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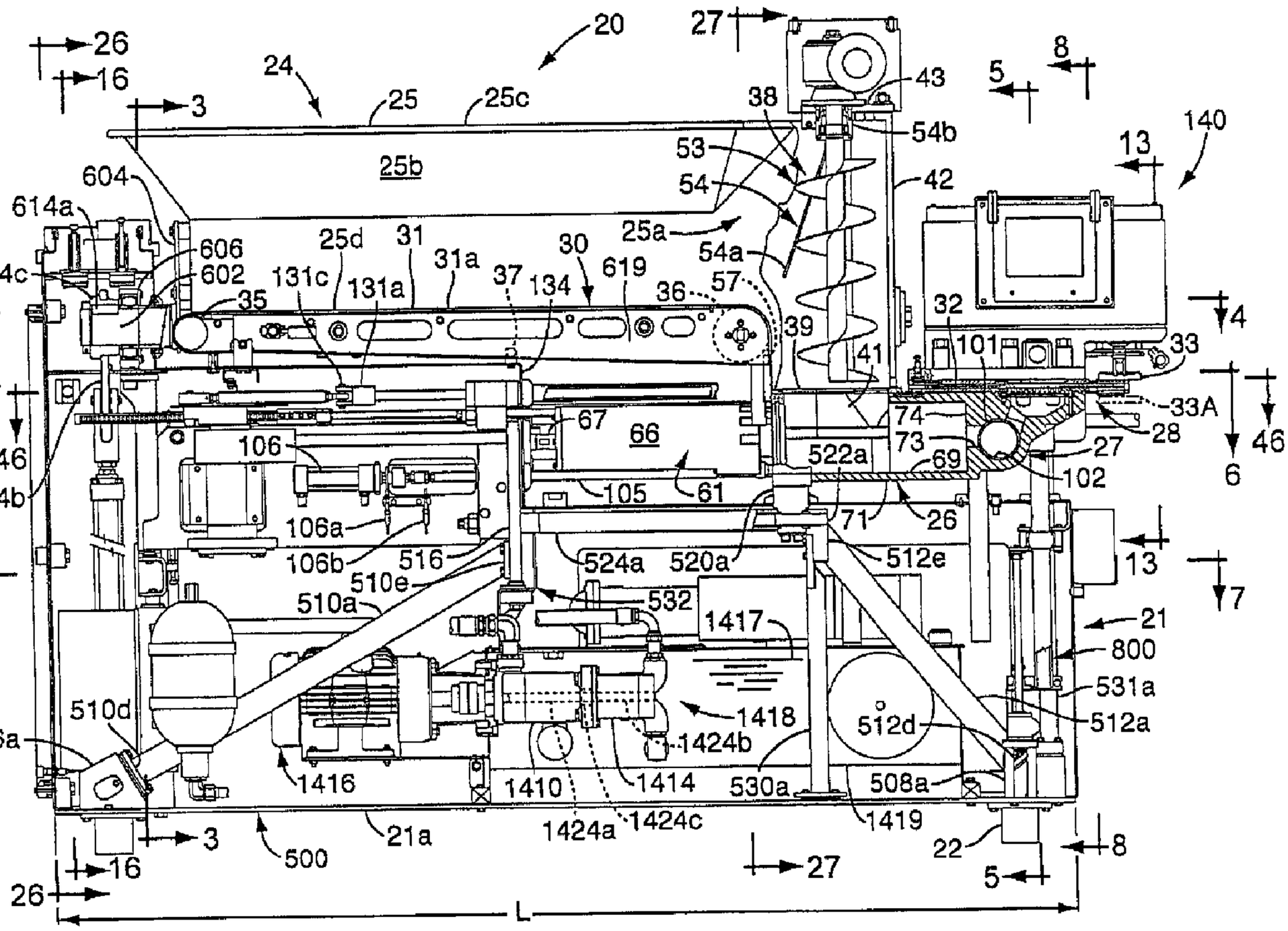


(57) Abrégé/Abstract:
A patty forming apparatus has a machine base that includes a cooling air system that closes up the base upon loss of power. The apparatus includes a food product hopper and conveyor that are hingedly retractable. The hopper includes a controllable level sensing mechanism arranged to be moved by food product level within the hopper. A hydraulic pump is positioned to be at least partially submerged in hydraulic fluid, to be pumped by the pump, within a reservoir.

ABSTRACT

A patty forming apparatus has a machine base that includes a cooling air system that closes up the base upon loss of power. The apparatus includes a food product hopper and conveyor that are hingedly retractable. The hopper includes a controllable level sensing mechanism arranged to be moved by food product level within the hopper. A hydraulic pump is positioned to be at least partially submerged in hydraulic fluid, to be pumped by the pump, within a reservoir.

Patty-Forming Apparatus

Background Of The Invention

Use of pre-processed foods, both in homes and in restaurants, has created a demand for effective high-capacity automated food processing equipment. That demand is particularly evident with respect to hamburgers, molded steaks, fish cakes, and other molded food patties.

Food processors utilize high-speed molding machines, such as FORMAX F-6, F-12, F-19, F-26 or F-400 reciprocating mold plate forming machines, available from Formax, Inc. of Mokena, Illinois, U.S.A., for supplying patties to the fast food industry. Prior known high-speed molding machines are also described for example in U.S. patents 3,887,964; 4,372,008; 4,356,595; 4,821,376; and 4,996,743.

Although heretofore known FORMAX patty-molding machines have achieved commercial success and wide industry acceptance, the present inventors have recognized that needs exist for a forming machine having an even greater energy efficiency, an even greater durability and an even greater duration of maintenance free operation. The present inventors have recognized that needs exist for an enhanced controllability and ability to tune a patty-forming machine for particular food materials to be processed, for an enhanced effectiveness of a patty-forming machine in producing uniform patties, for an even greater output rate of patties from a patty-forming machine, for an enhanced convenience for cleaning and maintenance of a patty-forming machine, and for a smoother and quieter patty-forming machine operation.

Summary Of The Invention

The present invention provides an improved cooling air system for a patty-forming apparatus having a machine base. The machine base includes an enclosing wall and contains equipment within the machine base that generates heat, such as electric motors, electrical and control equipment. The machine base includes an air inlet opening and an air outlet opening through the enclosing wall. At least one air fan is arranged to move outside air from the air inlet opening to the air outlet opening. A first air damper is arranged to close one of the air inlet opening or the air outlet opening. The first air damper is configured to automatically close if power is interrupted to the apparatus.

According to a further enhancement of the invention, the first air damper is arranged to close the air inlet opening, and a second air damper is arranged to close the air outlet opening. The second air damper is also configured to automatically close if power is interrupted to the apparatus.

Thus, when the machine is powered down for cleaning, the dampers automatically close the air intake and/or outlet openings. The fan will be powered off. This effectively battens down the machine base and prevents wash water, spray and contaminants from entering the machine base. Also, the fact that the machine is pressurized during operation by the fans can prevent some contaminants from entering the machine base during operation.

The present invention provides an improved food product hopper assembly for a food patty molding apparatus. The food product hopper of the

assembly is configured for containing a supply of food product and is in flow-communication with a food delivery apparatus for discharging food product from the hopper.

According to one aspect of the invention, the hopper is hinged along one side to a machine housing or framework and can be pivoted upwardly to reveal a hopper bottom for cleaning and inspection.

According to the preferred embodiment, the hopper has an open bottom face and the food delivery apparatus comprises a hopper conveyor having a top conveying surface, closing a substantial portion of the open bottom face.

Preferably, the conveyor is also arranged to pivot about an axis of the shaft, and an actuator is configured to pivot both the hopper and the conveyor. The actuator is operative to pivot the hopper to an angle greater than 45 degrees and the conveyor to a lesser angle. Preferably, the actuator is configured to pivot the conveyor about 30 degrees or less.

According to a further aspect of the invention, the hopper comprises a unitary part. Because there are no joints or bolted seams, a smooth and easily cleanable surface is provided by the hopper.

According to a further aspect of the invention, in a food patty molding apparatus having a food product hopper configured for containing a supply of food product and in flow-communication with a food delivery apparatus for discharging food product from the hopper, a level sensing mechanism is located at least partially in the hopper. The level sensing mechanism comprises a food material engaging member arranged to be moved by food product within the

nopper, a pneumatic cylinder operatively connected to the engaging member and to the hopper, and a sensing element. The pneumatic cylinder exerts a selectable resistance to movement of the engaging member. A sensing element is arranged to receive a proximity signal corresponding to movement of the engaging member, to sense level of food product within the hopper.

The invention provides an improved hydraulic fluid pump system for a patty-forming apparatus, wherein food product is delivered under pressure from food product pump cylinder by force from a plunger to mold plate cavities. The plunger is driven by force from a hydraulic cylinder into the pump cylinder, wherein the hydraulic cylinder is supplied with hydraulic fluid by a pump. According to one aspect of the invention, the pump is positioned to be at least partially submerged in hydraulic fluid, to be pumped by the pump, within a reservoir.

The invention provides an improved mold cover lift system for a reciprocating mold plate type patty-forming machine. To change mold plates and/or to thoroughly clean the machine, the mold cover must be lifted. The system of the invention includes two jacks that utilize jackscrews that are turned by a motor drive. The jack screws turn drive nuts that lift columns that lift the mold plate cover. According to the invention, secondary nuts are applied to the jackscrews, beneath the drive nuts. The secondary nuts limit the downward movement of the mold cover in the unlikely event that the drive nuts fail to limit such movement.

The invention provides a lubrication system for a patty-forming apparatus

of the kind having a reciprocating mold plate driven by parallel drive rods from a cavity fill position to a patty discharge position, and two food product pumps alternatively operable to supply food product to the mold plate. The food product pumps are selected to communicate food product to the mold plate by a rotatable tube valve. A knockout mechanism includes knockout plungers that are reciprocal between a stand by position and a deployed position to displace patties from the mold plate. The knockout mechanism includes a rotary member that converts rotation input to reciprocation of the knockout plungers.

According to one aspect of the invention, the lubrication system includes a plurality of bearings, at least one bearing journaling each drive rod. The bearings each have a lubrication oil channel therein. A lubrication oil reservoir is connected by a conduit to the lubrication oil channels. A pump is arranged to deliver oil from the reservoir through the conduit and through the channels to lubricate sliding movement of the rods through the bearings. The mold plate drive mechanism, being so lubricated, runs smoother, quieter, with greater energy efficiency and with greater durability.

According to another aspect of the invention, a substantially sealed oil containing compartment is provided for the knockout mechanism. The rotary member is arranged within the oil containing compartment. The rotary member is at least partly submerged beneath a level of lubricating oil within the compartment. The knockout mechanism includes a crank rod pivotally connected to the rotary member within the compartment. The crank rod is also pivotally connected to a knockout frame which drives one or more knockout rods

which drive the knockout plungers. The pivotal connections between the rotary member, the crank rod and the frame are all located within the compartment and are all lubricated by oil within the compartment. The knockout mechanism, being so lubricated, runs smoother, quieter, with greater energy efficiency, and with greater durability.

According to another aspect of the invention, at least one tube valve bushing is provided for journaling rotary movement of the tube valve. The tube valve bushing has a channel therein for being filled with lubricating material. Preferably, the tube valve is fit within a manifold that directs food product from the food product pumps to the mold plate, and the tube valve bushing is externally mounted to the manifold.

The present invention provides a frame structure for a reciprocating mold plate type food product forming apparatus that includes an angular strut configuration for resisting horizontal reciprocating forces caused by the reciprocating mold plate and associated drive, and a tie rod arrangement for resisting reaction forces caused by food product compression in a food product plunger pump. A typical forming apparatus comprises at least one hydraulically driven pump that includes a pump piston or plunger driven into a pump cylinder by a hydraulic cylinder to pressurize food product. The tie rod arrangement resists the reaction force from this pressurizing.

According to one aspect of an exemplary embodiment, a frame portion supports a reciprocating mold plate. A base plate supports the frame portion. A first angular strut extends from a rear location forward and upwardly to an

elevated central location and is fixed to the frame portion. A second angular strut extends from a forward location rearward and upwardly to the elevated central location and is fixed to the frame portion. The first and second struts transfer the horizontal component of the reciprocating forces into the base plate.

According to another aspect of the exemplary embodiment, at least one of the angular struts is fastened to the central location and to the base plate to be removable.

According to another aspect of the exemplary embodiment, the struts are designed to be adjustable in position during installation and easily installed and reinstalled as necessary. The replaceable struts allow for a more efficient assembly of the apparatus, particularly for the installation or removal of mechanical equipment within the machine base. If for any reason a strut is damaged, a replacement can be installed without undue difficulty.

According to another aspect of an exemplary embodiment, the frame portion supports a hydraulic cylinder and a pump cylinder, and comprises rods operatively connected between the hydraulic cylinder and the pump cylinder, the rods having a thickness to resist a reaction force caused by the pump piston pressurizing food product within the pump cylinder.

According to another aspect of the invention, the heretofore known multipart, assembled and fastened together pump housing and tube valve manifold is replaced with a one piece pump housing and tube valve manifold cast or otherwise formed as a single part. The one piece pump housing/valve manifold also functions as an integral part of the machine frame.

Numerous other advantages and features of the present invention will be become readily apparent from the following detailed description of the invention and the embodiments thereof, and from the accompanying drawings.

Brief Description Of The Drawings

Figure 1 is a perspective view of a patty-forming machine of the present invention;

Figure 1A is an elevational view of the patty-forming machine of Figure 1;

Figure 2 is a longitudinal sectional view of the patty-forming machine of Figure 1, with components and/or panels removed for clarity;

Figure 3 is a sectional view taken generally along line 3-3 of Figure 2, with components and/or panels removed for clarity;

Figure 4 is a sectional view taken generally along line 4-4 of Figure 2, with components and/or panels removed for clarity;

Figure 5 is a sectional view taken generally along line 5-5 of Figure 2, with components and/or panels removed for clarity;

Figure 6 is a sectional view taken generally along line 6-6 of Figure 2, with components and/or panels removed for clarity;

Figure 7 is a sectional view taken generally along line 7-7 of Figure 2, with components and/or panels removed for clarity;

Figure 8 is a sectional view taken generally along line 8-8 of Figure 2, with components and/or panels removed for clarity;

Figures 9A-9K are enlarged fragmentary sectional views taken from Figure 2, showing the machine configuration as the mold plate is moved along its path of reciprocation;

Figure 10A is a fragmentary sectional view taken generally along line 10A-10A of Figure 9A, with components and/or panels removed for clarity;

Figure 10B is a fragmentary sectional view taken generally along line 10B-10B of Figure 9E, with components and/or panels removed for clarity;

Figure 11A is a fragmentary sectional view taken generally along line 11A-11A of Figure 9A, with components and/or panels removed for clarity;

Figure 11B is a fragmentary sectional view taken generally along line 11B-11B of Figure 9E, with components and/or panels removed for clarity;

Figure 12 is a fragmentary sectional view taken generally along line 12-12 of Figure 9B, with components and/or panels removed for clarity;

Figure 13 is an enlarged fragmentary sectional view taken generally along line 13-13 of Figure 2;

Figure 13A is a fragmentary sectional view taken from Figure 13, with components removed for clarity;

Figure 14 is a fragmentary sectional view taken generally along line 14-14 of Figure 13;

Figure 15 is a schematic block diagram showing a control system of the patty-forming machine

Figure 16 is a fragmentary sectional view taken generally along line 16-16 of Figure 2;

Figure 16A is a fragmentary sectional view taken generally along line 16A-16A of Figure 16;

Figure 16B is an enlarged fragmentary sectional view taken from Figure 4;

Figure 16C is a fragmentary sectional view taken generally along line 16C-16C of Figure 16B;

Figure 16D is a sectional view taken generally along line 16D-16D of Figure 16C;

Figure 17 is an elevational view of a tube valve of the present invention;

Figure 18 is a sectional view taken generally along line 18-18 of Figure 17;

Figure 19 is a sectional view taken generally along line 19-19 of Figure 17;

Figure 20 is a sectional view taken generally along line 20-20 of Figure 17;

Figure 21 is an elevational view taken generally along line 21-21 of Figure 20;

Figure 22 is an enlarged diagrammatic cross section of the tube valve of Figure 17, showing the positions of and rotary expanse of inlet and outlet ports of the tube valve;

Figure 23 is an enlarged fragmentary sectional view taken generally along line 23-23 of Figure 5;

Figure 24 is an enlarged fragmentary sectional view taken from Figure 5;

Figure 24A is an elevational view of a bushing taken from Figure 23;

Figure 25 is a view taken generally of along line 25-25 of Figure 24;

Figure 25A is a sectional view taken generally of along line 25A-25A of Figure 25;

Figure 26 is an enlarged, sectional view taken generally along line 26-26 of Figure 2;

Figure 27 is an enlarged, sectional view taken generally along line 27-27 of Figure 2;

Figure 28 is a diagrammatic view of the frame system of the invention;

Figure 29 is an enlarged, fragmentary sectional view taken from the left side of Figure 2;

Figure 30 is an enlarged, fragmentary sectional view taken from a front portion of Figure 2, with components and/or panels removed for clarity;

Figure 31 is sectional view taken generally along line 31-31 of Figure 30;

Figure 32 is sectional view taken generally along line 32-32 of Figure 31 in a first stage of operation;

Figure 33 is sectional view similar to Figure 31 in a second stage of operation;

Figure 34 is a diagrammatic view of a lube oil system of the invention;

Figure 35 is an enlarged fragmentary sectional view taken from the right side of Figure 6;

Figures 36-38 are alternate mold plate and fill slot arrangements for the patty-forming machine;

Figure 39 is a sectional view of an alternate embodiment of the valve arrangement shown in Figure 12, taken generally along line 39-39 from Figure 9A;

Figure 40 is a sectional view taken generally along line 40-40 of Figure 39;

Figure 41 is a sectional view taken generally along line 41-41 of Figure 39;

Figure 42 is a diagram of the frame system of the patty-forming machine;

Figure 43 is an enlarged view of a portion of the frame system taken from Figure 42;

Figure 44 is an exploded perspective view of a hopper and some attached components of the patty-forming machine;

Figure 45 is an enlarged fragmentary sectional view taken generally along line 45-45 of Figure 5.

Figure 46 is an enlarged, fragmentary sectional view taken generally along line 46-46 of Figure 2 and showing a further aspect of the invention;

Figure 47 is a sectional view taken generally along line 47-47 of Figure 46;

Figure 48 is a plan view of an alternate embodiment tube valve of the invention in a first rotary position;

Figure 49 is a plan view of an alternate embodiment tube valve of the invention in a second rotary position;

Figure 50 is a plan view of the alternate embodiment tube valve of Figure 49 in a third rotary position;

Figure 51 is a plan view of the alternate embodiment tube valve of Figure 49 in a fourth rotary position;

Figure 52 is a sectional view taken generally along line 52-52 of Figure 46;

Figure 53 is a sectional view taken generally along line 53-53 of Figure 6;

Figure 59 is a position versus time diagram for a mold plate according to the invention;

Figure 54A is a fragmentary sectional view taken generally along line 54A-54A of Figure 13A showing the knockout apparatus in a rear position, with some panels and/or components removed for clarity;

Figure 54B is a sectional view similar to Figure 36A showing the knockout apparatus in a forward position;

Figure 55 is an exploded perspective view of a portion of Figure 2;

Figure 56 is an exploded perspective view of a portion of the frame structure of the apparatus;

Figure 57 is an exploded perspective view of a rear portion of the frame structure of the apparatus;

Figure 58 is an exploded perspective view of a front portion of the frame structure of the apparatus;

Figure 60 is a diagram of a first mold plate waveform;

Figure 61 is a diagram of a second mold plate waveform;

Figure 62 is a diagram of a third mold plate waveform; and

Figure 63 is a diagram of a fourth mold plate waveform;

Detailed Description Of The Preferred Embodiments

While this invention is susceptible of embodiment in many different forms, there are shown in the drawings, and will be described herein in detail, specific embodiments thereof with the understanding that the present disclosure is to be

considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

General Description Of The Apparatus

The high-speed food patty molding machine 20 illustrated in the figures comprises an exemplary embodiment of the invention.

The molding machine 20 includes a machine base 21, preferably mounted upon a plurality of feet 22, rollers or wheels. The machine base 21 supports the operating mechanism for machine 20 and can contain hydraulic actuating systems, electrical actuating systems, and most of the machine controls. The base can be clad in 3/16 inch stainless steel panels or skin. The machine 20 includes a supply 24 for supplying moldable food material, such as ground beef, fish, or the like, to the processing mechanisms of the machine.

A control panel 19, such as a touch screen control panel, is arranged on a forward end of the apparatus 20 and communicates with a machine controller 23, shown in Figure 24.

As generally illustrated in Figures 2 - 6, supply means 24 comprises a large food material storage hopper 25 that opens into the intake of a food pump system 26. The food pump system 26 includes at least two food pumps 61, 62, described in detail hereinafter, that continuously, or intermittently under a pre-

selected control scheme, pump food material, under pressure, into a valve manifold 27 flow-connected to a cyclically operated molding mechanism 28.

In the operation of machine 20, a supply of ground beef or other moldable food material is deposited into hopper 25 from overhead. An automated refill device (not shown) can be used to refill the hopper when the supply of food product therein is depleted. The floor of hopper 25 at least partially closed by a conveyor belt 31 of a conveyor 30. The belt 31 includes a top surface 31a for moving the food material longitudinally of the hopper 25 to a hopper forward end 25a.

The food material is moved by supply means 24 into the intake of plunger pumps 61, 62 of pumping system 26. The pumps 61, 62 of system 26 operate in overlapping alteration to each other; and at any given time when machine 20 is in operation, at least one of the pumps is forcing food material under pressure into the intake of manifold 27.

The manifold 27 comprises a path for feeding the food material, still under relatively high pressure, into the molding mechanism 28. Molding mechanism 28 operates on a cyclic basis, first sliding a multi-cavity mold plate 32 into a receiving position over manifold 27 (Figure 9A) and then away from the manifold to a discharge position (Figure 9F) aligned with a series of knock out cups 33. When the mold plate 32 is at its discharge position, knock out cups plungers or cups 33 are driven downwardly as indicated by 33A in Figure 2, discharging hamburgers or other molded patties from machine 20. The molded patties are

deposited onto a conveyor 29 (Figure 1A), to be transported away from the apparatus 20.

Food Supply System

The food supply means 24 and associated hopper 25 are illustrated in Figures 2 - 6. As seen, the conveyor belt 31 spans completely across the bottom of hopper 25, around an end of idler roller or pulley 35 and drive roller or pulley 36, the lower portion of the belt being engaged by a tensioning roller 37. In some cases the tensioning roller 37 may not be necessary, and can be eliminated. A drum motor (not visible) is provided within the drive roller 36 for rotating the drive roller.

The belt 31 can include a longitudinal V-shaped rib on an inside surface thereof that fits within a V-shaped cross sectional notch provided on the rollers 35, 36 to maintain a lateral centering of the belt during operation.

The forward end 25a of hopper 25 communicates with a vertical pump 38 having an outlet 39 at least partly open into a pump intake manifold chamber 41. A vertically oriented frame 42 extends above hopper 25 adjacent the right-hand side of the outlet 39. A motor housing 40 is mounted on top of the frame 42. A support plate 43 is affixed to the upper portion of frame 42 extending over the outlet 39 in hopper 25. The frame comprises four vertical tie rods 44a surrounded by spacers 44b (Figure 5).

As shown in Figure 5, the vertical pump 38 comprises two feed screw motors 45, 46 that drive feed screws 51, 52. The two electrical feed screw motors 45, 46 are mounted upon the support plate 43, within the motor housing

40. Motor 45 drives the feed screw 51 that extends partly through opening 39 in alignment with a pump plunger 66 of the pump 61. Motor 46 drives the feed screw 52 located at the opposite side of hopper 25 from feed screw 51, and aligned with another pump plunger 68 of the pump 62.

A level sensing mechanism 53 is located at the outlet end of hopper 25. The mechanism is shown in detail in Figure 45. The mechanism 53 comprises an elongated sensing element 54. As the moldable food material is moved forwardly in the hopper 25, it may accumulate to a level in which it engages and moves the sensing element 54 to a pre-selected degree. When this occurs, a signal is generated to stop the drive for the roller 36 of conveyor 31. In this manner the accumulation of food material at the forward end 25a of hopper 25 is maintained at an advantageous level.

The element 54 includes a food engaging leg 54a, and a bent-off leg 54b. The bent off leg 54b includes a welded–on axle 54c that is journaled for pivoting on each end by bushings held by two lugs 54d. An air cylinder 55 is arranged on the support plate 43. The air cylinder 55 exerts a pre-selected force on the upper leg 54b to oppose rotation of the entire element 54 caused by pressure from food product in the hopper. The cylinder 55 is remotely adjustable to change the force to compensate for variable food material density or to change the level desired at the feed screws 51, 52.

A proximity sensor assembly 56 is arranged next to the cylinder 55 on the support plate 43. A bracket 56a guides a moving shaft 56b. A proximity sensor 56c is mounted to the bracket 56a. The shaft 56b includes a metal target 56d

that is sensed by the proximity sensor 56c. The shaft 56b extends through a bushing 43 held on the support plate 43. A lower end of the shaft 56b makes contact with a head of an adjustment screw 54e threaded into the bent off leg 54b. A spring 56e surrounds an upper portion of the shaft 56b and abuts a horizontal portion 56f of the bracket 56a. The spring thus urges the shaft into contact with the adjustment screw 54e. The bent off leg 54b includes an up turned end 54f that contacts the motor housing when the element 54 is rotated counterclockwise (Figure 45) to a maximum amount by the cylinder 55 corresponding to low or no level of food product to the right of the portion 54a as seen in Figure 45, or to left of the portion 54a as seen in Figure 2.

Figure 45 shows the element 54 rotated to a maximum extent clockwise subject to a high level of food product in the forward end 25a of the hopper 25. The proximity target 56d has passed the sensor 56c to trigger a signal to the machine control 23 to turn off the conveyor 30.

When machine 20 is in operation, the feed screw motor 45 is energized whenever plunger 66 is withdrawn to the position shown in Figure 2, so that feed screw 51 supplies meat from hopper 25 downwardly through outlet 39 into one side of the intake 41 of the food pumping system 26. Similarly, motor 46 actuates the feed screws 52 to feed meat to the other side of intake 41 whenever plunger 68 of the pump 62 is withdrawn. In each instance, the feed screw motors 45, 46 are timed to shut off shortly after the plunger is fully retracted, avoiding excessive agitation of the meat. As the supply of food material in the outlet 39 is depleted, the conveyor belt 31 continuously moves food forwardly in the hopper

and into position to be engaged by the feed screws 51, 52. If the level of meat at the outlet 39 becomes excessive, conveyor 30 is stopped, as described above, until the supply at the hopper outlet is again depleted.

The wall of the outlet 39 immediately below conveyor drive rollers 36 comprises a belt wiper plate 57 that continuously engages the surface of the conveyor belt 31 to prevent leakage of the food material 38 from the hopper at this point.

Food Pump System

The food pump system 26 of molding machine 20 is best illustrated in Figures 2 and 6. Pump system 26 comprises the two reciprocating food pumps 61, 62 mounted within the machine base 21. The first food pump 61 includes a hydraulic cylinder 64. The piston (not shown) in cylinder 64 is connected to an elongated piston rod 67; the outer end of the elongated piston rod 67 is connected to the large plunger 66. The plunger 66 is aligned with a first pump cavity 69 formed by a pump cavity enclosure or pump housing 71. The forward wall 74 of pump cavity 69 has a relatively narrow slot 73 that communicates with the valve manifold 27 as described more fully hereinafter.

Preferably, the pump housing 71 and the valve manifold 27 are cast or otherwise formed as a one piece stainless steel part.

The second food pump 62 is essentially similar in construction to pump 61 and comprises a hydraulic cylinder 84. Cylinder 84 has an elongated piston rod 87 connected to the large plunger 68 that is aligned with a second pump cavity

89 formed in housing 71. The forward wall 94 of pump cavity 89 includes a narrow elongated slot 93 communicating with manifold 27.

Advantageously, the plungers 66, 68 and the pump cavities 69, 89 have corresponding round cross sections for ease of manufacturing and cleaning.

An elongated proximity meter 75 is affixed to the first pump plunger 66 and extends parallel to piston rod 67 into alignment with a pair of proximity sensors 76 and 77. A similar proximity meter 95 is fixed to and projects from plunger 68, parallel to piston rod 87, in alignment with a pair of proximity sensors 96, 97. Proximity sensors 76, 77 and 96, 97 comprise a part of the control of the two pumps 61, 62, shown in Figure 15.

The meters 75, 95 and sensors 76, 77, 96, 97 monitor the plunger positions in small, precise increments, such as every 0.25 inches. The meters include teeth or other targets that are sensed by the sensors and counted by machine electronics, such as in the controller 23, or in intervening electronics and communicated to the controller 23.

Two further proximity sensors 78, 98 responsive to targets on an inside facing surfaces of the meters 75, 95 respectively, are provided which communicate to the controller 23, or to intervening electronics that communicate with the controller 23, the home position of the respective plunger which corresponds to a front end of each plunger being just inside, and sealed by a front ring seal 99 (Fig. 2) to the pump housing 71. The home position of each plunger is used by the controller to calibrate or set the machine position control of the plungers 66, 86.

In operation, the first pump 61 pumps the moldable food material into manifold 27 and the second pump 62 receives a supply of the moldable food material for a subsequent pumping operation. Pump 61 begins its pumping stroke, and compresses food product in pump cavity 69, forcing the moldable food material through slot 73 into manifold 27. As operation of molding machine 20 continues, pump 61 advances plunger 66 to compensate for the removal of food material through manifold 27. The pump can maintain a constant pressure on the food material in the cavity 69 during the molding cycle, or preferably can provide a pre-selected pressure profile over the molding cycle such as described in U. S. Patent 4,356, 595 or as utilized in currently available FORMAX machines. The pressure applied through pump 61 is sensed by a pressure sensing switch 78 connected to a port of the cylinder 64.

As plunger 66 advances, the corresponding movement of proximity meter 75 signals the sensor 76, indicating that plunger 66 is near the end of its permitted range of travel. When this occurs, pump 62 is actuated to advance plunger 68 through pump cavity 89, compressing the food material in the second pump cavity in preparation for feeding the food material from the cavity into manifold 27. The pressure applied through pump 62 is sensed by a pressure sensing switch 79 connected to one port of cylinder 84.

When the food in the second pump cavity 89 is under adequate pressure, the input to manifold 27 is modified so that subsequent feeding of food product to the manifold is effected from the second pump cavity 89 with continuing advancement of plunger 68 of the second pump 62. After the manifold intake

has been changed over, pump 61 is actuated to withdraw plunger 66 from cavity 69.

