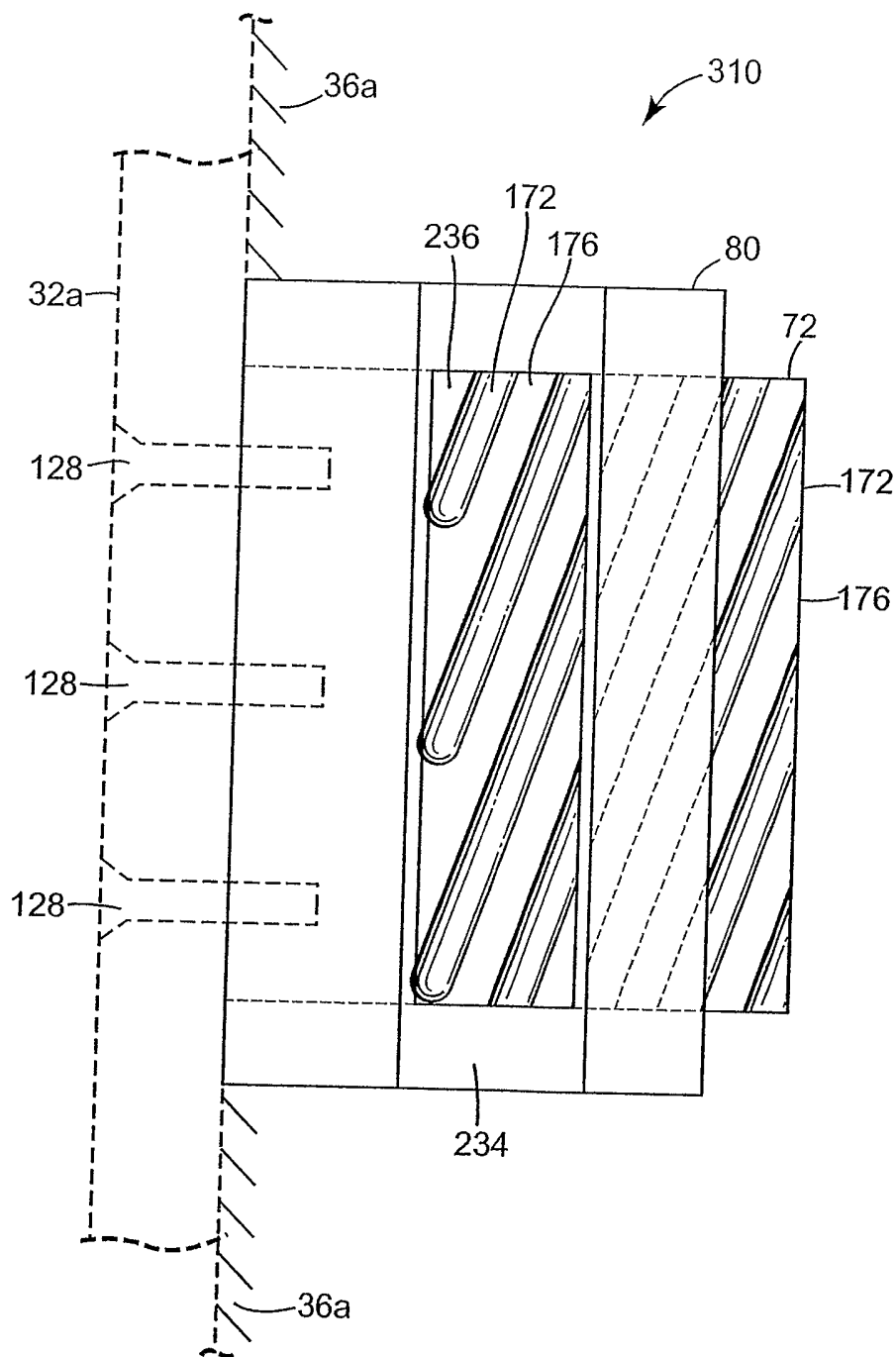


Fig. 9A

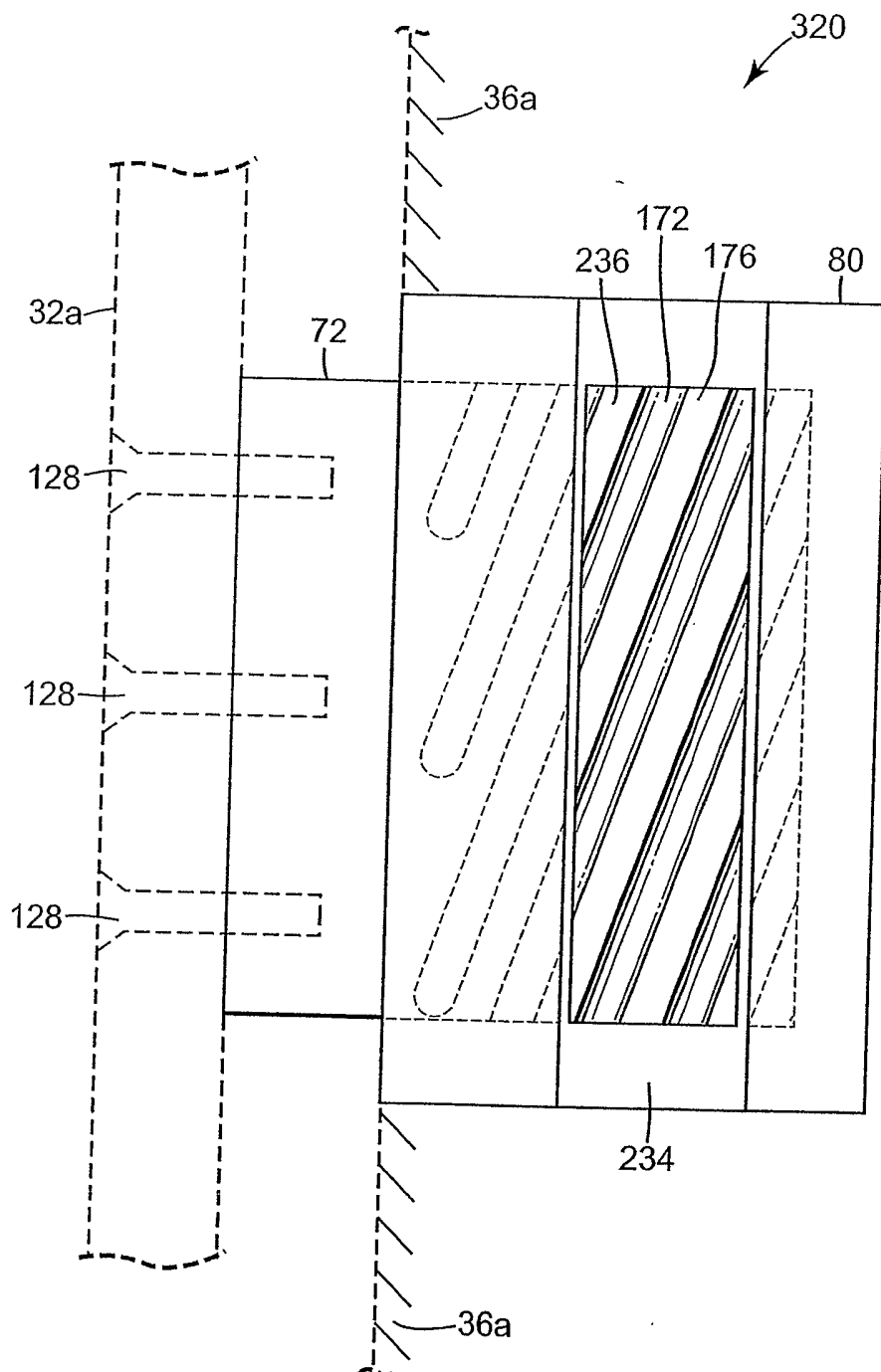


Fig. 9B

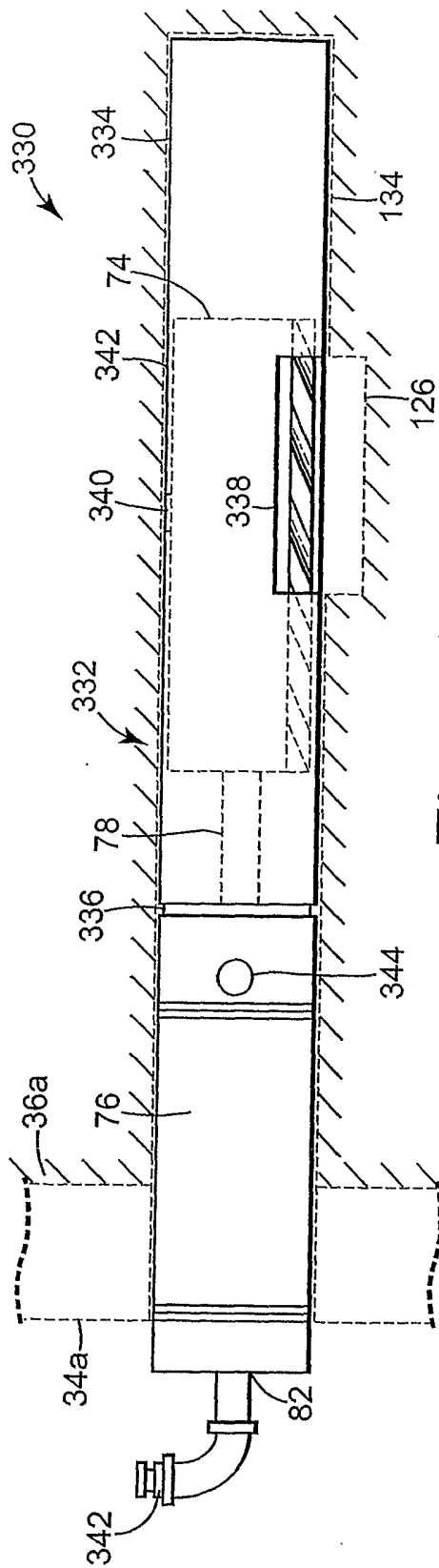


