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(54) Title: CAM APPARATUS FOR VALVE STEM ACTUATION

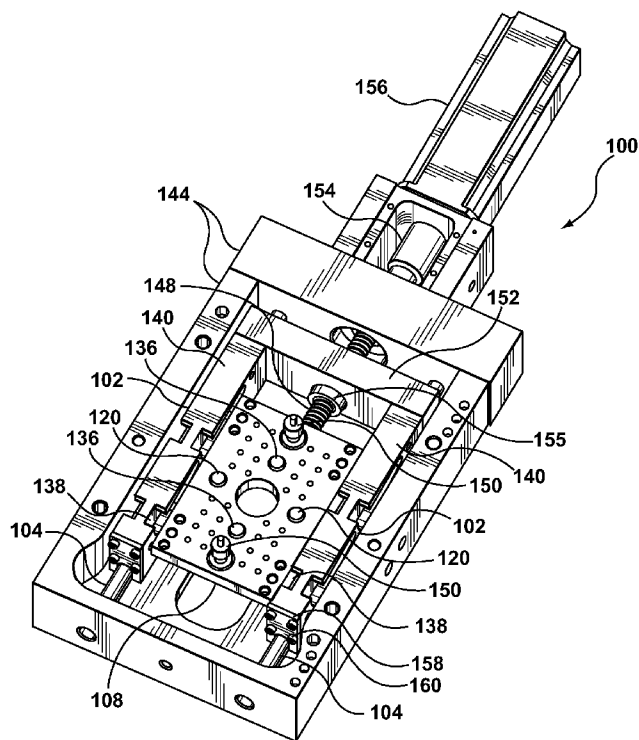


FIG. 1

(57) Abstract: Cam apparatus (100) translates linear cam bar (102) movement to perpendicular valve stem (110) actuation in an injection molding system. Cam bars (102) reciprocate on linear bearings (146) such that an actuation plate (108), fitted with a plurality of valve stems (110), is cycled normal to the direction of the cam bar (102) movement via cam followers (106) traveling within cam slots (112) in the cam bars (102). The cam slots (112) in the cam bars (102) are profiled such that the cam followers (106) affect the speed and force at which the valve stems (110) travel. The cam followers (106) of the actuation plate (108) travel in cam slots (112) in the cam bars (102) from a valve stem forward position, to a valve stem retracted position. The actuation plate (108) may be removed from the cam bars (102) via open ended slots in the cam bars (102).

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FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,
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CAM APPARATUS FOR VALVE STEM ACTUATION

5 Technical Field of the Invention

The present invention relates to, but is not limited to, injection molding systems, and more specifically the invention relates to a cam apparatus whereby the cam followers of a valve stem actuation plate are guided in cam slots within a plurality of cam bars which have an egress for the actuation plate for

10 maintenance thereon.

Background

Mechanical shut-off, or closure, of an injection molding gate orifice is commonly achieved using a valve stem, or pin, which is actuated via pneumatic, hydraulic or electromechanical means. The actuator may be positioned

15 congruent with the valve stem movement or adjacent to the valve stems and connected by means of a lever mechanism, or additionally, perpendicular to the valve stem movement utilizing a wedge device.

When the actuator movement is positioned perpendicular to the valve stem movement, the force required to move the valve stem is dependent on the friction between the mating components. If using an electromechanical actuator, this frictional load will result in an additional torque requirement and higher power consumption, necessitating a larger electric motor, than if an alternative arrangement were implemented. The additional friction will also result in

20

increased wear between components, resulting in loss of positional accuracy or in their premature failure.

A plurality of valve stems are often mounted together on a single actuation plate for simplicity of design and minimization of redundant components.

5 Additionally, reduced pitch spacing between valve stems can be realized without individual piston actuators for each valve stem requiring proximate installations. However, in this case, disassembly for service or maintenance becomes difficult. To replace a single valve stem it will be required to remove the entire actuation plate assembly from the mold. Mold disassembly can be somewhat labor
10 intensive, while separation of the hot runner from the mold is usually less complicated. Therefore, it is more desirable for the actuation plate and valve stems to remain with the hot runner, and then subsequently be easily removed from the hot runner as one unit.

15 Additionally, it is crucial that the timing, or relative position, of the valve stems be maintained throughout the entire maintenance procedure with respect to the cam slots and the cam followers of the actuation plate which travel therein. Valve stems are aligned with their respective gate orifices to within microns to ensure accurate, non-destructive engagement and any mis-adjustment due to the removal and insertion of the actuation plate process would be catastrophic to
20 the mold. For this reason, proper alignment must be ensured throughout the entire maintenance procedure.

Because injection forces are so high, the precision of any cam follower and cam arrangement in a hot runner system is in jeopardy of being damaged due to mechanical stresses being conveyed to these components unintentionally. Any slight variation in cam follower tangency to a cam slot will affect not only the
5 balance of the entire actuation plate assembly, but the ultimate valve stem position, which will result in premature wear of the cam followers, cams and any upstream linkages, as well as misalignment of the valve stems with the gate orifices, which will cause costly damage to both components.

U.S. Pat. No. 6,113, 381 describes the use of inclined planes to translate
10 linear actuator movement to perpendicular valve stem movement via electromechanically actuated slide blocks in diagonal grooves. These bearing surfaces must be flat and parallel and in addition to having multiple frictional contact surfaces susceptible to high wear, their requirement for a close, mating fit results in a limited ability to adjust the profile of motion of the valve stems.
15 Additionally, the range of motion of the block-in-groove design results in a flat velocity profile precluding any variation in speed or force of valve stem travel.

While U.S. Pat. No. 7,210,922 B1 describes a valve pin activation plate, whereby a plurality of valve stems are positioned together on one plate and are simultaneously reciprocated via some method, the details of this aspect of the
20 invention are not described nor claimed in that document.

For the foregoing reasons, the present invention is directed to overcoming one or more of the problems or disadvantages set forth above, and for providing a cam apparatus whereby a valve stem actuation plate is guided on cam

followers in profiled cam slots, and which also has a method of removing the entire actuation plate from the hot runner for ease of maintenance.

Summary

The present invention is directed to an apparatus utilizing a cam and cam
5 follower design to translate linear cam bar movement to perpendicular valve stem
actuation in an injection molding system. The cam bars reciprocate up and down
on linear bearing rails such that very low friction cam followers, such as rollers or
the like, attached to an actuation plate fitted with a plurality of valve stems, are
cycled normal to the direction of the cam bar movement. Cam slots in the cam
10 bars are profiled such that they may cause the cam followers traveling therein to
affect the speed and force at which the valve stems travel while at the same time
reducing frictional effects and their associated power requirement.