Thereafter, when plunger 68 is near the end of its pressure stroke into pump cavity 89, proximity sensor 96, signals the need to transfer pumping operations to pump 61. The changeover process described immediately above is reversed; pump 61 begins its compression stroke, manifold 27 is changed over for intake from pump 61, and pump 62 subsequently retracts plunger 68 back to the supply position to allow a refill of pump cavity 89. This overlapping alternating operation of the two pumps 61, 62 continues as long as molding machine 20 is in operation.

The valve manifold 27, shown in Figures 2 and 6, holds a manifold valve cylinder or tube valve 101 fit into an opening 102 in housing 71 immediately beyond the pump cavity walls 74 and 94.

According to one embodiment, valve cylinder 101 includes two longitudinally displaced intake slots 107 and 108 alignable with the outlet slots 73 and 93, respectively, in the pump cavity walls 74 and 94. Slots 107 and 108 are angularly displaced from each other to preclude simultaneous communication between the manifold and both pump cavities 69 and 89. Cylinder 101 also includes an elongated outlet slot 109. The valve cylinder outlet slot 109 is generally aligned with a slot 111 (see Figure 9A) in housing 71 that constitutes a feed passage for molding mechanism 28.

One end wall of valve cylinder 101 includes an externally projecting base end 103 that is connected to a drive linkage 104, which in turn is connected to

the end of the piston rod 105 of a hydraulic actuator cylinder 106 (Figure 2). Proximity sensors 106a, 106b communicate the rotary position of the valve cylinder to the machine controller 23.

When the pump 61 is supplying food material under pressure to molding mechanism 28, actuator cylinder 106 has retracted piston rod 105 to the inner limit of its travel, angularly orienting the manifold valve cylinder 101. With cylinder 101 in this position, its intake slot 107 is aligned with the outlet slot 73 from pump cavity 69 so that food material is forced under pressure from cavity 69 through the interior of valve cylinder 101 and out of the valve cylinder outlet slot 109 through slot 111 to the molding mechanism 28. On the other hand, the second intake slot 108 of valve cylinder 101 is displaced from the outlet slot 93 for the second pump cavity 89. Consequently, the food material forced into the interior of valve cylinder 101 from pump cavity 69 cannot flow back into the other pump cavity 89.

Tube Valve System

Figure 17 illustrates the tube valve 101 separate from the apparatus 20. The tube valve includes the base end 103 and a distal end 404. The distal end 404 is inserted first into the opening 102 of the housing 71 during installation. The base end 103 includes an end flange 406 having two tapped holes 408 for connection to the drive link 104 by fasteners 409a and spacers 409b as shown in Figure 24. The base end 103 further includes a groove 410 for a ring seal 411,

such as an O-ring or a D-ring, and a smooth annular surface 412 that is journaled within a base end bearing or bushing 413 shown in Figures 12 and 13A.

The distal end 404 includes a reduced diameter guide portion 416 that positions a smooth annular surface 420 into a distal end bearing or bushing 421 as shown in Figure 24. A ring seal 422, such as an O-ring or D-ring, is positioned within an inside groove 423 of the opening 182. A smooth annular surface 424 of the distal end 404 engages and seals against the ring seal 422 (Figure 23).

As illustrated in Figure 24A, both bushings 413, 421 include a crown-shaped profile having openings 425 spaced around a circumferential surface that abuts the manifold 27 when installed. Each bushing 413, 421 include openings 426 for fasteners to fasten the bushings 413, 421 to the manifold 27, and an inside circumferential grease groove 427 in communication with a grease fitting 428.

As illustrated in Figure 25, the linkage 104 includes a lever bar 429 that is fastened to the base end 103 by the fasteners 409a, and spacers 409b. The rod 105 includes an extension 105a that has a square cross section. The extension has a rectangular notch 105b that is open towards a back side of the lever bar 429.

A follower block 430 is rotatably connected to the back side of the lever bar 429 by a threaded shank 431 of a knob 432. In this regard, the follower block 430 includes a block portion 433a and a cylinder portion 433b having a threaded bore 434 to engage the shank 431. The lever bar 429 includes a cylindrical bore

436 that receives the cylinder portion 433b. The cylinder portion 433b is free to rotate in the bore 436.

The block portion 433a is free to vertically slide within the notch 105b. Three positions of the block portion 433a are shown in Figure 14: 433a, 433ab, 433aa. Two positions of the lever bar 429 are shown: 429 and 429aa.

Figure 18 illustrates the relative size and orientation of the inlet port 108 with respect to the valve 101.

Figure 19 illustrates the relative size and orientation of the inlet port 107 with respect to the valve 101.

Figures 20 and 21 illustrate the relative size and orientation of the outlet port 109 with respect to valve 101.

Figure 22 illustrates the respective rotary positions of the inlet ports 107, 108 and the outlet port 109 around the circumference of the tube valve 101. The ports 107,108,109 have angular expanses of 107A, 108A, and 109A respectively. Preferably, for a 4.4 inch diameter tube valve, given the reference angle 0 degrees shown in Figure 22, the angular position and expanse 107A is approximately between 205 degrees and 267 degrees, the angular position and expanse 108A is approximately between 134 degrees and 197 degrees, and the angular position and expanse 109A is approximately between 0 degrees and 137 degrees. The sidewalls of the ports are not all cut radially, in such cases the angles are taken at the furthest radial point on the sidewall that defines the port.

Figures 46-52 illustrate a second embodiment tube valve 1601 and manifold 527. Figure 46 is taken generally along oblique line 46-46 of Figure 47.

Figure 46 illustrates the valve manifold 527 and the pump chambers 69, 89 of the pump housing 71 from above, taken from an angle. The mold plate and breather plate are removed in this figure so that the inside cavities of the valve manifold 527 and pump chambers 69, 89 are visible. Similar to the previously described embodiment, it is preferred that the pump housing 71 and the manifold 527 are formed as a unitary part.

The manifold 527 includes three oblong inlet openings 111a, 111b and 111c. The openings 111a, 111b and 111c are substantially equal in open area. The openings 111a, 111b, 111c receive food material from the alternate embodiment tube valve 1601 shown in Figures 48-51.

Figure 46 illustrates the pump chambers 69, 89 empty, i.e., there are no plungers 66, 68 shown. On a top surface 650 of the pump housing 71 and/or manifold 527 there are three grooves or indentations 1652, 1654, 1656 that communicate with bores or holes 1652a, 1654a, 1656a, respectively.

As shown in Figure 47, the first plunger 66 is in a position to begin a filling cycle of food material 660. A front face 1662 of the plunger 66 includes a beveled region 1664 around beveled approximately 180°, around a top edge of the plunger 66, constituting the upper portion of the circumference of the plunger 66. This bevel is approximately 15° and acts to hold the plunger 66 down given the pressure of the food material within the pump chamber.

The center groove 1654 on the top surface 1650 is shown dashed in Figure 47. The center groove 1654 extends from the bore 1654a to an open area 1654b that is open to the hopper 25. The other grooves 1652, 1656 and

bores 1652a, 1656a are similarly configured as that shown in Figure 47 for groove 1654 and bore 1654a. These grooves 1652, 1656 have open areas 1652b, 1656b to the hopper 25.

Figure 48-51 show the alternate tube valve 1601 in detail. The alternate tube valve 1601 is as described previously as the tube valve 101 except as herein distinguished. When the inlet port 107 is in registry with the pump chamber 69 there are three outlet ports 109a, 109b, 109c that are in registry with the openings 111a, 111b, 111c, to pass food material 660 to the molding mechanism 28.

As can be seen in Figure 48, the outlet port 109a that is closest to the inlet port 107 has a smallest, most restrictive opening, the center outlet port 109b has a slightly greater opening, and the far outlet port 109c has the greatest opening. This progressive tube valve outlet opening arrangement, with the smallest outlet opening closest to the feeding inlet to the tube valve, assists in equalizing the food product pressure across the width of the manifold 27 and molding mechanism 28. A more even food product pressure allows for a more consistent density of molded products across a width of the mold plate.

As seen in Figure 49, the tube valve is rotated so that the second inlet port 108 is in registry with the second pump cavity 89. The tube valve1601 provides progressive openings 119a, 119b, 119c that are smallest near the inlet port 108 and largest at the opposite end of the tube valve 1601, in mirror image reversal of the openings 109a, 109b, 109c shown in Figure 48. When the inlet port 108 is in registry with the pump chamber 89, the three outlet ports 119a, 119b, 119c are

open to the openings 111a, 111b, 111c to pass food material 1660 to the molding mechanism 28. This progressive tube valve outlet opening arrangement, with the smallest outlet opening closest to the feeding inlet to the tube valve, assists in equalizing the food product pressure across the width of the manifold 27 and molding mechanism 28. A more even food product pressure allows for a more consistent density of molded products across a width of the mold plate.

It is also within the scope of the invention that the center ports 109b, 119b and 111b and 119b be eliminated and that just two outlet ports 109a, 109c and 119a, 119c and corresponding two inlet ports 111a, 111c be used. As described, the outlet ports 109c, 119c would be larger than the outlet ports 109a, 119a.

Figure 50 illustrates the tube valve rotated so the inlet port 107 and two substantially rectangular surface depressions 1710, 1712 can be seen. The depressions 1710, 1712 have a constant radial depth (preferably about 3/16" deep) from the cylindrical surface of the tube valve 1601. The center surface depression 1710 is slightly longer than the end surface depression 1712. When the first plunger 66 is in operation, pushing food product through the inlet port 107, the surface depressions 1710, 1712 are in flow communication with the bores 1652a, 1654a, and the grooves 1652, 1654.

Figure 51 illustrates the tube valve rotated so the inlet port 108 and two substantially rectangular surface depressions 1810, 1812 can be seen. The depressions 1810, 1812 have a constant radial depth (preferably about 3/16" deep) from the cylindrical surface of the tube valve 1601. The center surface depression 1810 is slightly longer than the end surface depression 1812. When

the second plunger 68 is operating, pushing food product through the inlet port 108, the surface depressions 1810, 1812 are in flow communication with the bores 1654a, 1656a, and the grooves 1654, 1656.

Figure 52 shows the configuration of the tube valve 1601 when the inlet port 107 is used. Rectangular recesses 1710, 1712, communicate with the bores 1652a, 1654a and the grooves 1652, 1654 to vent air to the hopper.

When reloading the pump box with product, the following occurs. For example, when reloading the pump cavity 89 for plunger 68, the plunger 68 retracts and the feed screws rotate. The combination of the vacuum created by the plunger 68 withdrawing from the pumping chamber, and the turning screws, forces food product in front of the plunger 68. The plunger is then advanced into the chamber 89 to initially compress the food product before filling begins. As the plunger 68 advances to the pump chamber 89, there will be air inter-mixed with food product. This air must be removed before the plunger 68 starts its mold plate cavity-filling cycle.

The plunger 68 advances to compress the reloaded product, while the plunger 66 continues to feed food product through the full open port 107 in the tube valve 601. The tube valve 601 is blocking the plunger 68 from feeding the food product into the manifold 527; however the grooves 1710, 1712 communicate with bores 1652a, 1654a in the pump box or manifold 527. Grooves 1652, 1654 on the manifold and pump housing top surface 1650 allow air (but not product) from the pump chamber 89 to escape back to the hopper,

during initial compression of the food product within the pump chamber 89 against the tube valve 1601.

The process alternates with the tube valve rotational shift of about 70 degrees, to change the active plunger 66, 68.

As a further feature of the invention, a plurality of breather holes 1902 are provided at each longitudinal end of the tube valve, through the tube valve wall. The breather holes 1902 are in communication with an inside of the tube valve and to an outside circumferential groove 1906a, 1906b respectively that is in communication with the depressions 1712, 1812 respectively. Thus, air trapped at either end within the tube valve can be expressed back to the collection area, the hopper, via the breather holes 1902, the grooves 1906a, 1906b and the depressions 1712, 1812.

Molding Mechanism

As best illustrated in Figure 9A, the upper surface of the housing 71 that encloses the pump cavities 69 and 89 and the manifold 27 carries a support plate or wear plate 121 and a fill plate 121a that forms a flat, smooth mold plate support surface. The mold support plate 121 and the fill plate 121a may be fabricated as two plates as shown, or a single plate bolted to or otherwise fixedly mounted upon housing 71. The fill plate 121a includes apertures or slots that form the upper portion of the manifold outlet passage 111. In the apparatus illustrated, a multi fill orifice type fill plate 121a is utilized. A simple slotted fill plate is also encompassed by the invention.

Mold plate 32 is supported upon plates 121, 121a. Mold plate 32 includes

a plurality of individual mold cavities 126 extending across the width of the mold plate and alignable with the manifold outlet passageway 111. Although a single row of cavities is shown, it is also encompassed by the invention to provide plural rows of cavities, stacked in aligned columns or in staggered columns. A cover plate 122 is disposed immediately above mold plate 32, closing off the top of each of the mold cavities 126. A mold cover casting or housing 123 is mounted upon cover plate 122. The spacing between cover plate 122 and support plate 121 is maintained equal to the thickness of mold plate 32 by support spacers 124 mounted upon support plate 121. Cover plate 122 rests upon spacers 124 when the molding mechanism is assembled for operation. Cover plate 122 and mold cover 123 are held in place by six mounting bolts, or nuts tightened on studs, 125.

As best illustrated in Figures 3, 6, and 53 mold plate 32 is connected to drive rods 128 that extend alongside housing 71 and are connected at one end to a transverse bar 129. The other end of each drive rod 128 is pivotally connected to a connecting link 131 via a coupling plate 131a and a pivot connection 131c, shown in Figure 29. The pivot connection 131c can include a bearing (not visible in the figures) surrounding a pin 131d within an apertured end 131e of the connecting link 131. The pin 131d includes a cap, or carries a threaded nut, on each opposite end to secure the crank arm to the coupling plate 131a.

Each drive rod 128 is carried within a guide tube 132 that is fixed between a wall 134 and a front bearing housing 133. The connecting links 131 are each pivotally connected to a crank arm 142 via a pin 141 that is journalled by a

bearing 141a that is fit within an end portion of the connecting link 131. The pin crank arm 142 is fixed to, and rotates with, a circular guard plate 135. The pin 141 has a cap, or carries a threaded nut, on each opposite end that axially fixes the connecting link 131 to the crank arm 142 and the circular guard plate 135. The connecting link 131 also includes a threaded portion 131b to finely adjust the connecting link length.

The crank arms 142 are each driven by a right angle gear box 136 via a "T" gear box 137 having one input that is driven by a precise position controlled motor 138 and two outputs to the gearboxes 136. The "T" gear box 137 and the right angle gear boxes 136 are configured such that the crank arms 142 rotate in opposite directions at the same rotary speed.

The precise position controlled motor can be a 6-7.5 HP totally enclosed fan cooled servo motor. The servo motor is provided with two modules: a power amplifier that drives the servo motor, and a servo controller that communicates precise position information to the machine controller 23.

The controller 23 and the servo motor 138 are preferably configured such that the servo motor rotates in an opposite rotary direction every cycle, i.e., clockwise during one cycle, counterclockwise the next cycle, clockwise the next cycle, etc.

A bearing housing 143 is supported on each gearbox 136 and includes a rotary bearing 143a therein to journal an output shaft 136a of the gear box 136. The output shaft 136a is fixed to the crank arm 142 by a clamp arrangement formed by legs of the crank arm 142 that surround the output shaft and have

fasteners that draw the legs together to clamp the output shaft between the legs (not shown), and a longitudinal key (not shown) fit into a keyway 136b on the output shaft and a corresponding keyway in the crank arm 142 (not shown).

A tie bar 139 is connected between the rods 128 to ensure a parallel reciprocation of the rods 128. As the crank arms 142 rotate in opposite rotational directions, the outward centrifugal force caused by the rotation of the crank arms 142 and the eccentric weight of the attached links 131 cancels, and separation force is taken up by tension in the tie bar 139.

One circular guard plate 135 is fastened on top of each crank arm 142. The pin 141 can act as a shear pin. If the mold plate should strike a hard obstruction, the shear pin can shear by force of the crank arm 142. The guard plate 135 prevents an end of the link 131 from dropping into the path of the crank arm 142.

The drive mechanism of the mold plate is easily reconfigured to change stroke length of different mold plates. For example, 6, 7, 8, 9, 10 or 11 inch stroke lengths are practically achievable with the apparatus by changing parts, such as the parts 131, 135, 142.

Figure 53 illustrates a proximity sensor 144 in communication with the machine control. A target 144a is clamped onto an extension 136d of the rotating shaft 136a. The proximity sensor 144 communicates to the controller 23 that the crank arm 142 is at a particular rotary position corresponding to the mold plate 32 being at a preselected position. Preferably, the proximity sensor 144 can be arranged to signal to the controller that the crank arm 142 is in the most

forward position, corresponding to the mold plate 32 being in the knockout position. The signal confirms to the controller that the knockout cups 33 can be safely lowered to discharge patties, without interfering with the mold plate 32.

During a molding operation, the molding mechanism 28 is assembled as shown in Figures 2 and 9A, with cover plate 122 tightly clamped onto spacers 124.

In each cycle of operation, knockout cups 33 are first withdrawn to the elevated position as shown in Figure 9F. The drive for mold plate 32 then slides the mold plate from the full extended position to the mold filling position illustrated in Figures 2 and 9A, with the mold cavities 126 aligned with passageway 111.

During most of each cycle of operation of mold plate 32, the knockout mechanism remains in the elevated position, shown in Figure 9A, with knockout cups 33 clear of mold plate 32. When mold plate 32 reaches its extended discharge position as shown in Figure 9F the knockout cups 33 are driven downward to discharge the patties from the mold cavities.

The discharged patties may be picked up by the conveyor 29 or may be accumulated in a stacker. If desired, the discharged patties may be interleaved with paper, by an appropriate paper interleaving device. Such a device is disclosed in U.S. Patent 3,952,478, or US Patent 7,159,372. In fact, machine 20 may be used with a wide variety of secondary equipment, including steak folders, bird rollers, and other such equipment.

By using a servo motor to drive the mold plate, the mold plate motion can be precisely controlled. The motion can have a fully programmable dwell, fill time, and advance and retract speeds.

Figure 59 illustrates one motion profile P1 for the movement of the mold plate 32 that is precisely controlled by the servomotor 138 and controller 23. The mold plate position (any point on the mold plate) is shown as a function of time between the most retracted position, the fill position, and the forward most extended position, the knockout position. The profile P1 of Figure 59 shows a rather sharp turn around at the fill position, with little or no mold plate stopping, or dwell period. At the knockout position, there is a dwell period to allow the knockout cups to descend into the mold plate cavities to displace the formed patties from the cavities.

On the same graph a knockout cup movement profile P2 is depicted, wherein the knockout cups are lowered and raised during a segment of time t1 that is within the dwell period of the mold plate stopped in the knockout position.

Figures 60-63 illustrate one cycle of different mold plate motion profiles that can be programmed by the controller 23 and the drive for the servomotor 138. The profile P3 in Figure 60 is appropriate for a mold plate stroke speed of 100 cycles/minute and a knockout dwell period of 0.088 seconds. The profile P3 shows little or no filling dwell period; adequate filling can occur during retraction and/or advancement of the mold plate before and after the fill position. The profile would be for a food product material that is soft, easily flowable, and possibly warm.

Figure 61 illustrates a profile P4 that is appropriate for a mold plate stroke speed of 100 cycles/minute and a cold, stiff or viscous product that requires a dwell period at the fill position to adequately fill the cavities.

Figure 62 illustrates a profile P5 appropriate for easily flowable food product and a mold plate stroke speed of 120 cycles/minute.

Figure 63 illustrates a profile P6 appropriate for viscous product that requires a dwell period at the fill position to adequately fill the cavities, and a mold plate stroke speed of 120 cycles/minute.

All of the profiles P3-P6 are for a 9 inch mold plate stroke length and allow for a 0.088 second knockout period. The different motion profiles for mold plate movements illustrated in Figure 31-34 can be selected by an operator via the input screen 19 and the controller 23.

Lubricating Oil System

Figure 34 illustrates a mold drive rod lubricating system 1000 incorporated into the apparatus 20. The lubrication system 1000 includes front bearings 1002 and rear bearings 1002 for each drive rod 128. The location of the bearings is shown in Figure 6.

A pump 1008 takes suction from reservoir 1010 holding lubricating oil 1012. A motor 1016 being either an electric, hydraulic, pneumatic or other type motor, drives the pump. The pump circulates lubricating oil through tubing and/or passages through the machine base area to the bearings 1002, 1004 and returns the lubricating oil through a filter 1022 to the reservoir. The pump, motor, reservoir and filter are all located within the machine base 21.

Figure 35 illustrates a front bearing 1002. The other front bearing and the rear bearings 1004 are configured in substantially identical manner. The front bearing 1002 includes a housing 1032 having an internal bore 1036 for holding a sleeve bearing element 1038. The sleeve bearing element 1038 has an inside surface sized to guide the drive rod 128 and has a helical groove 1042 facing and surrounding the drive rod 128. An oil inlet port 1050 communicates lubricating oil into an open end of the helical groove. Lubricating oil proceeds through the helical groove to an opposite end of the bearing element 1038 to a first outlet groove 1052 in communication with a second outlet groove 1054 through a longitudinal channel (not shown). The second outlet groove 1054 is in communication with an outlet port 1056. The inlet port 1050 is in fluid communication with the pump 1008 and the outlet port 1056 is in fluid communication with the oil return lines to the filter 1022. A front seal 1060 and a rear seal 1062 retain oil within the housing 1032.

Knock Out System

Molding mechanism 28 further comprises a knockout apparatus 140 shown in Figures 2, 9A, 13-14, and 54A-54B. The knockout apparatus comprises the knockout cups 33, which are fixed to a carrier bar 145. Knockout cups 33 are coordinated in number and size to the mold cavities 126 in mold plate 32. One knockout cup 33 aligned with each mold cavity 126. The mold cavity size is somewhat greater than the size of an individual knockout cup.

The knockout apparatus 140 is configured to drive the carrier bar 145 in timed vertical reciprocation.

Figures 13-14, and 54A-54B illustrate the knockout apparatus 140 in more detail. The carrier bar 145 is fastened to knockout support brackets 146a, 146b. The knockout support brackets 146a, 146b are mounted to two knockout rods 147. Each knockout rod 147 penetrates through a sidewall of a housing 148 and is connected to a knockout beam 149.

The knockout beam 149 is pivotally mounted to a crank rod 151 that is pivotally connected to a fastener pin 156 that is eccentrically connected to a crank hub 155 that is driven by a motor 157.

The motor 157 is preferably a precise position controlled motor, such as a servo motor. An exemplary servomotor for this application is a 3000 RPM, 2.6 kW servo motor provided with a brake. The servo motor is provided with two modules: a power amplifier that drives the servo motor, and a servo controller that communicates precise position information to the machine controller 23.

The controller 23 and the motor 157 are preferably configured such that the motor rotates in an opposite direction every cycle, i.e., clockwise during one cycle, counterclockwise the next cycle, clockwise the next cycle, etc.

A heating element 160 surrounds, and is slightly elevated from the knockout carrier bar 145. A reflector 161 is mounted above the heating element 160. The heating element heats the knock out cups to a pre-selected temperature, which assists in preventing food product from sticking to the knock out cups.

In Figures 13-14 the crank hub 155 is rotated into a position wherein the crank rod 151 is vertically oriented and the knockout beam 149 is lifted to its

maximum elevation. The knockout rods are fastened to the knockout beam 149 by fasteners 152. The knockout support brackets 146a, 146b are in turn fastened to the knockout rods 147 by fasteners 153. Each knockout cup 33 is fastened to the knockout carrier bar by a pair of fasteners 154a and spacers 154b. An air flap or air check valve 33a can be provided within each cup to assist in dispensing of a meat patty from the cup 33.

As shown in Figure 14, the motor 157 is supported by a bracket 170 from a frame member 172 that is mounted to the mold cover casting 123. The bracket 170 includes one or more slotted holes, elongated in the longitudinal direction (not shown). One or more fasteners 173 penetrate each slotted hole and adjustably fix the motor 157 to the frame member. The motor 157 includes an output shaft 176 that is keyed to a base end of the crank hub 155. The fastener pin 156 retains a roller bearing 178 thereon to provide a low friction rotary connection between an annular base end 151a of the crank rod 151 and the pin 156.

The crank rod 151 has an apertured end portion 179 on an upper distal end 151b opposite the base end 151a. The apertured end portion 179 is held by a fastener pin assembly 180 through its aperture to a yoke 182. The yoke 182 is fastened to the knockout beam 149 using fasteners. The crank rod 151 is length adjustable. The fastener pin assembly 180 can include a roller or sleeve bearing (not shown) in like fashion as that used with the fastener pin 156 to provide a reduced friction pivot connection.

The housing 148 is a substantially sealed housing that provides an oil bath. Preferably, the housing walls and floor is formed as a cast aluminum part. The crank hub 155, the pin 156, roller bearing 178, the apertured end portion 179, the fastener pin 180 and the yoke 182 are all contained within the oil bath having an oil level 183. The limits of the oil bath are defined by a housing 184 having a front wall 185, a rear wall 186, side walls 187, 188, a top wall 189 and a sleeve 190. The sleeve 190 is a square tube that surrounds a substantial portion of the crank rod 151 and is sealed around its perimeter to the top wall 189 by a seal element 196a. The sleeve 190 is connected to the beam 149 and penetrates below the top wall 189. As the yoke 182 reciprocates vertically, the beam 149 and the sleeve 190 reciprocate vertically, the sleeve 190 maintaining a sealed integrity of the oil bath.

The crank rod 151 includes side dished areas 151a that act to scoop and propel oil upward during rotation of the hub 155 to lubricate the pin 180 and surrounding areas.

The knockout rods 147 are guided to reciprocate through the side walls 187, 188, particularly, through upper and lower bearings 191a, 191b. The rods 147 are sealed to the top wall by seals 192. The bearings 191a can include an internal groove 193 that is in flow-communication with a lubricant supply through port 194.

A lubricant system 194a is provided to provide lubricant to the bearings 191a, 191b. The system 194a includes a lubricant reservoir 194b that is filled with lubricant, such as oil, and connected to plant air 194c via an electronically

controlled valve 194d. The machine controller 23 periodically, according to a preset routine, actuates the valve 194d to propel some lubricant into the bearings 191a. Lubricant can run down the knockout rod 147 into a dished top 191c of the lower bearings 191b to allow oil to penetrate between the knockout rods 147 and the lower bearings 191b.

An outer cover 195 is fastened and sealed around the side walls 187, 188 and front and rear walls 185, 186 by fasteners, spacers 196 and a seal 197. Any lubricating oil that passes through the seal can be returned to the oil bath via dished out drain areas and drain ports through the top wall.

The front wall 185 includes an oil level sight glass 185a, a fill port 185b (shown dashed in Figure 13), a drain port 185c (Figure 14); and an access hole closed by a screw 185d (Figure 14).

The crank hub 155 is journaled for rotation by two roller bearings 198, 199. The roller bearings 198, 199 are supported by a collar assembly 200 bolted to the rear wall 186 and to the motor 157.

The housing 148 is fastened to a support plate 201 by fasteners 201a. The support plate 201 is fastened to circular adapter plates 201b by fasteners 201c. The circular adapter plates 201b are removably fit into circular holes 201d in the casting 123. The circular adapter plates 201b include a bottom flange 201e which abuts the casting 123. The circular adapter plates 201b surround the bearings 191b and associated bearing assembly 191c.

As shown in Figure 13A, the left bracket 146a is fixedly connected to the left knockout rod 147 using the fastener 153 while the right bracket 146b is

connected for a sliding connection. In this regard the right fastener 153 passes through an inverted T-nut 153a that passes through the bracket 146b and fits into a back up washer 153b that abuts the top side of the bracket 146b. The bracket 146b includes an oversized opening in the lateral direction that allows the bracket 146b to shift laterally with respect to the T-nut and knockout rod 147. This arrangement allows the bar 145 to expand and contract laterally with respect to the knockout rods 147. When the knockout cups 33 are heated by the heating element 160, the carrier bar 145 can become heated as well. Preferably, the carrier bar 145 is composed of aluminum which can expand to a significant degree. The sliding connection of the bracket 146b accommodates this thermal expansion.

The knockout assembly is changeable to extend further forwardly to minimize knockout cup cantilever and stress in supporting members. This is accomplished by loosening the bracket 170 from the frame member 172 and sliding the motor 157 and the connected parts forward or rearward and replacing the circular adapter plates that guide the knockout rods 147.

As demonstrated in Figures 54A and 54B, to change the longitudinal position of the knockout cups 33, the support plate 201 is shifted longitudinally. Replacement circular adapter plates 201bb are fit into the casting 123 from below. The replacement circular adapter plates 201bb include different hole patterns for the knockout rods 147, forwardly or rearwardly shifted, to accommodate the new position of the support plate 201.

A proximity sensor 202 is bolted to the outer cover 195, and a target 203 is provided on the crank beam 149 to be sensed by the proximity sensor 202. The proximity sensor 202 communicates to the controller 23 that the knockout cups are raised and the mold plate can be retracted without interfering with the knockout cups.

The movement of the knock out cups is fully programmable for different motion profiles, including dwell, accelerations and extend and retract speeds. Such motion profiles may be useful depending on the properties of the food product to be discharged from the mold plate cavities. Because both the mold plate and the knock out cups can be driven by programmably controlled servo motors, they can be flexibly sequenced without being restricted in motion by a common mechanical system.

<u>Auxiliary Pump System For Air And Fines From The Breather System</u>

Figures 9A through 12 and 36-41 illustrate another aspect of the invention. According to this aspect, the mold plate 32 includes two ends, a forward end 202 and a rearward end 204. The cavities 126 are located at a central position between the ends 202, 204. Elongated connection recesses 208 are located at a rearward position, near the rearward end 204. Relief recesses 209 are located between the connection recesses 208 and the cavities 126. In Fig. 9A the mold plate 32 is in a fill position, fully retracted toward the rear. The cover plate or breather plate 122 includes breather holes 216 that are in air communication with the cavities 126 while the mold plate is in the fill position.

The holes 216 are in communication with a top side air channel in the form of a dished region 220 of the cover plate 122. The dished region 220 includes branch regions 222 that extend forwardly. The branch regions 222 are in air communication with an antilip channel 230 open on a bottom side of the cover plate 122, through narrow apertures 234.

On a rearward portion of the dished region 220 are recesses 237 that are in communication with through holes 238 that extend through the thickness of the cover plate 122. In the mold plate position of Figure 9A, the through holes 238 are open into the elongated connection recesses 208.

On a rearward portion of the cover plate 122 is a bottom side recess 242 that is in communication with an overhead valve passage 246 that can be closed by action of a valve 250, particularly by action of a valve element 252 of the valve 250. The valve element 252 is in the open position as shown in Figure 9A. The valve element is movable within a valve chamber 258 formed into a bottom side of the mold cover 123.

The valve chamber 258 extends laterally and is flow connected to two through bores 264, 266 that each extend through the cover plate 122, the spacer 124, the top plate 121, and an insert plate 270 fit on a recess 272 of the pump housing 71. The recess 272 is open into the pump inlet 39.