Fig. 10A

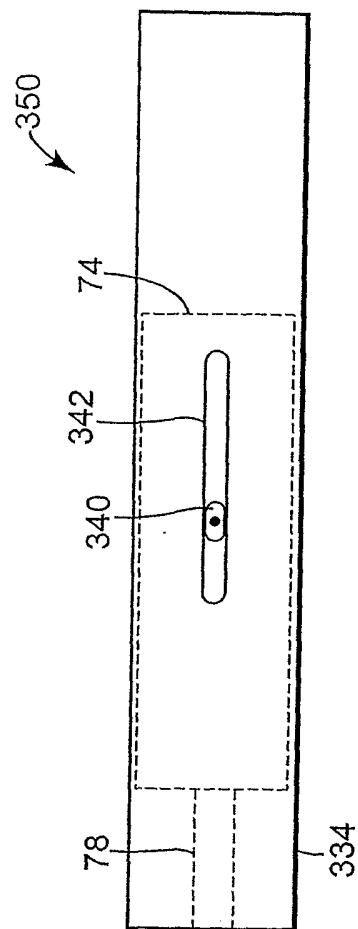


Fig. 10B

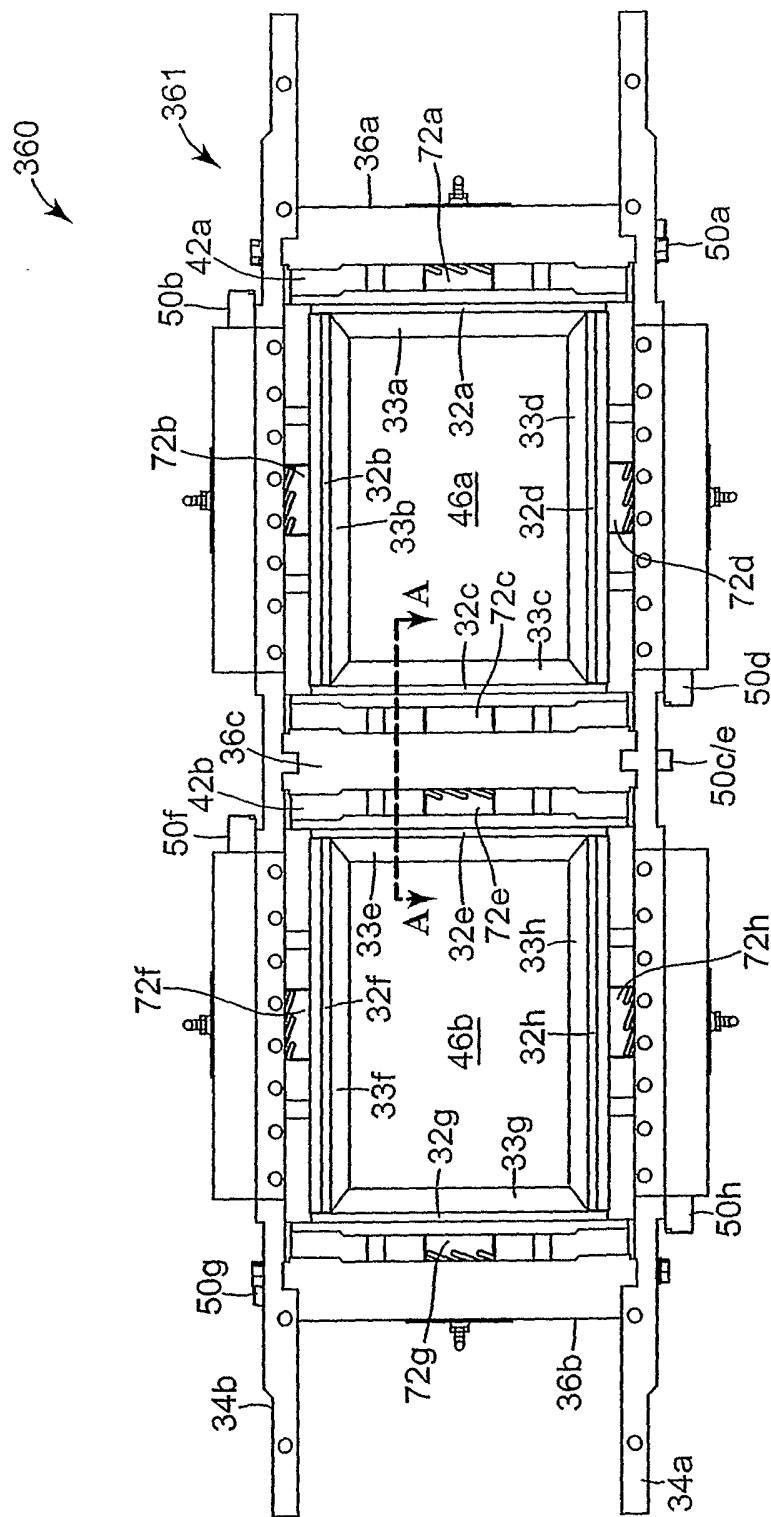


Fig. 11A

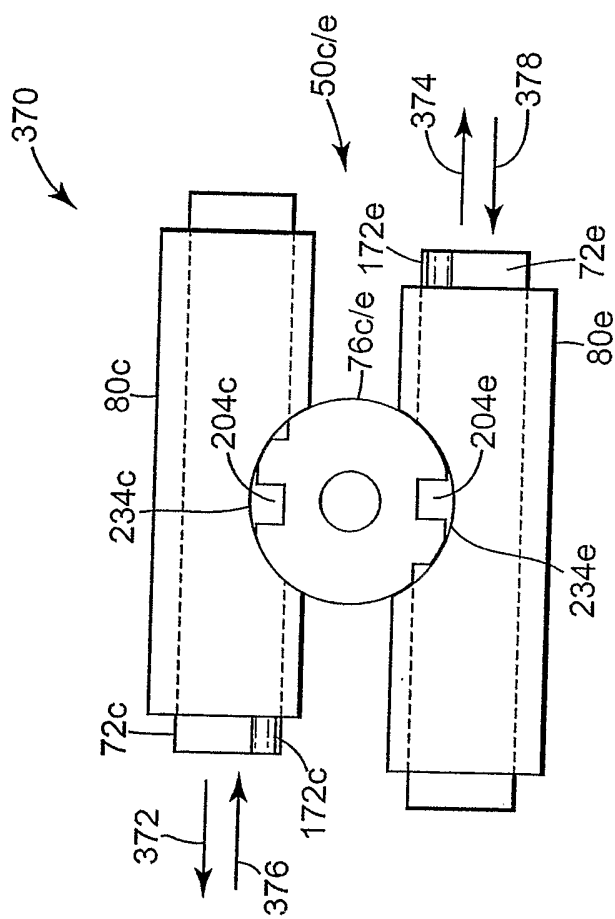