In one aspect of the present invention, the profile of the cam slot has a
first position at which the cam followers, attached to the actuation plate, cause
15 the valve stems to be in a gate closed position.

In another aspect of the present invention, the profile of the cam slot has a
second position at which the cam followers, attached to the actuation plate,
cause the valve stems to be in a gate open position.

In yet another aspect of the present invention, the profile of the cam slot
20 has a third position at which the cam followers, attached to the actuation plate,
are disengaged from the second position and poised in an exit slot for imminent
removal.

In a further aspect of the present invention, in anticipation of removal of the actuation plate and valve stems for servicing, a locking pin is inserted through the frame of the hot runner and into the cam bars to ensure the exact position of the valve stems is maintained upon re-installation of the actuation plate, to
5 ensure accuracy of alignment of each valve stem to gate orifice. The cam followers, and hence the actuation plate, can then be removed through the exit slots from the cam bars which have openings on their clamp face. The actuation plate and valve stems are now free of the hot runner for ease of maintenance.

In another aspect of the present invention, a plurality of mechanical stops
10 are attached to either the actuation plate or to the backing plate, to limit the amount of travel by the actuation plate in certain phases of travel to ensure its precise location is achieved and to prevent excessive injection force from being transferred to the cam followers.

The present invention provides the ability to simultaneously translate a
15 plurality of valve stems through a multiplicity of positions, which include a gate open, gate closed, and service position, via the precise travel of cam followers, attached to an actuation plate, in profiled cam slots in a cam apparatus.

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description,
20 appended claims and accompanying drawings.

Brief Description of the Drawings

FIG. 1 is an isometric assembly view of the cam apparatus including the drive mechanism.

FIG. 2 is an exploded isometric view isolating the cam assembly.

5 FIG. 3 is a side view of the cam apparatus illustrating the degrees of movement inherent in the system, including the lateral movement of the cam bar causing rotation of the cam followers which follows the profiled cam slots resulting in perpendicular translation of the actuator plate and attached valve stems.

10 FIG. 4 is a side view of the cam apparatus showing the cam bar with cam followers in the first position resulting in the valve stems being in their forwardmost, or gate closed position.

FIG. 5 is a side view of the cam apparatus where the cam followers are residing in the second position in the cam bar thereby moving the stems to a
15 retracted, or gate open position.

FIG. 6 is a side view of the cam apparatus showing the cam followers in a transitional service position within the cam bar.

FIG. 7 is a side view of the cam apparatus depicting how the entire actuation plate sub-assembly can be removed from the cam bar openings for
20 maintenance.

FIGS. 8A and 8B show the valve stem, guided by the nozzle tip, in a gate open and gate closed position, respectively.

FIGS. 9A and 9B are side views of the cam apparatus illustrating the travel distance of both the cam followers and the cam bars and the resulting perpendicular translation of the valve stem actuation plate.

Detailed Description

5 Referring to the drawings, and initially to FIG. 1, a cam apparatus **100** of a hot runner injection molding system, in accordance to the present invention, is shown. The components shown are not a complete representation of the entire hot runner but are rather those necessary to understand and practice the present invention.

10 Referring now to FIG. 1 and FIG. 2, an electric motor **156** rotates a ball screw **148** through a coupling **154** which in turn causes axial translation of a yoke **152** via ball screw nut **155**, though it may be appreciated that the drive mechanism may also be pneumatic or hydraulic alternatively. Attached to the yoke **152** are a plurality of cam bars **102** which traverse bearing rails **104** via
15 linear bearings **146**, each linear bearing **146** attached to the cam bars **102** via a plurality of fasteners **160**, such as socket head cap screws, or equivalent, securing a retaining cap **158**. Each cam bar **102** has a plurality of cam slots **112** cut therein, each cam slot **112** having a profile **114** generally angled in design, as shown in FIG. 3, though it may be appreciated that the profile **114** of the cam slot
20 **112** need not be limited to a linear contour but may be of any polynomial curve such as a spline or the like.

An actuation plate **108** is fitted with a plurality of guide pins **150** which align the actuation plate **108** perpendicular to the bearing rails **104**. Attached to

the periphery of the actuation plate **108** are a plurality of cam followers **106**, the cam followers being of very low friction, such as rollers or the like, which, in use, reside in the cam slots **112** within the cam bars **102**. Linear movement of the cam bars **102**, as described above, in turn cause the cam followers **106** to rotate
5 as the profile **114** of the cam slot travels there over, further illustrated in FIG. 3.

Referring again to FIG. 3 and also FIGS. 8A and 8B, a plurality of valve stems **110** are installed in an actuation plate **108** and are positioned at a pitch spacing as determined by the proximity of gate orifices **166** on the molded articles **168**.

10 As the yoke **152** and cam bars **102** move laterally, the angular contour of the profile **114** of the cam slots **112** causes the cam followers **106**, and consequently the actuation plate **108**, to translate the valve stems **110**, en masse, perpendicularly, causing the valve stems **110** to advance toward or retract from the gate orifices **166**.

15 Turning now to FIG. 4; the cam bar **102** is shown in a position such that the cam followers **106** are engaged near the end of the cam slot **112** at a first position **116** which will yield the valve stems **110**, and more importantly, the valve stem tips **164** fully forward in a gate closed position **118** thus precluding the resin flow **170** through nozzle tip **162** from entering gate orifice **166**, as shown in detail
20 in FIG. 8B. A plurality of first mechanical stops **120** attached to the actuation plate **108**, as shown in FIGS. 1 and 2, limit the travel of the cam followers **106** in the cam slots **112** to the first position **116**.

FIG. 5 illustrates the cam bar **102** in a second position **122** whereby the cam followers **106** are at the lowest point of the cam slots **112** which renders the valve stems **110**, and more particularly, the valve stem tips **164** in a gate open position **128**, thus allowing resin flow **170** through nozzle tip **162** and the gate orifice **166** into the molded article **168**, as shown in FIG. 8A. A plurality of second mechanical stops **124** installed on either the backing plate **126** or the actuation plate **108** engages the actuation plate **108** to limit the travel of the cam followers **106** in the cam slots **112** to the second position **122**. It is also at this second position **122** when the injection pressure required to fill the molded article **168** also acts upon the valve stems **110**, and consequently, the actuation plate **108**. A plurality of second mechanical stops **124**, attached to either the backing plate **126** or the actuation plate **108**, prevents the load from being translated to the cam followers **106** by positioning the actuation plate **108** such that the cam followers **106** are not in contact with the profile **114** of the cam slots **112** at their tangencies.