In the position shown in Figure 9A, the cavities are filled through a plurality of fill apertures or slots 121b through fill plate 121a (see Figure 38 as an example of fill apertures) fastened to the pump housing 71. The mold plate 32 is

beginning its forward travel, driven by the drive rods 128 via the link 129. The valve element 252 is up; the valve 250 is open.

As illustrated in Figure 9B, when the connection recess 208 is no longer in communication with the bottom side recess 242, the moving end 204 of the plate 32 creates a suction chamber 280S formed between the spacer 124, the end 204, the breather plate 122 and the top plate 121. The element 252 is drawn down by the suction to close the valve passage 246.

In the position of the mold plate shown in Figure 9C, the cavities 126 have moved into a position to be relieved in pressure by the antilip slot 230, any expansion of the patties is cut as the patties pass under the antilip bar 231. Further suction is drawn in the chamber 280 by movement of the end 204.

As shown in Figure 9D, maximum suction is developed at this point in the chamber 280S by movement of the end 204.

As shown in Figure 9E, the end 204 has passed under the through hole 238. The suction chamber 280 draws air and meat fines from the chambers and recesses 230, 234, 222, 220, 237, 238 into the suction chamber 280S.

Figure 9F illustrates the mold plate 32 in its discharge position. The relief recesses 209 open the antilip channel 230 to outside air. Outside air flushes through the series of recesses and other passages identified as 209, 230, 234, 222, 220, 237, and 238 and into the suction chamber 280S under influence of a vacuum present in the suction chamber 280S. The pressure in the suction chamber 280S and the connected chambers and passages 238, 237, 220, 222,

234, 230 is increased to atmospheric pressure. The valve element 252 is then elevated and the valve 250 is then open.

Figure 9G illustrates the patty has been discharged by downward movement of the cup 33, which subsequently has been elevated. The patty has been deposited onto the conveyor. The mold plate 32 begins a rearward movement. The suction chamber 280 now becomes a compression or pump chamber 280P. Any air or meat fines drawn into the suction chamber 280S can now be transported by positive pressure or pumping action of the pump chamber 280P through the open valve 250 and into the pump inlet 39 as now described.

Figure 9H illustrates that for a brief time during the return stroke of the mold plate, the mold plate moved a small amount to the left of the position shown in Figure 9H, the moving end 204 will pump air rearward through the pump chamber 280P and forward through the passages 238, 237, 220, 222, 234, 230, 126 to atmosphere. However the latter forward path is more restrictive than the rearward path so little flows in this direction. Most air and fines are pumped through the chamber 280P, through the recess 242, through the valve passage 246, through the recess 258, through the bores 264 and 266, through the recess 272 and into the pump inlet 39.

Figure 9I illustrates that the end 204 has passed the passage 238 and thus all of the air and fines in the pump chamber 280P must pass rearward toward the pump inlet 39.

Figure 9J illustrates the cavities 126 become open to the fill slots 121b of the fill plate 121a wherein the cavities begin to fill with meat under pressure. The

pump chamber is continuously reduced in volume as the end 204 proceeds rearward. The valve 250 is still open.

Figure 9K illustrates a late stage of movement of the mold plate 32. The cavities 126 are continuing to be filled. The meat, under pressure forces air and meat fines through the apertures 216 into the chambers 220, 222, 237, 238, 208. The valve 250 remains open wherein the mold plate reaches the position of Figure 9A, the air and meat fines can exit the chambers 220, 222, 237, 238, 208 by virtue of the recess 208 being in air flow communication with the recess 242 and the passages 246, 258, 264, 266, 272 and 39.

Although a single row of cavities is shown in the mold plate 32 in Figures 10A-11B, 14 and 15, it is encompassed by the invention to provide multiple rows of cavities, in straight or staggered columns, such as described in U.S. Patents 6,454,559; 6,517,340; 4,872,241; 6,572,360; and/or 3,747,160; or international patent publications WO 01/41575 and/or WO 02/102166.

Figures 36-38 illustrate alternate mold plates 1232, 1234, 1236 having similar mold plate features as described above, but having two rows of cavities 1238 in staggered columns. In Figures 36 and 37 the cavities are filled by individual fill slots 1242 below the mold plates 1232, 1234. In Figure 38, the cavities 1238 are filled by a plurality of fill apertures 1250 in registry with the cavities 1238. The apertures 1252 that are not in registry with the cavities are shown but are not drilled through the plate 1236.

Furthermore, the apparatus 20 can also have, in conjunction with the mold plate and fill plate arrangements, a stripper or seal off mechanism such as described in U.S. Patents 4,821,376; 4,697,308; and/or 4,372,008, or as available on current FORMAX F-26 machines.

Figures 39-41 illustrates an alternate valve arrangement than described with regard to Figure 12. The porting of the valve elements 252 remains the same. The mechanism for opening and closing the valve elements 252 is modified. The sectional view is broken along its vertical centerline CL to show two valves 1290 with elements 252 lowered, and closed, to the left of the centerline CL, and two valves 1290 with elements 252 raised, and opened, shown to the right of the centerline CL. It should be understood however that in operation all four valve elements raise-and-lower together to open and close the valves.

The valves 1290 are mounted on a support bar 1300. The valves 1290 are mounted to the bar by a threaded adjustment mechanism 1304. The adjustment mechanism includes a handle 1306 locked onto a threaded shaft 1308 that is threaded into a valve stem assembly 1310 such that when the threaded shaft 1308 is turned by the handle 1306, the threaded shaft selectively raises or lowers the valve element 252 by precise amounts to set valve clearance and to ensure that the valves seat at the same time given their common movement. The valve stem assembly includes a ring seal 1311 to seal against a stationary sleeve 1312 of the valve 1290.

The support bar 1300 is supported on two rods 1320, 1322. A crossbar 1326 spans between the rods 1320, 1322 and is fastened thereto. A bracket 1330 is supported on a machine wall 1336. A pair of pneumatic cylinders 1342, 1344 are fixed to the bracket 1330 and have actuation rods or piston rods 1348, 1350 fixed to the crossbar 1326. When the rods 1348, 1350 extend together from the cylinders 1342, 1344, the crossbar 1326 raises the rods 1320, 1322, which raises the support bar 1300, which raises the valve stems 1310 and the valve elements 252. This opens the valves 1290.

Contracting the rods 1348, 1350 into the cylinders 1342, 1344 has the opposite effect, lowering the valve elements 252 and closing the valves 1290.

The pneumatic cylinders 1342, 1344 are signal-connected via pneumatic tubing and electronics to the machine controller that can precisely control the raising and lowering of the valve element to be synchronized with the mold plate movements. The valve element can be positively raised and lowers according to a precisely controlled timing sequence rather than being controlled by vacuum or positive pressure in the suction chamber or pump chamber.

Figure 15 illustrates in schematic form, the control system of the present invention. The machine controller 23 can be programmed to control the servo motor drives 138, 157 and the pneumatic cylinders 1342, 1344, via the interface 1345, to be properly sequenced to coordinate the movements of the knockout cups and the valves 1290 with the movement and position of the mold plate 32. The controller can be pre-programmed, or programmed through the control panel 19, to control the mold plate accelerations, decelerations, advance and retract

speeds, and dwell durations. These mold plate movement parameters can be selected depending on the particular product being molded, the characteristics of the food material, the selected production output rate of the machine, or other factors. The controller can control the advance and retract speeds, the accelerations and decelerations, and the dwell durations of the knock out cups 33 as well. These knock out cup movement parameters can be selected depending on the particular product being molded, the characteristics of the food material, the selected production output rate of the machine, or other factors. The controller can have pre-programmed routines for a selectable product and output rate that are selectable via the control panel 19 that sets and coordinates the mold plate 32 movements, the knock out cup 33 movements and the valve 1290 movements.

The controller also controls the operation of the hydraulic cylinders 64, 84 to control the food pumps 61, 62.

Machine Frame System

The preferred embodiment apparatus 20 of the present invention utilizes an exemplary frame 500 as illustrated in Figures 2, 3, 5-8 and 26-28, 42-43, and 56-58.

The frame 500 includes a thick base plate 21a. The base plate 21a comprises a stainless steel plate, ½ inch thick. Two rear anchors 506a, 506b and two forward anchors 508a, 508b are fastened to the base plate 21a with fasteners 507a and keys 507b, in a rectangular pattern. The base plate 21a and the anchors have recesses or keyways to receive the keys 507b.

Two rear struts 510a, 510b extend obliquely forward in parallel from the rear anchors 506a, 506b and are fastened thereto using fasteners and shims. Two forward struts 510a, 510b extend obliquely rearward in parallel from the front anchors 508a, 508b and are fastened thereto using fasteners and shims.

As illustrated in Figures 2, 26, 28, and 56 each rear strut 510a, 510b comprises a rectangular tube column 510c having a plate flange 510d, 510e welded to each end thereof. The tube columns preferably have 3 inch by 2 inch by ¼ inch thick cross sections. The bottom plate flange 510d is fastened to the respective anchor 506a, 506b using fasteners and shims. Each anchor includes a central stud threaded into the anchor and abutting the respective base plate and used for positioning and spacing the bottom flange 510d so that the shims may be installed before the strut is fastened to the anchor. The top plate flange 510e is fastened to a vertical backing plate 516 using fasteners 507a and a key 507b fit into keyways in the flange 510e and the backing plate 516.

As illustrated in Figures 2, 5 and 56, each of forward struts 512a, 512b comprises a rectangular tube column 512c having a plate flange 512d welded to each bottom end thereof and a block flange 512e welded to each top end thereof. The tube columns preferably have 3 inch by 2 inch by ¼ inch thick cross sections. Each bottom plate flange 512d is fastened to a respective anchor 508a, 508b. The top block flanges 512e, 512e are fastened to a respective connection block 520a, 520b, by a tie rod 522a, 522b that is threaded into the respective block flange 512e. The connection blocks 520a, 520b are fastened to the manifold 27.

The tie rods 522a, 522b are surrounded by respective surrounding sleeves or spacers 524a, 524b located between respective connection block 520a, 520b and the vertical backing plate 516. The tie rod 522a, 522b are tensioned by nuts 525a, 525b via tie backing blocks 526a, 526b. The spacers 524a, 524b are compressed between the connection blocks 520a, 520b and the backing plate 516 when the nuts 525a, 525b are tightened.

The tie rods 522a, 522b are preferably 1 ¼ inch in diameter and the spacers are 2 ¾ inch in outside diameter.

The connection blocks 520a, 520b are supported by internal columns 530a, 530b that are fastened to the base plate 21a (Figures 2 and 13) and the block flanges 512e. The internal columns 530a, 530b are preferably square tubes having a 2 inch by 2 inch by ¼ inch thick cross section. The vertical backing plate 516 is supported by a wall 532 provided within the machine base 21. The plate 516 is fastened to the wall 532.

A pair of columns 531a, 531b supports the manifold 27 at a front of the machine (Figures 2, 8, and 58). The columns are formed by tie rods 531c surrounded by tubular spacers 531d. The tie rods 531c are fastened to the anchors 508a, 508b using nuts 531e. The upper end of the tie rod can be threaded into the manifold 27. The tubular spacer is compressed between the manifold 27 and the respective anchor 508 a, 508b when the nuts 531e are tightened.

As shown in Figures 3 and 6, three more tie rods, with associated spacers or sleeves are used. Two top level tie rods 532a, 532b, surrounded by spacers

or sleeves 536a, 536b, and located laterally outside the pump cavities 69, 89 are threaded into threaded bores in the pump housing 71. The tie rods 532a, 532b are tensioned with nuts 537a, 537b on a rear side of backing plate 516, via the backing blocks 526a, 526b. A central tie rod 540 surrounded by a spacer or sleeve 542 and located laterally between the pump cavities 69, 89 is threaded into a threaded bore in the pump housing 71 and is tensioned by a nut 543 and washer pressed directly against the backing plate 516.

The tie rods, when tensioned, compress the spacers or sleeves 525a, 525b, 536a, 536b and 542 tightly between the backing plate 516 and the pump housing 71 and the connection blocks 520a, 520b which are fastened to, or formed as part of the manifold housing 71.

The tie rods 532a, 532b, 540 have a diameter of 1 ¼ inch and the spacers 536a, 536b and 542 have a 2 ¾ inch outside diameter.

The hydraulic cylinders 64, 84 have front flanges 64a, 84a bolted to the backing plate 516 via two reinforcing washer plates 548a, 548b. Thus, when one of the hydraulic cylinders 64, 84 drives the respective piston 66, 68 into the pump cavity 69, 89 to pressurize the food product therein, a reaction force is created that tends to separate the backing plate 516 from the pump housing 71. The five tie rods oppose this reaction force by tension in the tie rods. Because the tie rods take up this reaction force, instead of the machine frame, the associated stress within the machine frame is reduced, or eliminated.

As shown in Figures 3 and 6, the T gear box 137 is supported from a pedestal 568 on a support plate 570. The right angle gearboxes 136 are also

supported from pedestals 569 fastened to the plate 570 (Figure 29). The support plate 570 is fastened to a bottom of two vertically oriented, parallel, longitudinally arranged plates 571, 572. The plates 571, 572 are supported at a rear by being fastened to a crossbeam 574 that is supported by sidewalls of the machine base 21.

The longitudinally arranged plates 571, 572 are laterally braced by a cross brace 577. The plates 571, 572 extend to the backing plate 516 and are fastened thereto by being fastened to the backing blocks 526a, 526b respectively by fasteners 573, locating pins 573a, and keys 573b fit into corresponding keyways in the blocks 526a, 526b and the plates 571, 572 (Figure 57).

According to the preferred embodiment, the backing plate 516 has a thickness of 1 ¼ inches. The plates 571, 572 can have thicknesses of ¾ inches and heights of 13 ¼ inches. The support plate 570 can have a thickness of 1¼ inches.

For additional rigidity, the bearing housings 143 that are located above each right angle gear box 136, are connected by pre-stressed tie rods 580a, 580b to the backing plate 516. The tie rods 580a, 580b are threaded into tapped holes in the backing plate 516 and secured to each respective housing 143 by a nut 581. A vertical, rectangular opening 143d is provided through each bearing housing 143 to access the nuts 581 (Figure 29). Each nut 581 is threaded onto an end of one rod 580a, 580b and tightened against the respective bearing housing 143. The tie rods 580a, 580b are surrounded by respective tubes 582a, 582b. The tubes 582a, 582b are compressed between a respective housing 143

and the backing plate 516 when the nuts 581 are tightened onto the tie rods 580a, 580b. The tie rods 580a, 580b, and the tubes 582a, 582b fix the bearing housings 143 with respect to the backing plate 516. The tie rod 580b and tube 582b are not shown in Figure 29 but are identically configured and attached in parallel fashion as the tie rod 580a, 582a. The tie rods have a diameter of ¾ inches.

As shown in Figure 28, reciprocating forces from the mold plate and drive system originate substantially in the horizontal plane of movement of the mold plate. These reciprocating forces are resisted by forces transmitted through the plates 570, 571, 572 and the tie rod/tube combinations 580a, 582a and 580b, 582b to the vertical backing plate 516. The horizontal component of some of the reciprocation forces is transferred through the vertical backing plate through the rear struts 510a, 510b and into the base plate 21a.

The horizontal component of some of the reciprocation forces is transferred through the tie rod/ tube combinations 532a, 536a; 532b, 536b; 540,542; 522a, 524a; and 522b, 524b to the pump housing 71 and the blocks 520a, 520b. These forces are transferred through the blocks 520a, 520b through the forward struts 512a, 512b and into the base plate 21a.

According to one aspect of the invention, the individual struts 510a, 510b, 512a, 512b are removable given the fact that they are fastened in place using fasteners and can be removed from the machine base 21 and replaced. This is particularly advantageous during assembly and replacement of other

components, wherein the struts can be removed for access to other components within the machine base 21.

All of the internal structural members can be composed of structural steel, except the base plate 21a is preferably composed of stainless steel and the pump housing 71 and manifold 27 are preferably composed of stainless steel. Figure 58 illustrates the pump housing 71 and the valve manifold 27 as a single cast stainless steel part. By forming these parts as a unitary part, significant assembly time is reduced, and the machine part count is reduced.

Hopper System

The hopper 25 can be constructed as a unitary, one piece part (Figure 13), comprised of a 0.09 inch thick welded and polished stainless steel part. A one piece hopper is advantageous to reduce leakage.

As shown in Figure 3, the hopper 25 is supported at a rear by a hinge shaft 602 via a rear bracket 604 that is fastened to a rear wall 25d of the hopper 25. The bracket 604 is fixed to the hinge shaft 602 to rotate therewith. The fixing can be by a press fit engagement, a keyed arrangement between the bracket and the shaft, or by the bracket being fastened to the shaft with fasteners, or by another known non-rotation fixation method.

As shown in Figures 4, 5, 16, 27 and 29, the hinge shaft 602 is supported from the machine base 21 and journaled for rotation by a rear support 606 (Figures 4 and16) and by a front support 608 (Figure 5). The rear support 606 includes a roller bearing 612 that surrounds the hinge shaft 602 and provides for

a reduced-friction rotation of the hinge shaft. The front support 608 comprises a sleeve bearing that provides for a reduced-friction rotation of the hinge shaft.

As shown in Figures 5 and 44, the hopper 25 and feed screw frame 42 are fixed to the shaft 602 by a bracket 610 that includes two bosses 610a each with a bore 610b. The bracket 610 is fixed to rotate with the shaft 602 by use of a non-circular, hexagonal opening 611a in the bracket 610 (See Figure 13) that fits tightly over a correspondingly shaped end protrusion 611b (Figure 4) of the shaft 602. The bracket is then tightly clamped to the shaft by a bolt 609 and a washer 609b (Figures 4 and 5), the bolt 609 engaged into a threaded bore in the protrusion 611b. The bracket 610 is fixed to the frame 42 by the bosses 610a being fit within a gap along the spacers 44b of the front two spacers 44b and the associated tie rods 44a being inserted through the bosses 610a and spacers 44b and then tightened. The tie rods 44a are tightened via threaded inserts 613a to a horizontal plate 613 that forms part of the hopper assembly.

Also shown in Figure 44, the base plate 613 includes four slots 613b, arranged symmetrically, two on each side of the hopper. Four studs 613c (one shown) are threaded into threaded holes in the pump housing 71, and fit within the slots 613b when the hopper is pivoted down to its operational position. Four nuts 613d secure the base plate 613 and the hopper 25 to the pump housing 71.

At a rear of the apparatus, as shown in Figures 16 and 29 a crank lever 614 is provided that is keyed by a key 614a to the shaft 602.

A large threaded lock nut or lock collar 615 is threaded tightly onto a threaded end of the shaft and locked with a set screw 615a. The crank lever 614

is pivotally connected at a distal end to an actuator, such as a hydraulic cylinder 616. The cylinder 616 is pivotally connected at an opposite end thereof to an anchor lug 618 fixed to the base plate 21a. The cylinder is signal-connected via a hydraulic/electronic interface to the machine controller. Expansion of the cylinder 616 causes the crank lever 614 to be turned counterclockwise (Figure 16) by about 85 degrees to the position shown as 614aa. The shaft 602 is thus turned about 85 degrees, as is the hopper 25 to the position marked 25aa.

By rotating the hopper 25 to the position shown as 25aa, the conveyor belt 31 is exposed for cleaning or removal. The plate 613, being a part of the hopper assembly, pivots with the hopper 25, as does the frame 42.

As a further aspect of the embodiment, as shown in Figures 2 and 4, the conveyor 30 includes a frame 619 having a hinge-side sidewall 620, an opposite-side sidewall 621, a plurality of lateral tie rods 622, a plurality of longitudinal ribs 623 supported on the tie rods 622, and two lateral tie rod beams 624, 625. The lateral tie rods 622 and the tie rod beams 624, 625 each have surrounding sleeves or spacers between the sidewalls 620, 621 and are fixed at opposite ends by nuts or the like to the sidewalls 620, 621. The conveyor frame 619 is simply supported on the machine base along the opposite-side sidewall 621.

Two intermediate fixtures 636, 638 (Figures 4, 16B-16D) are welded or otherwise fixed to the wall 620 of the conveyor and surround the shaft 602. The intermediate fixtures 636, 638 are rotatable with respect to the shaft 602 about the axis of the shaft 602. The fixtures 636, 638 have cross pins 640, 642 respectively. The fixtures are in two pieces that are assembled around the shaft

using fasteners 643. Two lift pins 644, 646 with enlarged heads extend from the shaft adjacent opposite sides of each fixture 636, 638. The pins are press fit and fixed into bores in the shaft 602 by fasteners 648. During rotation of the shaft 602 by about 85 degrees for the hopper 25 to assume the position indicated as 25aa in Figure 10, the pins 644, 646 sweep a first portion of the 85 degrees freely until contact is made with the pins 640, 642. The pins 644, 646 sweep the last portion of the 85 degrees, lifting the pins 640, 642 and rotating the conveyor upward about 13 degrees. This raises the conveyor from its support on the opposite-side 621 of the frame 619. At this position, the conveyor can be cleaned or repaired as required. The surface area beneath the conveyor belt can be cleaned as well. The conveyor belt 31 can be removed and/or cleaned.

Although the 85 degree hopper tilt and 13 degree conveyor tilt are advantageous, it is anticipated that other angular tilts such as 45 degrees – 90 degrees for the hopper and 10 degrees – 30 degrees for the conveyor may be advantageous as well. The location and size or shape of the pins 644, 646 can be adjusted to select the hopper and conveyor tilt amounts.

The hopper 25 and conveyor 30 are pivoted by the actuator 616 via the machine controller, particularly by instructions give to the controller via the control panel 19.

The hopper tilt system is configured such that apparatus can be easily factory converted from a right side operating apparatus to a left side operating apparatus, that is, the hopper assembly is factory reversible across the longitudinal centerline of the apparatus. For example the crank lever 614

comprises a lever arm 614b that is welded to a collar 614c that is secured to the shaft 602. In the factory, the lever arm 614b can easily be switched for a right side operation by flipping over the lever arm and welding the lever arm the collar. The remaining shaft supports and brackets can be reused for mounting the system on the opposite side of the machine. Parts needing to be designed and manufactured can be reduced, given the bidirectional feature of the design.

Cooling Air System

The present invention also provides an improved cooling air system. The cooling air system includes two axial fans 702, 704 shown in Figure 16 and 29 that draw air in on a top side and discharge air downward into the machine base 21. The fans 702, 704 are mounted on elevated baffle plate 706 within a fan chamber 708. The baffle plate 706 provides openings beneath the fans 702, 704, for axial airflow into the machine base 21. The fan chamber includes a rectangular surrounding side wall 710 having a seal 712 around its upper lip.

A cover 716 is provided over top side wall 710. The cover 716 is movable up-and-down. In Figure 29, the cover 716 is shown in broken fashion to illustrate the movement of the cover 716. It is understood however that the cover 716 is one part and is either raised her lowered as one part. The elevated position of the cover 716 is indicated as 716a shown on the right side half of the cover 716 and the lowered position is indicated as 716b shown on the left side half of the cover.

Plural pneumatic cylinders 722, eight according to the preferred embodiment, are fastened at base ends to the baffle plate 706. The pneumatic

cylinders include extendable rods 726 that are fastened to the cover 716. The cylinders 722 are configured such that when energized with pressurized air the cylinders extend rods 726 to elevate the cover 716 to the position indicated as 716a, held above the seal 712. Outside air can be admitted under the cover and up and over the seal 712 to the inlet of the fans 702, 704 as indicated by the arrows "A." The cylinders 722 overcome the compression force of springs 730 within the cylinders 722 to elevate the cover 716 as shown in position 716a. If the cylinders 722 are de-energized, such as by loss of electrical power to the apparatus 20, the springs 730 urge the cover 716 downward onto the seal 712, as shown in position 716b, to close the inlet.

During operation, the cylinders 722 are energized, and the cover 716 is elevated as shown in position 716a. The fans 702, 704 force air through the machine base 21.

Air passes through the machine and exits the machine base 21 at a front of the machine base 21. As shown in Figures 7 and 8, two air exit dampers 740, 742 are provided having shut off plates 744, 746. The shut off plates 744, 746 are positioned over air openings 750, 752 through the base plate 502. The plates 744, 746 are carried by rods 754, 756 via self aligning couplings 754a, 756a and are raised and lowered by cylinders 758, 760. The cylinders are supported by a bracket 764 from the machine base 21 or other stationary structure.

Within the cylinders 758, 760 are springs (not shown) that are configured to urge the plates 744, 746 downward from the elevated, open position indicated as 744a, 746a to the lowered, closed position indicated as 744b, 746b.

During operation, cylinders 758, 750 are energized and pneumatic pressure elevates the plates 744, 746 to the position 744a, 746a, overcoming the urging of the springs within the cylinders 758, 760.

If power is interrupted to the apparatus 20, the plates 744, 746 are lowered by the springs within the cylinders 758, 760 to close the air exit dampers 740, 742.

When the apparatus 20 is washed and sanitized, power is normally shut off. Because power is interrupted, the cover 716 is automatically closed and the air exit dampers 740, 742 are automatically closed. Thus, spray, wash water and debris are prevented from entering the machine base 21.

The hopper tilt system, the control panel 23, and the cooling air system are configured such that apparatus can be easily factory converted from a right side operating apparatus to a left side operating apparatus, that is, factory reversible across the longitudinal centerline of the apparatus.

Hydraulic System

The apparatus incorporates a hydraulic system such as described in U.S. Patent 3,887,964 or Re 30, 096,. or as currently used on FORMAX F-26 machines. In such systems a lower pressure, higher volume hydraulic pump and a higher pressure, lower volume hydraulic pump are used. The lower pressure pump is useful for moving the hydraulic piston and the

associated plunger a large distance such as from a retracted position to a position wherein the food product is initially compressed within the cylinder by the plunger. The higher pressure pump is useful to move the plunger an incremental distance each mold plate reciprocation cycle, to deliver food product under pressure into the mold cavities.

One improvement in the present invention is the fact that the lower pressure pump 1410 and the higher pressure hydraulic pump 1414 are both driven by a common electric motor 1416, in series on the motor output shaft, wherein the pumps 1410, 1414 are located in the hydraulic fluid reservoir 1418, submerged below a hydraulic fluid fill line 1417. By being submerged, the pumps run quieter, cooler and more efficiently.

The motor 1416 is preferably a 15 HP totally enclosed, fan cooled motor. As shown in Figures 29 and 55, the motor 1416 is supported on a platform 1416a that is supported in cantilever fashion from the reservoir 1416. The motor includes a rotary output shaft 1416b.

The reservoir 1418 is preferably a stainless steel tank. A bottom 1419 of the reservoir is advantageously visible for inspection and cleaning and sanitizing. The reservoir 1418 can be elevated from the base 21a on isolation mounts.

As shown in Figure 2, the pumps 1410 and 1414 have pump shafts 1424a, 1424b connected by a coupling 1424c, shown dashed. As shown in Figures 29 and 55, the pump shaft 1424a is coupled to the motor output shaft 1416b by a mechanical coupling 1426. A motor mount 1430 surrounds the coupling 1426 as it is sealed to a wall 1418a of the reservoir 1418 by a ring seal

1430a clamped between a backing ring 1430b that is fastened through the wall 1418a to the motor mount 1430. The lower pressure pump 1410 is bolted to the backing ring in sealed fashion.

Mold Cover Lift System

During mold plate change or to clean the apparatus, it is necessary to lift the mold housing or mold cover 123 from above the mold plate 32. The bolts 125 are removed as a first step for lifting of the housing 123.

A mold housing lift mechanism 800 is mounted inside the machine base 21 and extends upward to the housing 123. The lift mechanism includes two jacks 802, 804 shown in Figures 8 and 27. The jacks are operatively connected to right angle drives 808, 810, which are operatively connected to a T type right angle drive 814, via drive shafts 818, 820 and respective couplings 823, 824, 826, 828, 830. The right angle drive 814 is driven into rotation by a hydraulic motor 836.

The jack 802 is described below with the understanding that the jack 804 is identically configured and functions identically, in tandem, as the jack 802.

As shown in Figures 8, 27 and 30-33, the drive 808 turns a threaded rod or jackscrew 842 that drives a nut drive assembly 844 vertically. The jack screw 872 is journaled for rotation at a top end by a guide 845. The jack screw 842 and guide 845 can include a bearing therebetween for smooth journaled rotation of the jackscrew. The drive assembly 844 is operatively connected to a lift column 850 via a bracket 851 which is vertically driven with the drive nut assembly. The

columns 850 of the jacks 802, 804, are fixed to the housing 123 by bolts 856, 858. The columns 850 are hollow and can also serve as wire and tube conduits.

As shown in Figures 30-31, the bracket 851 is clamped onto a bottom of column 850. The bracket 851 rests on a drive nut 870 that is driven by the drive rod 842. A limit plate 862 is fastened to the drive nut 870 by spacers 867 and fasteners 866. A collar 874 is fastened to the bottom of the drive nut 870 with fasteners 875.

The drive nut 870 has inside threads engaged to the outside threads of the drive rod 842. A secondary nut 882 is threaded onto the jackscrews 842 beneath the drive nut 870.

Proximity target, magnetic plate 892 is fastened to a mounting plate 894 which is fastened to the bracket 851 by fasteners 900. A proximity sensor 908 is mounted within the machine base 21 along the vertical path of the magnetic plate 892 and set at a maximum acceptable. The magnetic plate 892 sets an acceptable vertical range for a mold cover operating elevation. If the mold cover is elevated beyond this range, the sensor 908 will be below the magnetic plate 892 and will so signal the machine controller which will prevent operation of the machine.

A further proximity target 904 is fastened to a lateral side of the bracket 851. Proximity sensor 910 is mounted at an elevated position within the machine base along the vertical path of the target 904 and signals a pre-determined raised maximum height of the mold cover casting for a mold plate change out

procedure. The proximity sensor 910 signals the machine controller to stop the motor 836 at that point.

The collar 874 has internal protruding pins 878, surrounding the jackscrew 842 and a secondary nut 882. The secondary nut includes notches 886 for receiving the pins 878. During normal lifting operation, the pins will be engaged to, or will engage, the secondary nut 882 as shown in Figure 14. The secondary nut 882 ceases to rotate freely with the jackscrew 842 and thereafter travels with the assembly 844 up and down on the jackscrew 842. The secondary nut 882 provides backup support for the drive nut 870 in the unlikely event that the drive nut fails to support the bracket 851.

As shown in Figure 32, before engagement with the pins of the drive nut assembly 844, the secondary nut 882 is free to rotate with the jackscrew 842 between the nut 870 and the pins 878. Once the pins 878 are relatively elevated with respect to the nut 882 to engage the notches 886 the secondary nut moves vertically with the assembly 844. If the drive nut 870 fails during lifting, the secondary nut 882 is in a position to support the drive nut assembly and bracket 851, but will not function to lift the nut assembly 844. If the jackscrew is turned, the secondary nut 882 will rise to the point until it disengages from the pins 878 and then turn substantially freely with the rotating jackscrew 842.