Fig. 11B

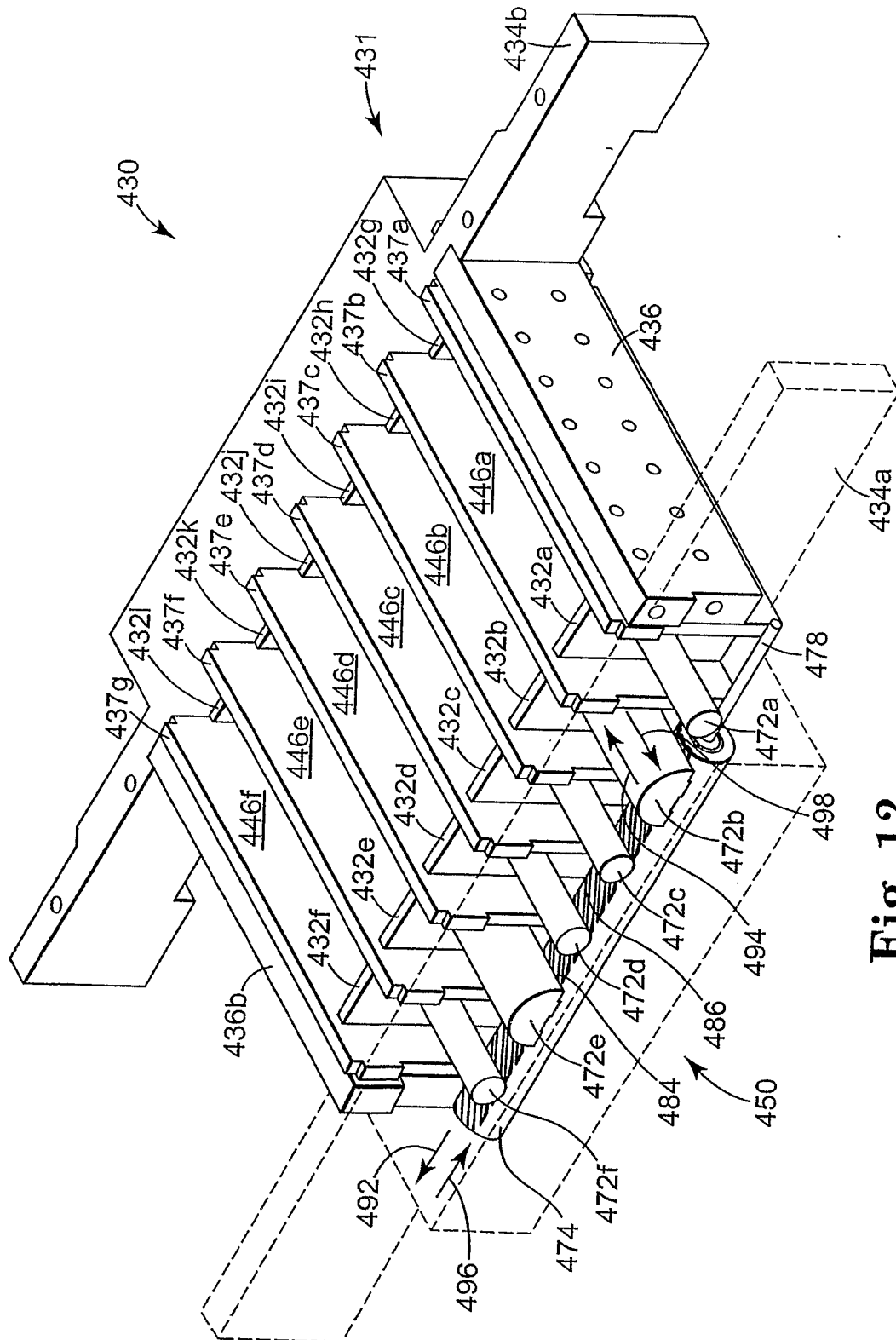


Fig. 12

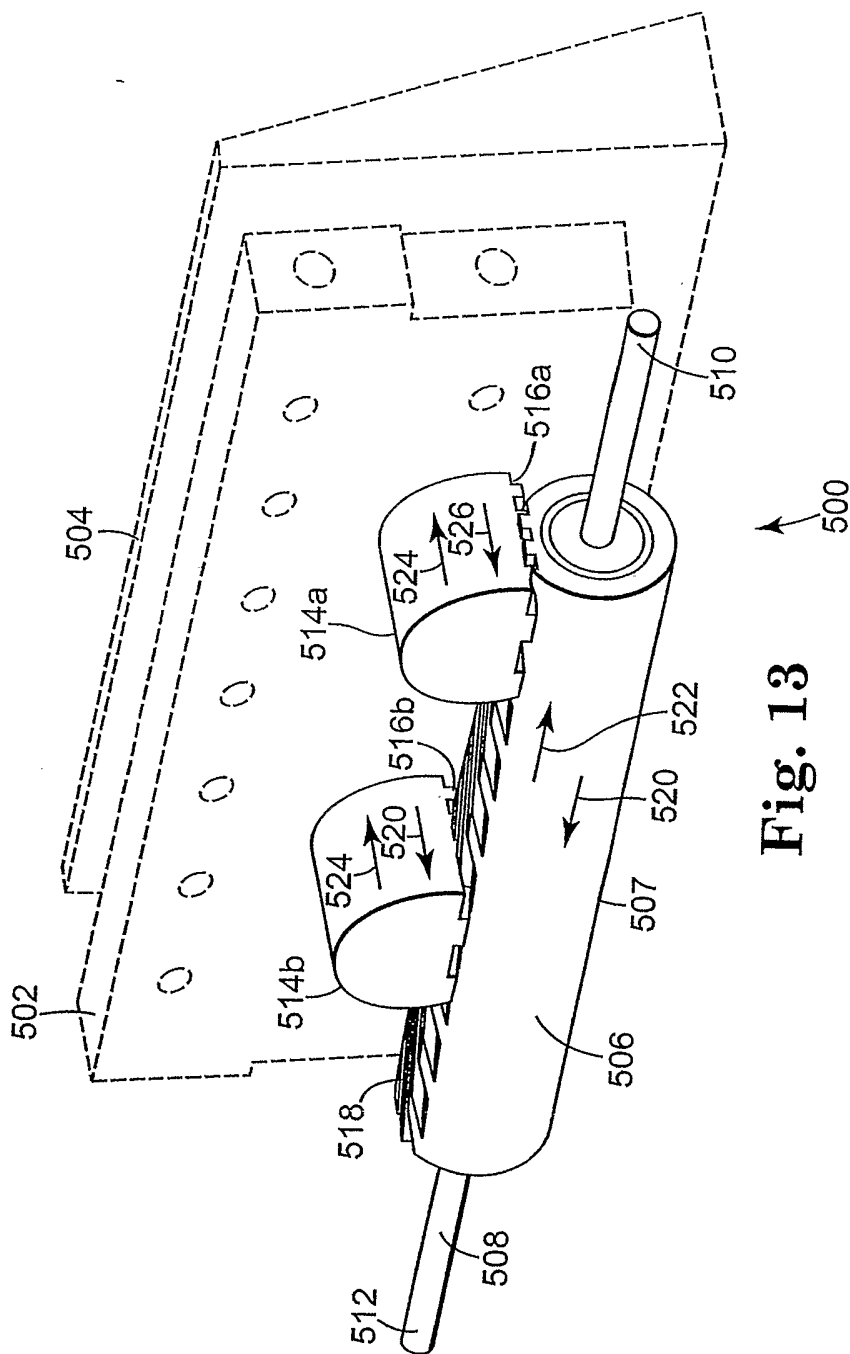


Fig. 13

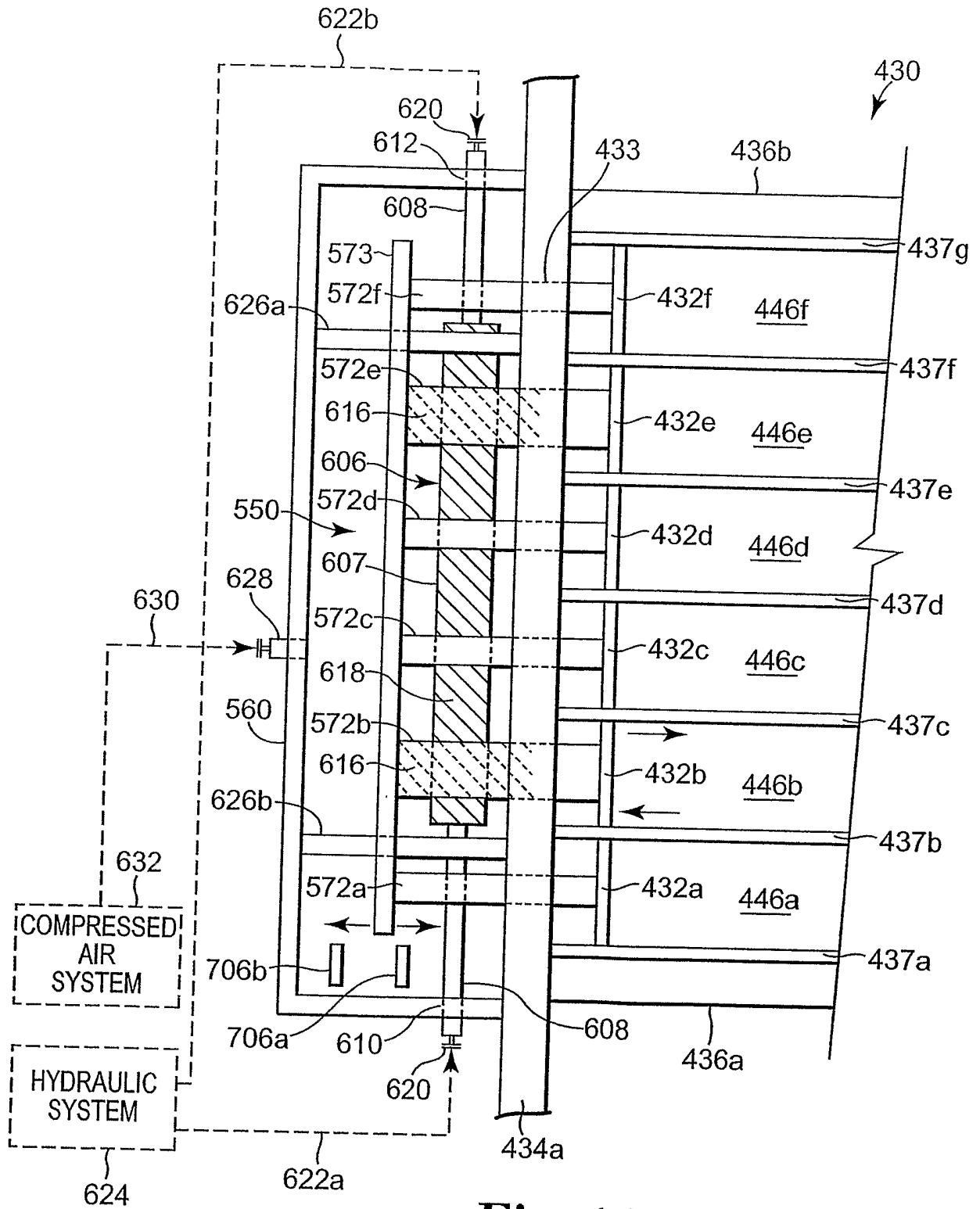