Referring now to FIG. 6, cam bar **102** is shown positioned such that the cam followers **106** are disengaged from the cam slots **112** and are poised in a third position **130**. As shown in FIGS. 1 and 2, a plurality of third mechanical stops **136** are positioned on the actuation plate **108** serve to locate the exit slots **132** in line with the cam followers **106** such that the actuation plate **108** will remain in a service position **134**. It is in this service position **134** whereby a plurality of locking pins **142** are to be installed through the frame assembly **144**

and into each cam bar **102** to ensure the accuracy of their position prior to removal of the actuation plate **108** from the cam bars **102**.

FIG. 7 illustrates a subsequent position available to the actuation plate **108** from the abovementioned service position **134**, that being its complete removal from the cam bars **102**. This feature is made possible by disengaging the cam followers **106** from the exit slots **132** which terminate in a plurality of openings **138** on the clamp face **140** of each cam bar **102** as show in FIG. 2. The actuation plate **108**, complete with valve stems **110**, can be removed from the entire cam apparatus **100** for ease of maintenance and/or valve stem **110** replacement. Once service work is completed, the reverse procedure is followed by lowering the actuation plate **108** with valve stems **110** therein, back into the exit slots **132** in the cam bars **102**. The locking pins **142** serve to ensure that the final position of the actuation plate **108**, and hence the valve stems **110**, is accurately maintained for future molding.

Referring now to FIGS. 9A and 9B, the movement of the cam bars **102**, within the cam apparatus **100**, is shown to illustrate the total displacement of the cam slots **112** as 'delta y' causing the cam followers **106**, attached to the actuation plate **108**, to translate said actuation plate **108** perpendicular to the movement of the cam bars **102**, a distance of 'delta x'. Actuation plate **108** is limited to relative perpendicular travel via a plurality of guide pins **150**. FIG. 9A shows the cam bars **102** as having moved down to their lowest position, while FIG. 9B shows the cam bars **102** in their uppermost position.

Description of the embodiments of the present inventions provides examples of the present invention, and these examples do not limit the scope of the present invention. It is to be expressly understood that the scope of the present invention is limited by the claims. The concepts described above may be adapted for specific conditions and/or functions, and may be further extended to a variety of other applications that are within the scope of the present invention.

Having thus described the embodiments of the present invention, it will be apparent that modifications and enhancements are possible without departing from the concepts as described. Therefore, what is to be protected by way of letters patent are limited by the scope of the following claims:

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What is claimed is:

1. A cam apparatus (100) for a valve stem actuator comprising:
a plurality of cam bars (102), movably mounted on a plurality of bearing
5 rails (104); and
a plurality of cam followers (106) joined to an actuation plate (108).

2. The cam apparatus (100) according to claim **1**, further including a plurality
of valve stems (110) operatively mounted to the actuation plate (108).
10

3. The cam apparatus (100) according to claim **1**, wherein the cam bars
(102) have a plurality of cam slots (112).

4. The cam apparatus (100) according to claim **3**, wherein the cam slots
15 (112) have a profile (114) wherein the linear movement of the profile (114) of the
cam slots (112) causes the cam followers (106) to translate the actuation plate
(108) to a plurality of perpendicular positions.

5. The cam apparatus (100) according to claim **4**, wherein the profile (114) of
20 the cam slots (112) has a first position (116), wherein when in the first position
(116), the cam followers (106) of the actuation plate (108) move the valve stems
(110) to a gate closed position (118).

6. The cam apparatus (100) according to claim 4, wherein the profile (114) of the cam slots (112) has a second position (122), wherein when in the second position (122), the cam followers (106) of the actuation plate (108) move the valve stems (110) to a gate open position (128).

5

7. The cam apparatus (100) according to claim 6, further including a plurality of second mechanical stops (124), attached to either a backing plate (126) or the actuation plate (108), for limiting the movement of the cam followers (106) in the cam slots (112) to the second position (122).

10

8. The cam apparatus (100) according to claim 4, wherein the profile (114) of the cam slots (112) has a third position (130), wherein when in the third position (130), the cam followers (106) disengage from the second position (122) of the profile (114) and align in a plurality of exit slots (132) in the cam bars (102) and

15 move the actuation plate (108) to a service position (134).

9. The cam apparatus (100) according to claim 1, further including a plurality of first and third mechanical stops (120, 136), attached to either the actuation plate (108) or a backing plate (126), for limiting the movement of the cam

20 followers (106) in the cam slots (112) to the first and third positions (116, 130).

10. The cam apparatus (100) according to claim **8**, wherein the exit slots (132) terminate in a plurality of openings (138) on a plurality of clamp faces (140) on the cam bars (102) through which the cam followers (106) may fully disengage the actuation plate (108) from the cam bars (102).

5

11. A method of synchronized valve stem actuation, comprising the steps of:
movably mounting a plurality of cam bars (102) on a plurality of bearing rails (104), the plurality of cam bars (102) having a plurality of cam slots (112);
joining a plurality of cam followers (106) to an actuation plate (108);
10 operatively mounting a plurality of valve stems (110) to the actuation plate (108); and
reciprocating movement of the cam bars (102), wherein the cam followers (106) of the actuation plate (108) cause the plurality of valve stems (110) to simultaneously cycle forward and back.

15

12. The method of claim **11**, further comprising the step of:
moving the cam bars (102) linearly, the cam bars (102) each having cam slots (112) therein, the cam slots (112) further having a profile (114) to move the cam followers (106) and the actuation plate (108) to a plurality of perpendicular
20 positions.

13. The method of claim **11**, further comprising the step of:

moving the cam bars (102) such that the cam slots (112) cause the cam followers (106) to travel to a first position (116) causing the actuation plate (108) to move the valve stems (110) to a gate closed position (118).

5

14. The method of claim **13**, further comprising the step of:

limiting the movement of the cam followers (106) in the cam slots (112) to the first position (116) via a plurality of first mechanical stops (120), attached to either the actuation plate (108) or a backing plate (126).

