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

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
26 April 2018 (26.04.2018)

(10) **International Publication Number**
WO 2018/072010 A1

(51) **International Patent Classification:**
B29C 45/04 (2006.01) *B29C 45/17* (2006.01)

(21) **International Application Number:**
PCT/CA2017/051074

(22) **International Filing Date:**
13 September 2017 (13.09.2017)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
62/409,937 19 October 2016 (19.10.2016) US

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) **Title:** LINEAR ACTUATOR FOR A MOLDING OR ROBOTICS SYSTEM

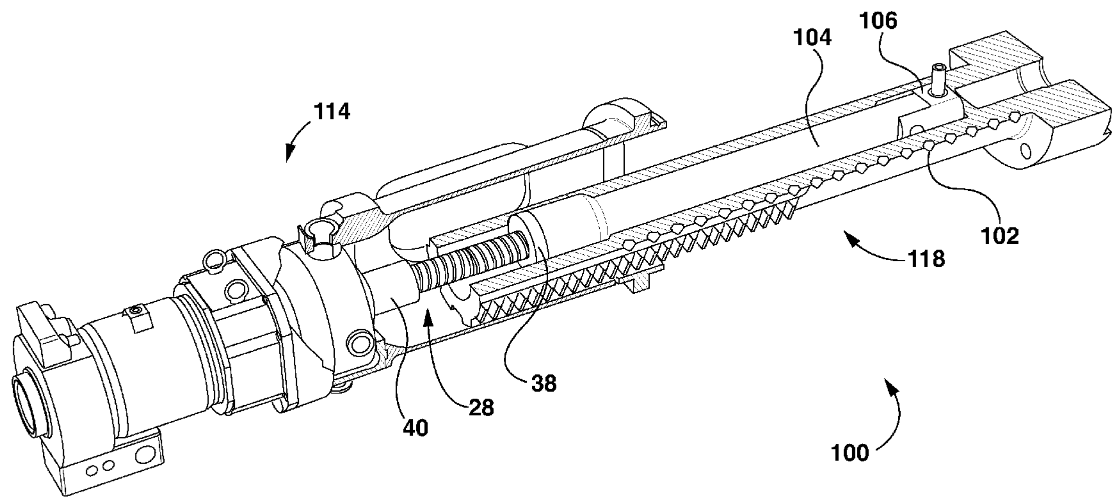

FIG. 2

(57) **Abstract:** A linear actuator to impart linear motion to a payload using a double-threaded ballscrew between a stationary platen and a movable platen. A rotational force applied to the ballscrew by a motor on the stationary platen causes the ballscrew move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the stationary platen in a forward direction and the movable platen moves linearly relative to the ballscrew in the forward direction. The rear end of the ballscrew is supported within a bore in the stationary platen, and the front end of the ballscrew is supported within the bore of the movable platen, in both the extended and retracted positions.

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[Continued on next page]

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*

LINEAR ACTUATOR FOR A MOLDING OR ROBOTICS SYSTEM

FIELD

The present application generally relates to linear actuators and, in particular, linear actuators for use in injection molding systems or robotics systems.

BACKGROUND

Injection molding machines and other industrial machinery or robotic often include a linear actuator for linearly moving one portion of the machine relative to another portion of the machine, for example in a clamping operation. As an example, an injection molding machine may have a clamp assembly that quickly and securely presses the cold half of a mold against a hot half of a mold to enable a subsequent injection operation. The clamp assembly then quickly withdraws the cold half of the mold after a cooling operation to enable removal or ejection of the molded parts. Some injection molding machines include a ballscrew for translating rotational motorized force into linear motion.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made, by way of example, to the accompanying drawings which show example embodiments of the present application, and in which:

Figure 1 shows an example embodiment of a portion of an injection molding machine;

Figure 2 shows a perspective partial cross-sectional view of an example of a linear actuator;

Figure 3 shows a cross-sectional perspective view of portion of the rear end of the linear actuator;

Figure 4 shows a cross-sectional close-up view of a central portion of the linear actuator;

Figures 5A-5D illustrate, in cross-sectional view, the example linear actuator in a retracted position, a partly retracted position, a partly extended position, and an extended position, respectively;

Figure 6 shows a partial view of a cross-section of the linear actuator of Figure 1;

Figure 7 shows an example embodiment of a clamp assembly having a crosshead and toggle linkages;

Figure 8 shows an example of a two-platen embodiment of a clamp assembly; and

Figure 9 shows an end view of an example of a two-ballscrew, two-platen embodiment of a clamp assembly.

Similar reference numerals may have been used in different figures to denote similar components.

DESCRIPTION OF EXAMPLE EMBODIMENTS

The present application describes devices for imparting linear displacement at high speed and force, which may find particular application in injection molding systems and/or robotics systems. Some embodiments of the present application may provide for improved service life and/or speed as compared to some existing linear actuators.

In a first aspect, the present application describes an actuator to impart linear motion to a payload. The actuator includes a stationary platen having a bore extending therein; a movable platen having a bore extending therein; a ballscrew with a forward end and a rear end, the ballscrew having a first thread and a second thread, where the first thread and the second thread are in opposing directions, the rear end of the ballscrew being supported within the bore of the stationary platen, and the forward end of the ballscrew being supported within the bore of the movable platen; a fixed nut attached to the stationary platen and engaging the first thread; a moving nut attached to the movable platen and engaging the second thread; and a rotational power source coupled to the rear end of the ballscrew to impart a rotational force to the ballscrew. The rotational force, when applied, is to cause the ballscrew to move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the stationary platen in a forward direction and the movable platen moves linearly relative to the ballscrew in the forward direction.

In another aspect, the present application describes an actuator to impart linear motion to a payload. The actuator includes a stationary platen having a bore extending therein; a crosshead having a bore extending therein; a movable platen; toggle linkages attached to the stationary platen and to the movable platen and supporting the crosshead, the toggle linkages translating linear force on the crosshead relative to the stationary platen to corresponding linear force upon the movable platen; a ballscrew with a front end and a rear end, the ballscrew having a first thread and a second thread, where the first thread and the second thread are in opposing directions, the rear end of the ballscrew being supported within the bore of the stationary platen, and the front end of the ballscrew being supported within the bore of the crosshead; a fixed nut attached to the stationary platen and engaging the first thread; a moving nut attached to the crosshead and engaging the second thread; and a rotational power source coupled to the rear end of the ballscrew to impart a rotational force to the ballscrew. The rotational force, when applied, is to cause the ballscrew to move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the stationary platen in a forward direction and the crosshead moves linearly relative to the ballscrew in the forward direction.

In yet another aspect, the present application describes an actuator to impart linear motion to a payload. The actuator includes a first platen having a bore extending therein; a second platen having a bore extending therein; a ballscrew having a first thread and a second thread, where the first thread and the second thread are in opposing directions, a first end of the ballscrew being supported within the bore of the first platen, and a second end of the ballscrew being supported within the bore of the second platen; a first nut attached to the first platen and engaging the first thread; a second nut attached to the second platen and engaging the second thread; and a rotational power source coupled to the rear end of the ballscrew to impart a rotational force to the ballscrew. The rotational force, when applied, is to cause the ballscrew to move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the first platen in a direction and the second platen moves linearly relative to the ballscrew in the direction.

Other aspects and features of the present application will be understood by those of ordinary skill in the art from a review of the following description of examples in conjunction with the accompanying figures.

In the description that follows, some example embodiments are described in the context of an injection molding system. It will be appreciated that aspects of the present application may be implemented in other industrial machines employing linear actuators and that the present application is not necessarily limited to injection molding applications.

In the present application, the term “and/or” is intended to cover all possible combinations and sub-combinations of the listed elements, including any one of the listed elements alone, any sub-combination, or all of the elements, and without necessarily excluding additional elements.

In the present application, the phrase “at least one of …or…” is intended to cover any one or more of the listed elements, including any one of the listed elements alone, any sub-combination, or all of the elements, without necessarily excluding any additional elements, and without necessarily requiring all of the elements.