Fig. 14

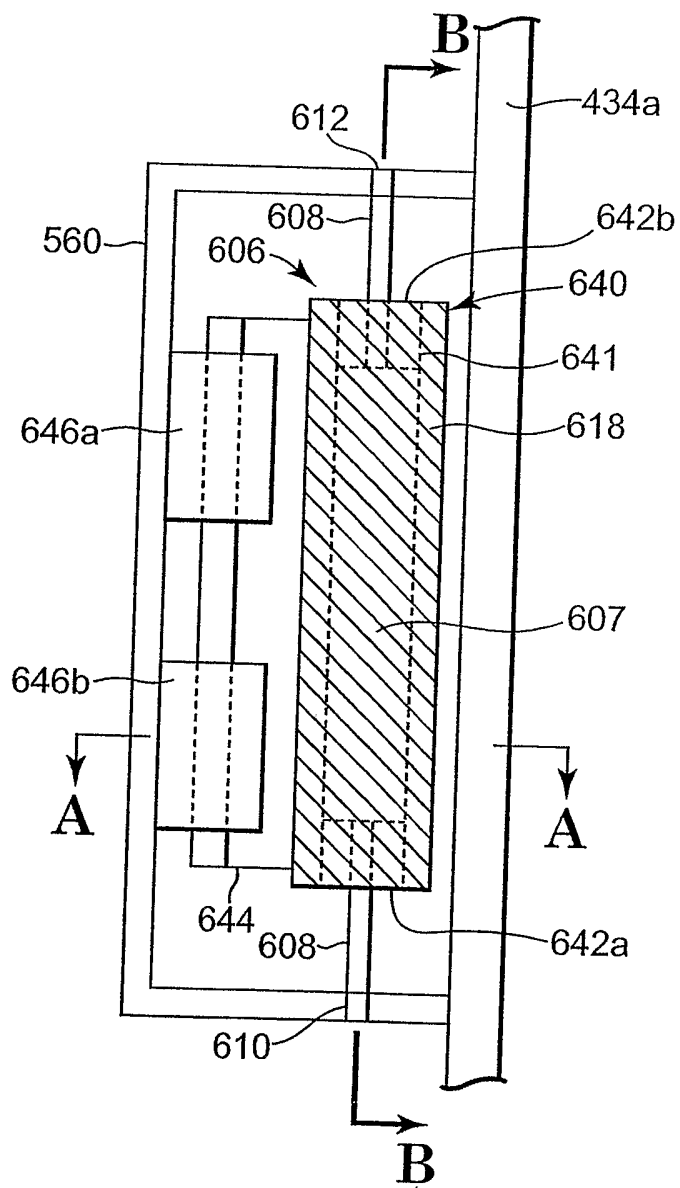


Fig. 15A

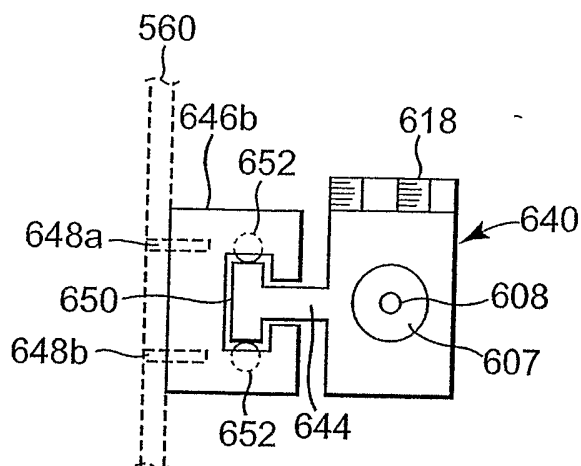


Fig. 15B

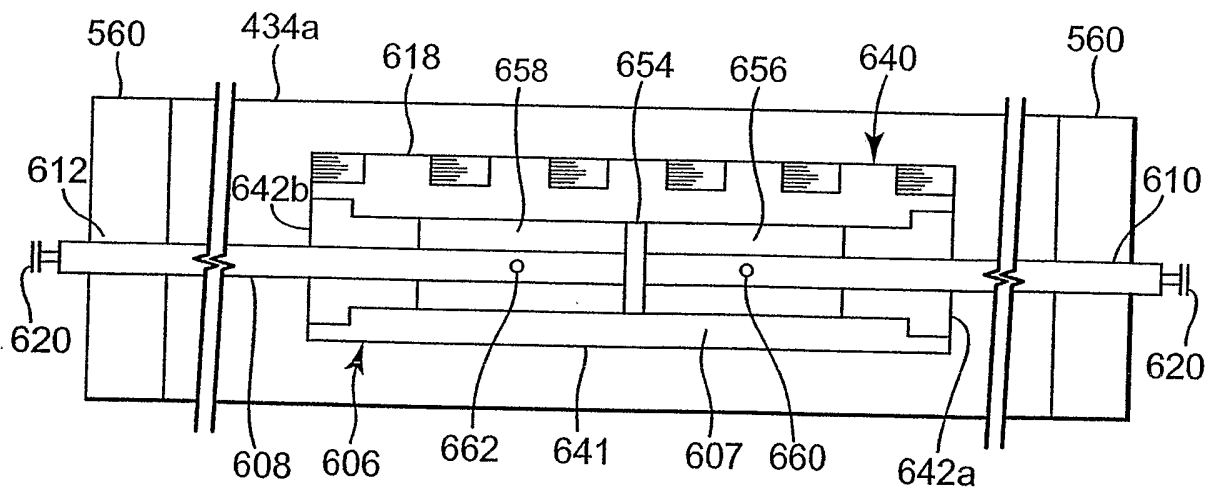