Figure 33 illustrates the assembly with the mold cover lowered and the nut 870 lowered a further amount with the plate 862 contacting, or adjacent to, the bracket 851. Thus, the nut assembly 844 can completely disengage from the bracket 851.

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred.

The invention claimed is:

1. In a patty forming apparatus having a machine base having an enclosing wall and containing equipment within said machine base that generates heat, the improvement comprising:

an air inlet opening and an air outlet opening through said enclosing wall;

an air fan arranged to move outside air from said air inlet opening to said air outlet opening;

a first air damper arranged to close one of said air inlet opening or said air outlet opening, said first air damper configured to automatically close if power is interrupted to said apparatus.

2. The patty forming apparatus according to claim 1, wherein said first air damper is arranged to close said air inlet opening, and further comprising a second air damper arranged to close said air outlet opening, said second air damper configured to automatically close if power is interrupted to said apparatus.

3. The patty forming apparatus according to claim 2, wherein said inlet opening is located on a top side of said machine base, and said first damper comprises a cover and at least one inlet pneumatic cylinder that elevates said cover above said inlet opening when energized, allowing outside air to enter said inlet opening, and at least one inlet spring configured such that when said inlet pneumatic cylinder is de-energized, said inlet spring urges said cover onto said inlet opening to close said inlet opening.

4. The patty forming apparatus according to claim 3, wherein said outlet opening is located on a bottom of said machine base, and said second damper comprises a plate over said outlet opening and an outlet pneumatic cylinder operatively connected to said plate to elevate said plate above said outlet opening to open said outlet opening when said outlet pneumatic cylinder is energized, and an outlet spring arranged to urge said plate onto said outlet opening to close said outlet opening when said outlet pneumatic cylinder is de-energized.

5. The patty forming apparatus according to claim 1, wherein said inlet opening is located on a top side of said machine base, and said first damper comprises a cover and at least one inlet pneumatic cylinder that elevates said cover above said inlet opening when energized, allowing outside air to enter said inlet opening, and at least one inlet spring configured such that when said inlet pneumatic cylinder is de-energized, said inlet spring urges said cover onto said inlet opening to close said inlet opening.

6. The patty forming apparatus according to claim 1, wherein said outlet opening is located on a bottom of said machine base, and said first damper comprises a plate over said outlet opening and an outlet pneumatic cylinder operatively connected to said plate to elevate said plate above

said outlet opening to open said outlet opening when said outlet pneumatic cylinder is energized, and an outlet spring arranged to urge said plate onto said outlet opening to close said outlet opening when said outlet pneumatic cylinder is de-energized.

7. The improvement according to claim 1, wherein said air inlet opening is formed through an upper portion of said enclosing wall and said air outlet is formed through a lower portion of said enclosing wall.

8. The improvement according to claim 1, wherein said first damper comprises a cover that is pneumatically powered to lift away from said air inlet opening to open said air inlet opening.

9. The improvement according to claim 1, wherein said second damper comprises a cover that is pneumatically powered to lift away from said air outlet opening to open said air outlet opening.

10. The improvement according to claim 1, wherein said first air damper is arranged to close said air inlet opening and further comprising a second air damper arranged to close said air outlet opening, said first air damper arranged outside of said enclosing wall and said second air damper arranged within said enclosing wall.

11. In a reciprocating mold plate, patty-forming apparatus wherein food product is delivered under pressure from a food product pump cylinder to mold plate cavities, wherein a plunger is driven during a first phase by force from a hydraulic cylinder from a retracted position distant from the pump cylinder to a ready position initially compressing food product loaded into said pump cylinder, and thereafter the plunger is driven during a second phase by said hydraulic cylinder to deliver food product under pressure into the mold plate cavities, wherein said hydraulic cylinder is supplied with hydraulic fluid during said first phase by a low pressure pump and during said second phase by a high pressure pump, the improvement comprising:

a reservoir containing hydraulic fluid to be pumped by said low pressure pump and said high pressure pump, wherein said low pressure pump and said high pressure pump are positioned to be at least partially submerged in hydraulic fluid within said reservoir.

12. The improvement according to claim 11, comprising an electric motor and wherein said high pressure pump and said low pressure pump are driven by said electric motor, said electric motor located outside said reservoir and including an output shaft coupled to said low pressure pump and said high pressure pump.

13. The improvement according to claim 12, wherein said high pressure pump and said low pressure pump are aligned along a common rotary axis.

14. The improvement according to claim 11, comprising an electric motor having an output shaft, said electric motor located outside said reservoir and having a sealed integrity to said reservoir, said output shaft penetrating said face and coupled to said low pressure and said high pressure pumps.

15. The improvement according to claim 14, wherein said low pressure pump and said high pressure pump have coupled drive shafts, and said output shaft is coupled to one of said drive shafts.

16. The improvement according to claim 15, comprising a mechanical coupling, said output shaft and said one drive shaft coupled together by said mechanical coupling.

17. The improvement according to claim 11, comprising an electric motor and a mechanical coupling, and wherein said high pressure pump and said low pressure pump are driven by said electric motor via said mechanical coupling, said electric motor located outside said reservoir.

18. In a reciprocating mold plate, patty-forming apparatus wherein food product is delivered under pressure from a food product pump cylinder to mold plate cavities, wherein a plunger is driven by force from a hydraulic cylinder, wherein said hydraulic cylinder is supplied with hydraulic fluid by a pump, the improvement comprising:

a reservoir containing hydraulic fluid to be pumped by said pump, wherein said pump is positioned to be at least partially submerged in hydraulic fluid within said reservoir.

19. In a reciprocating mold plate food patty-forming machine, wherein a mold plate reciprocates between a cavity fill position and a patty discharge position, the mold plate movable beneath a mold cover, a mold cover lifting apparatus, comprising:

a primary threaded drive that is configured to support and elevate said mold cover and which elevates or lowers upon input of rotary power to raise or lower said mold cover;

a motor operatively connected to said primary threaded drive to input rotary power to said primary threaded drive; and

a secondary threaded element that follows said primary threaded drive and is configured to support said mold cover if said primary threaded drive fails.

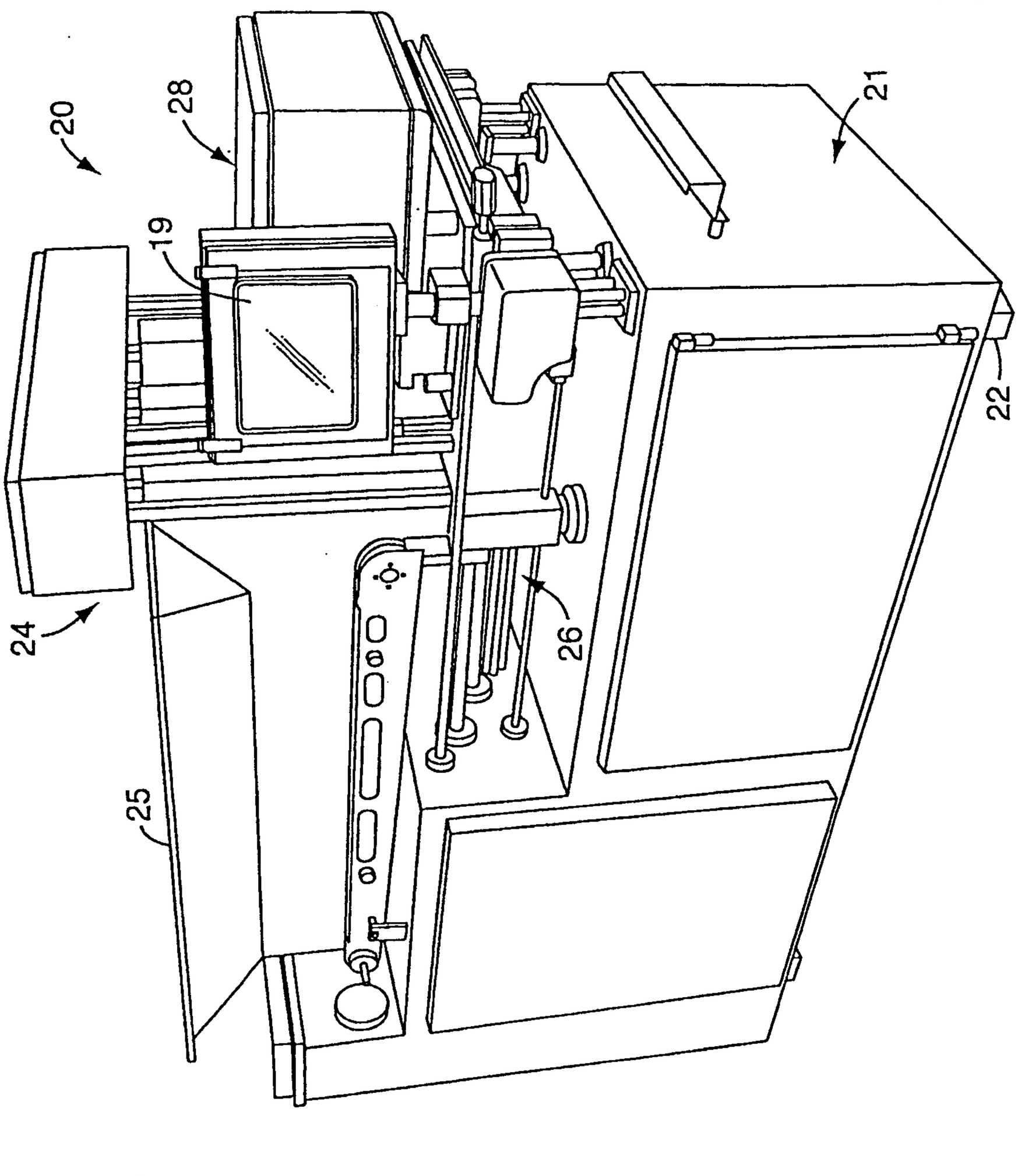
20. The lifting apparatus according to claim 19, wherein said primary threaded drive comprises a first nut guided for vertical movement without rotation and a threaded rod that is threadedly engaged with said first nut, rotation of said threaded rod vertically translating said first nut; said motor operatively connected to said threaded rod to rotate said threaded rod about its axis.

21. The lifting apparatus according to claim 20, wherein said secondary threaded element comprises a second nut also engaged with said threaded rod.

22. The lifting apparatus according to claim 21, wherein said first and second nuts are mutually engagable to translate on said threaded rod together.

23. The lifting apparatus according to claim 21, comprising a gear train operatively connected between said motor and said threaded rod.

FIG. 1



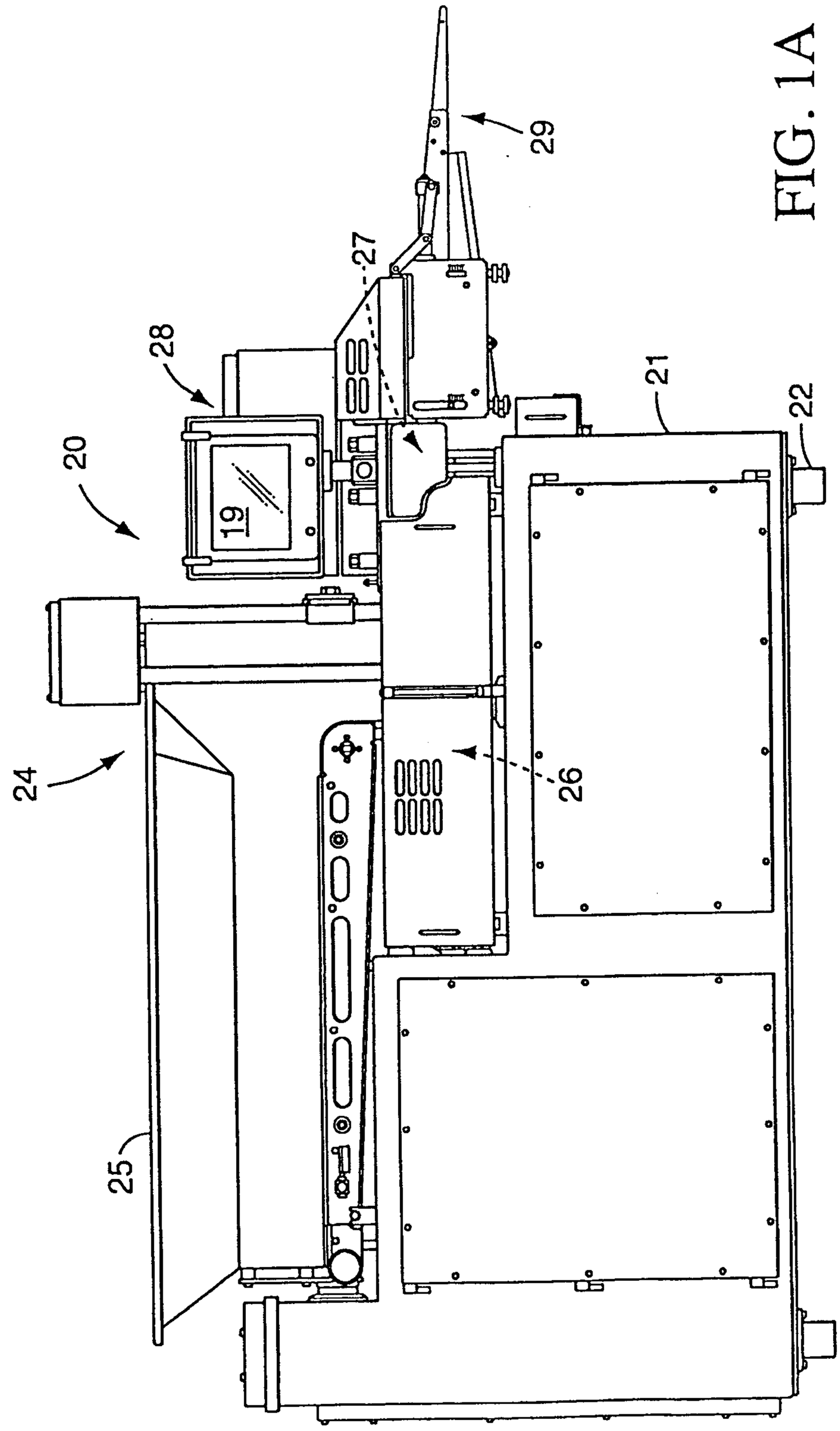


FIG. 1A

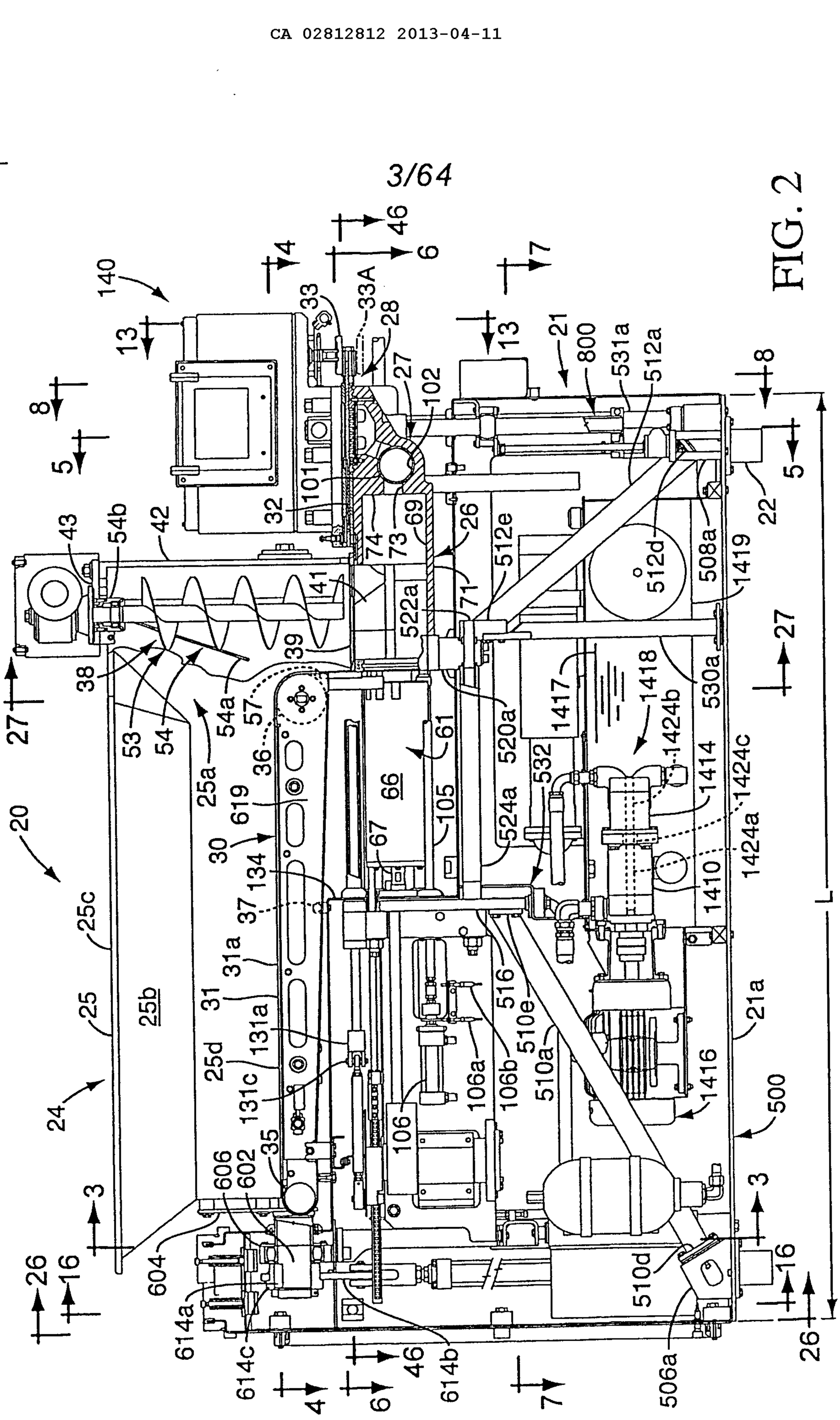

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FIG. 2

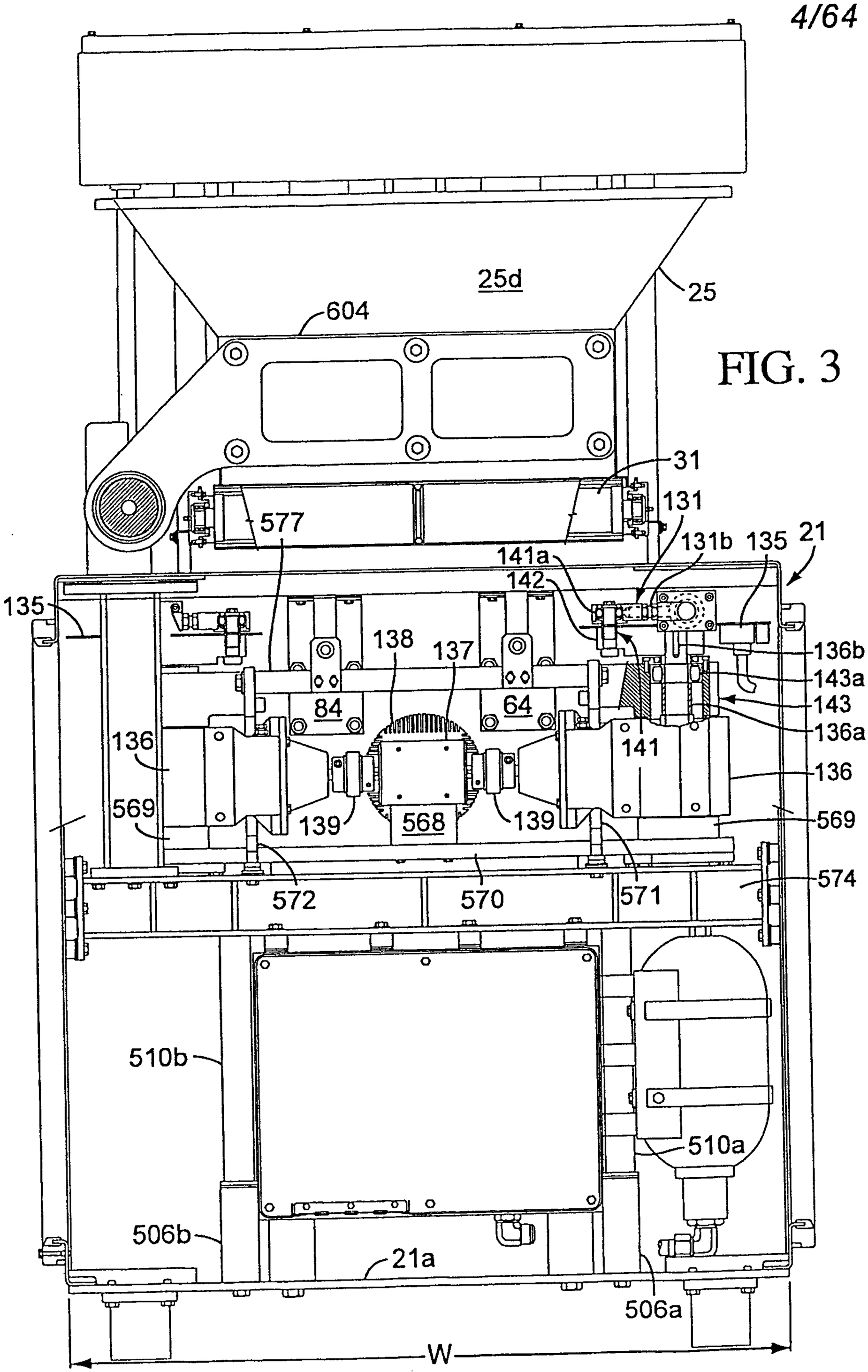
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FIG. 3

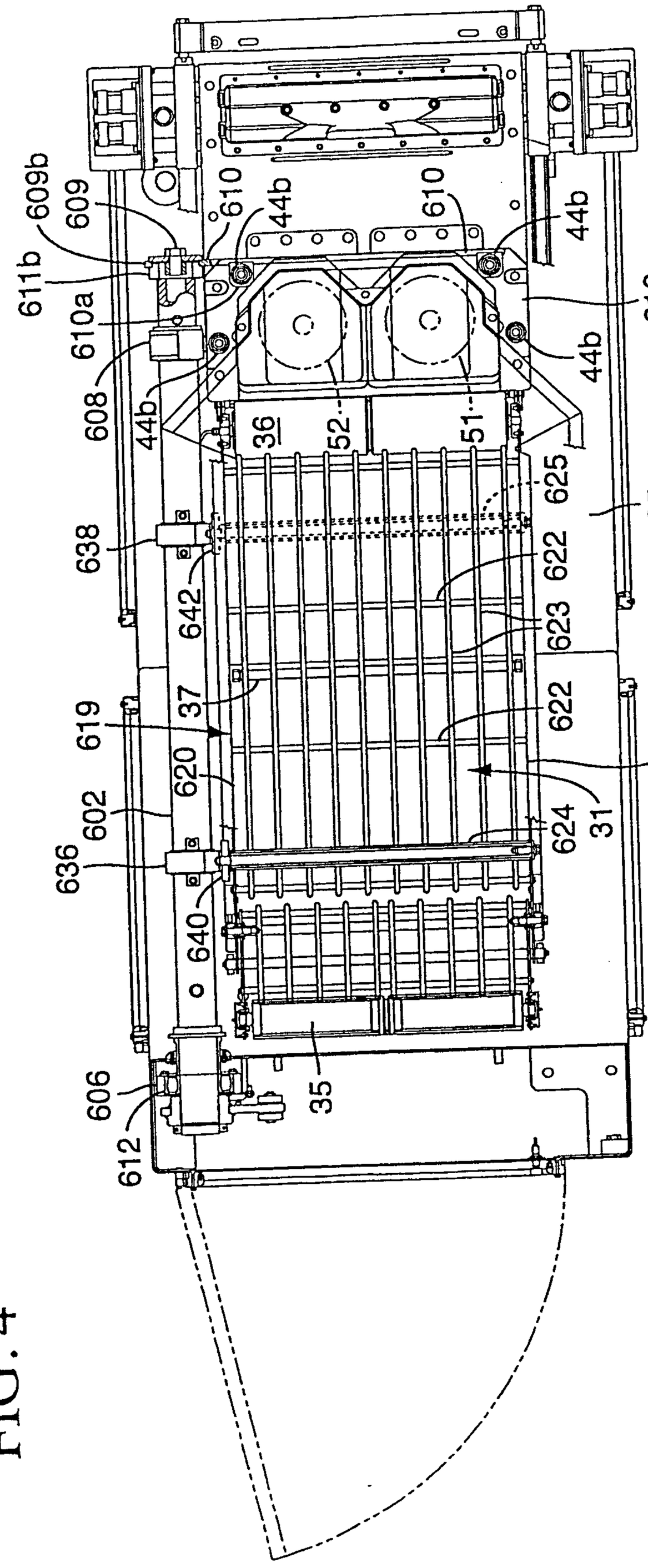
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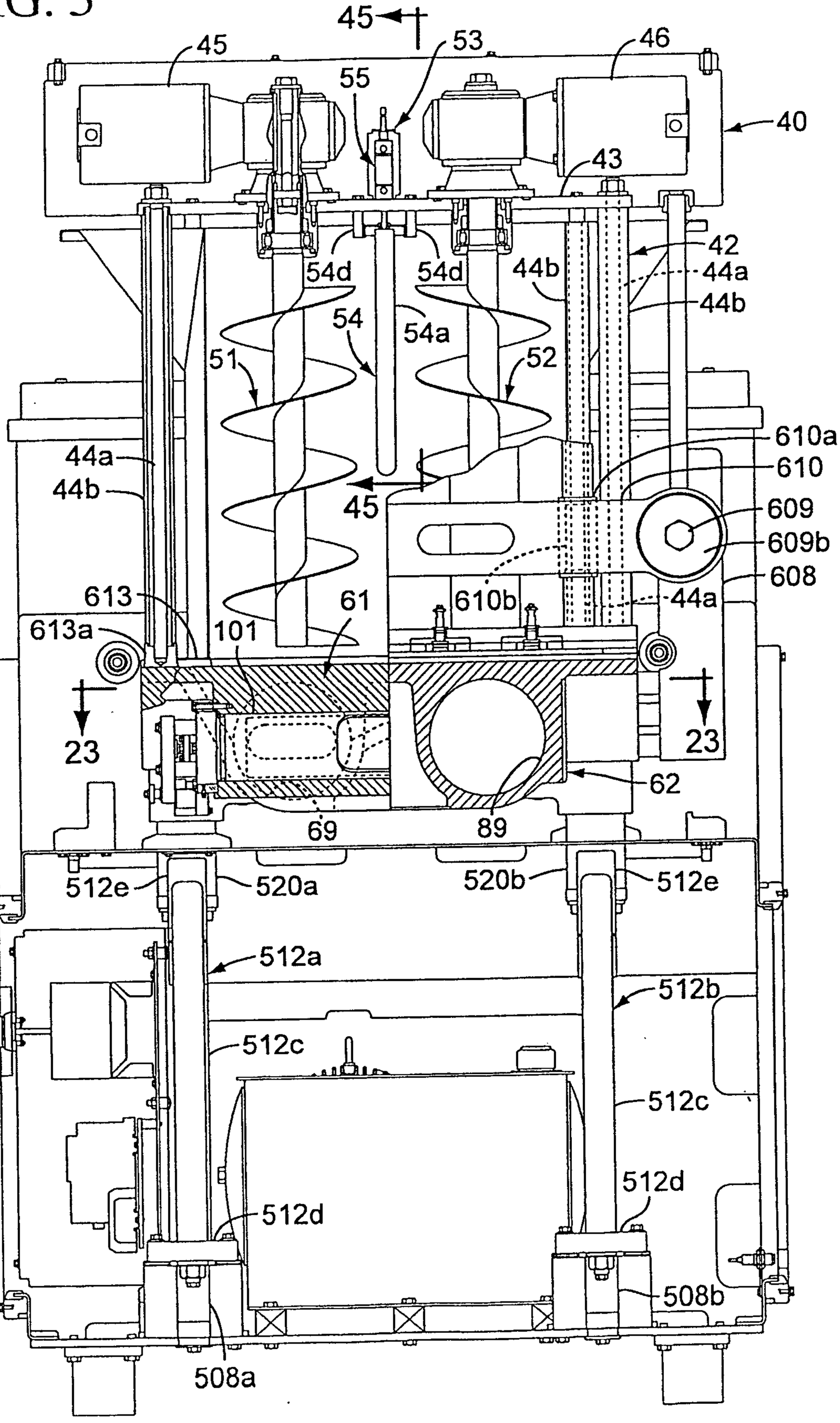
FIG. 4

FIG. 5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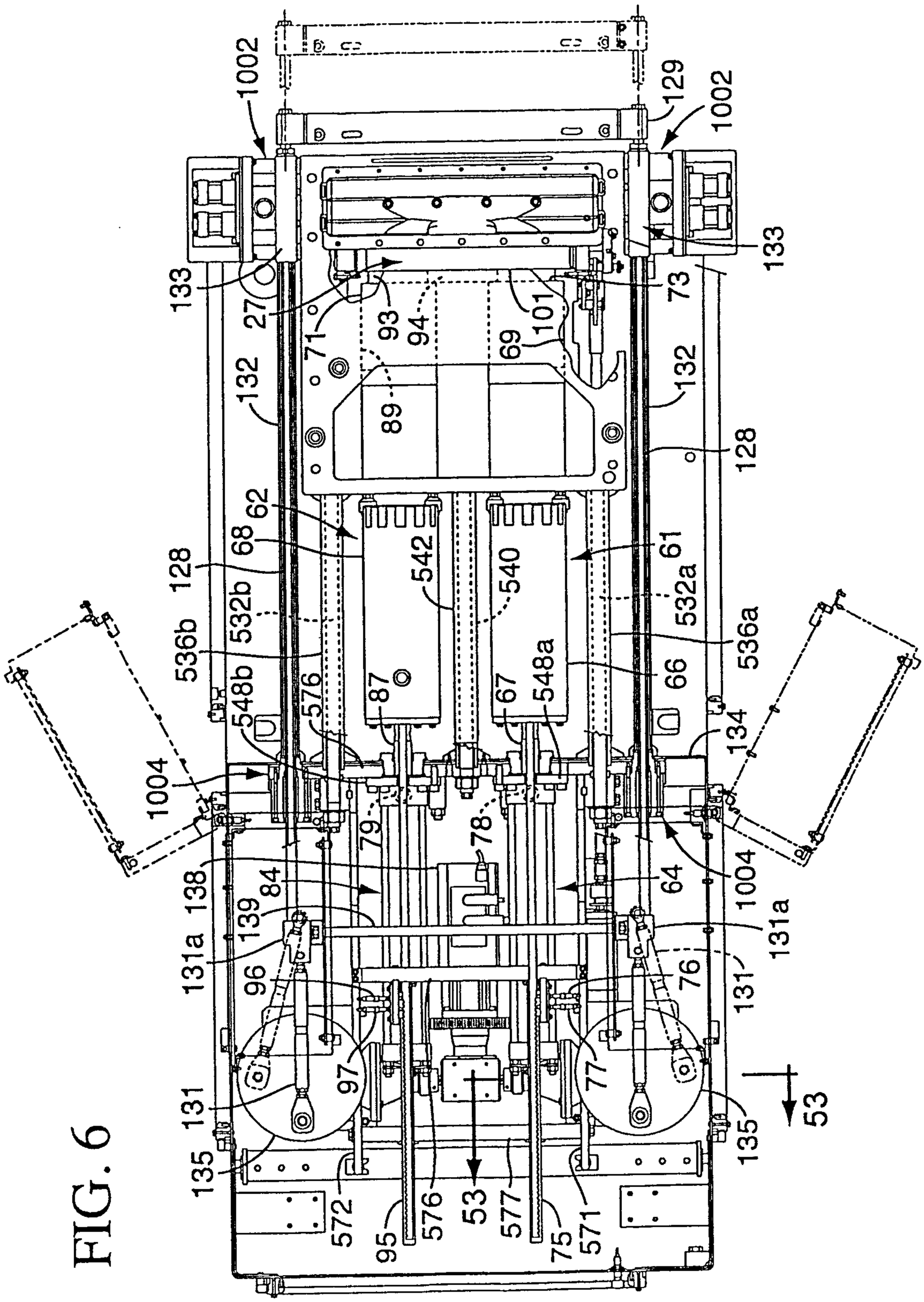
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FIG. 6