Reference is first made to Figure 1, which shows an example embodiment of a portion of an injection molding machine. In particular, Figure 1 depicts, in diagrammatic form, a clamp assembly 10. The clamp assembly 10 includes a first stationary platen 12 and a second stationary platen 14. The two stationary platen 12, 14 are spaced apart and are connected by tie bars 16. The clamp assembly 10 further includes a movable platen 18 that is located between the first and second stationary platens 12, 14 and is assembled to enable translational movement therebetween. In particular, portions of the movable platen 18 slide along a base/frame or are guided by the tie bars 16 and a linear actuator acts on the movable platen 18 to urge it towards to the first stationary platen 12 or to withdraw it from the first stationary platen 12. The linear actuator generates a linear force between the second stationary platen 14 and the movable platen 18 to cause the translational movement of the movable platen 18. The force applied between the second stationary platen 14 and the movable platen 18 urging the movable platen 18 toward the first stationary platen 12 will also impart force upon the tie bars 16.

The first stationary platen 12 may support a hot half of a mold 22, including a hot runner in some embodiments. The movable platen 18 supports a corresponding cold half of the mold 20. When the clamping operation occurs, the cold half of the mold 20 is forced against the hot half of the mold 22 and an injection operation takes place to fill the mold with liquefied material. The linear actuator applies the force to quickly and forcibly move the movable platen 18 from a withdrawn position to a clamping position, and then to withdraw the movable platen 18 after the molding cycle within the mold has occurred. In some embodiments the movable platen 18 may support the hot half of the mold and the first stationary platen 12 may support the cold half of the mold. In some cases, the respective halves of the mold may be referred to as a stationary half and a moving half.

The linear actuator includes a ballscrew 28. The ballscrew 28 is a long shaft extending between the second stationary platen 14 and the movable platen 18. A conventional ballscrew in a linear actuator has a set of external threads on the shaft that engage with internal threads on a nut that is affixed to the apparatus such that when the ballscrew is rotated, the mating threads cause relative linear movement between the nut and the ballscrew. In this example, however, the ballscrew 28 is double-threaded, where the two sets of threads 34, 36 are of opposite orientations. That is, the ballscrew 28 features both left-handed and right-handed threads 34, 36. A fixed nut 40 is mounted to the second stationary platen 14 and has internal threads that engage the threads 36 of the ballscrew 28. A movable nut 38 is attached to the movable platen 18 and has internal threads that engage the threads 34 of the ballscrew. When the ballscrew 28 is rotated, the ballscrew 28 moves linearly relative to both the second stationary platen 14 and the movable platen 18. This provides the ballscrew 28 with double the axial linear speed for a given rotations-per-minute (rpm) as compared to a single-threaded ballscrew, assuming the same thread lead. The ballscrew 28 may be configured to move between a retracted position in which the movable platen 18 is withdrawn away from the first stationary platen 12, and an extended position in which the movable platen 18 is advanced towards the first stationary platen 12 to forcibly join the hot half of the mold 22 to the cold half of the mold 20.

Advantageously, in many embodiments of the present application, both ends of ballscrew 28 are supported in this assembly, which may avoid whipping and the consequent reduction of service life. In some cases, the support at one end may be implemented using a hollow shaft drive mechanism, as will be described below, which may help to reduce footprint of the actuator and overall assembly.

Referring still to Figure 1, the ballscrew 28 includes a rear end 30 and a forward end 32. The rear end 30 is disposed within a bore 26 in the second stationary platen 14 and the forward end 32 is disposed within a bore 24 in the movable platen 18.

The bores 24, 26 are cylindrical in many embodiments and are of sufficient linear depth that the rear end 30 and forward end 32 of the ballscrew 28 remain within the respective bores 24, 26 when the ballscrew 28 is in the retracted position, extended position, or at an intermediate position between retracted and extended.

The second stationary platen 14 includes a rotational power source, which in this example includes a motor. In particular, in this example, the motor comprises a hollow shaft direct drive motor 50. In the case of the hollow shaft motor 50, the hollow shaft forms at least a portion of the bore 26 and is rotationally driven by the motor. The motor 50 may be direct drive motor in some embodiments. In some other embodiments, the motor may be connected to the hollow shaft via a transmission. The interior surface of the hollow shaft has axially-extending ridges (*e.g.* splines). The rear end 30 of the ballscrew 28 has cooperating ridges (*e.g.* splines) on its external surface that engage the ridges of the hollow shaft to impart rotational force to the ballscrew 28. The hollow shaft configuration may provide a better dynamic response than some alternatives.

Reference is now made to Figure 2, which shows a perspective partial cross-sectional view of a linear actuator 100, Figure 3, which shows a cross-sectional perspective view of portion of the rear end of the linear actuator 100, and Figure 4, which shows a cross-sectional close-up view of a central portion of the linear actuator 100.

The linear actuator 100 includes a stationary assembly 114 and a movable assembly 118. The movable assembly 118 is driven forward linearly or retracted linearly by rotation of the ballscrew 28 having opposite threads in cooperation with the fixed nut 40 and the movable nut 38.

The movable assembly 118, in this example, includes an interior cylinder 104 within an exterior cylinder 102. The interior cylinder 104 is attached at its forward end to the exterior cylinder 102 through a compensating element 106 that allows for some tolerance in the axial alignment of the interior cylinder 104 and exterior cylinder 102. This compensating element 106 can reduce or avoid bending stress and strain due to small misalignments within the linear actuator 100 in use.

The stationary assembly 114 features a hollow shaft direct drive motor for rotating the ballscrew 28. As shown in Figure 3, the bore within the stationary assembly 114 is partly formed by the hollow shaft 120 having internal axially-extending ridges. The ballscrew 28 includes an end sleeve 122 having cooperating external splines for engaging the hollow shaft 120. The end sleeve 122 is fixed to the ballscrew 28. In some other embodiments, the exterior surface of the ballscrew 28 includes the external splines for engaging the hollow shaft 120 such that the sleeve 122 is not needed.

Figures 5A-5D illustrate, in cross-sectional view, the linear actuator 100 in a retracted position, a partly retracted position, a partly extended position, and an extended position, respectively. In this illustrative example, the rear end of the ballscrew 30 includes the end sleeve 122 for engagement with the ridges of the hollow shaft 120. The hollow shaft is drive by a direct drive servo motor. Rotation of the ballscrew 28 causes linear axial movement of the ballscrew 28 due to the external threads on the rear half of the ballscrew 28 engaging with the threads of the fixed nut 40 attached to the stationary assembly 114.

When the ballscrew 28 is rotated, the external threads on the front half of the ballscrew 28 engage the movable nut 38 attached to the movable assembly 118, causing linear movement of the movable assembly 118 relative to the ballscrew 28.

It may be noted from Figure 5A that in this example embodiment the rear end 30 of the ballscrew 28 is at or proximate a distal end of the bore 26 and the forward end 32 of the ballscrew 28 is at or proximate an internal end of the bore 24, when the linear actuator 100 is in an fully retracted position.

Figure 6 shows a partial-view of a cross-section of the linear actuator 100, and in particular the forward end 32 of the ballscrew 28 within the bore 24 in the movable platen 18. The forward end 32 of the ballscrew 28 is supported for linear and rotational movement within the bore 24. In this example, the forward end 32 of the ballscrew 28 includes a narrowed portion 51 having a smaller radial diameter than the main portion of the ballscrew 28, which has a smaller radial diameter than a sleeve 52 which defines the inner wall of the bore 24. The forward end 32 of the ballscrew 28 is supported by a bearing assembly formed from a plain bearing 54 and a ball bearing assembly 56. The outer surface of the plain bearing 54 is the contact surface with the inner surface of the sleeve 52, and permits linear sliding of the ballscrew 28 within the sleeve 52. The ball bearing assembly 56 supports the narrowed portion 51 of the ballscrew 28 within the plain bearing 54 and permits rotation of the ballscrew 28 with respect to the plain bearing 54 and the sleeve 52.