Fig. 15C

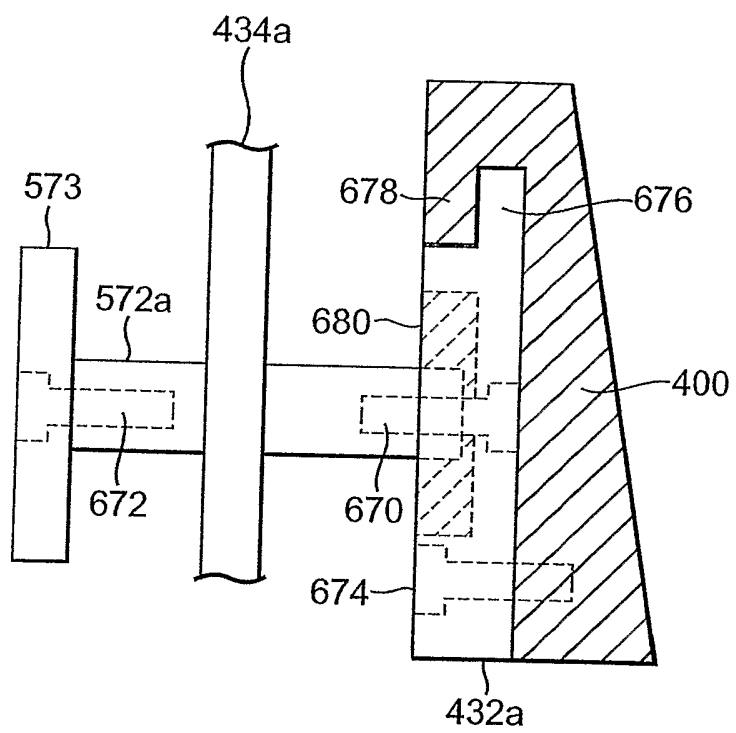


Fig. 16

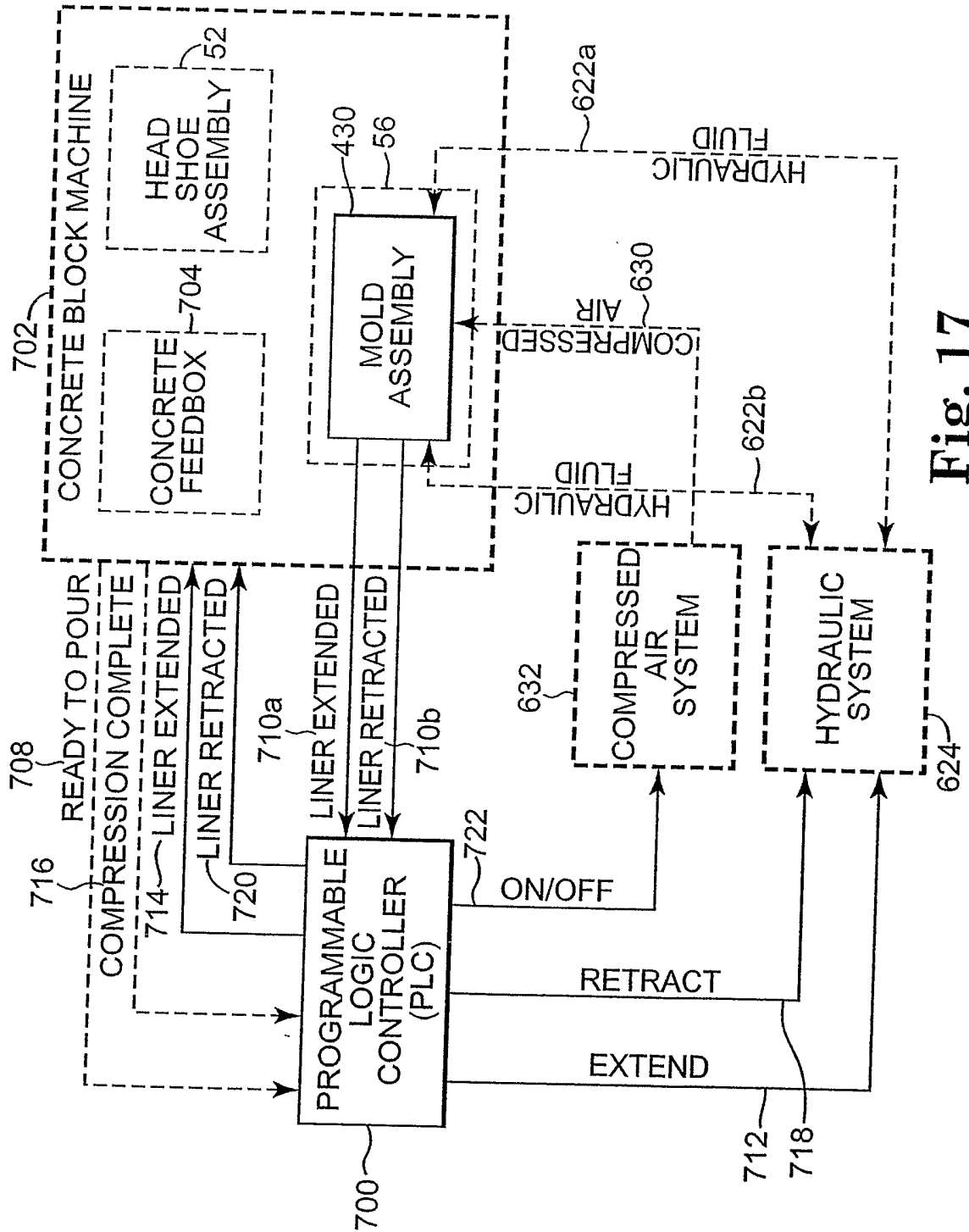


Fig. 17