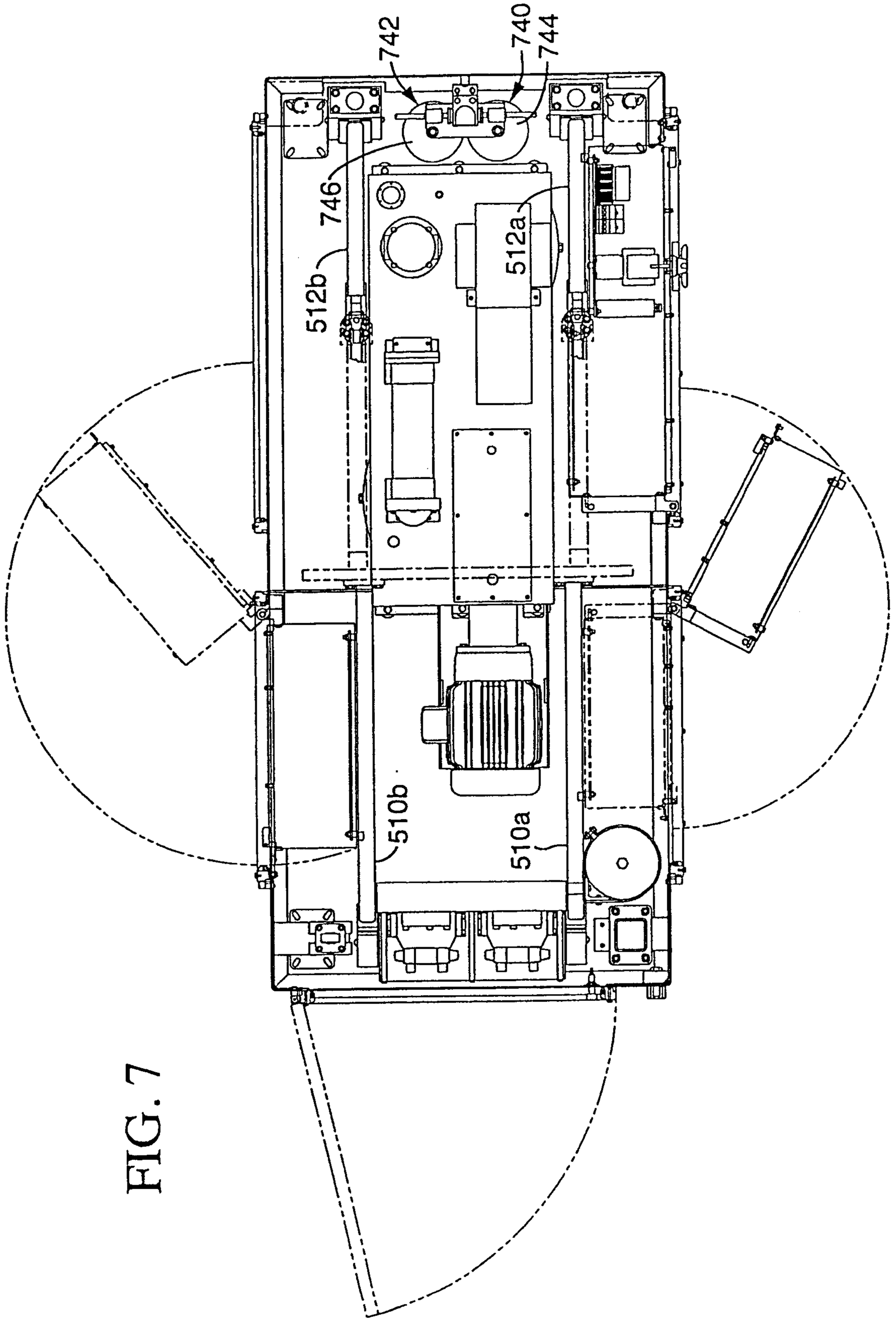
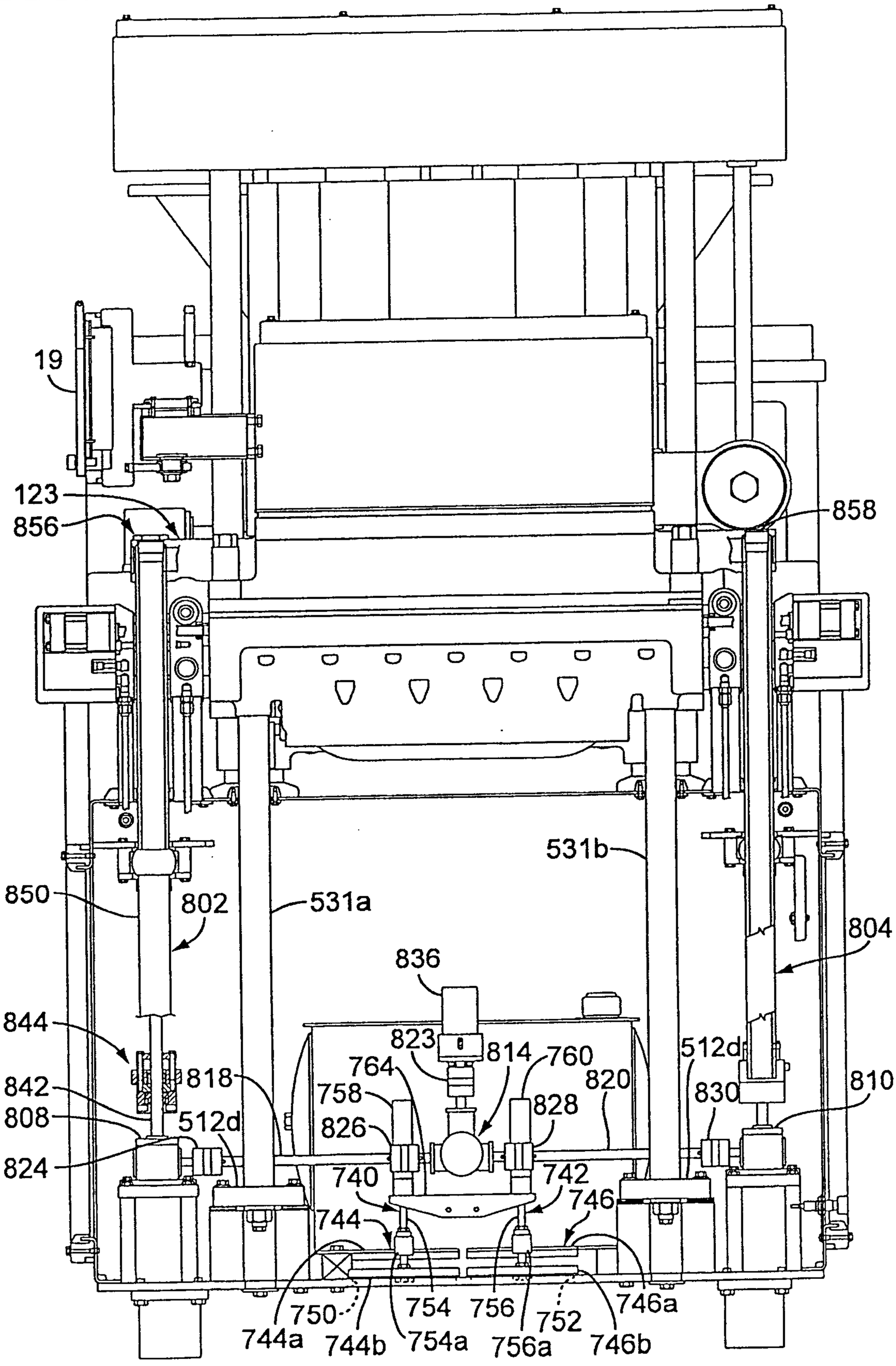


FIG. 7

FIG. 8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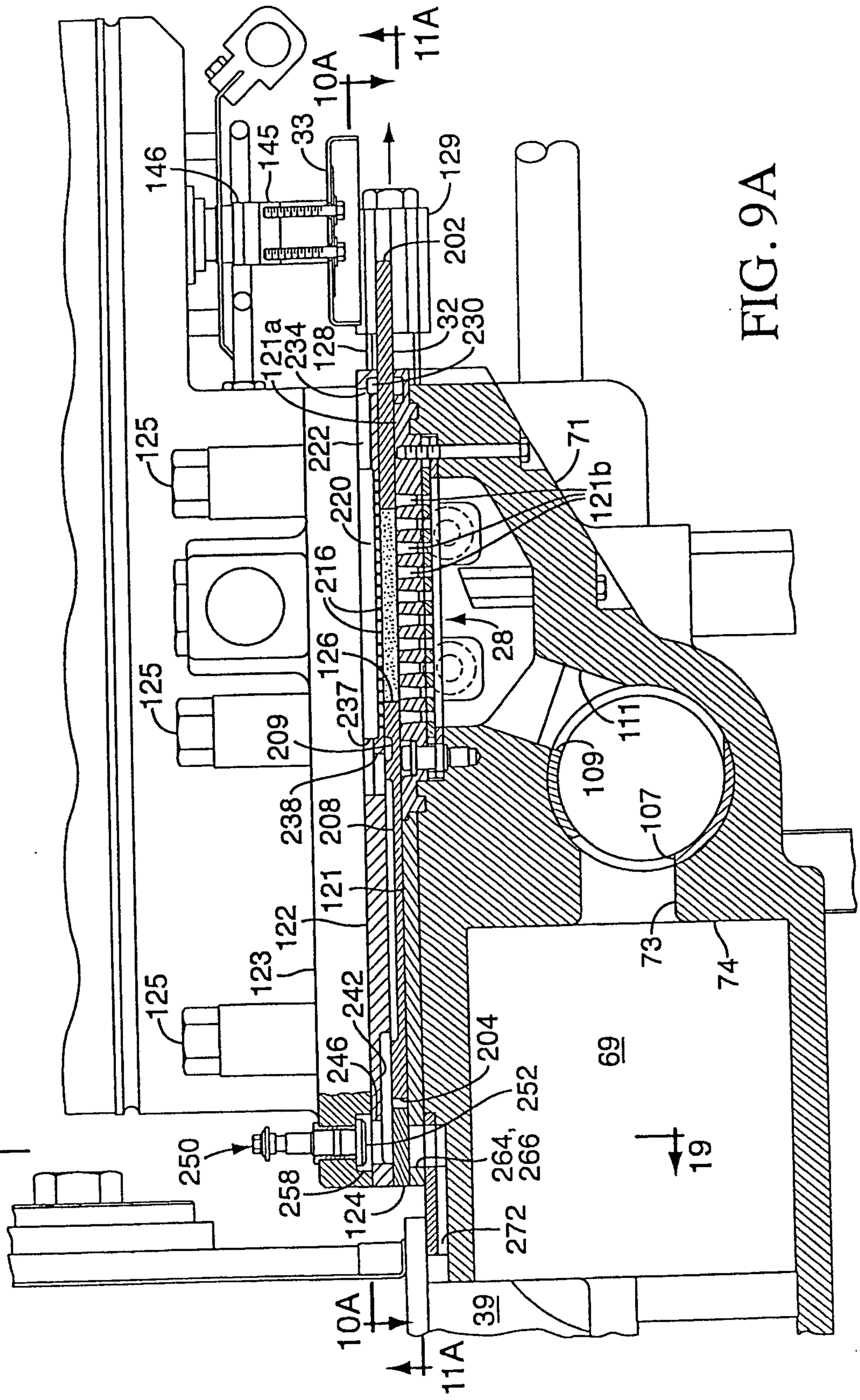
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FIG. 9A