Figure 7 shows another example embodiment of a clamp assembly 210 of an injection molding machine. The clamp assembly 210 in this embodiment includes a movable platen 218 and two stationary platen: a first stationary platen 212 and a second stationary platen 214. Tie bars 216 connect the first stationary platen 212 and the second stationary platen 214. The second stationary platen 214 is connected to the movable platen 218 by multiple toggle linkages 217. A ballscrew 228 having its rear end 230 supported in a cylindrical bore 226 where it may be driven by a hollow shaft direct drive motor 250, for example. A forward end 232 of the ballscrew 228 is supported within a cylindrical bore 224 of a crosshead 221 or by a similar tubular structure and assembly connected to the crosshead 221, as, for example, shown in Figure 6. The crosshead 221 is connected to the toggle linkages 217 and is guided relative to the stationary platen 214 (not all components shown for ease of illustration and understanding).

When the ballscrew 228 is rotated in one direction, it imparts a linear force upon the crosshead 221 moving it towards the movable platen 218. The toggle linkages 217 are configured so as to translate the linear movement of the crosshead 211 to a linear force upon the movable platen 218 moving it towards the first stationary platen 212. When the ballscrew 228 is rotated in the opposite direction, then the crosshead 221 is withdraw, which pulls the toggle linkages 217 such that they pull the movable platen 218 away from the first stationary platen 212.

In yet another embodiment, a simplified diagram of which is shown in Figure 8, a clamp assembly 310 includes one stationary platen 312 and a movable platen 318. A ballscrew 328 has one end supported within a bore 326 in a motor 350 and the other end supported within a bore 324 in the movable platen 318. The motor 350 for driving one end of the ballscrew 328 is mounted on either of the stationary platen 312 or the movable platen 318. Notably, the ballscrew 328 extending between the two platens 312, 318 is off-center with respect to the platens 312, 318. The approximate centerline of the two platens 312, 318 is indicated by reference numeral 319. Tie bars 316 may be used to guide the linear movement of the moving platen 318 relative to the stationary platen 312. The molds between the two platens 312, 318 are not shown for ease of illustration and clarity.

An end view of the simplified diagram of the clamp assembly 310 is shown in Figure 9. In this example, it will be noted that the clamp assembly 310 includes two ballscrews 328 situated on opposing sides and/or corners of the platens 312, 318. Three, for or more ballscrews may be used, with corresponding bores and motors, in some embodiments. The use of a single off-center ballscrew may impart a significant bending moment upon the platens 312, 318.

Although some of the above examples relate to clamp assemblies for injection molding machines, the present application may be applied to other assemblies. For example, some implementations may use a ballscrew assembly similar to one or more described herein in an ejection assembly, an injection unit, or other portions of an injection molding machine, or other industrial machines that employ linear actuators. In one example, the ballscrew assembly may be used as a linear actuator in a part ejection assembly, which includes a linear actuator to control a plate of pins used to eject parts from a mold. In another example, the ballscrew assembly may be used as a linear actuator in a valve gate assembly, which includes a linear actuator to control a set of valve plugs used to plug and unplug the tips of a plurality of valves.

Certain adaptations and modifications of the described embodiments can be made. Therefore, the above discussed embodiments are considered to be illustrative and not restrictive.

WHAT IS CLAIMED IS:

1. An actuator to impart linear motion to a payload, the actuator comprising:

a stationary platen having a bore extending therein;

a movable platen having a bore extending therein;

a ballscrew with a forward end and a rear end, the ballscrew having a first thread and a second thread, where the first thread and the second thread are in opposing directions, the rear end of the ballscrew being supported within the bore of the stationary platen, and the forward end of the ballscrew being supported within the bore of the movable platen;

a fixed nut attached to the stationary platen and engaging the first thread;

a moving nut attached to the movable platen and engaging the second thread; and

a rotational power source coupled to the rear end of the ballscrew to impart a rotational force to the ballscrew,

wherein the rotational force, when applied, is to cause the ballscrew to move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the stationary platen in a forward direction and the movable platen moves linearly relative to the ballscrew in the forward direction.

2. The actuator claimed in claim 1, wherein the bore within the stationary platen contains the rear end of the ballscrew in both the retracted and extended positions.

3. The actuator claimed in claim 2, wherein the bore within the movable platen contains the forward end of the ballscrew in both the retracted and extended positions.

4. The actuator claimed in claim 1, wherein the bore within the movable platen contains the forward end of the ballscrew in both the retracted and extended positions.

5. The actuator claimed in claim 1, wherein the rotational power source is mounted to the stationary platen and imparts the rotational force to the rear end of the ballscrew.

6. The actuator claimed in claim 5, wherein the rotational power source comprises a direct drive hollow shaft motor.

7. The actuator claimed in claim 6, wherein the direct drive hollow shaft motor includes a hollow shaft with a ridged interior surface that receives therein the rear end of the ballscrew, and wherein the rear end of the ballscrew is splined to engage the ridges of the hollow shaft.

8. The actuator claimed in claim 7, wherein the rear end of the ballscrew comprises an exterior surface, and the exterior surface is splined.

9. The actuator claimed in claim 8, wherein the rear end of the ballscrew includes an externally-splined sleeve in locked rotational engagement with an axial shaft of the ballscrew, and wherein the externally-splined sleeve engages the ridges of the hollow shaft.

10. The actuator claimed in claim 1, wherein the rotational power source comprises a direct drive hollow shaft motor.

11. The actuator claimed in claim 10, wherein the direct drive hollow shaft motor includes a hollow shaft with a ridged interior surface that receives therein one of the ends of the ballscrew, and wherein said one of the ends of the ballscrew is splined to engage the ridges of the hollow shaft.

12. The actuator claimed in claim 10, wherein the motor further includes a transmission to transfer rotational force to the ballscrew.

13. The actuator claimed in claim 1, wherein the actuator is used in an injection molding system.

14. The actuator claimed in claim 13, wherein the actuator is used in a clamp assembling in the injection molding system and wherein the payload comprises one side of a mold.

15. The actuator claimed in claim 1, further comprising tie bars attached to the stationary platen and upon which the movable platen moves in sliding relation to the stationary platen.

16. The actuator claimed in claim 1, wherein the bore in the movable platen has an inner surface formed by a sleeve, and wherein the forward end of the ballscrew includes a narrowed portion having a smaller radial diameter than a main portion of the ballscrew, and wherein the actuator includes a bearing assembly supporting the narrowed portion within the sleeve.

17. The actuator claimed in claim 16, wherein the bearing assembly includes a plain bearing having an outer surface in contact with the inner surface of the sleeve to permit linear sliding movement within the sleeve, and a ball bearing assembly between the plain bearing and the narrowed portion to permit rotation of the ballscrew.

18. An actuator to impart linear motion to a payload, the actuator comprising:

a stationary platen having a bore extending therein;

a crosshead having a bore extending therein;

a movable platen;

toggle linkages attached to the stationary platen and to the movable platen and supporting the crosshead, the toggle linkages translating linear force on the crosshead relative to the stationary platen to corresponding linear force upon the movable platen;

a ballscrew with a front end and a rear end, the ballscrew having a first thread and a second thread, where the first thread and the second thread are in opposing directions, the rear end of the ballscrew being supported within the bore of the stationary platen, and the front end of the ballscrew being supported within the bore of the crosshead;

a fixed nut attached to the stationary platen and engaging the first thread;

a moving nut attached to the crosshead and engaging the second thread; and

a rotational power source coupled to the rear end of the ballscrew to impart a rotational force to the ballscrew,

wherein the rotational force, when applied, is to cause the ballscrew to move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the stationary platen in a forward direction and the crosshead moves linearly relative to the ballscrew in the forward direction.

19. An actuator to impart linear motion to a payload, the actuator comprising:

a first platen having a bore extending therein;

a second platen having a bore extending therein;

a ballscrew having a first thread and a second thread, where the first thread and the second thread are in opposing directions, a first end of the ballscrew being supported within the bore of the first platen, and a second end of the ballscrew being supported within the bore of the second platen;

a first nut attached to the first platen and engaging the first thread;

a second nut attached to the second platen and engaging the second thread; and

a rotational power source coupled to the rear end of the ballscrew to impart a rotational force to the ballscrew,

wherein the rotational force, when applied, is to cause the ballscrew to move from a retracted position to an extended position, in which the ballscrew moves linearly relative to the first platen in a direction and the second platen moves linearly relative to the ballscrew in the direction.