10

15. The method of claim **11**, further comprising the step of:

moving the cam bars (102) such that the cam slots (112) cause the cam followers (106) to travel to a second position (122) causing the actuation plate (108) to move the valve stems (110) to a gate open position (128).

15

16. The method of claim **15**, further comprising the step of:

limiting the movement of the cam followers (106) and the actuation plate (108) to the second position (122) via a plurality of second mechanical stops (124), attached to either a backing plate (126) or the actuation plate (108), for preventing an injection force load from being translated to the cam followers (106).

20

17. A method of servicing a valve stem actuator, comprising the steps of:

moving a plurality of cam bars (102) to a third position (130) such that a plurality of cam followers (106), the cam followers (106) being attached to an actuation plate (108), are aligned in a plurality of exit slots (312) within the cam bars (102);

engaging a plurality of locking pins (142) through a frame assembly (144) and into the cam bars (102);

removing the actuation plate (108) by sliding the cam followers (106) along the exit slots (132) in the cam bars (102); and

disengaging the actuation plate (108) from the cam bars (102) via a plurality of openings (138) on a plurality of clamp faces (140) on the cam bars (102) through which the cam followers (106) may exit the cam bars (102).

18. The method of claim **17**, further comprising the step of:

limiting movement of the cam followers (106) in the cam slots (112) to the third position (130) via a plurality of third mechanical stops (136), attached to either the actuation plate (108) or a backing plate (126).

19. A cam apparatus (100) for use in a hot runner system, comprising:

a plurality of cam bars (102), the cam bars (102) having a plurality of cam slots (112);

an actuation plate (108), the actuation plate (108) having a plurality of
5 valve stems (110) attached thereto; and

a plurality of cam followers (106) joined to said actuation plate (108).

20. The cam apparatus (100) according to claim **19**, wherein the cam slots

(112) have a profile (114) which causes the linear movement of the cam bars
10 (102) to translate the cam followers (106) and the actuation plate (108) to a
plurality of perpendicular positions.

21. The cam apparatus (100) according to claim **20**, wherein the profile (114)

of the cam slots (112) is configured to vary the speed and force of the valve stem
15 actuation resulting from travel of the cam slots (112) over the cam followers
(106).

22. The cam apparatus (100) according to claim **19**, wherein the profile (114)

of the cam slots (112) has a first position (116), wherein when in the first position
20 (116), the cam followers (106) of the actuation plate (108) move the valve stems
(110) to a gate closed position (118).

23. The cam apparatus (100) according to claim **19**, wherein the profile (114) of the cam slots (112) has a second position (122), wherein when in the second position (122), the cam followers (106) of the actuation plate (108) move the valve stems (110) to a gate open position (128).

5

24. The cam apparatus (100) according to claim **19**, wherein the profile (114) of the cam slots (112) has a third position (130), wherein when in the third position (130), the cam followers (106) are aligned in a plurality of exit slots (132) in the cam bars (102), thereby moving the actuation plate (108) to a service position (134).

10

25. The cam apparatus (100) according to claim **19**, further including a plurality of first, second and third mechanical stops (120, 124, 136), attached to either the actuation plate (108) or a backing plate (126), for limiting the position of the actuation plate (108) in the first, second and the third positions (116, 122, 130).

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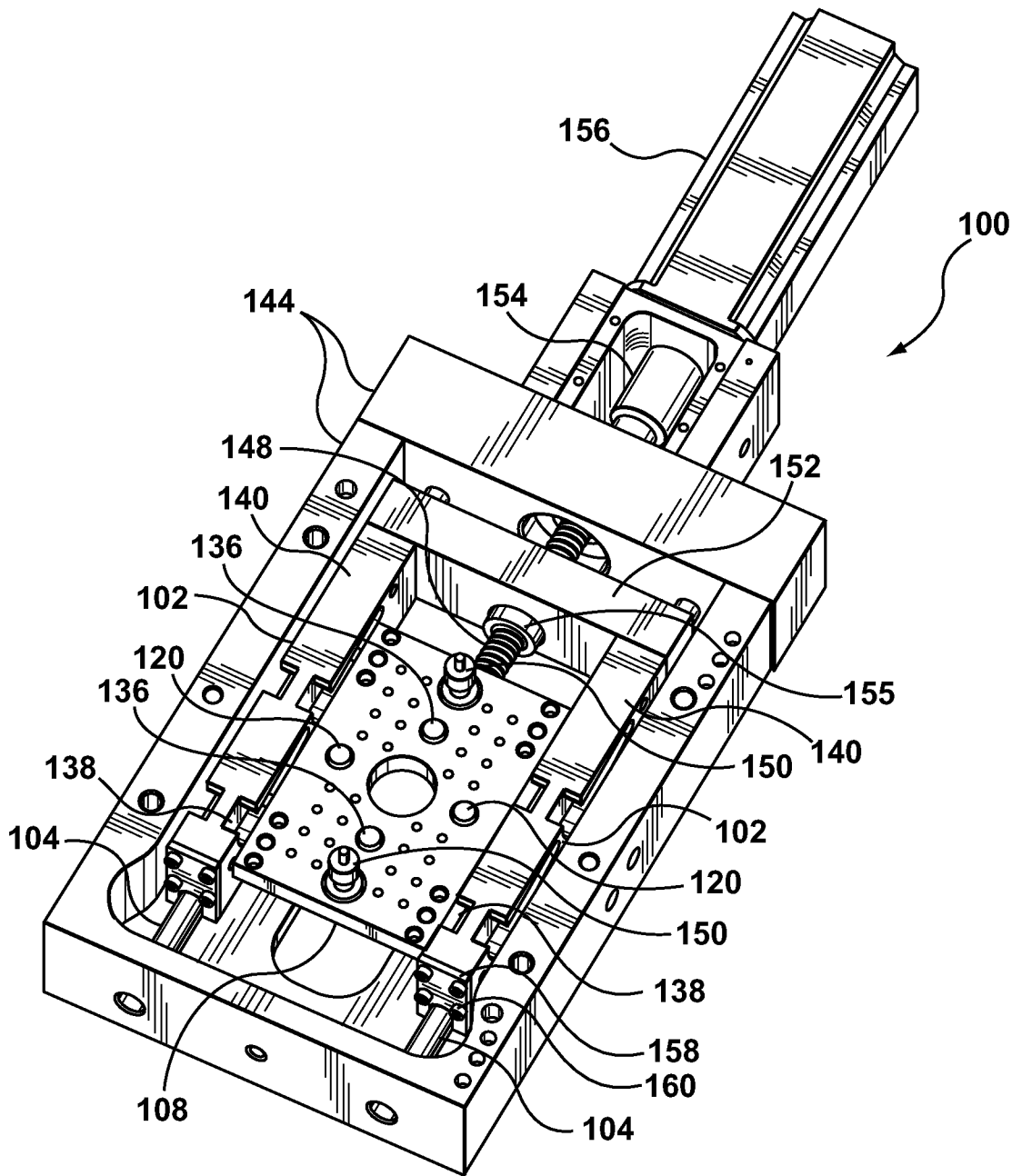