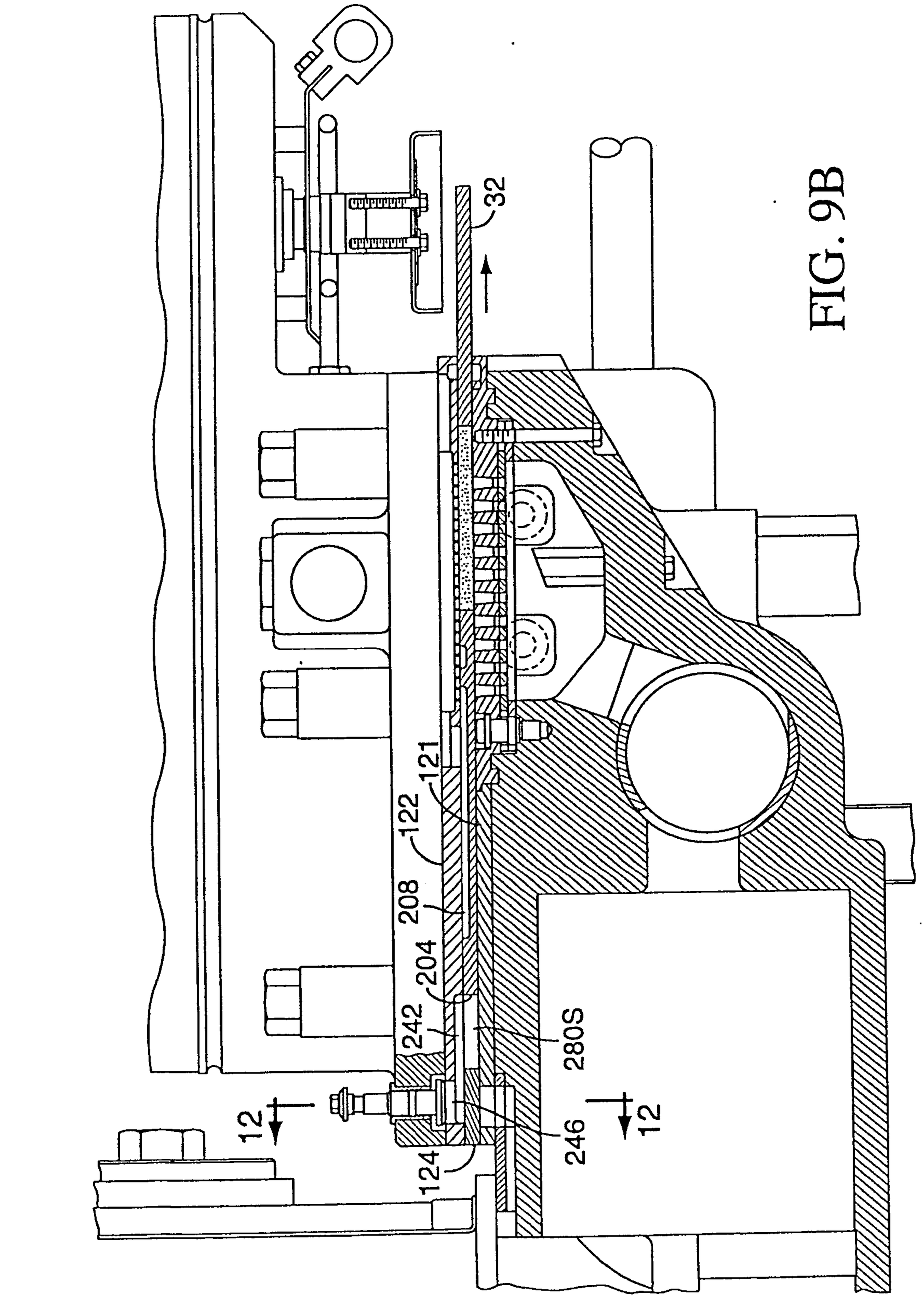

FIG. 9B

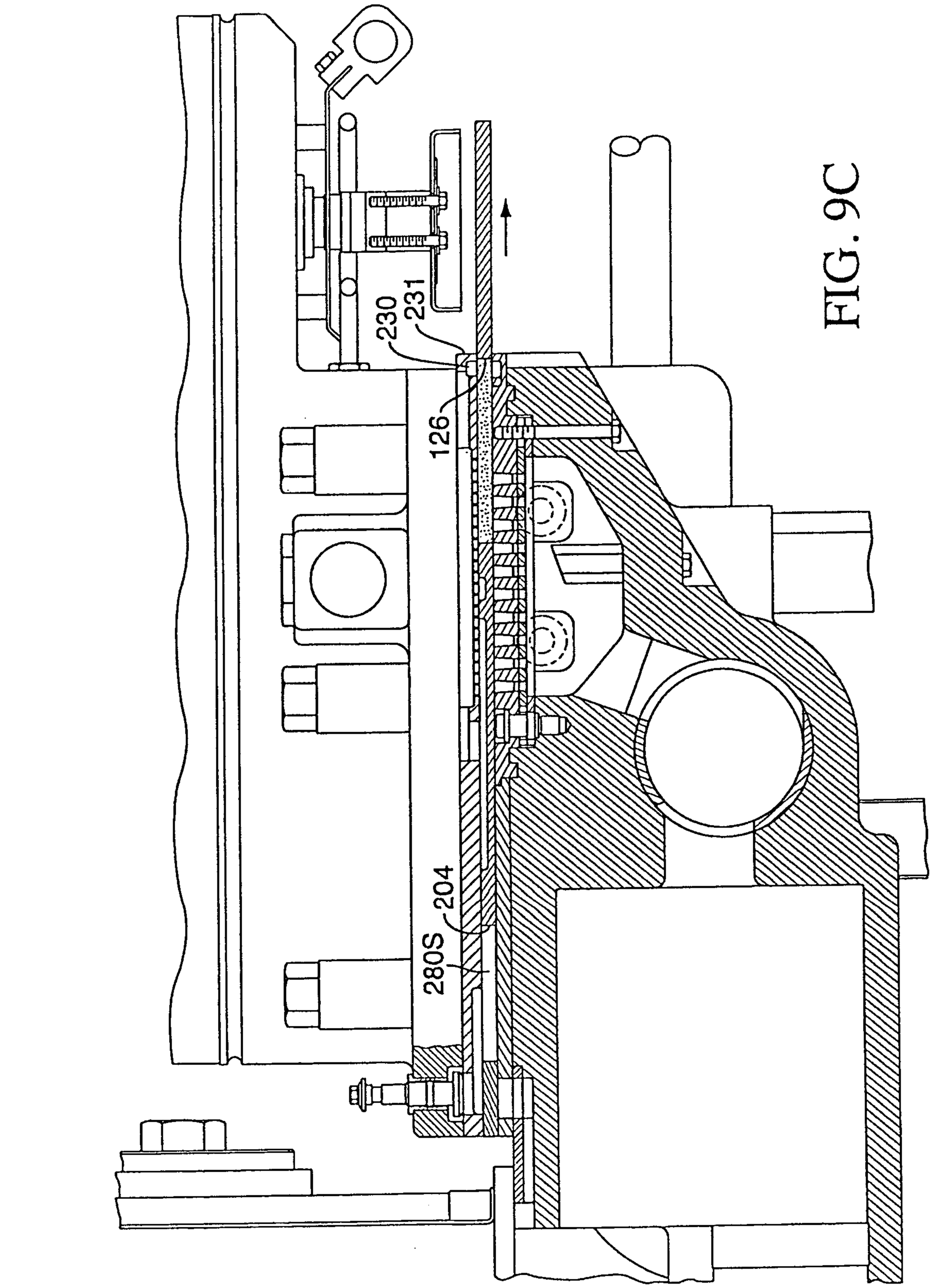

FIG. 9C

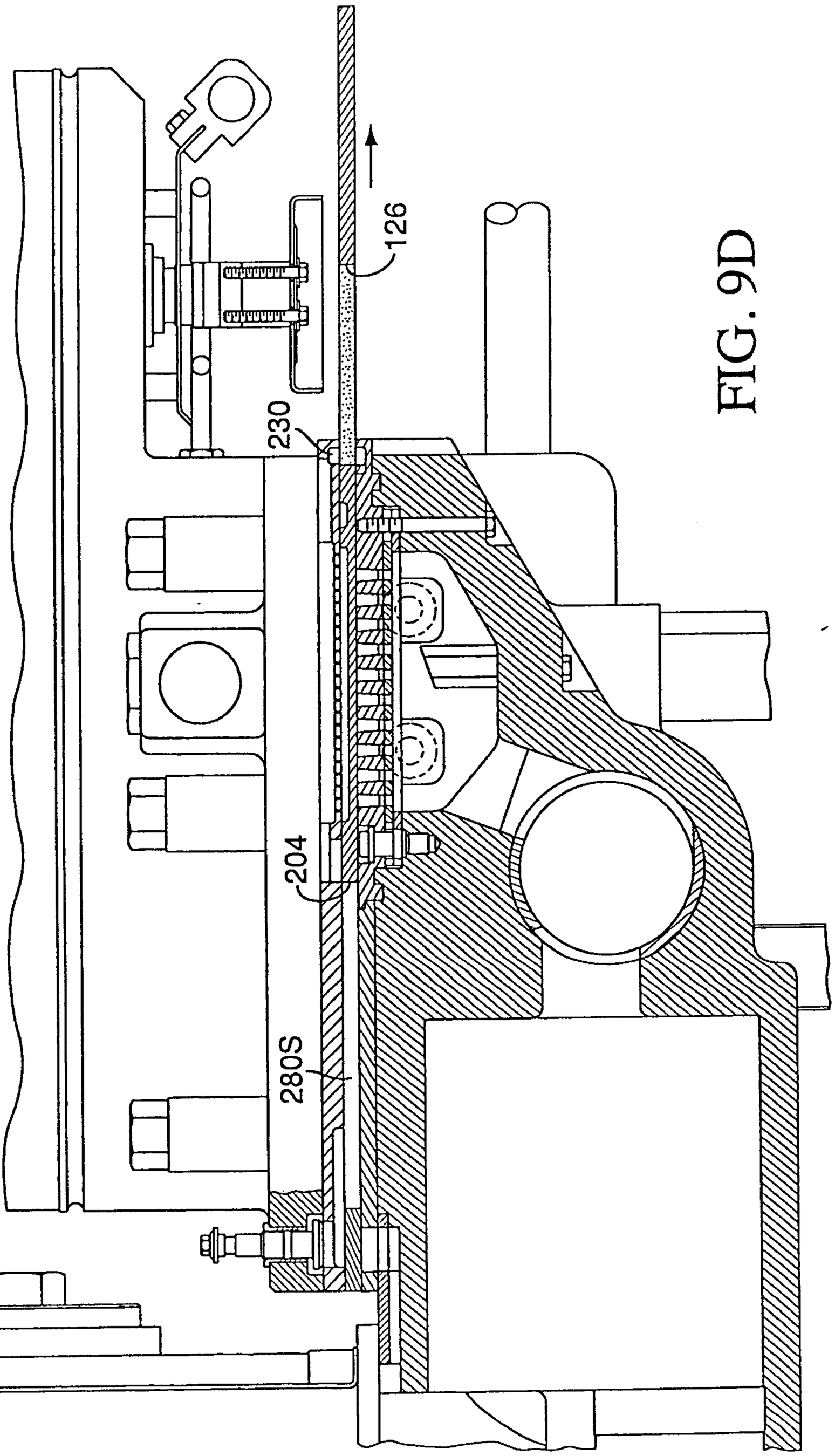

FIG. 9D

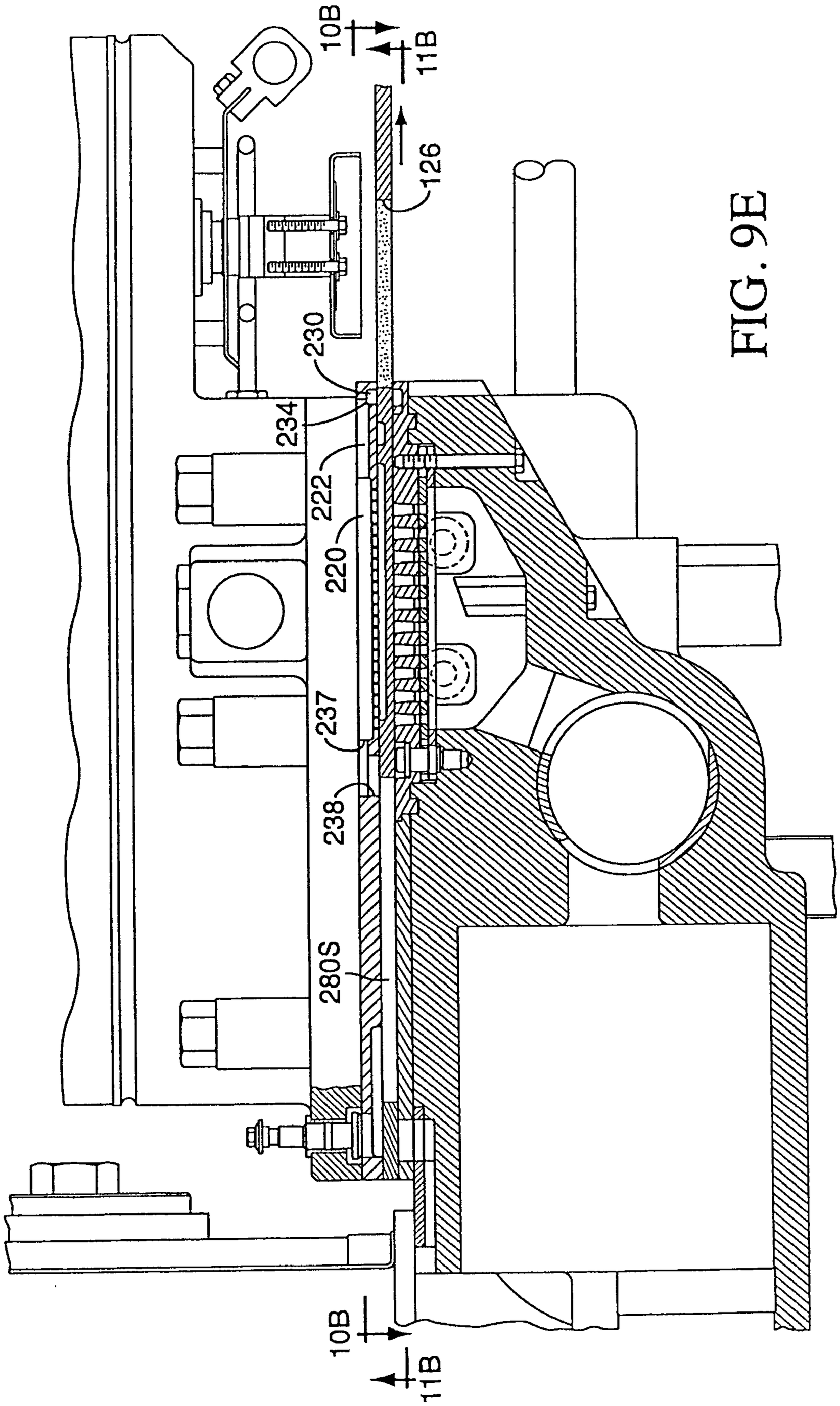

FIG. 9E

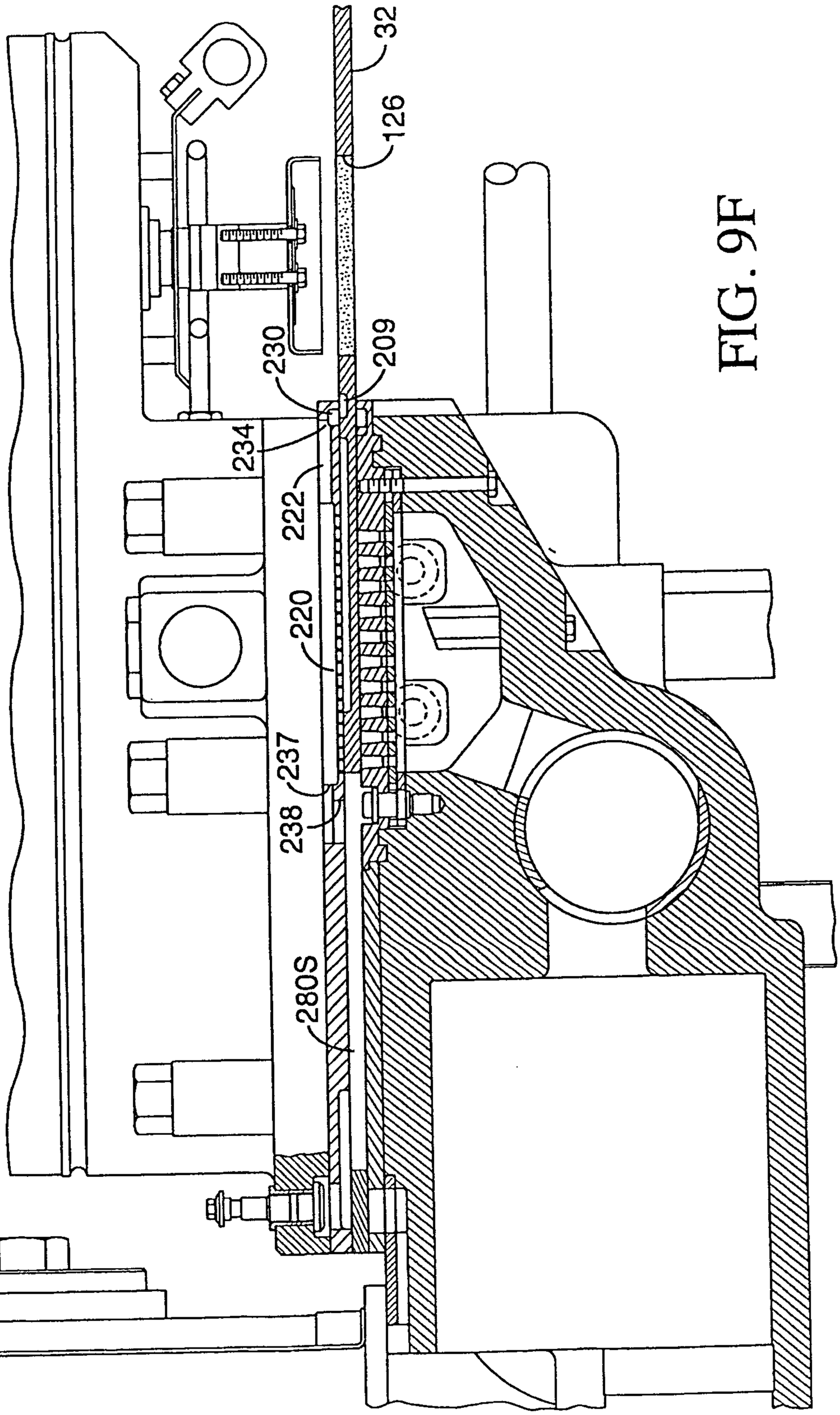

FIG. 9F

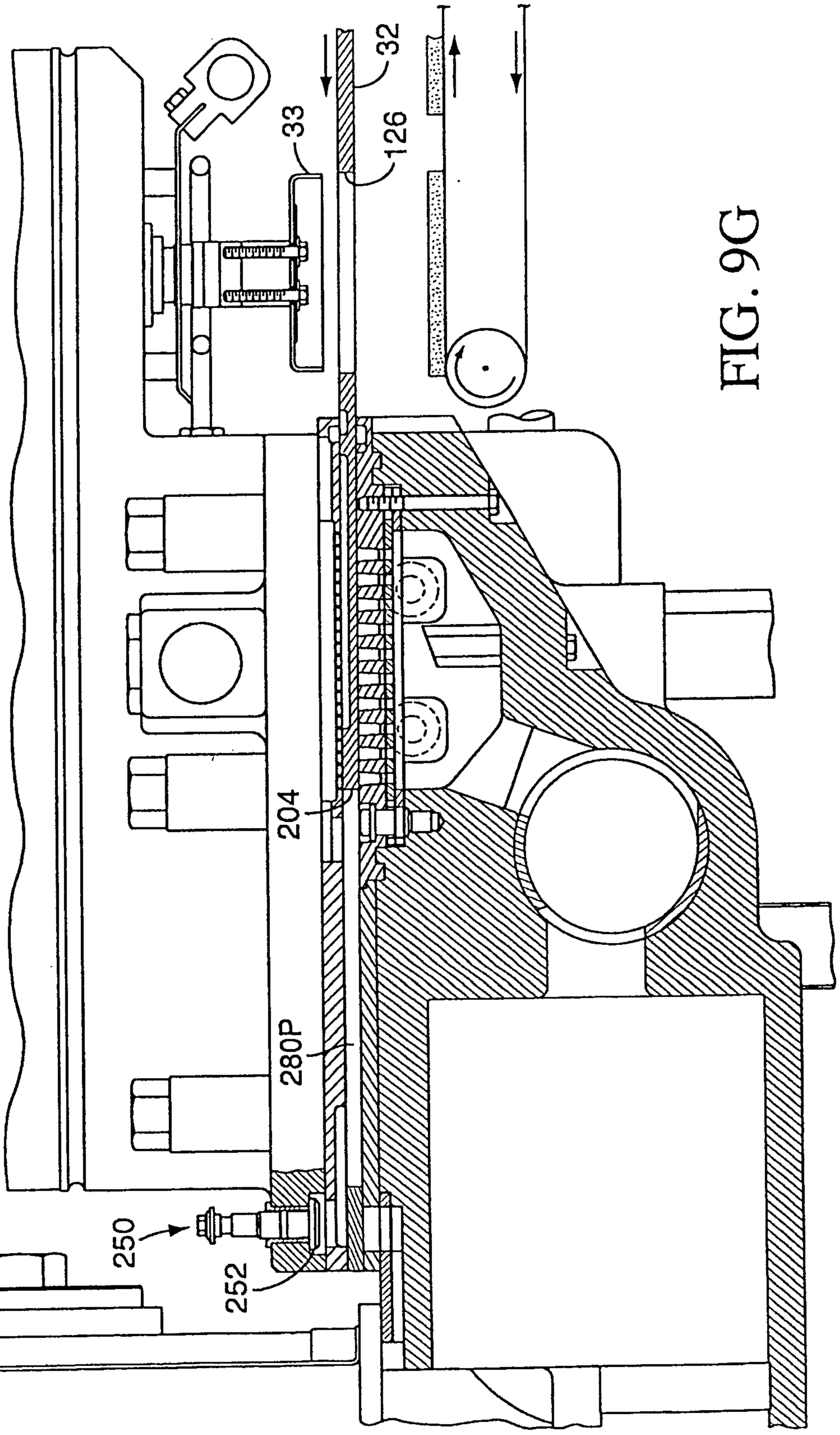

FIG. 9G

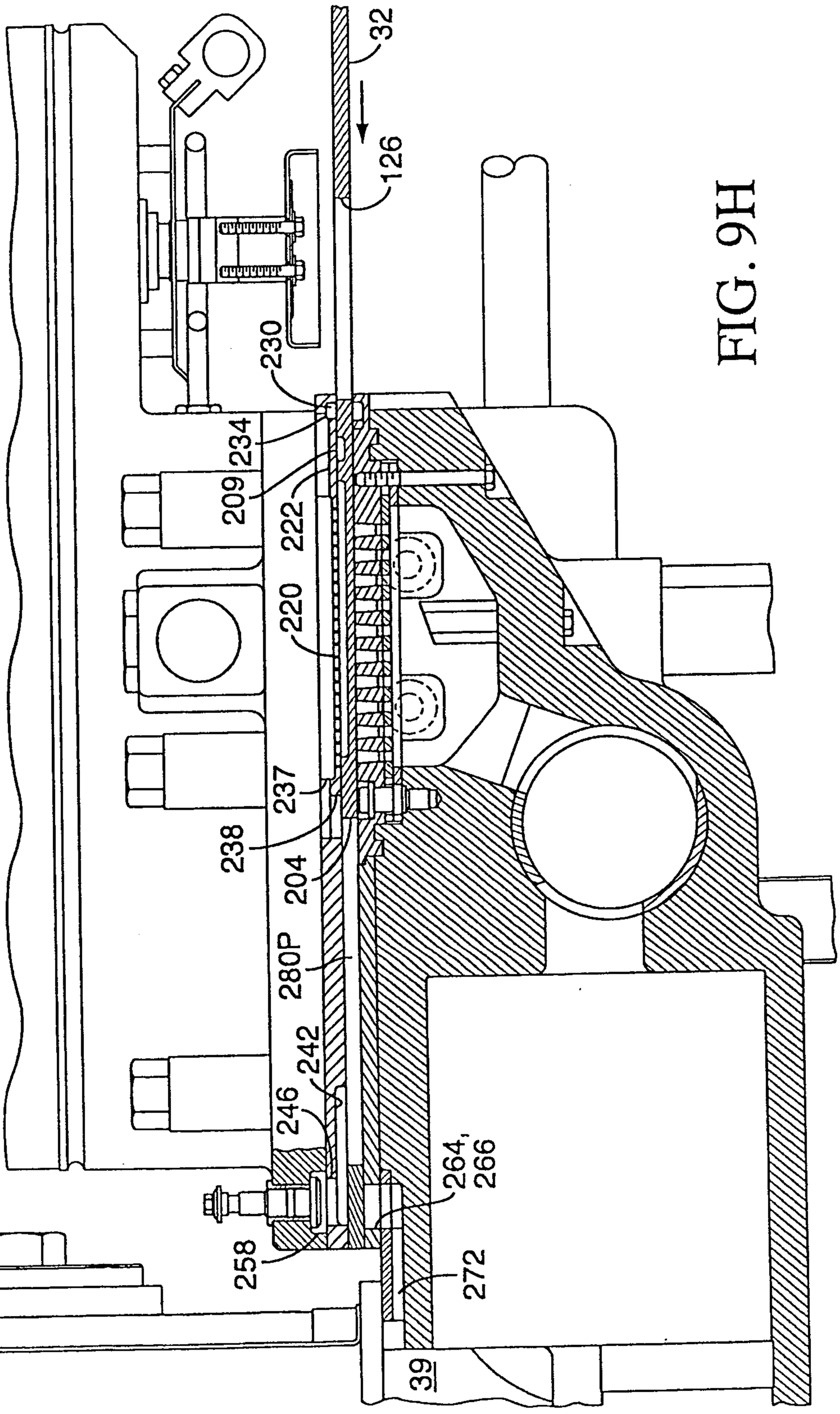
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FIG. 9H

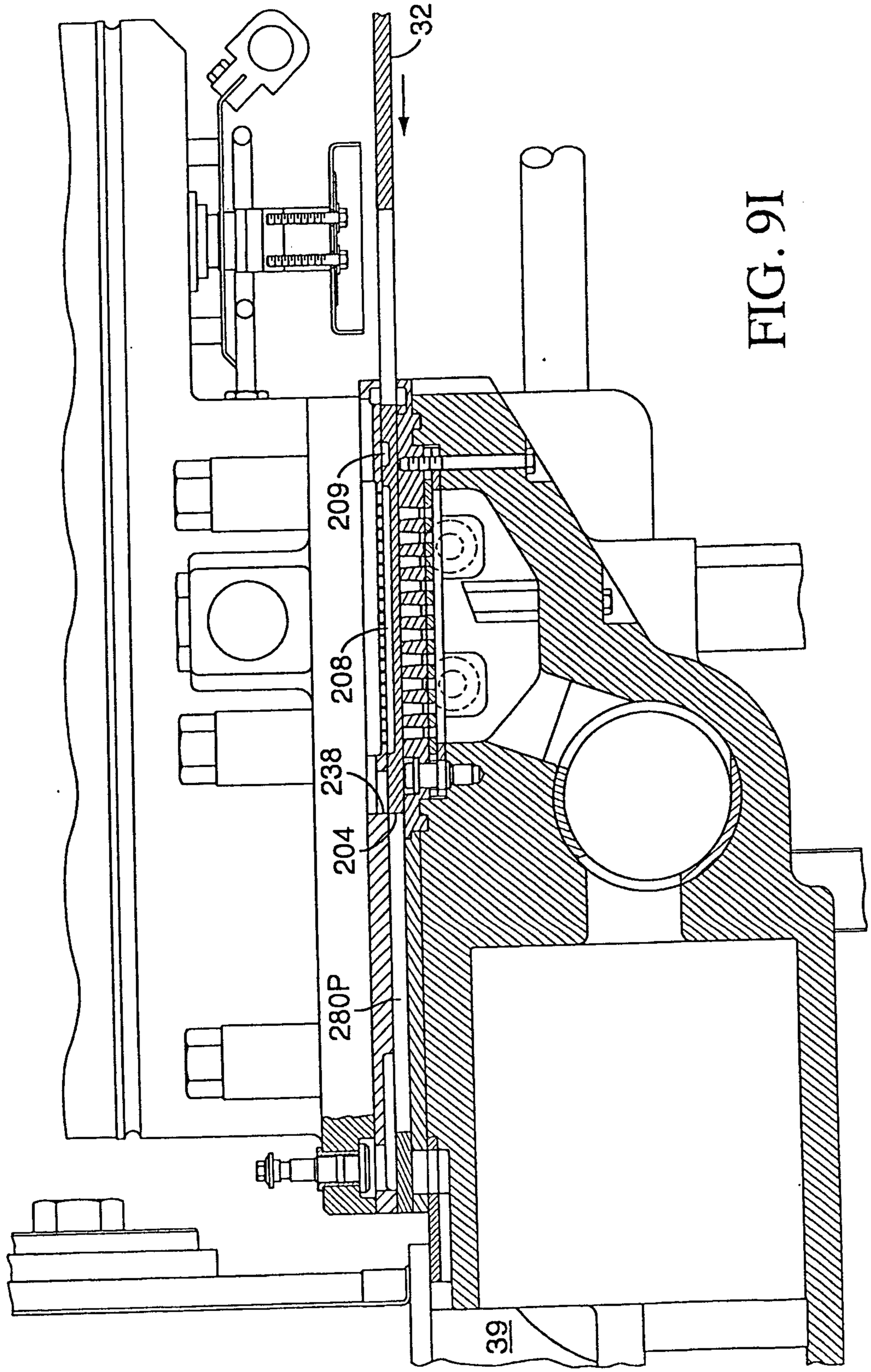


FIG. 9I

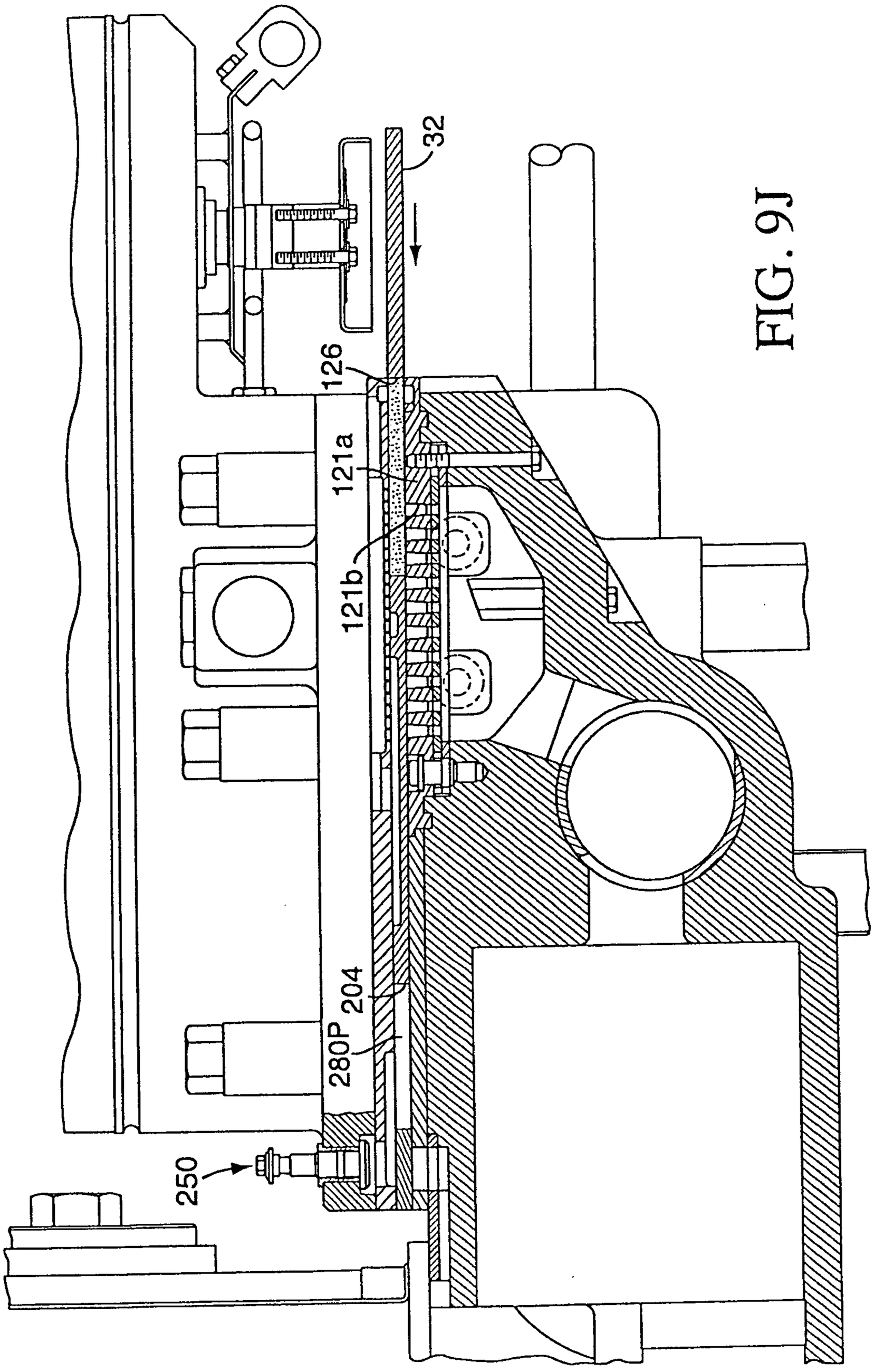


FIG. 9J

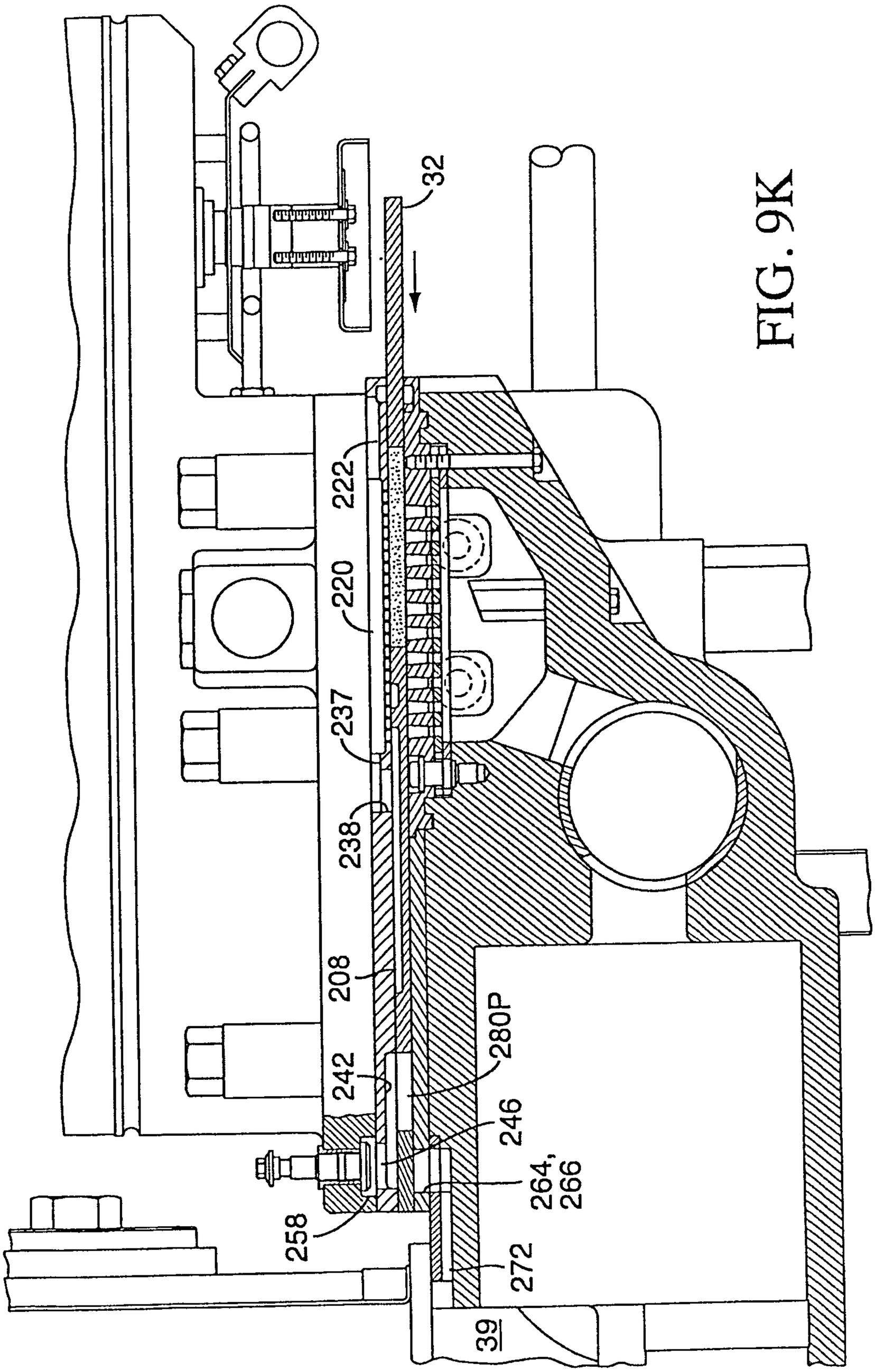


FIG. 9K

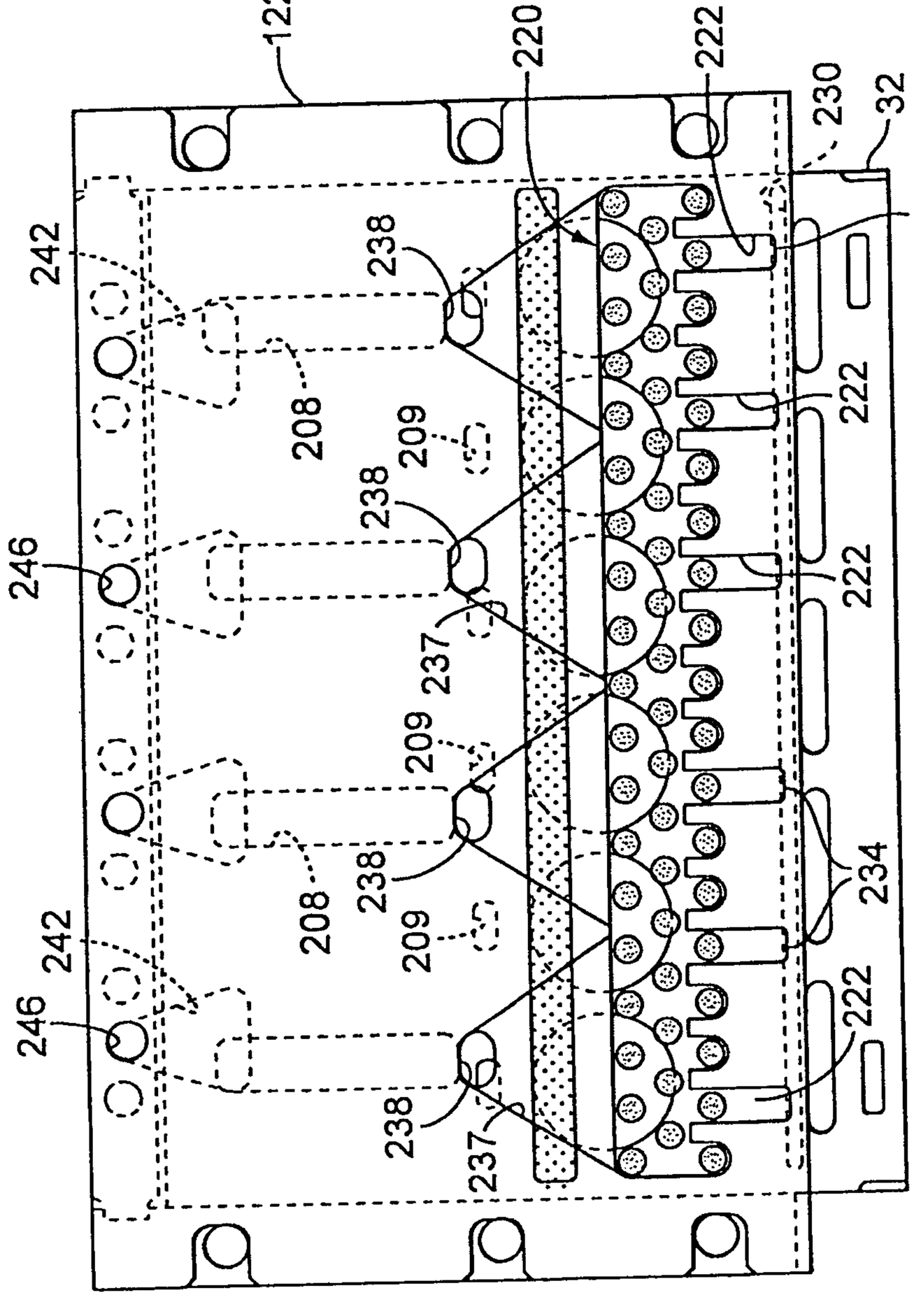
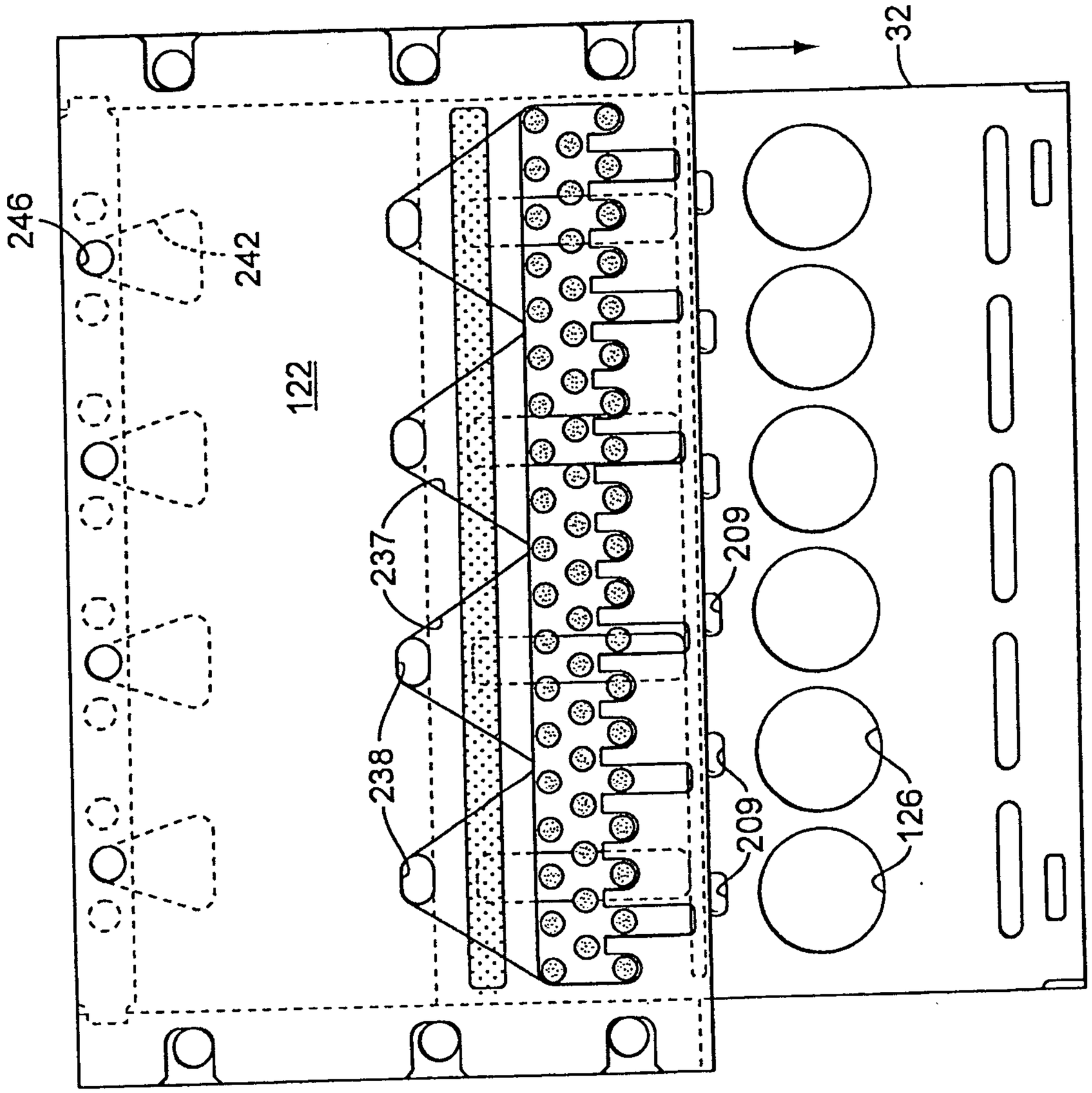