20. The actuator claimed in claim 19, wherein the ballscrew is off-center with respect to the platens, and wherein the actuator further comprises tie bars to guide the movement of the platens relative to each other and impart a clamping force.

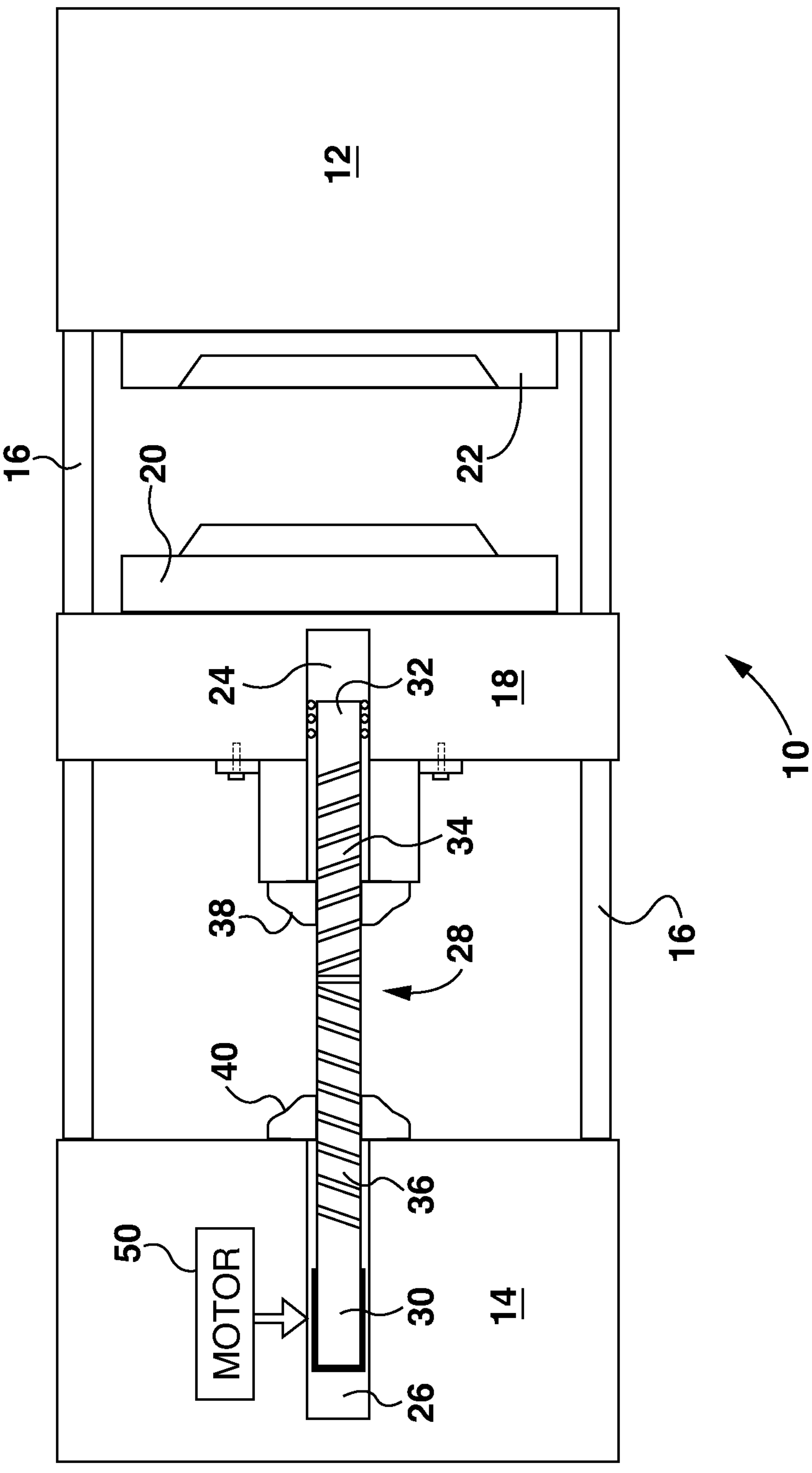


FIG. 1

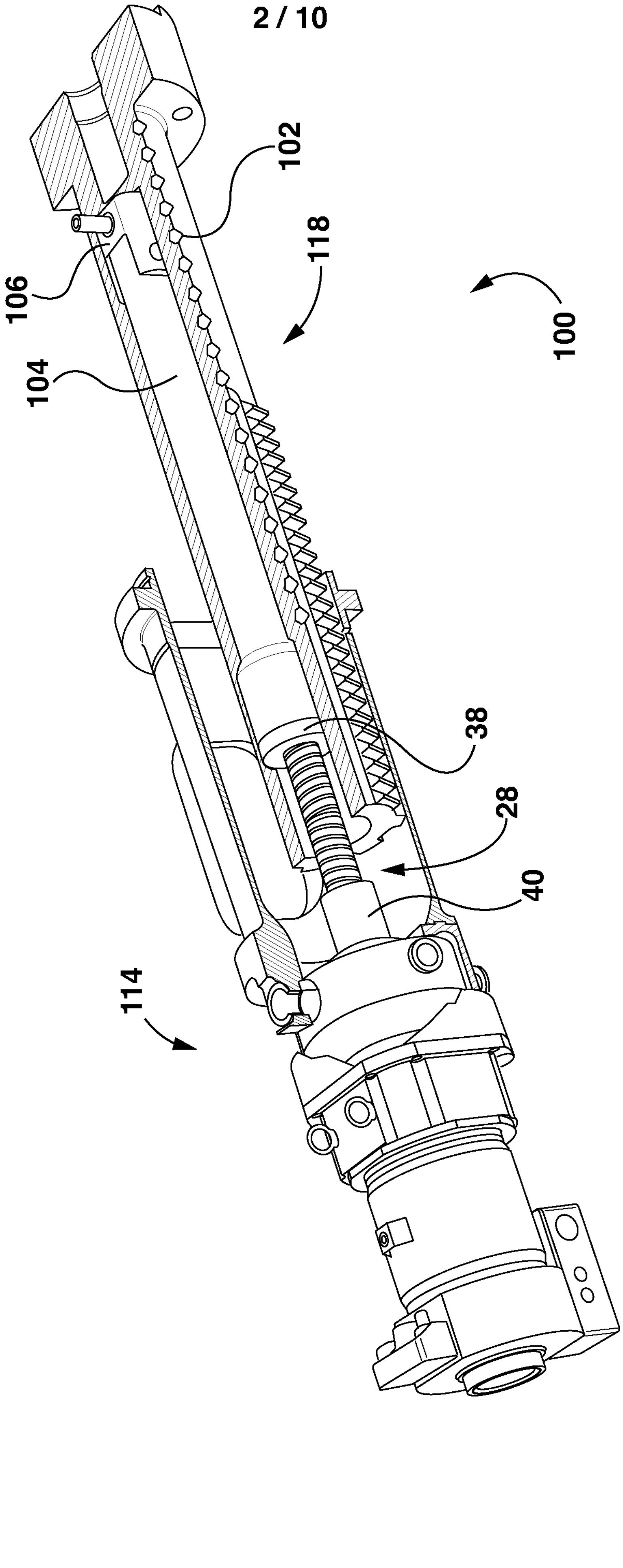


FIG. 2

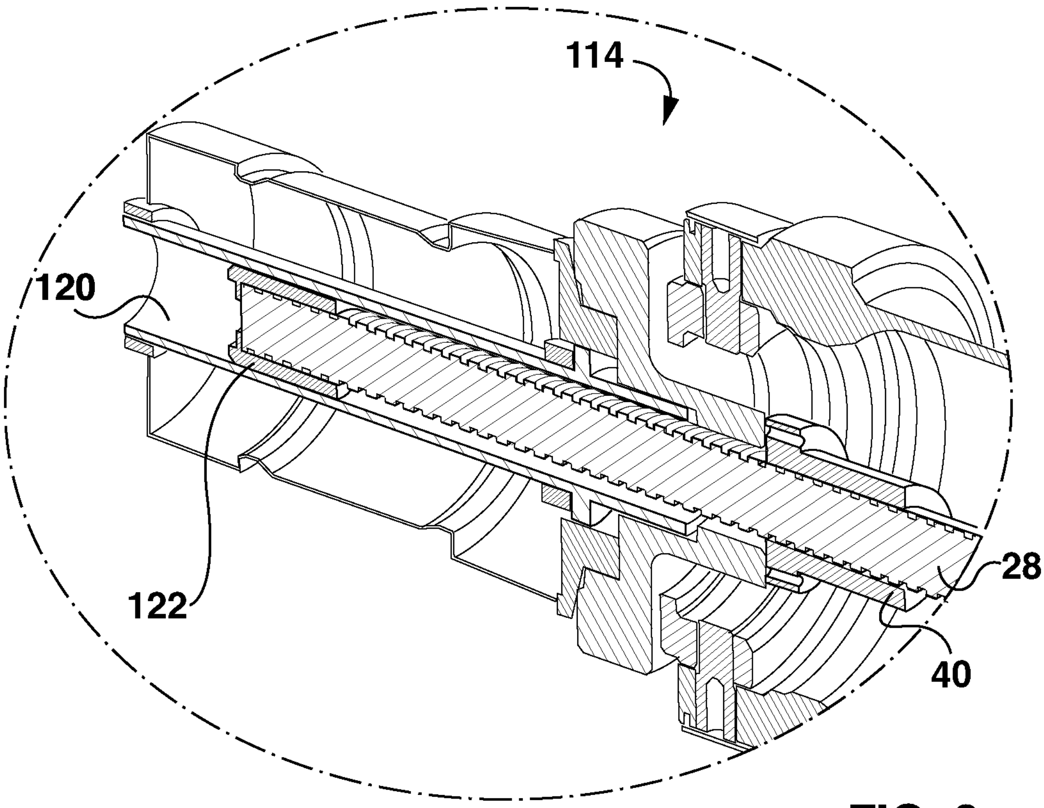


FIG. 3

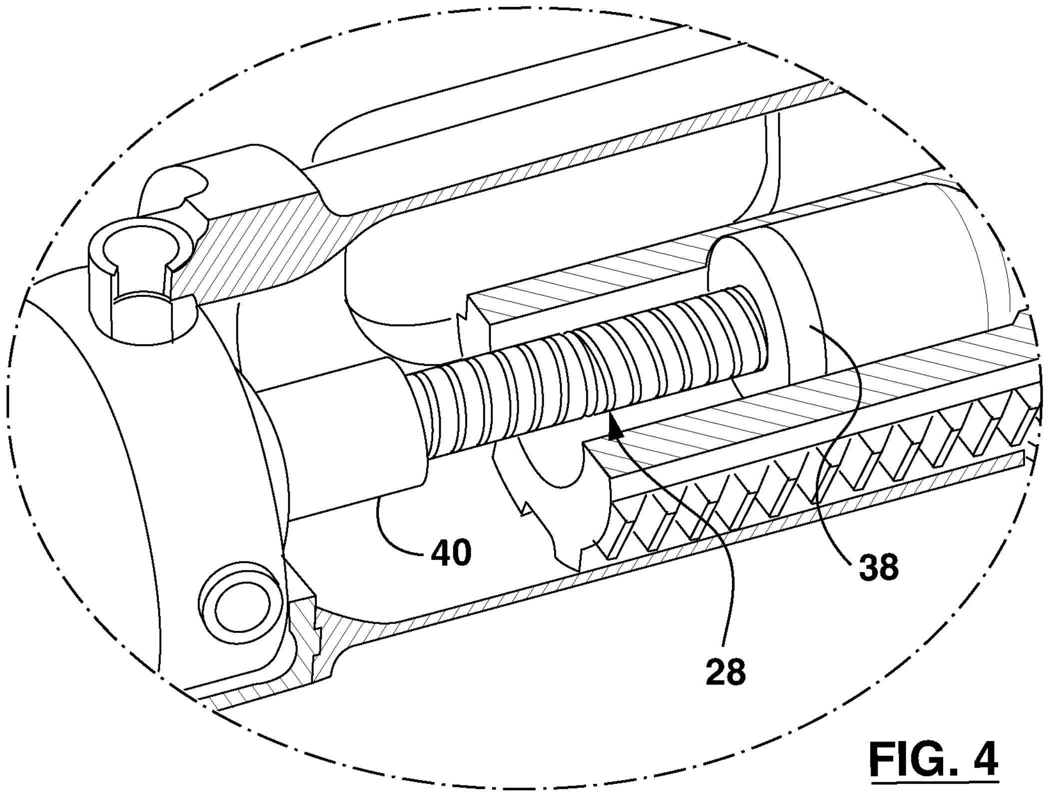


FIG. 4