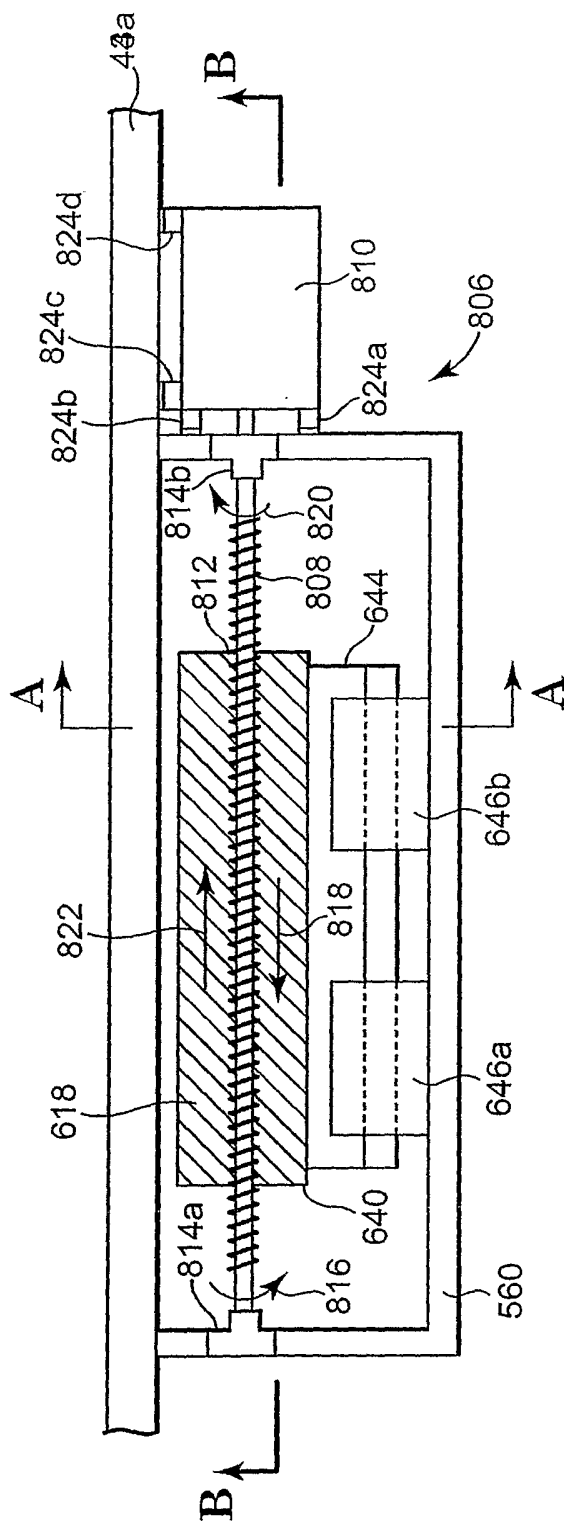


Fig. 18A

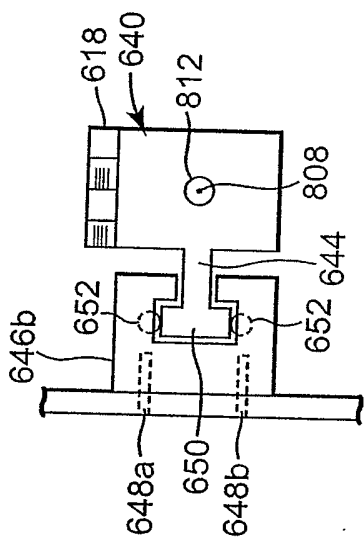


Fig. 18B

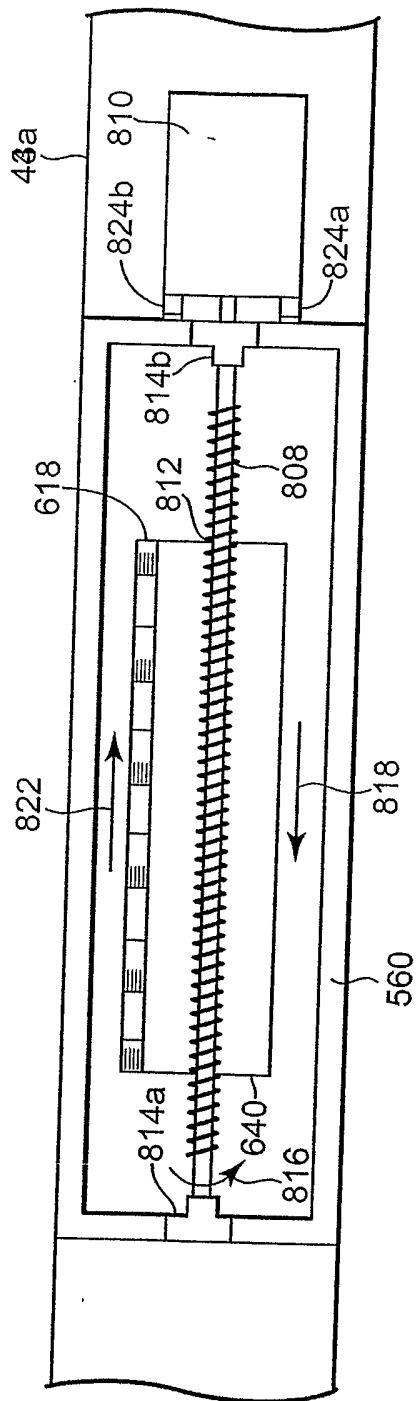


Fig. 18C