FIG. 10A

FIG. 10B



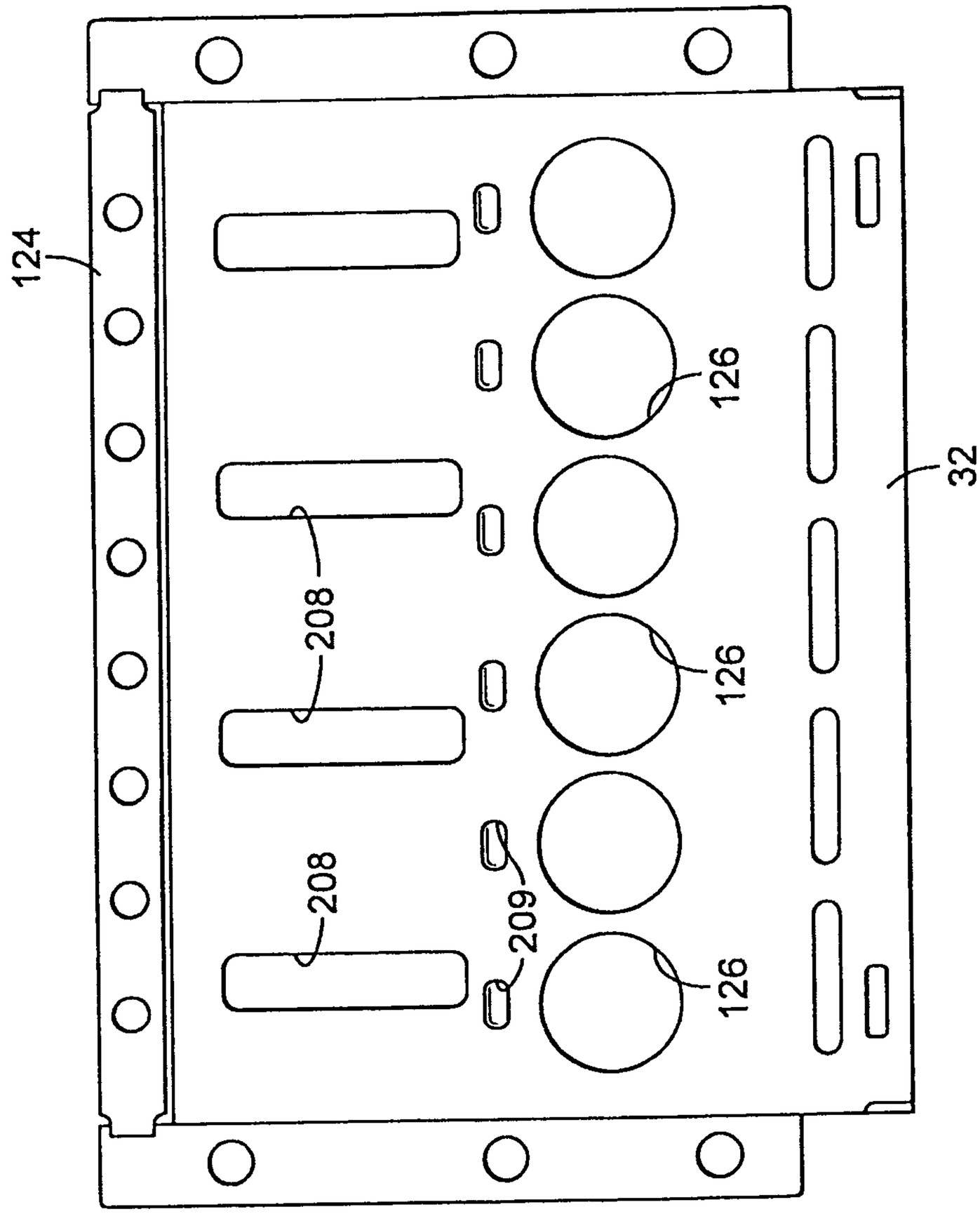
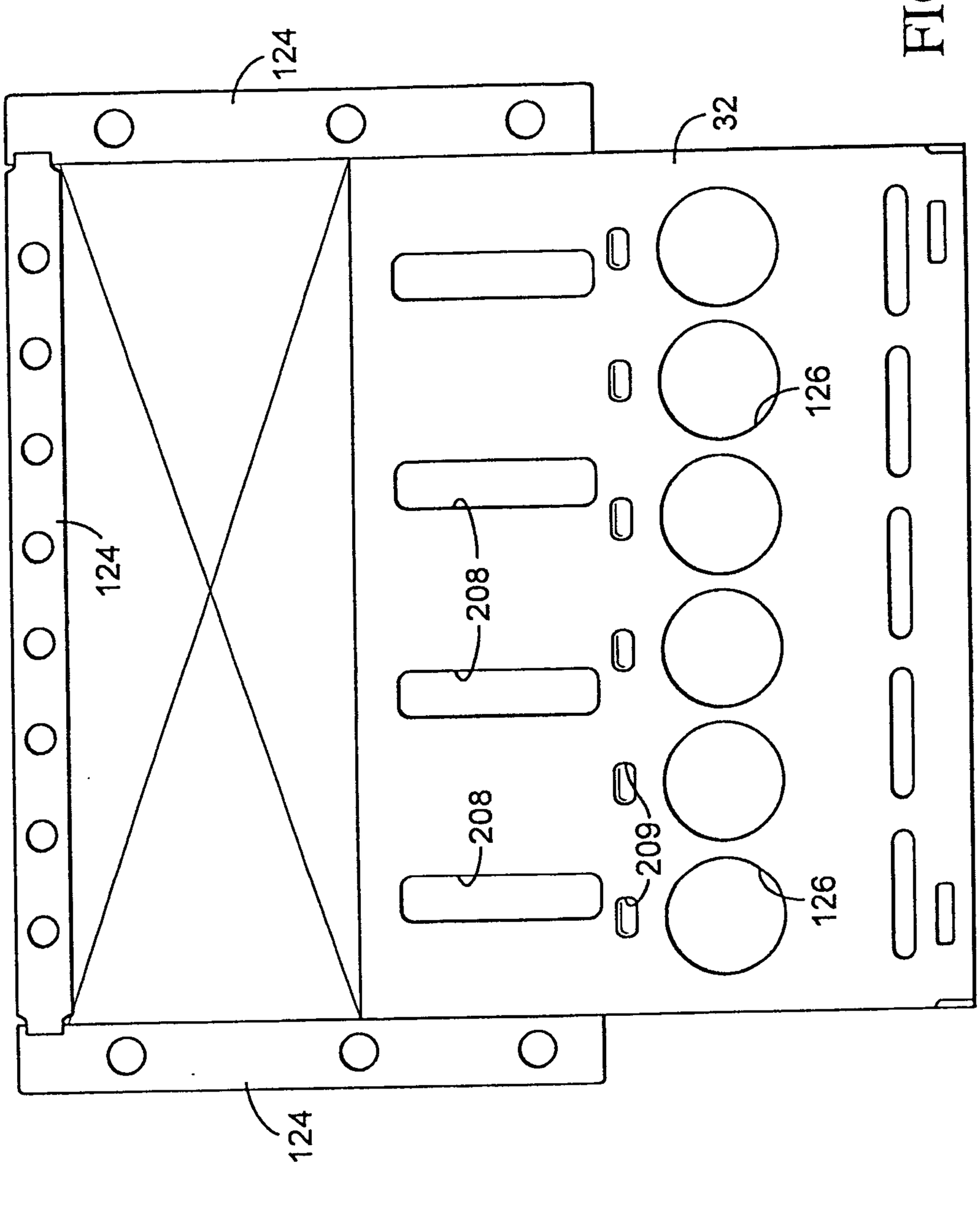


FIG. 11A

FIG. 11B



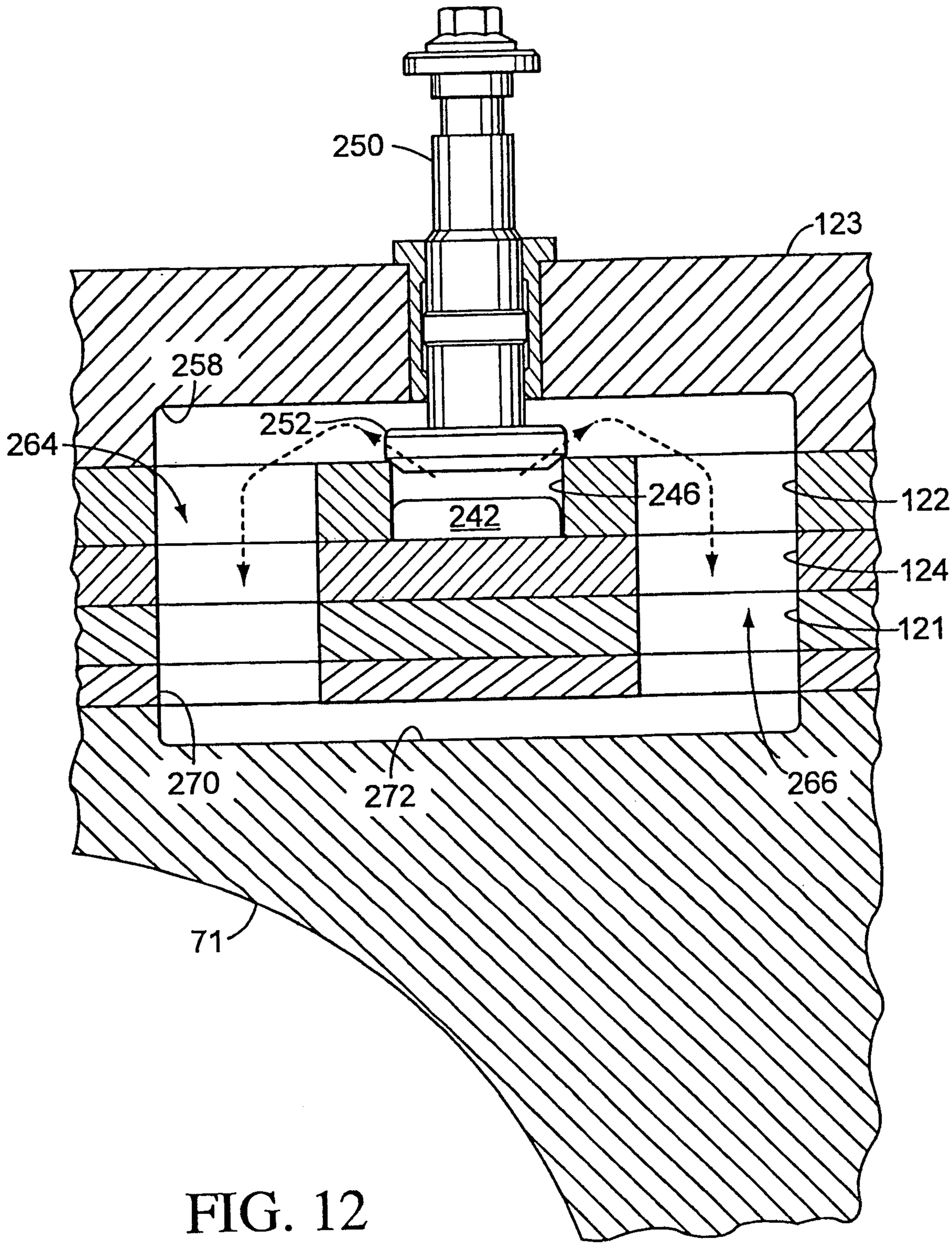


FIG. 12

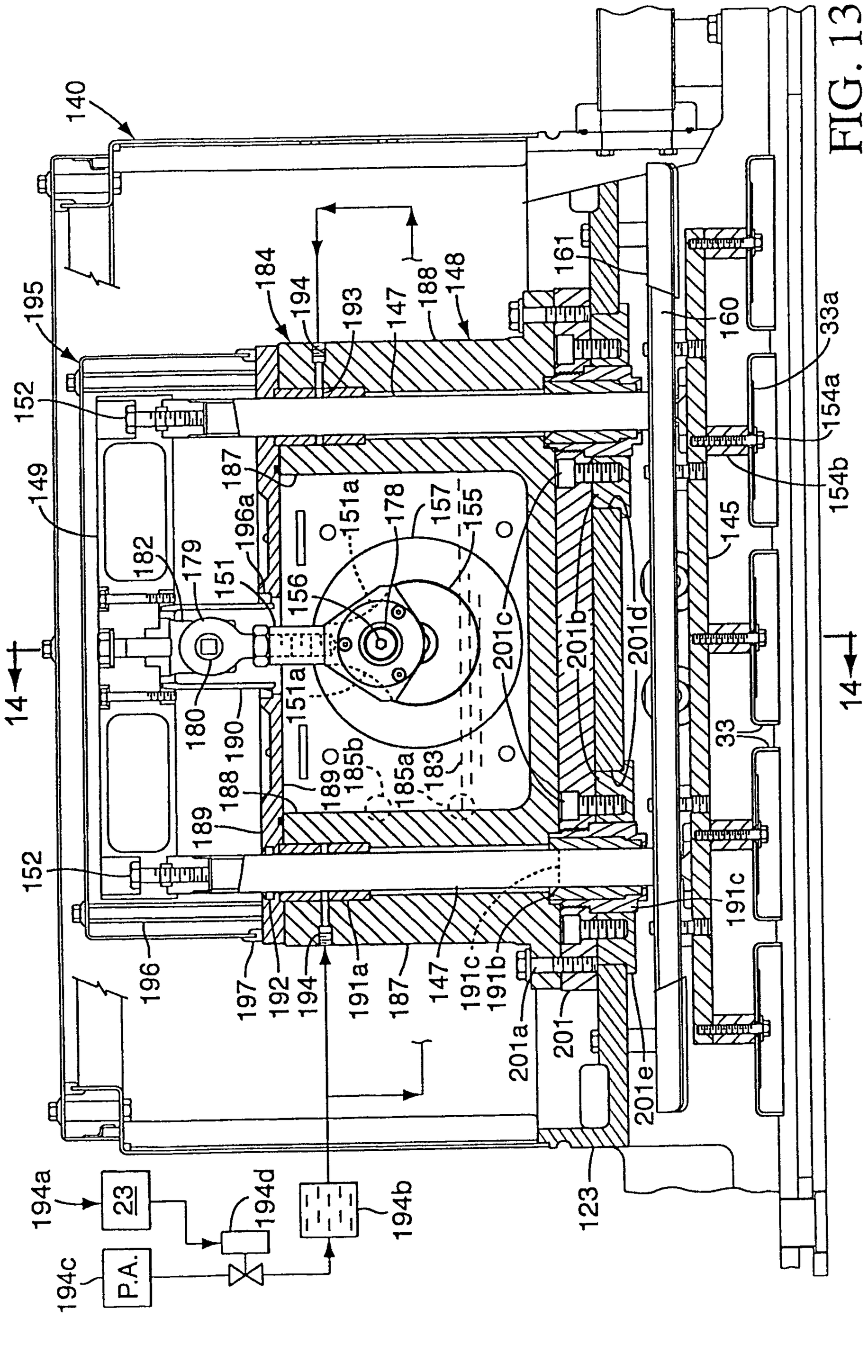

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FIG. 13

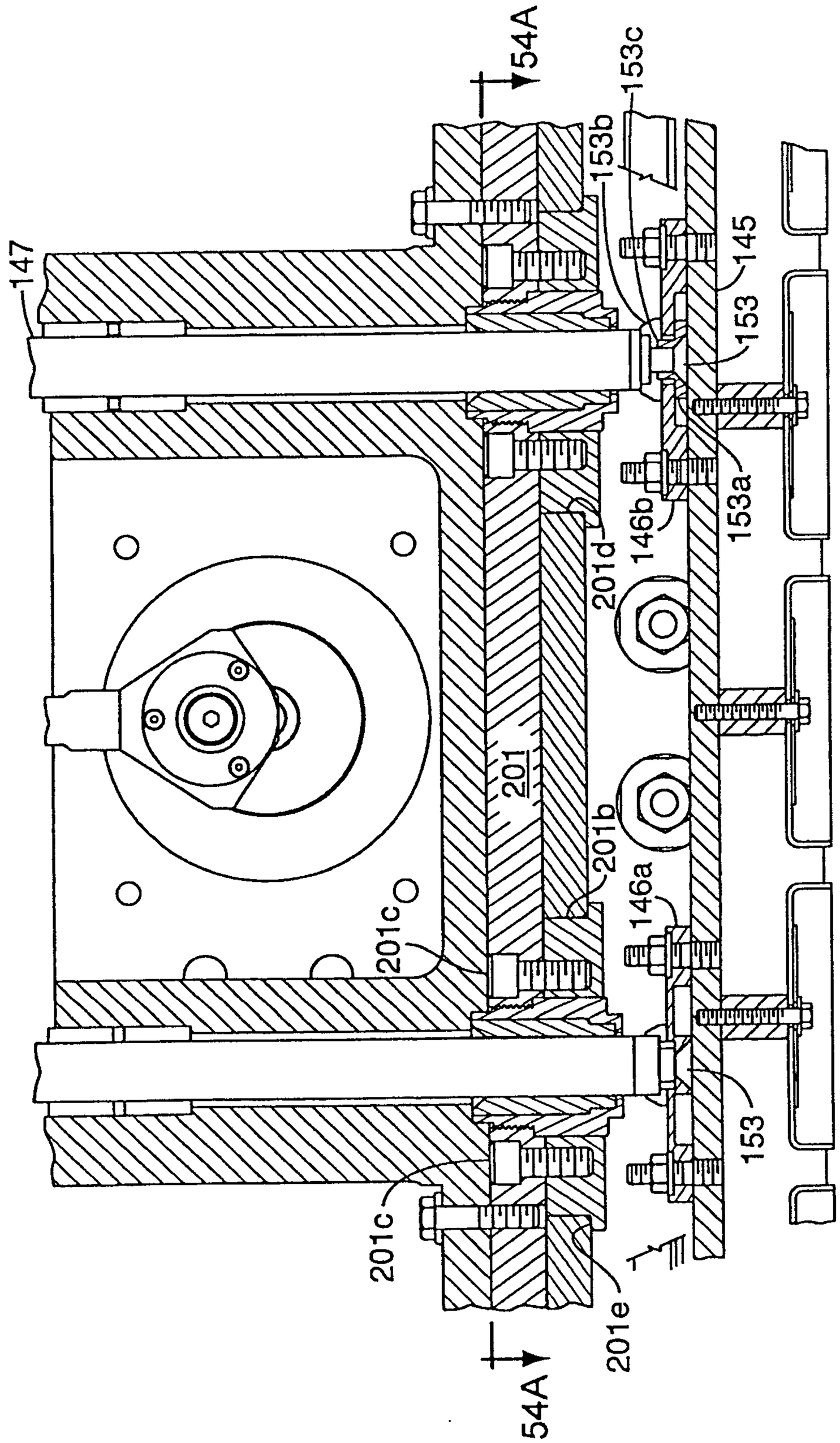
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FIG. 13A

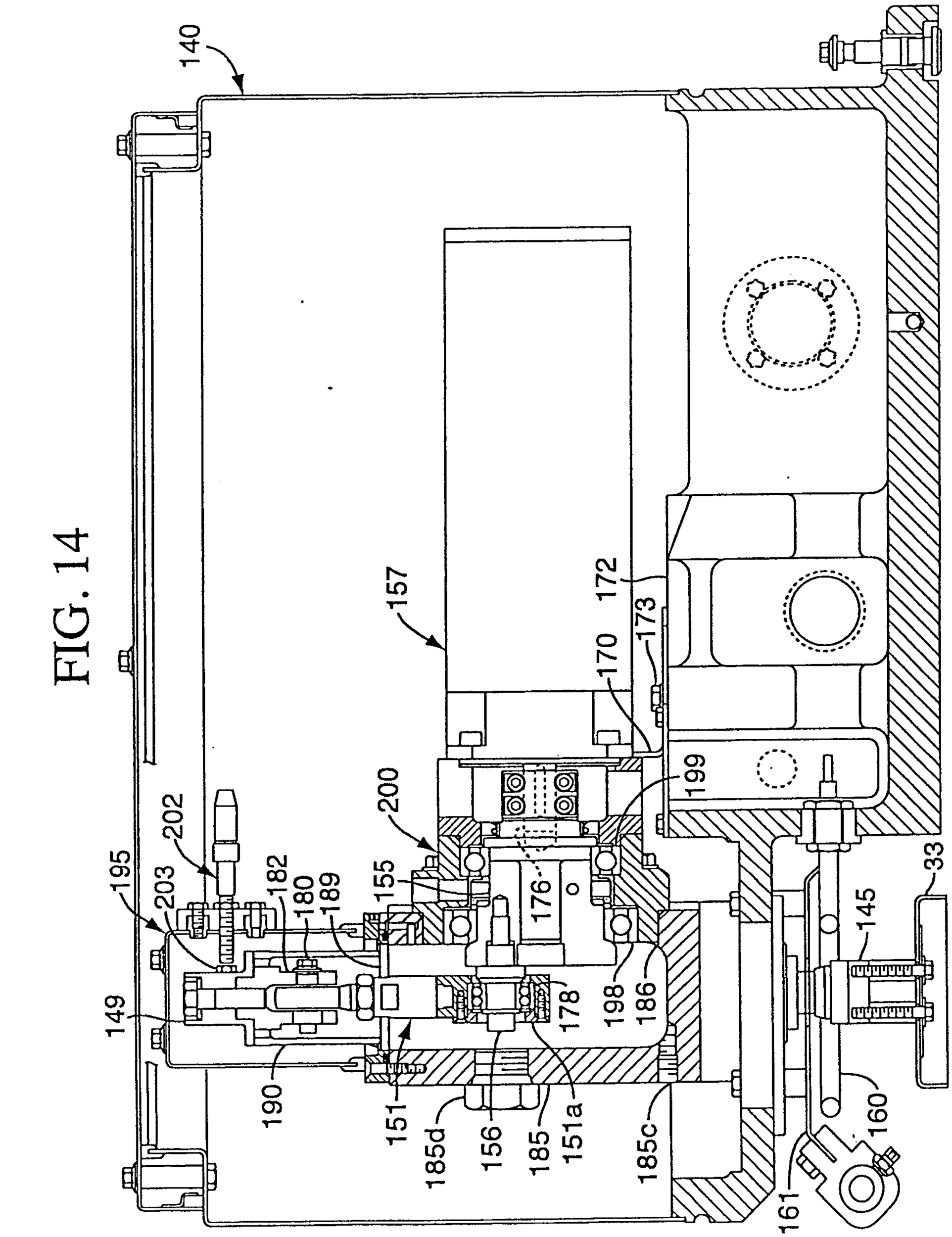
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FIG. 14

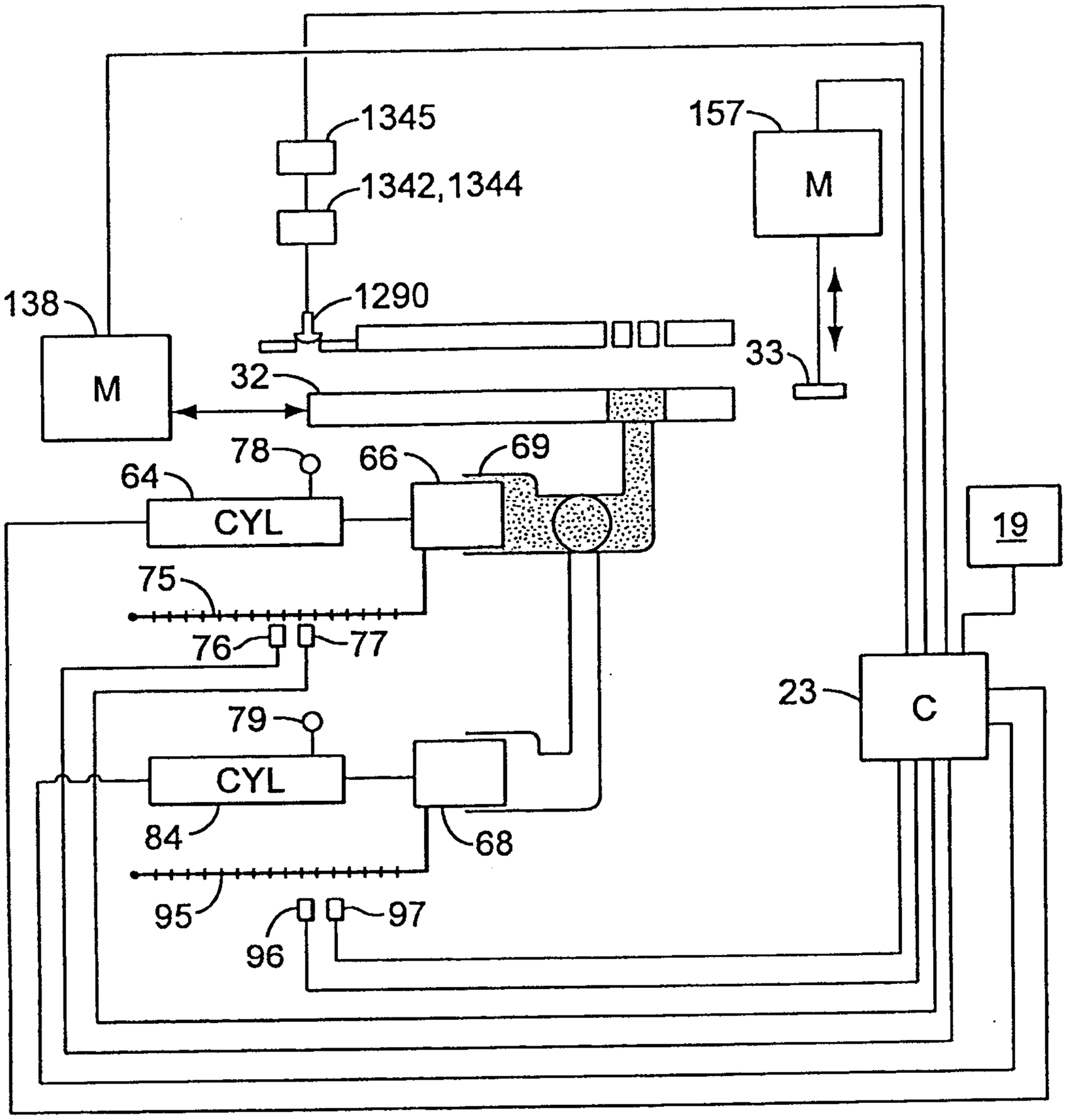
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FIG. 15