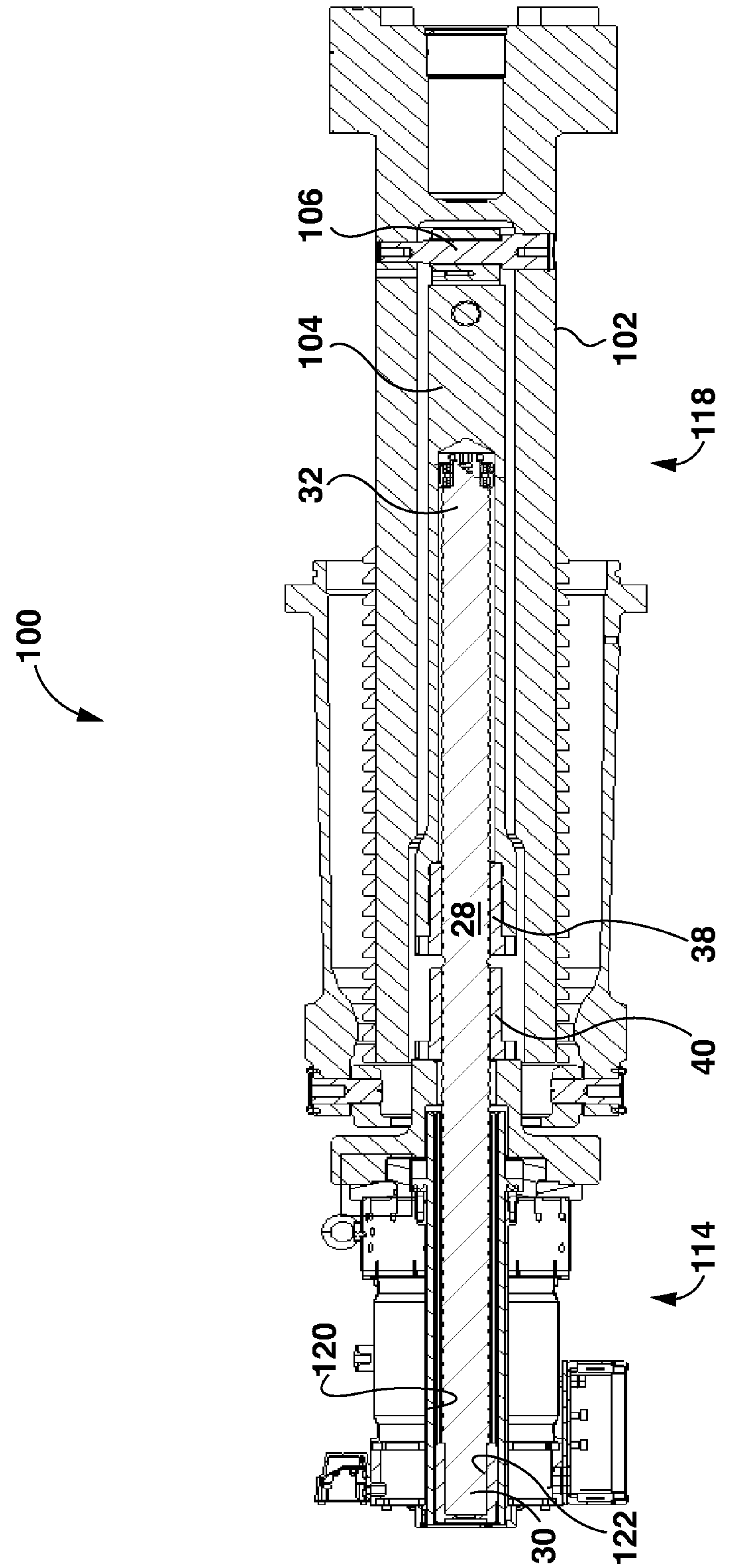


FIG. 5A

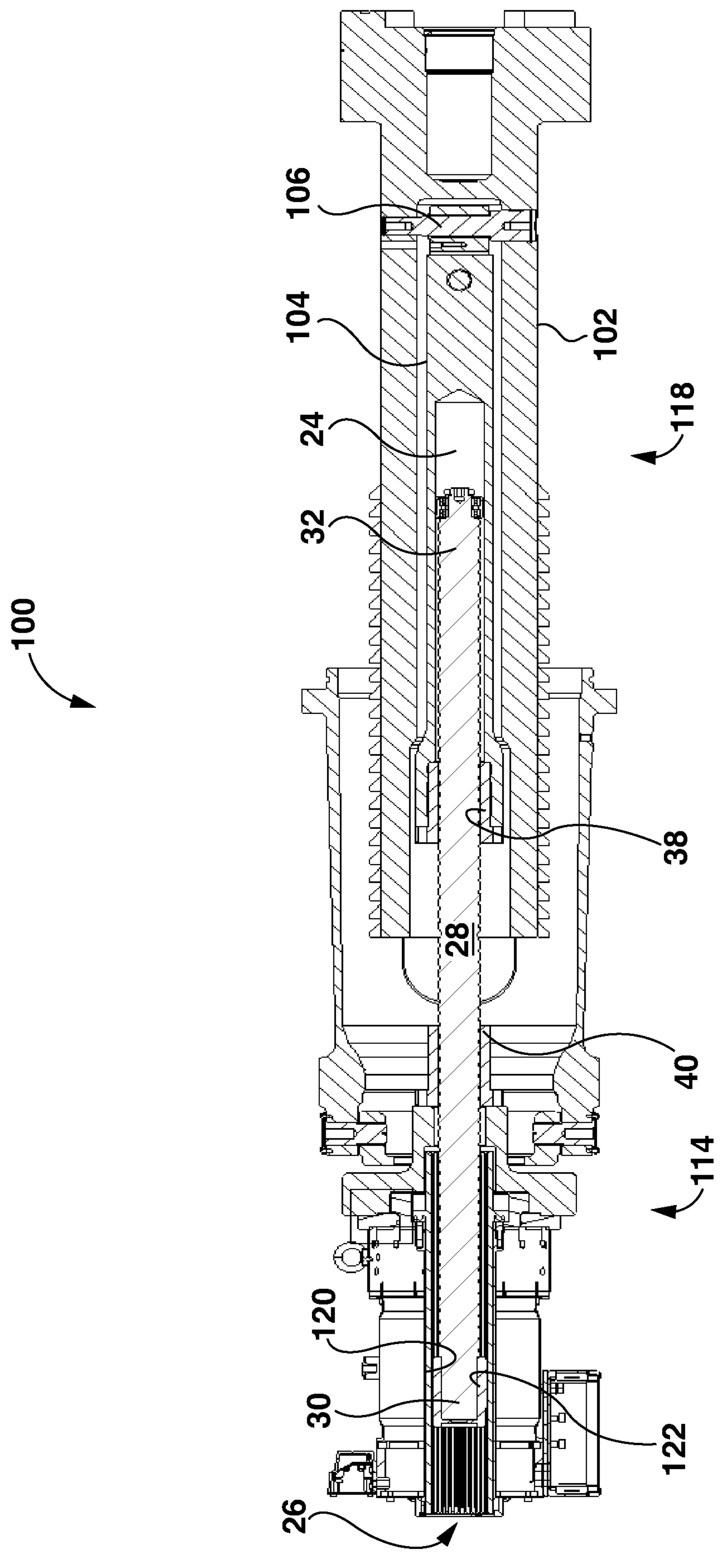


FIG. 5B

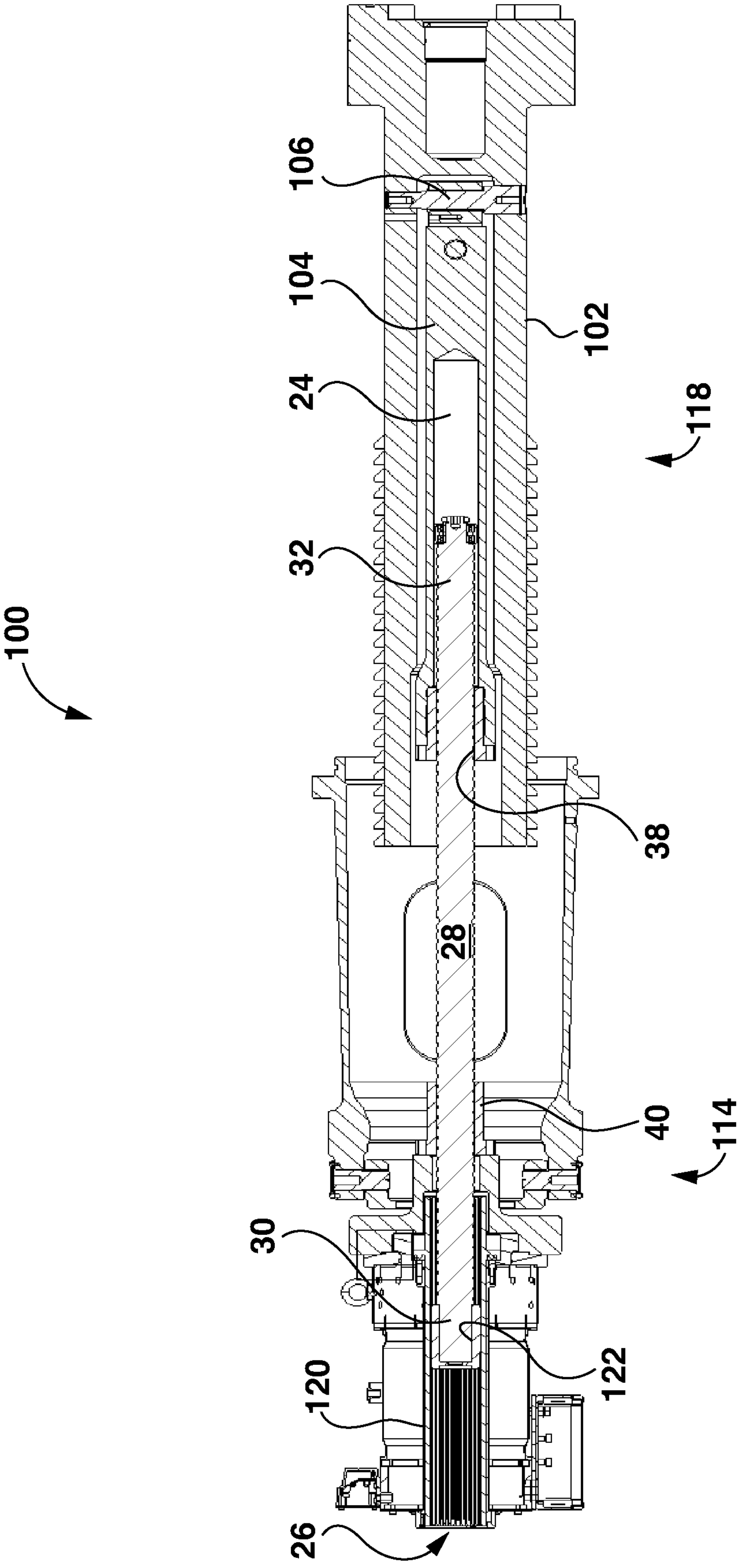


FIG. 5C

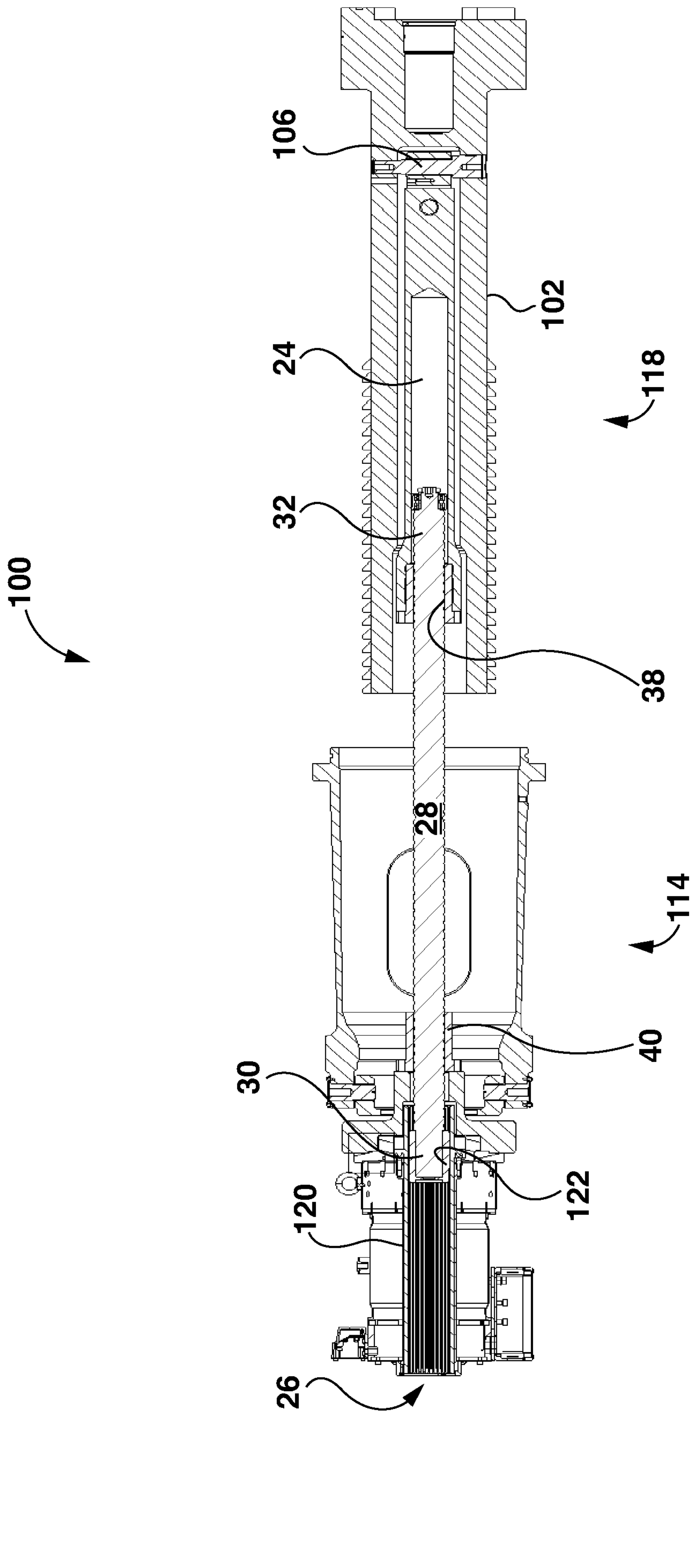


FIG. 5D

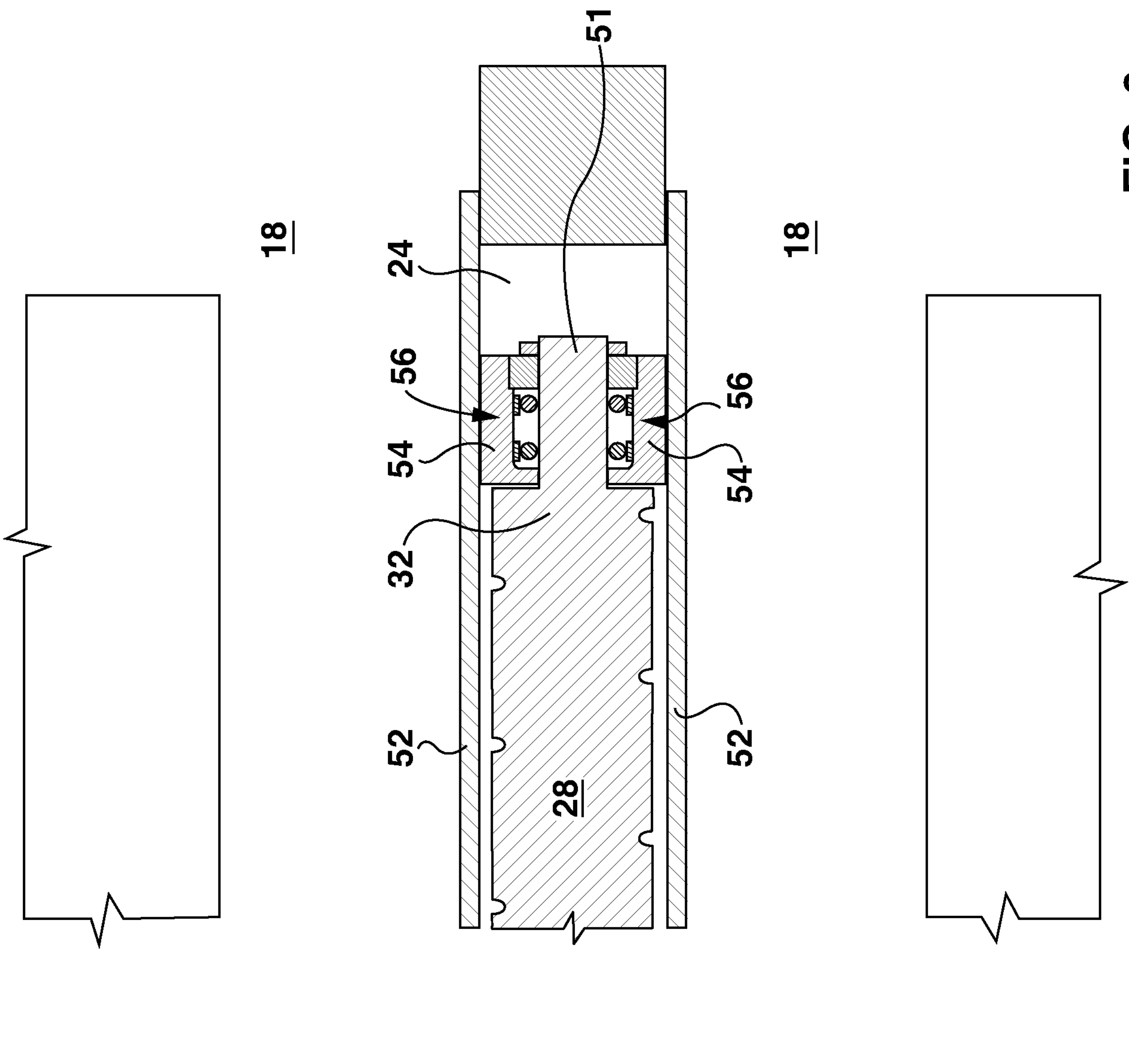


FIG. 6

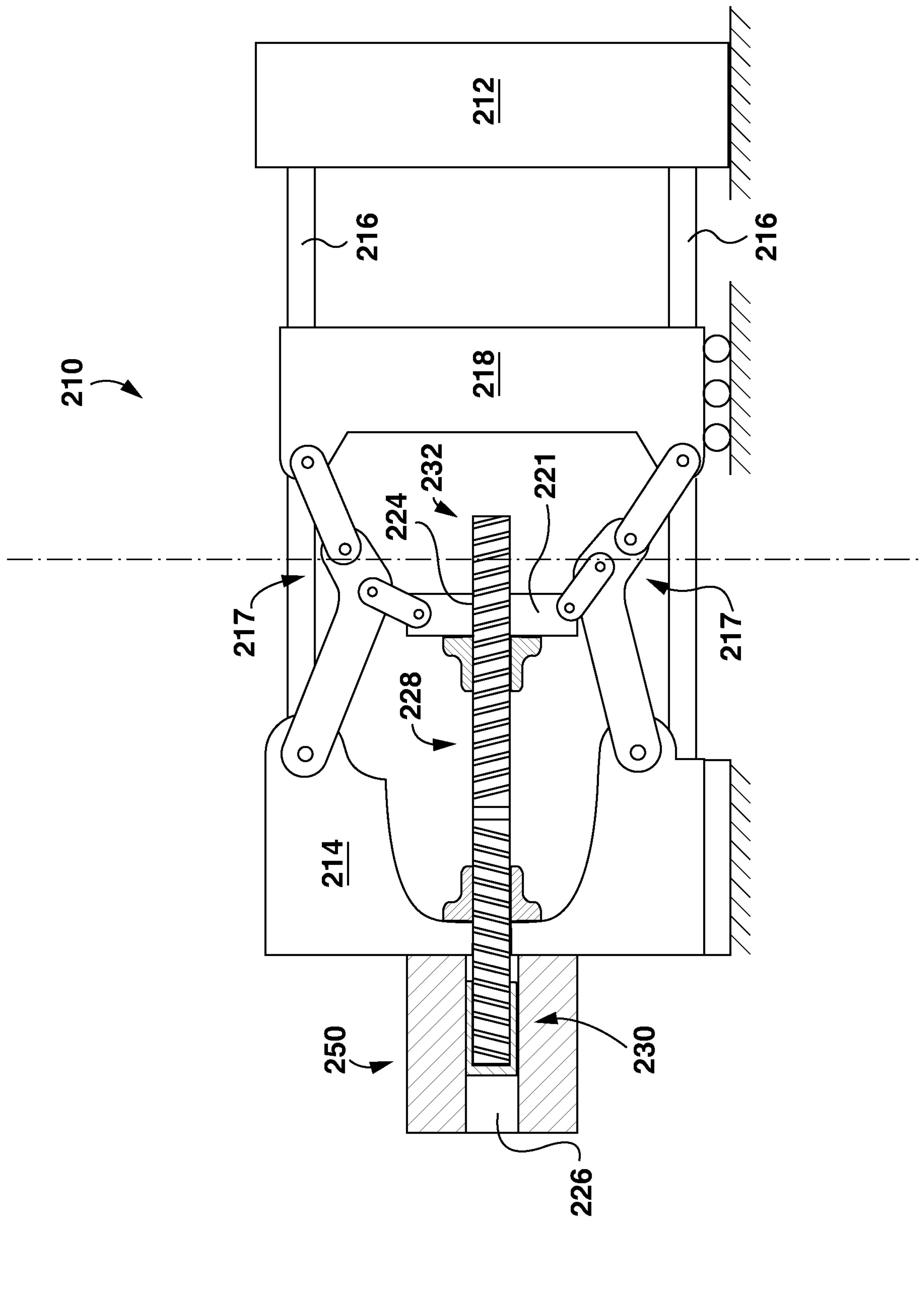
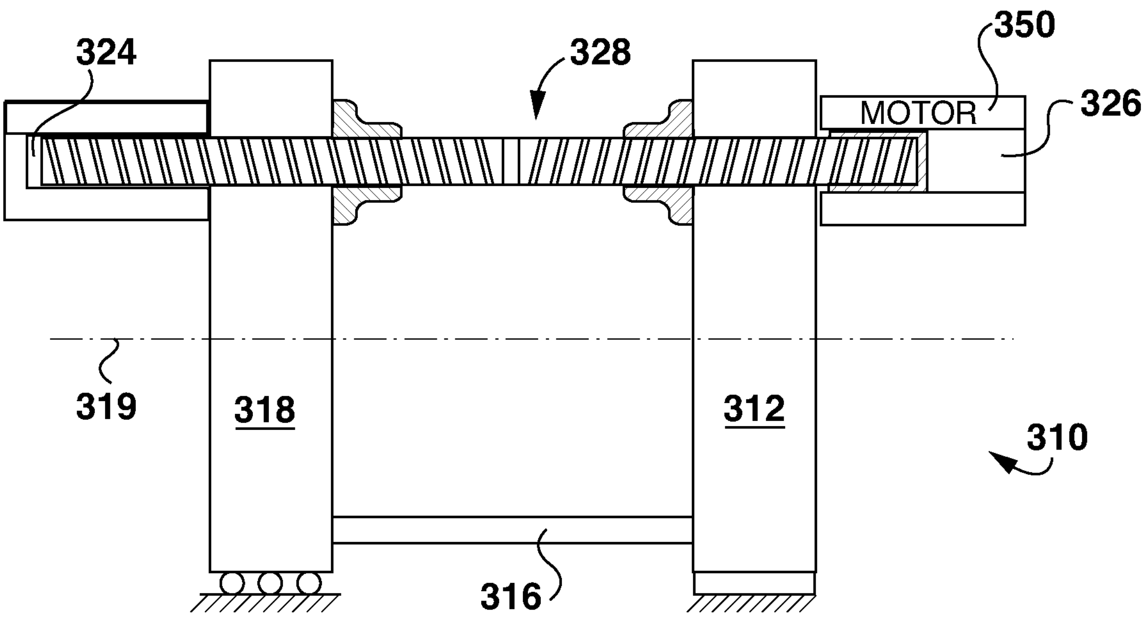


FIG. 7


324
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MOTOR
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310