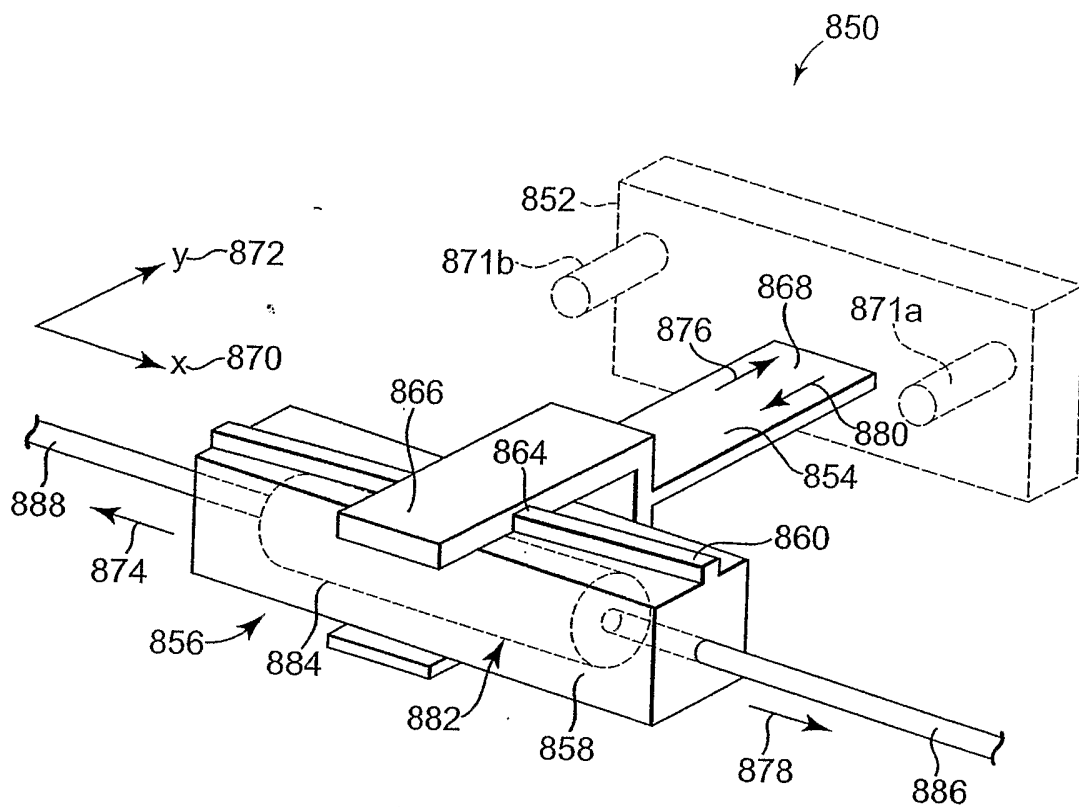


Fig. 19A

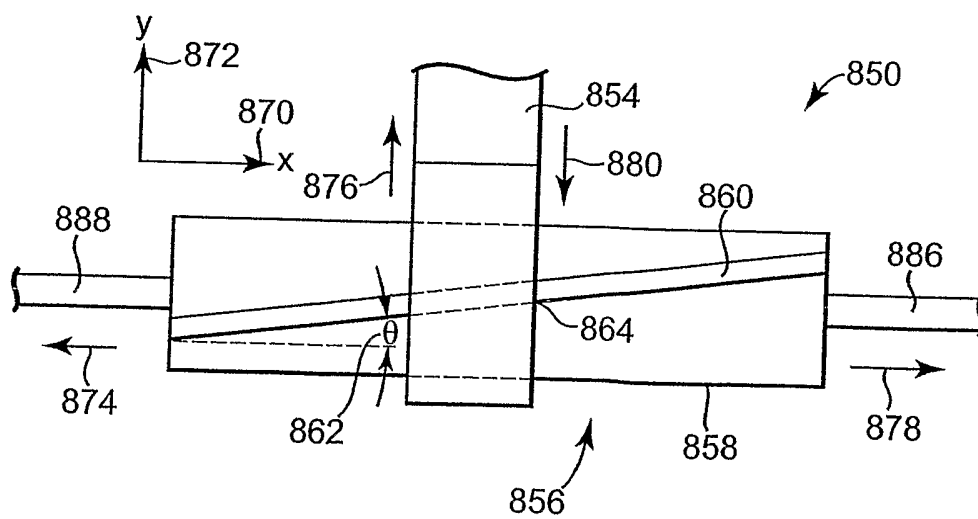


Fig. 19B

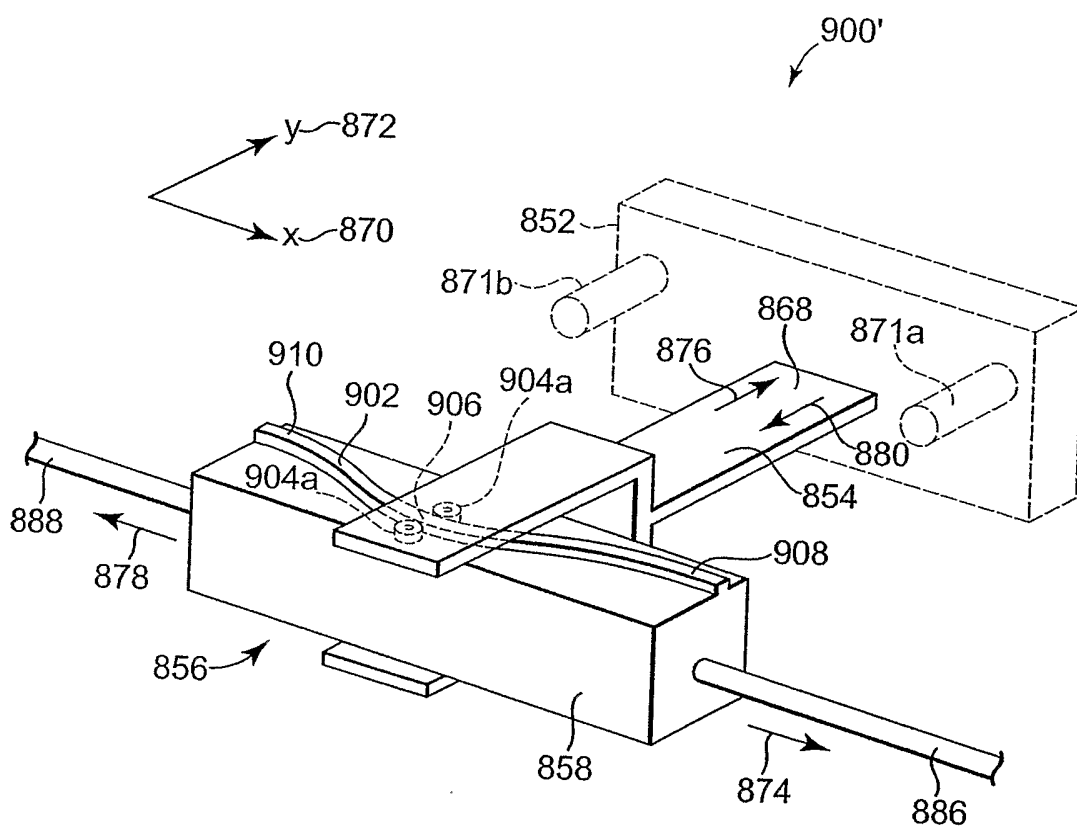


Fig. 20