FIG. 1

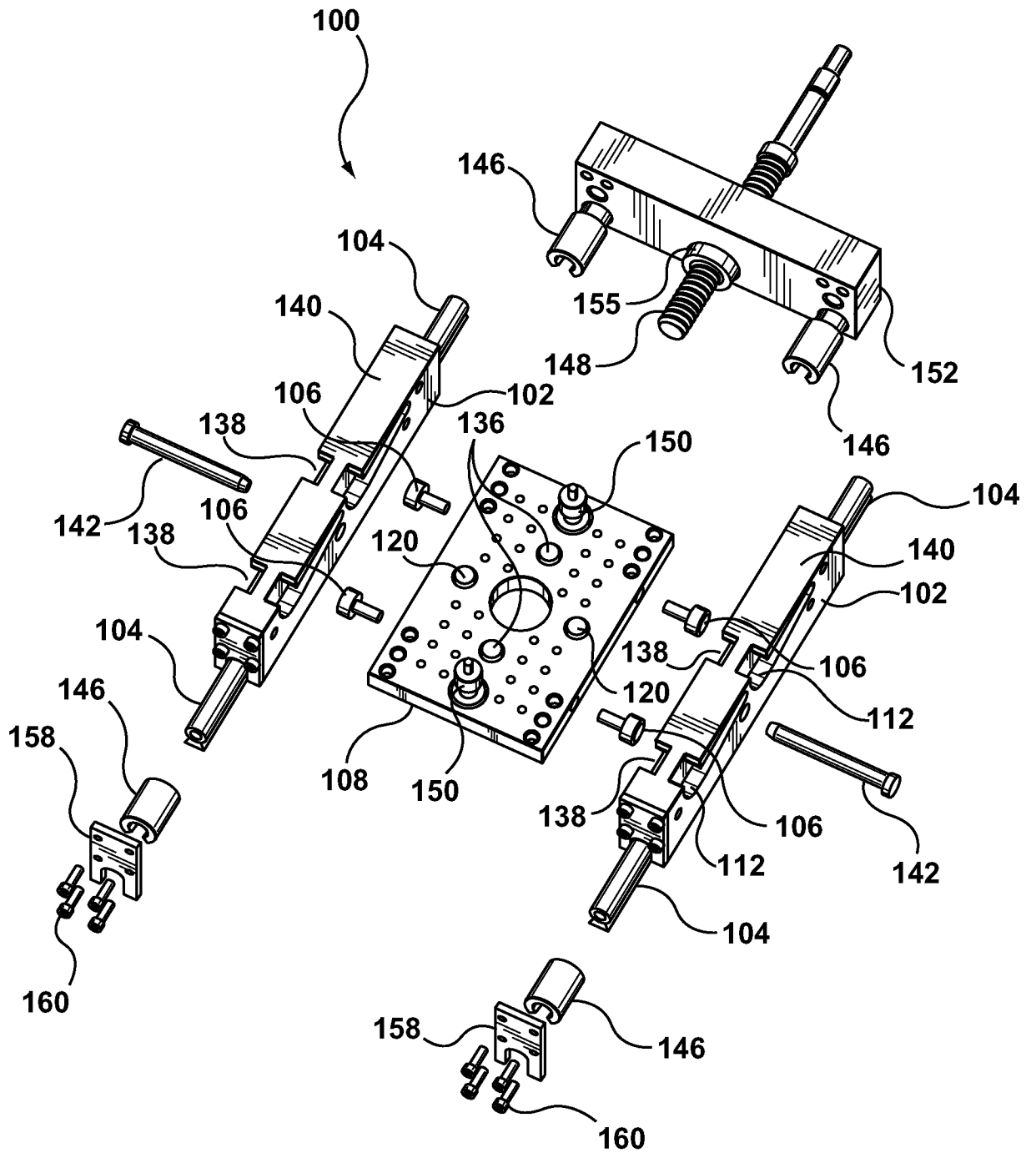


FIG. 2

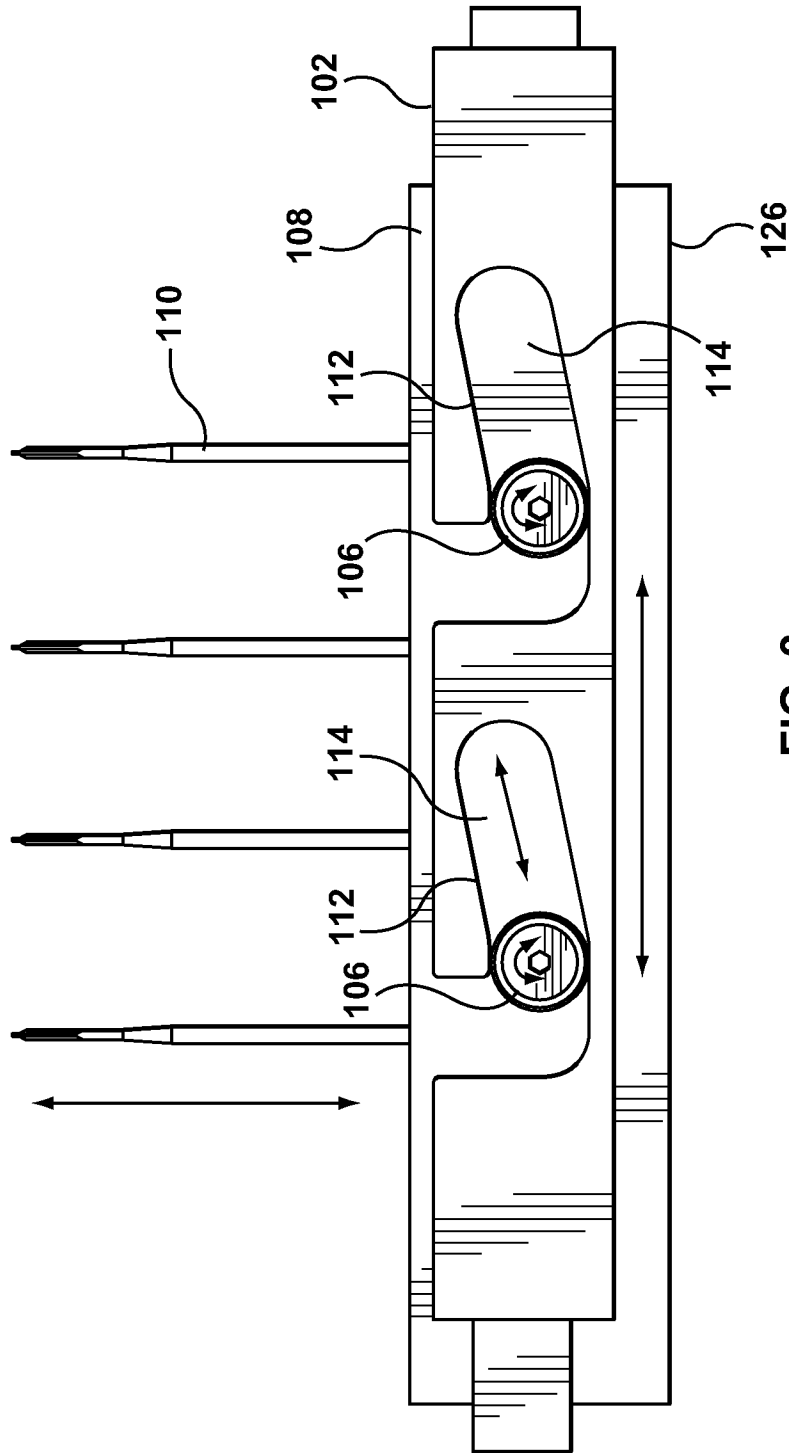


FIG. 3

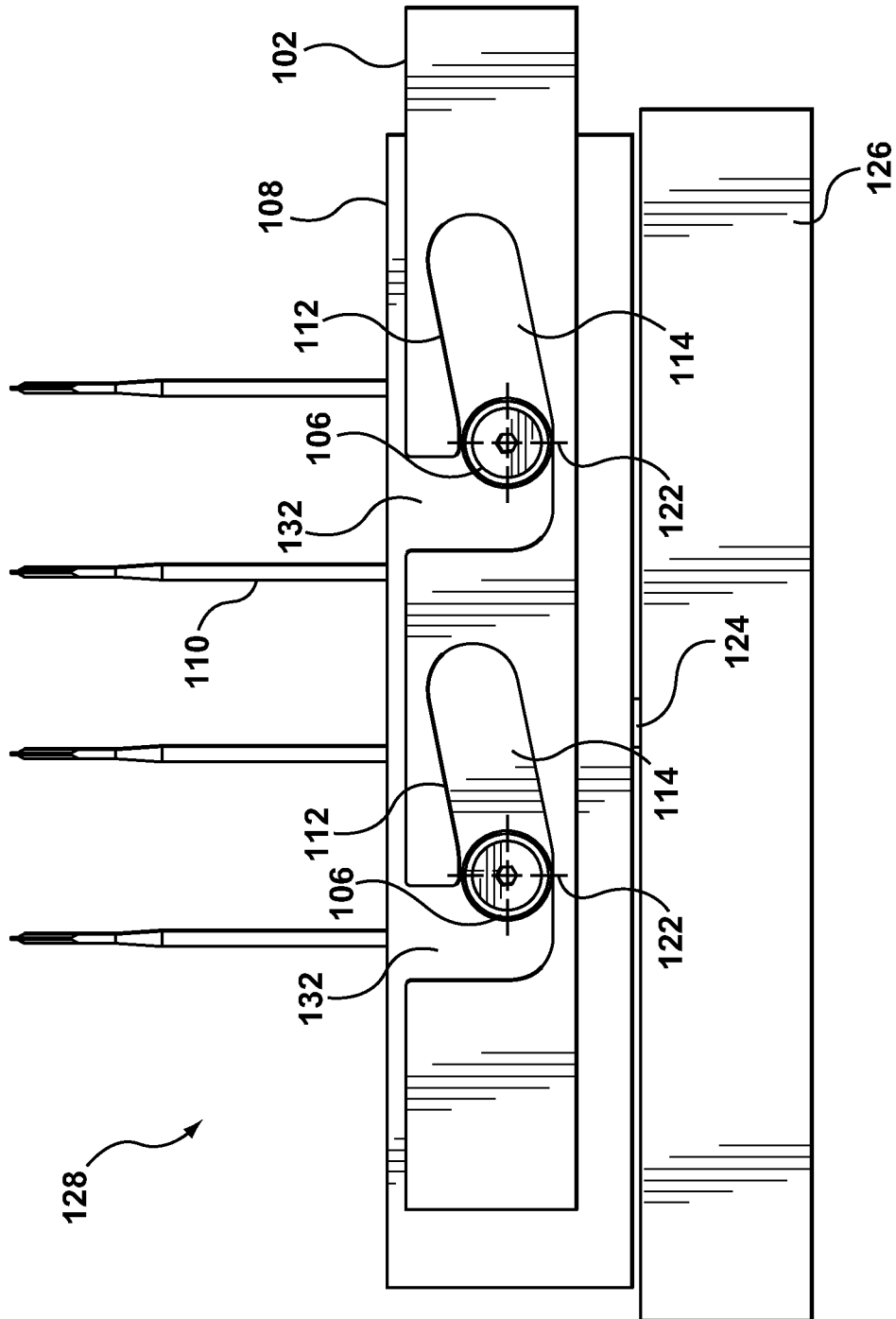


FIG. 5

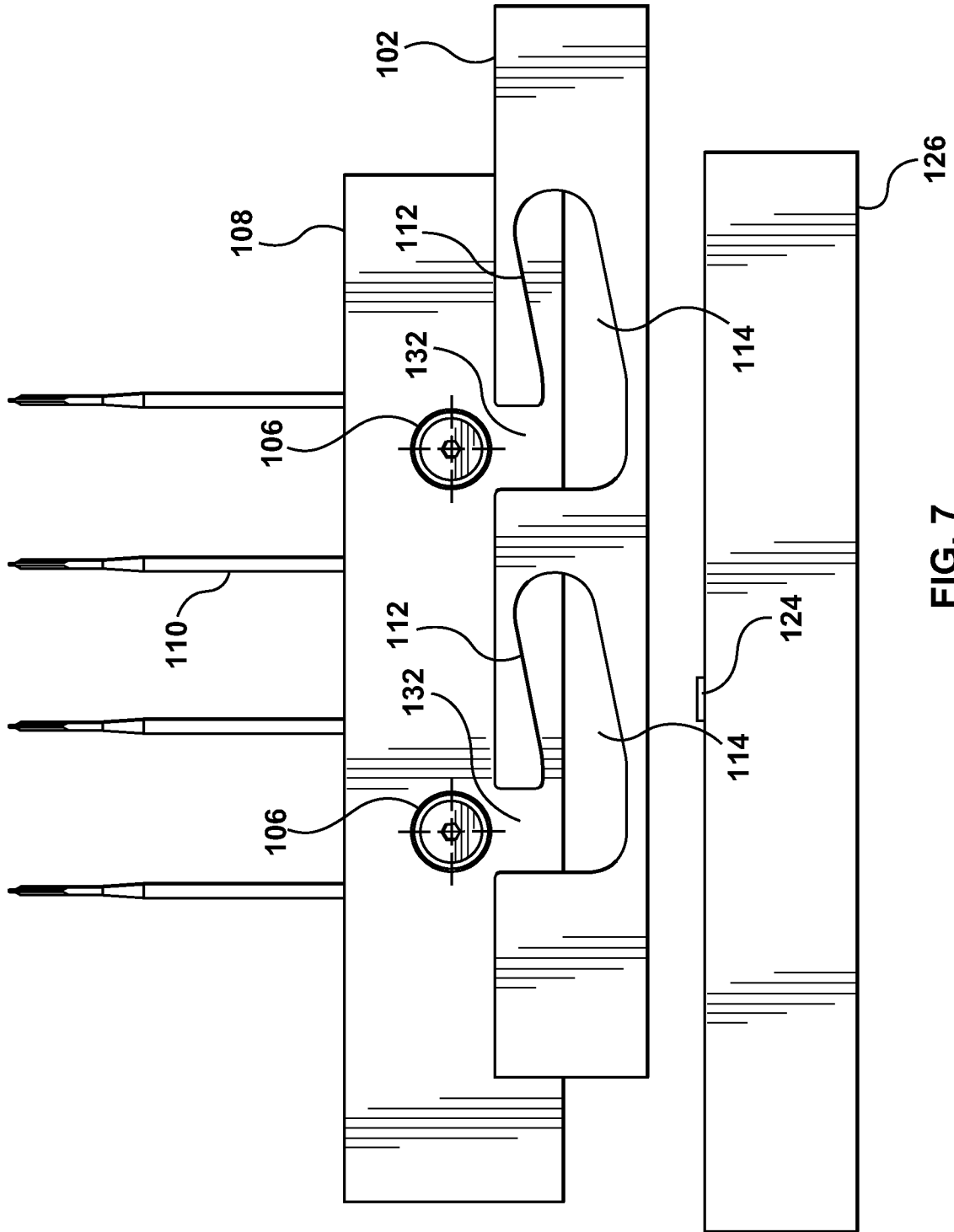


FIG. 7

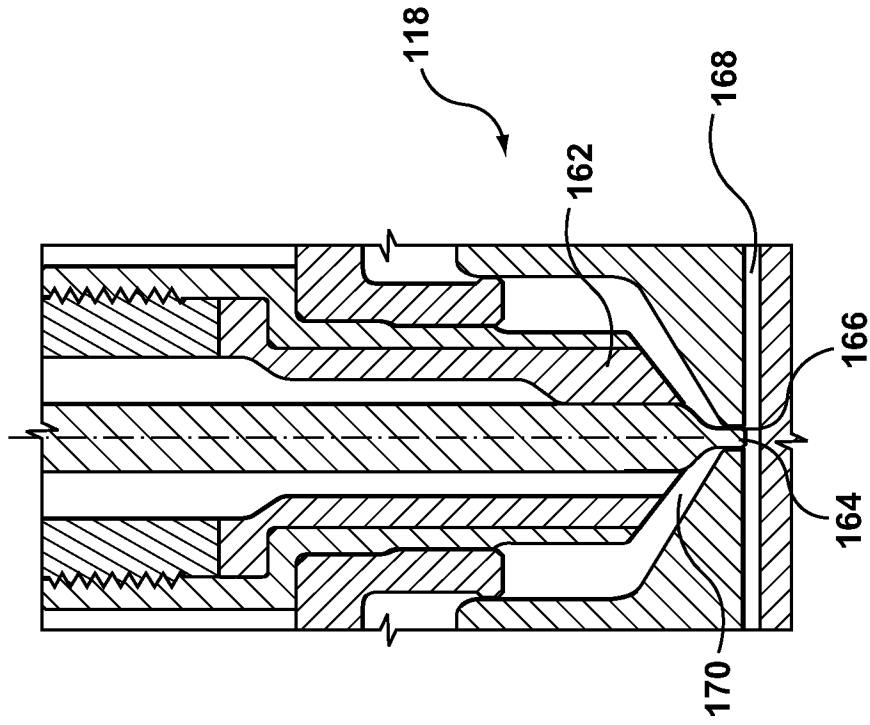


FIG. 8B

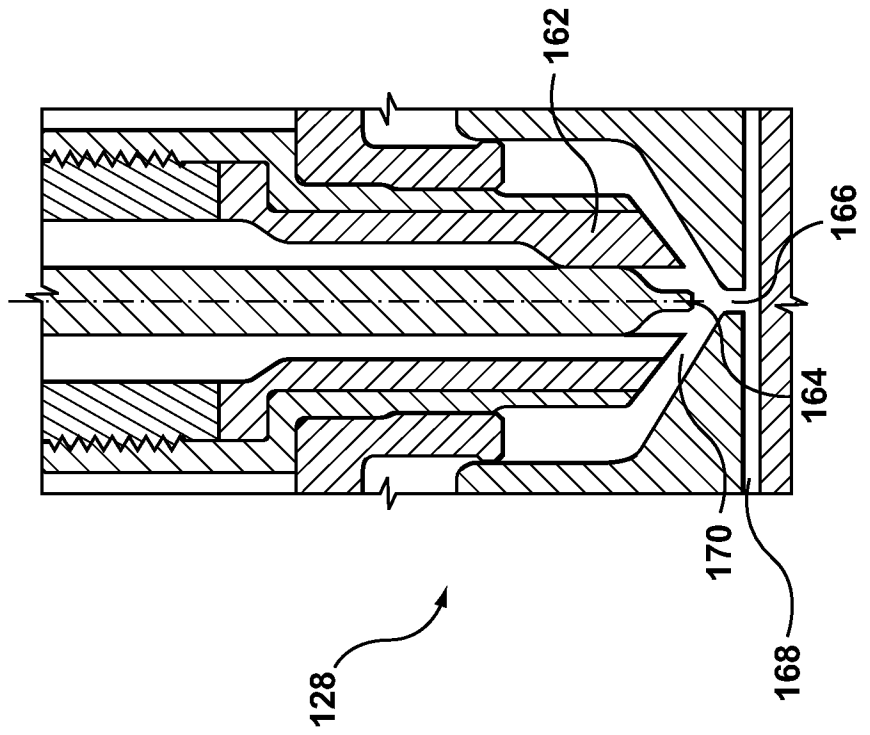


FIG. 8A

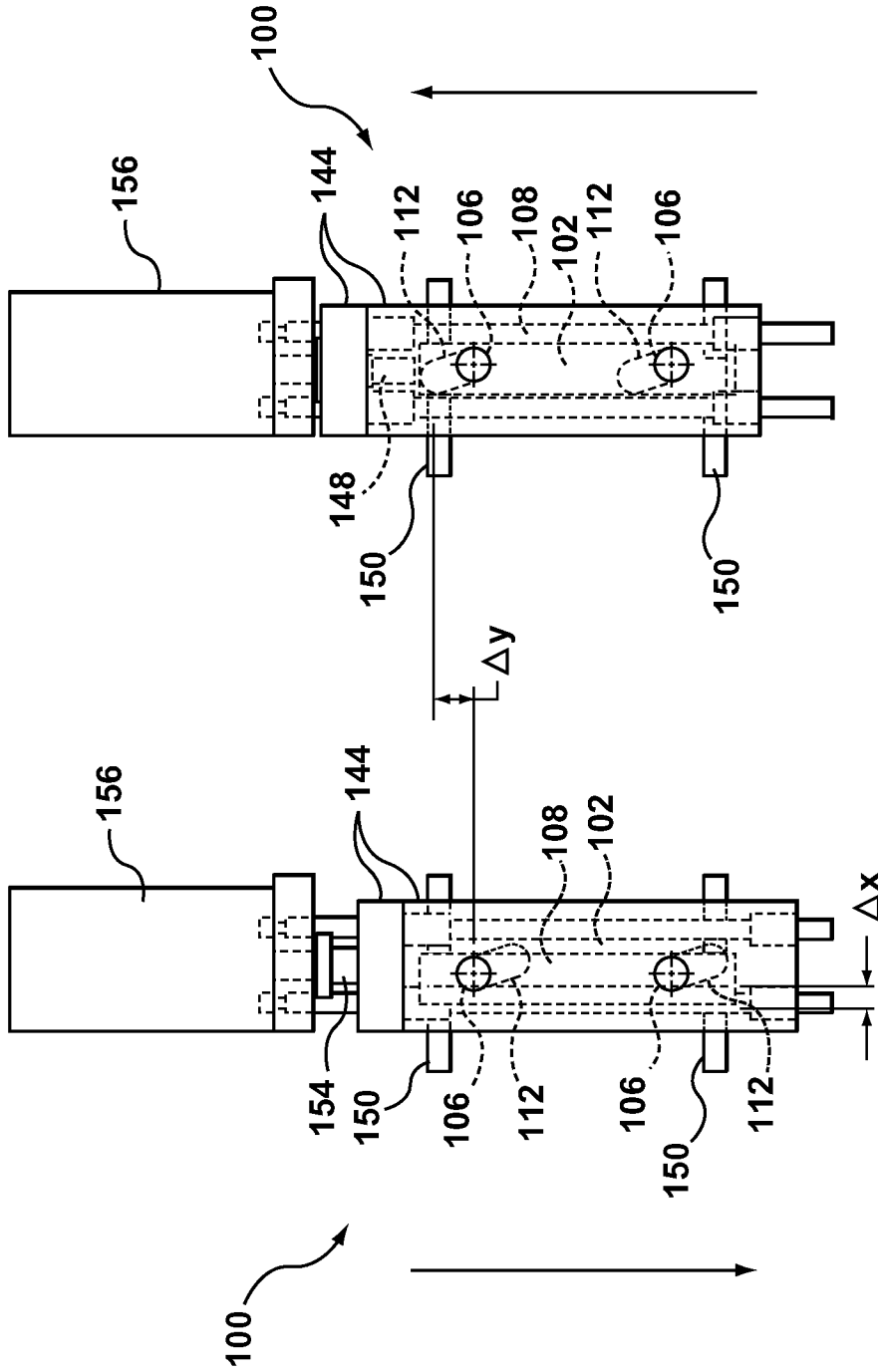


FIG. 9B

FIG. 9A

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 08/68012

A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - A23P 1/00; B29B 11/06; B29C 35/00, 45/00 (2008.04)
 USPC - 425/569
 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)
 USPC- 425/569

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 USPC- 264/328.1, 328.8, 328.9, 328.11, 328.15; 425/564, 566, 569, 570, 571, 574 (term limited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 PubWest (USPT,PGPB,EPAB,JPAB), Google Patents, Google
 Search Terms Used: mold, molding, die, cast, casting, cam, slot, follower, gate, valve, needle, pin, separation, removal, disassembly, lock, synchronization

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,113,381 A (Gellert et al.) 05 September 2000 (05.09.2000), [col 1, ln 65, 66, col 2, ln 1, col 4, ln 1-4, fig 1, fig 2, fig 4, fig 5]	1-6, 8, 10-13, 15, 17 and 19-24
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Y		7, 9, 14, 16, 18 and 25
Y	US 4,497,621 A (Kudert et al.) 05 February 1985 (05.02.1985), [fig 86]	7, 9, 14, 16, 18 and 25

Further documents are listed in the continuation of Box C.

* 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
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Date of the actual completion of the international search 29 September 2008 (29.09.2008)	Date of mailing of the international search report 02 OCT 2008
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