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FIG. 8

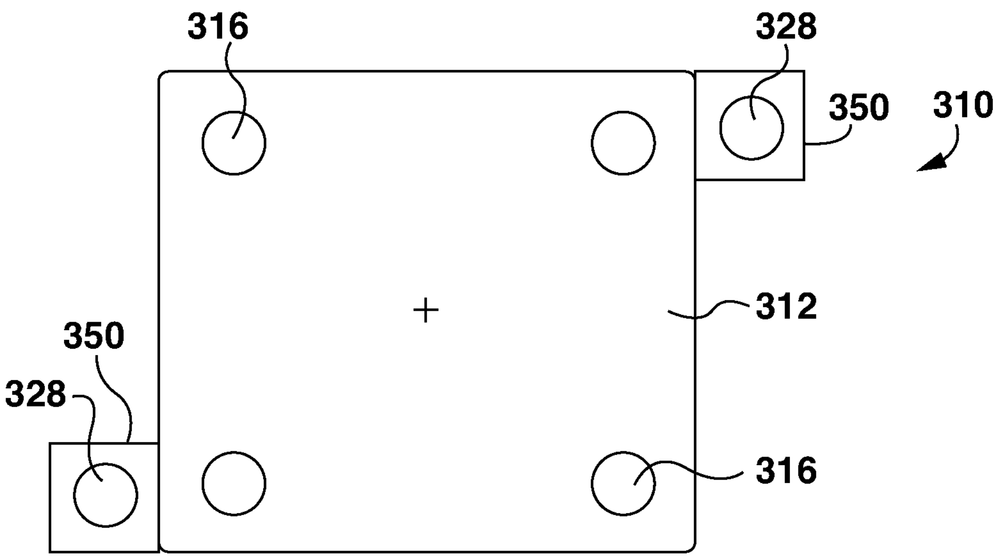
316
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FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2017/051074

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B29C 45/04*** (2006.01) , ***B29C 45/17*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: ***B29C 45/**** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

Questel-Orbit (Fampat) with key words, such as: injection molding/moulding machine, mov* platen, stationary/fixed platen, clamp*, ball, screw, oppos* and thread*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6468449 B1 (FUJIKAWA, M.) 22 October 2002 (22-10-2002) *whole document*	1-20
A	US 2014/0295020 A1 (SENGA, M.) 2 October 2014 (02-10-2014) *whole document*	1-20

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 05 December 2017 (05-12-2017)	Date of mailing of the international search report 05 December 2017 (05-12-2017)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Pengfei Zhang (819) 639-7928

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2017/051074

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		CN1106926C	30 April 2003 (30-04-2003)
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		DE102014004379A1	02 October 2014 (02-10-2014)
		JP2014208435A	06 November 2014 (06-11-2014)
		JP5670541B2	18 February 2015 (18-02-2015)