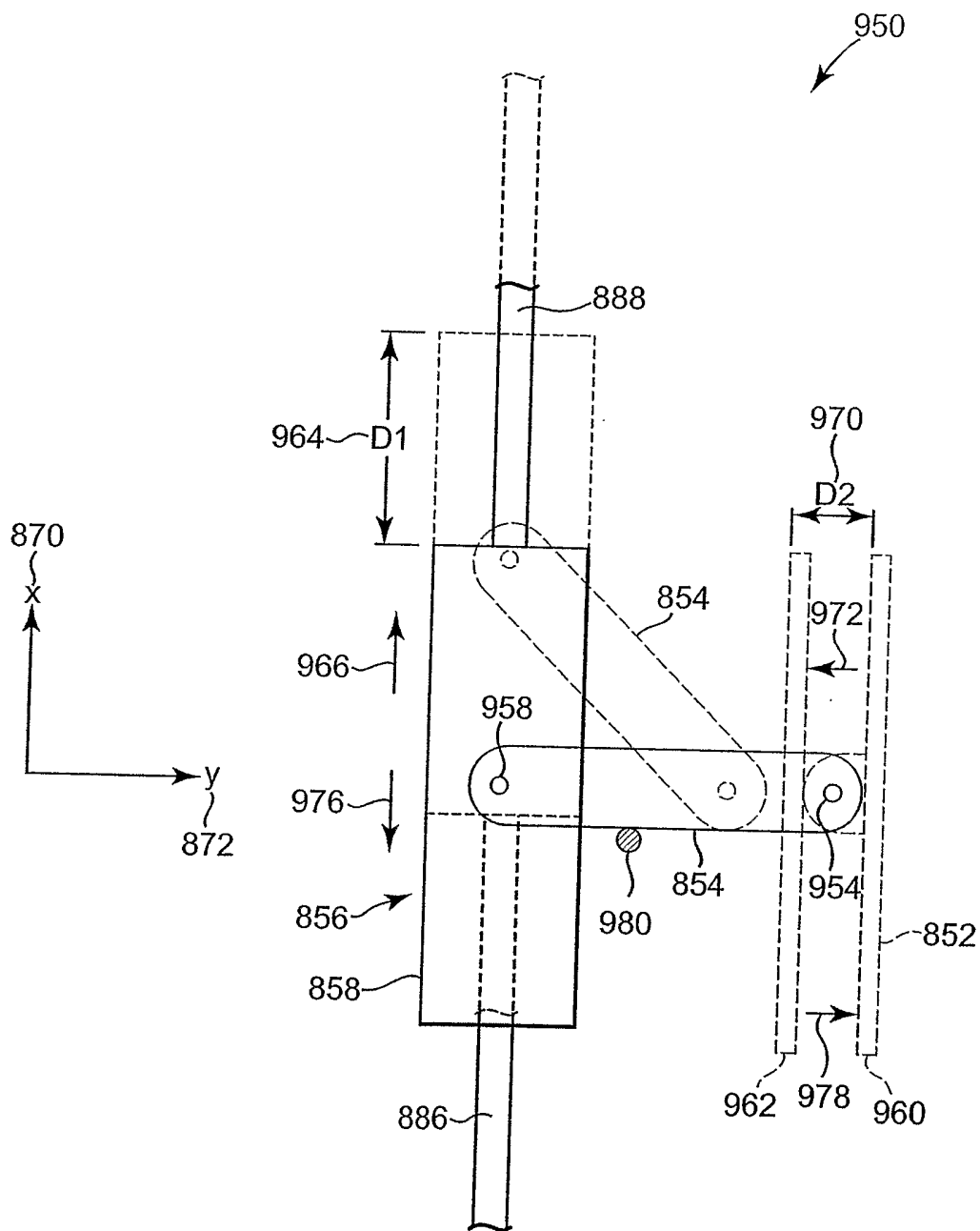


Fig. 21

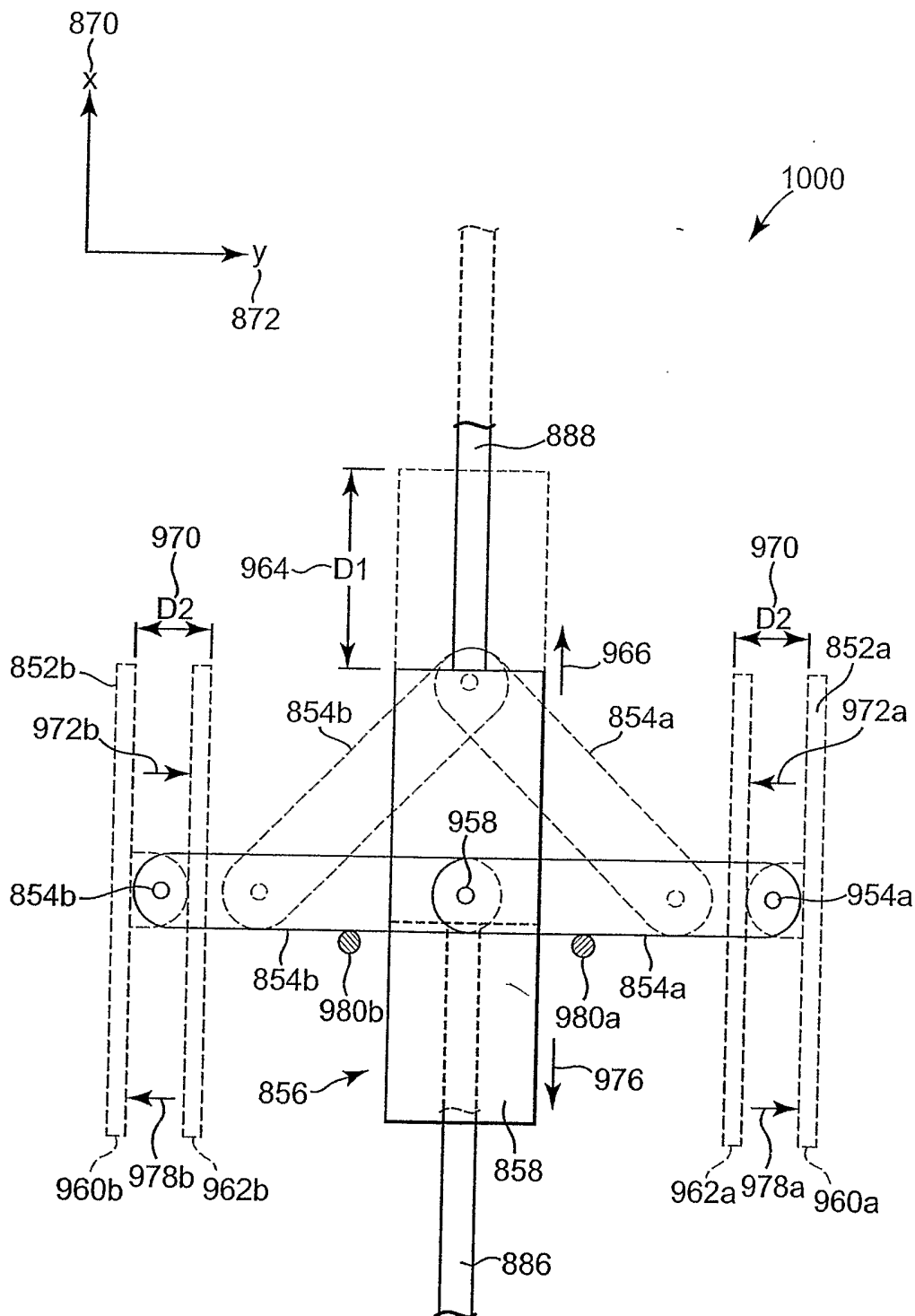


Fig. 22

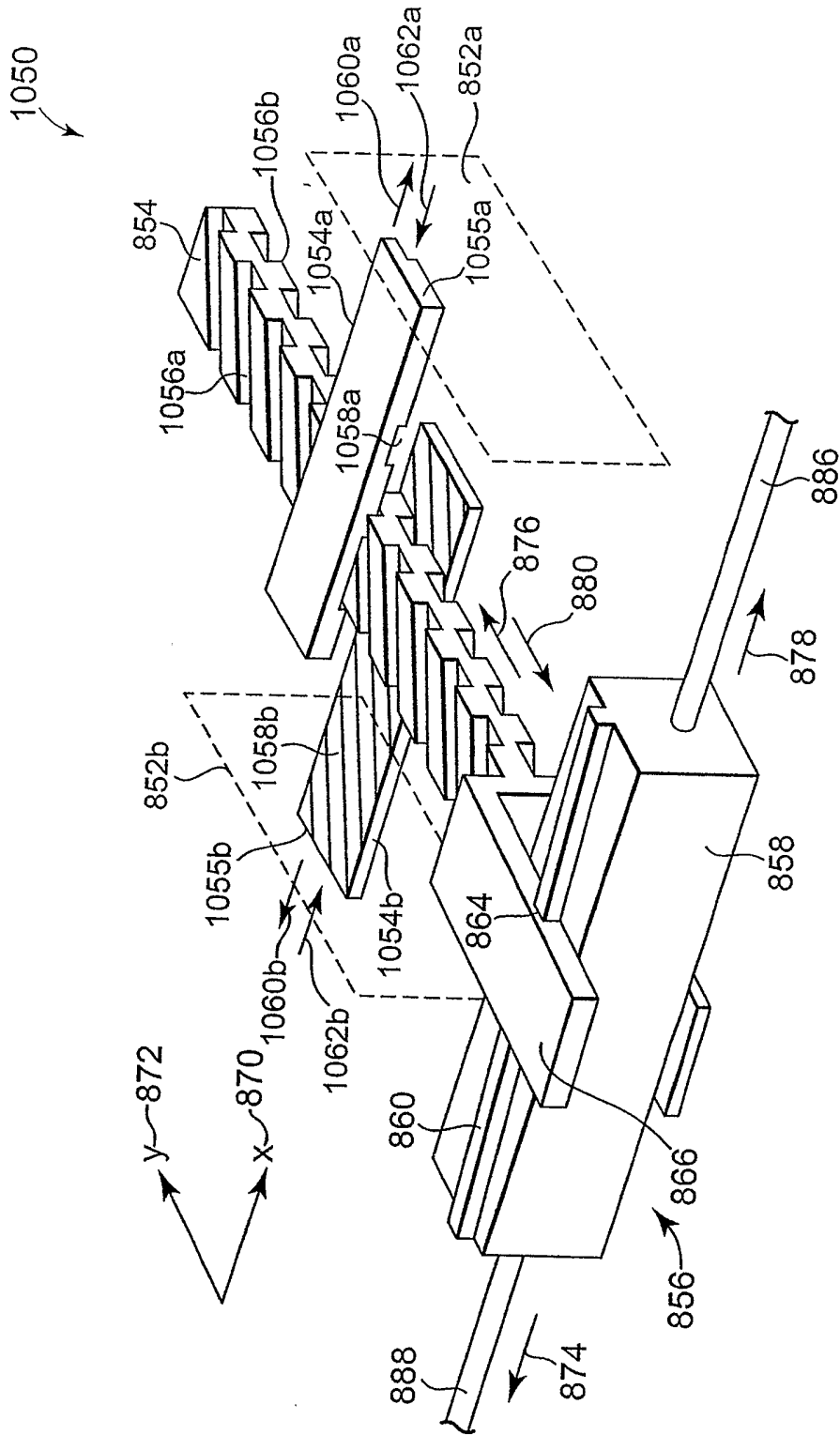


Fig. 23