FIG. 16A

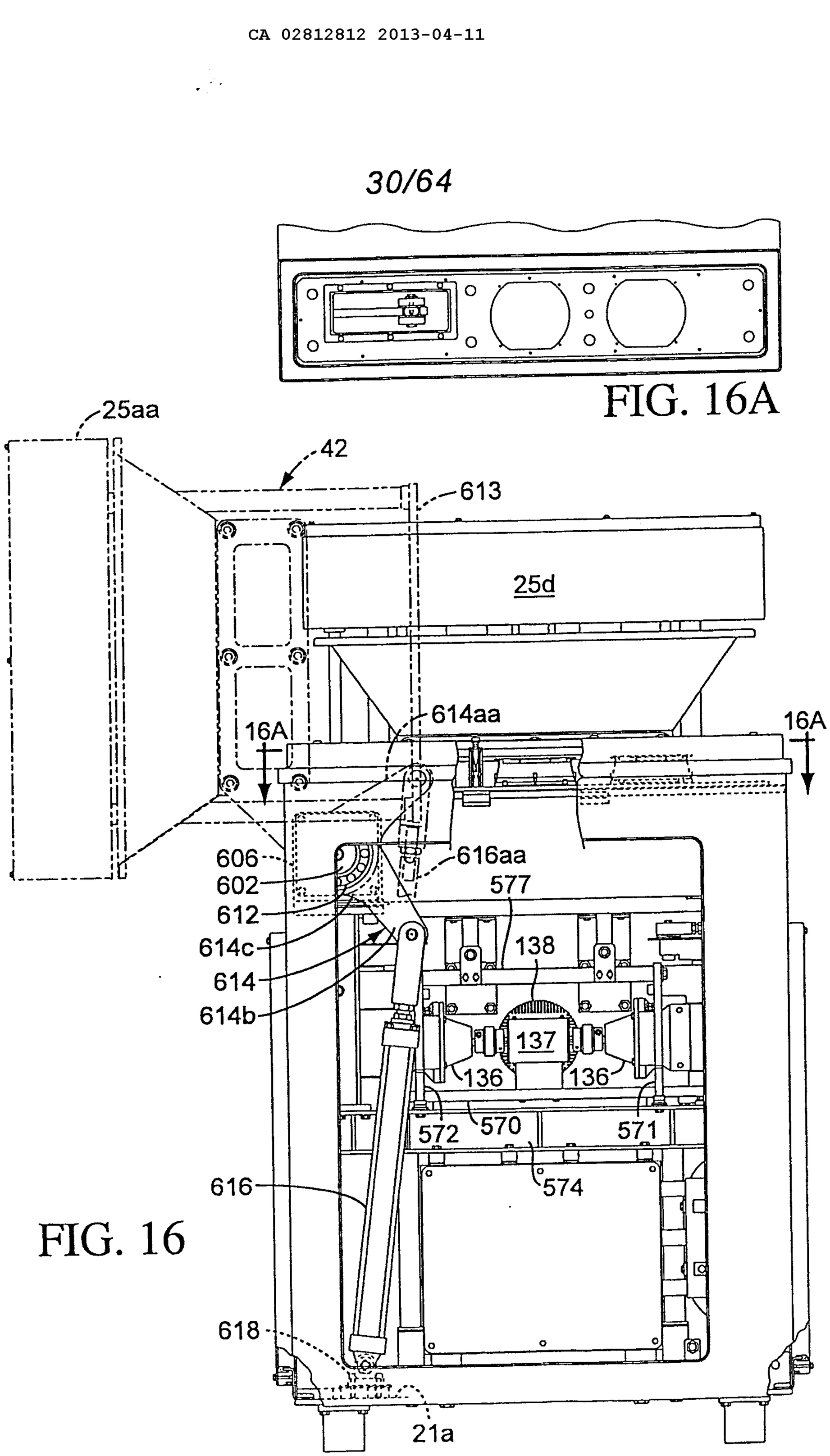


FIG. 16

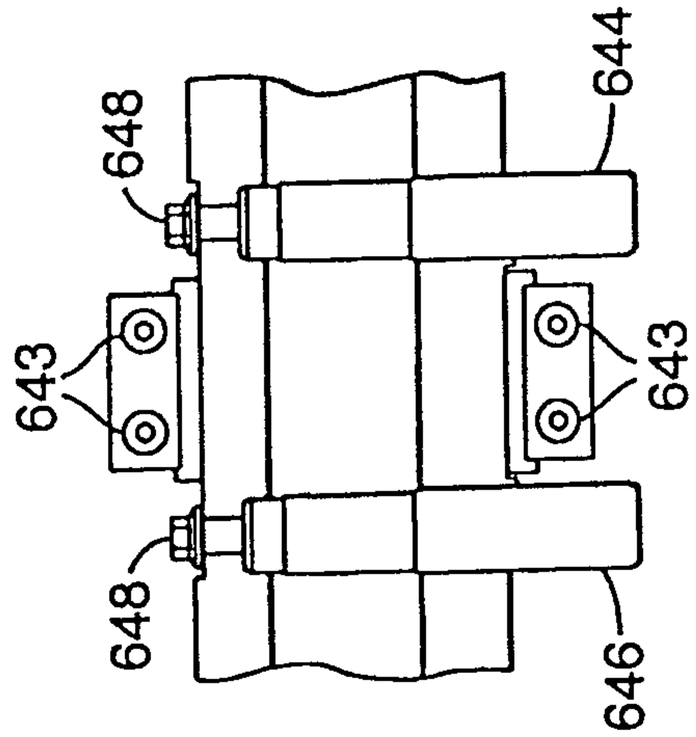


FIG. 16D

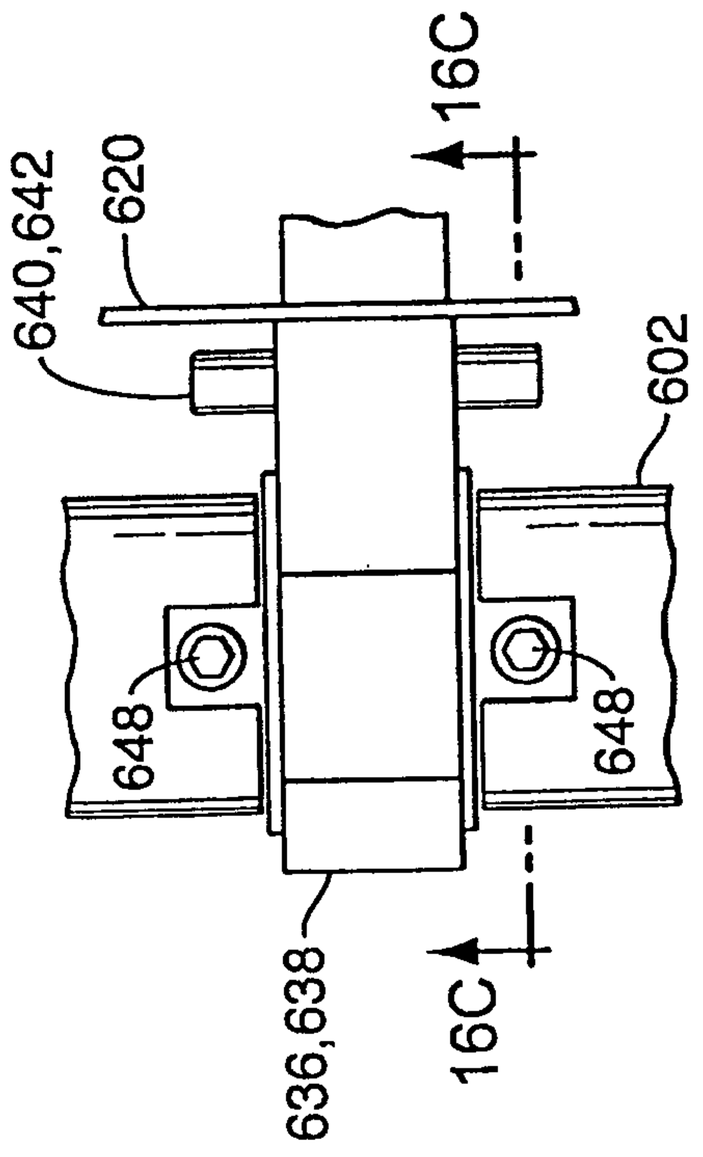


FIG. 16B

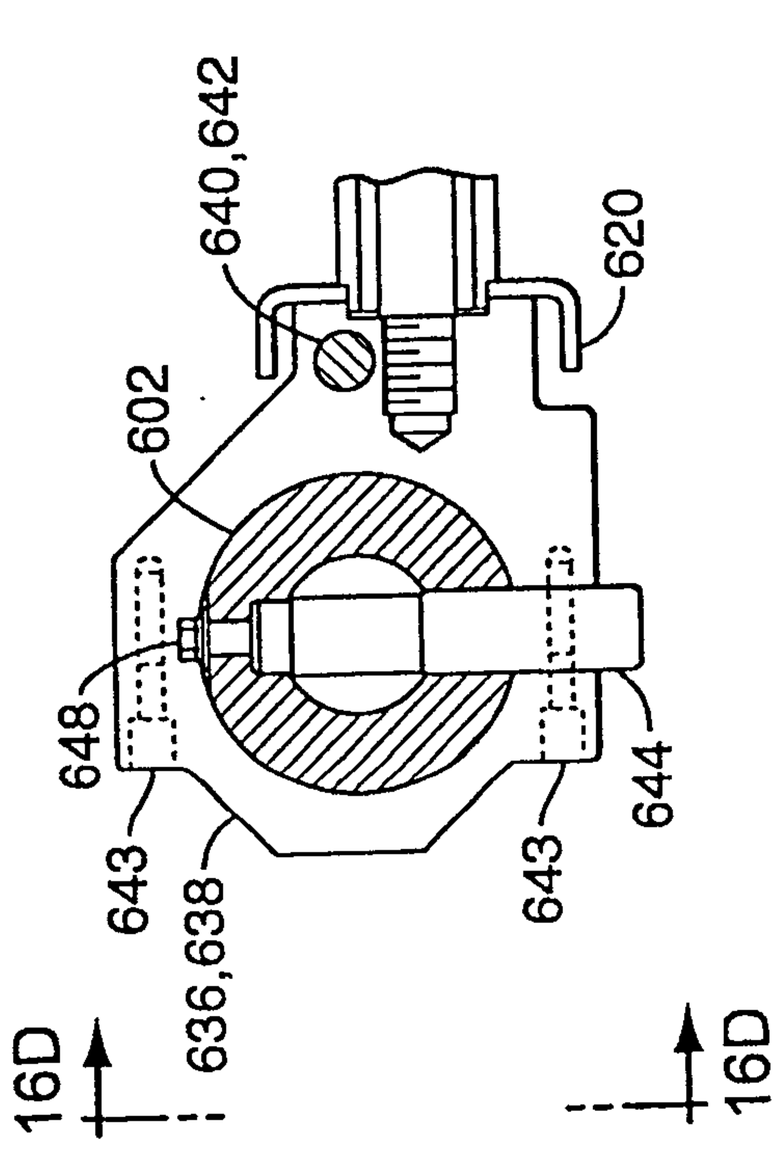


FIG. 16C

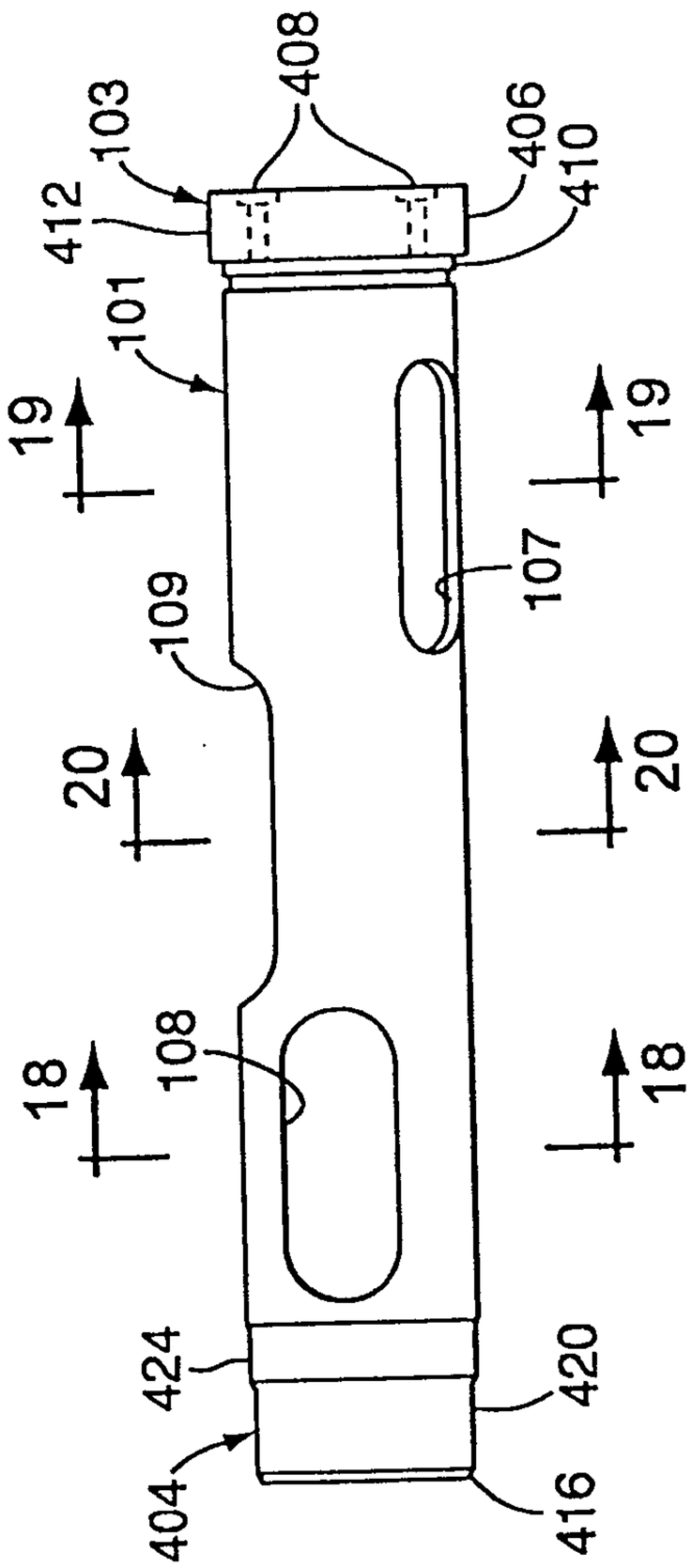


FIG. 17

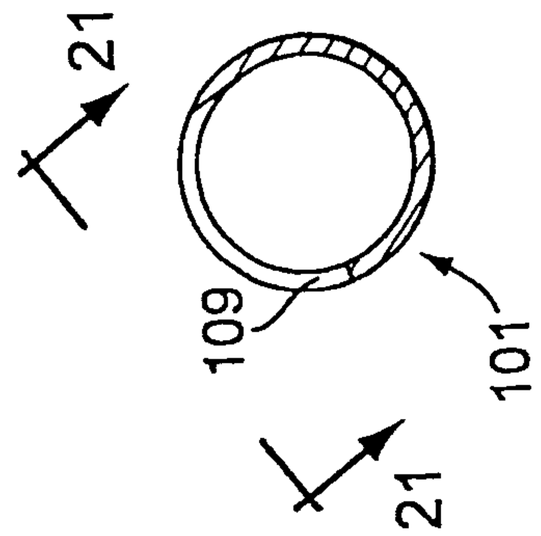


FIG. 20

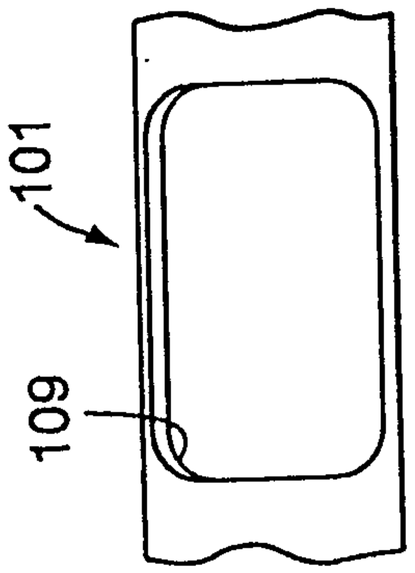


FIG. 21

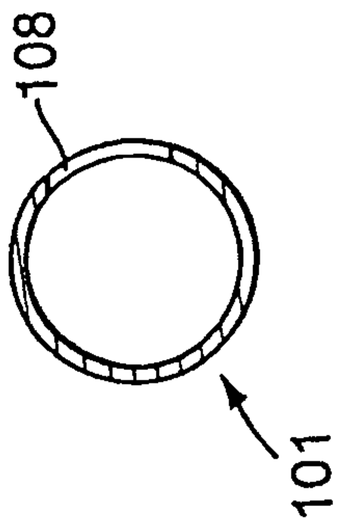


FIG. 18

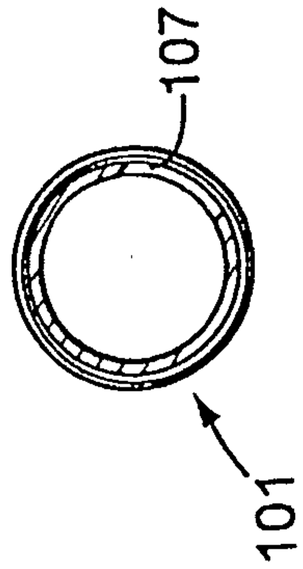


FIG. 19

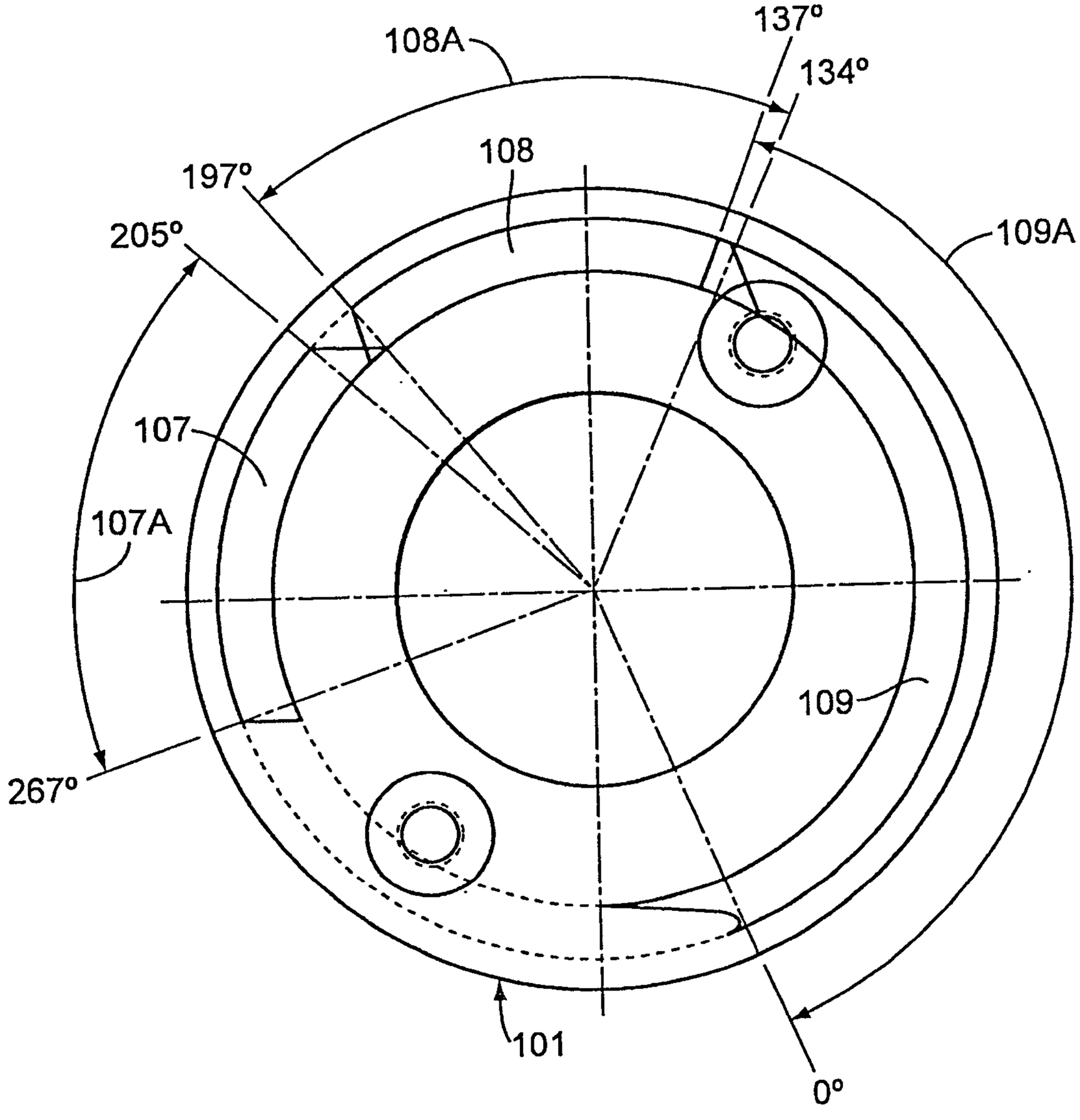


FIG. 22

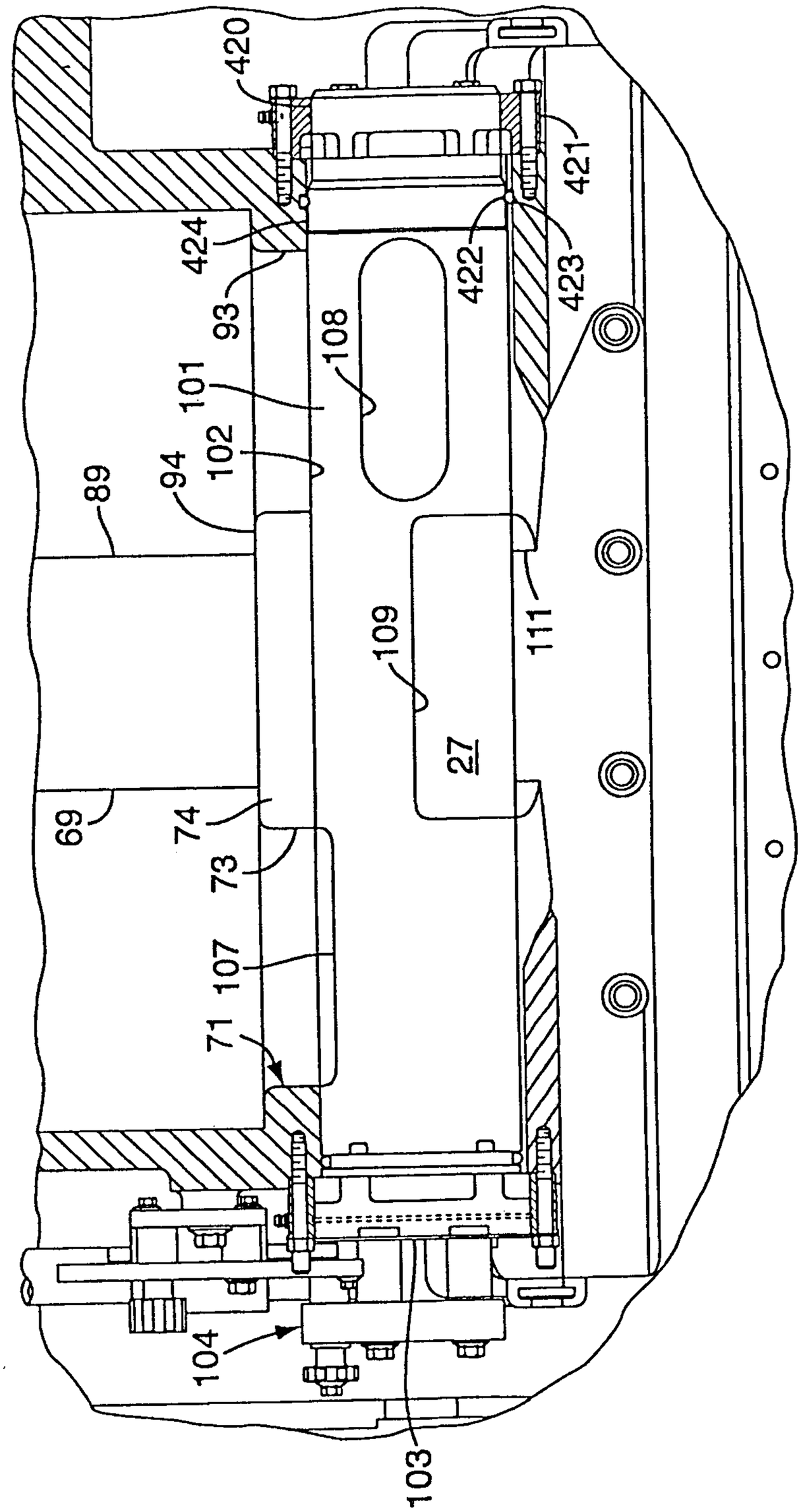

420
421
422
423
424
93
108
101
102
94
89
109
111
27
69
74
73
107
71
104
103

FIG. 23

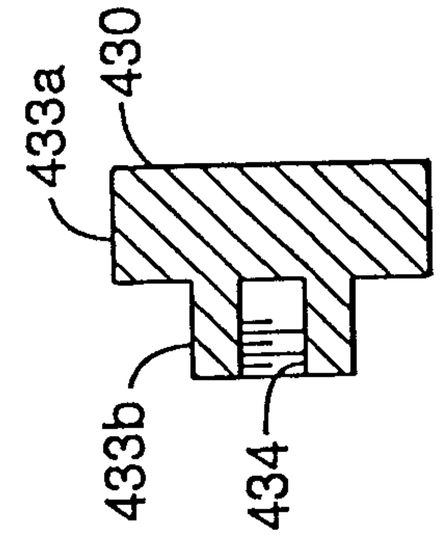


FIG. 25A

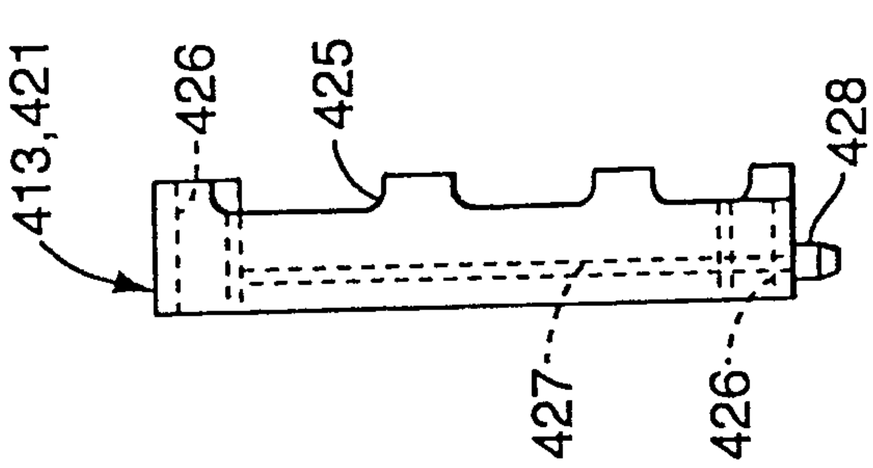


FIG. 24A

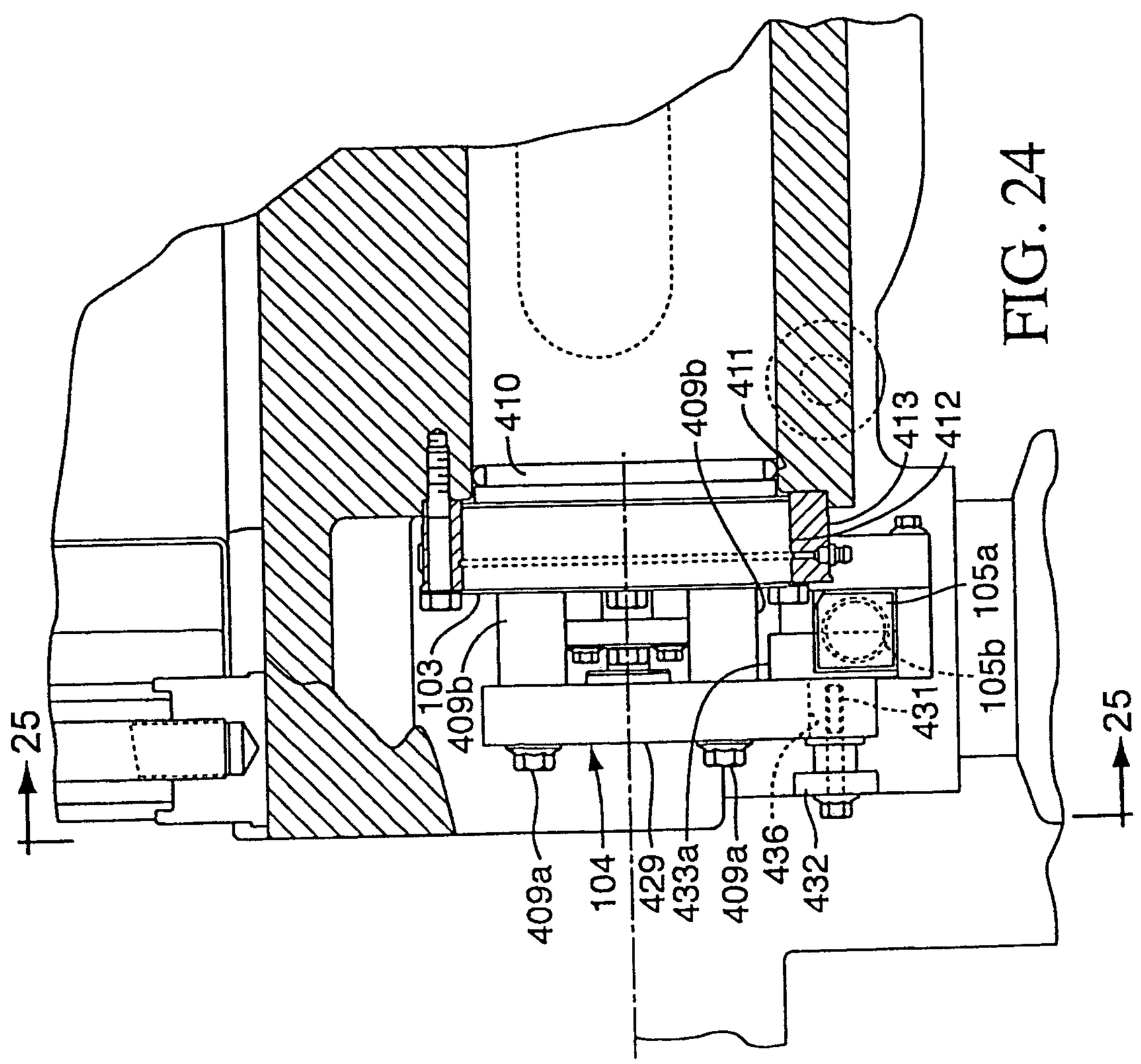


FIG. 24

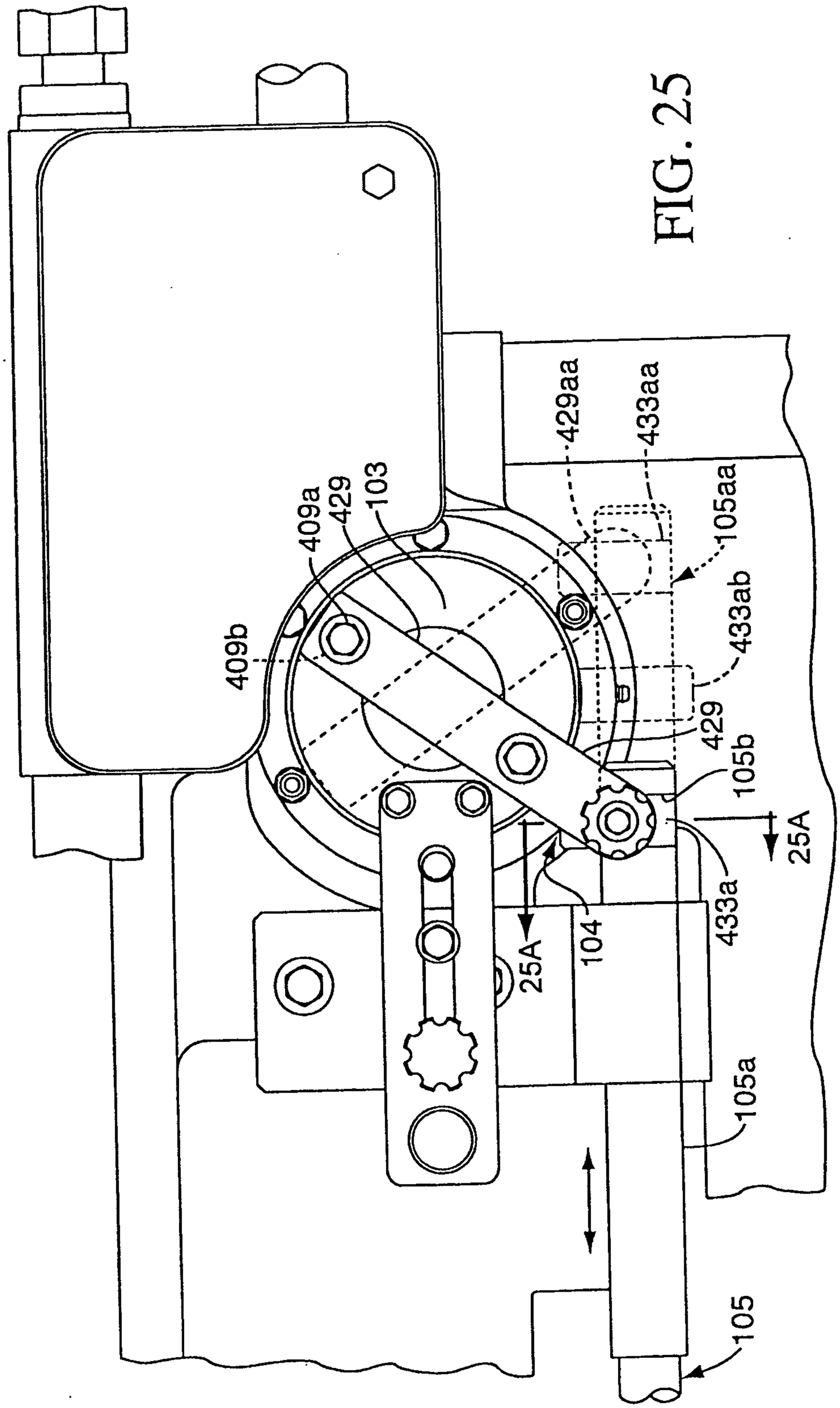

409b
409a
429
103
429aa
433aa
105aa
433ab
429
105b
25A
433a
104
25A
105a
105

FIG. 25

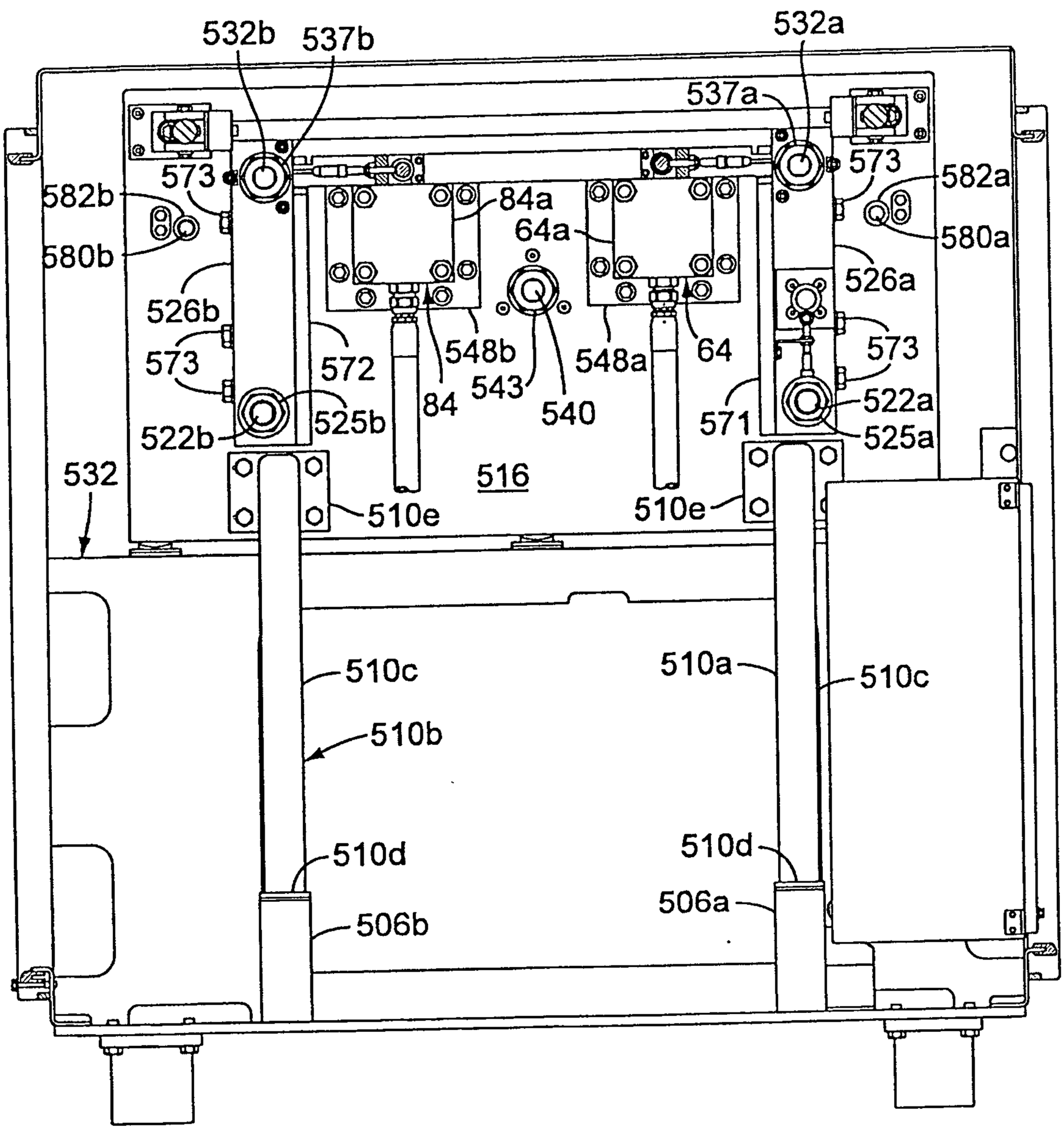

532b
537b
532a
537a
573
582b
580b
526b
573
572
522b
525b
532
84a
64a
548b
543
84
540
548a
64
516
510e
510e
573
582a
580a
526a
573
522a
571
525a
510c
510b
510d
506b
510a
510c
510d
506a

FIG. 26

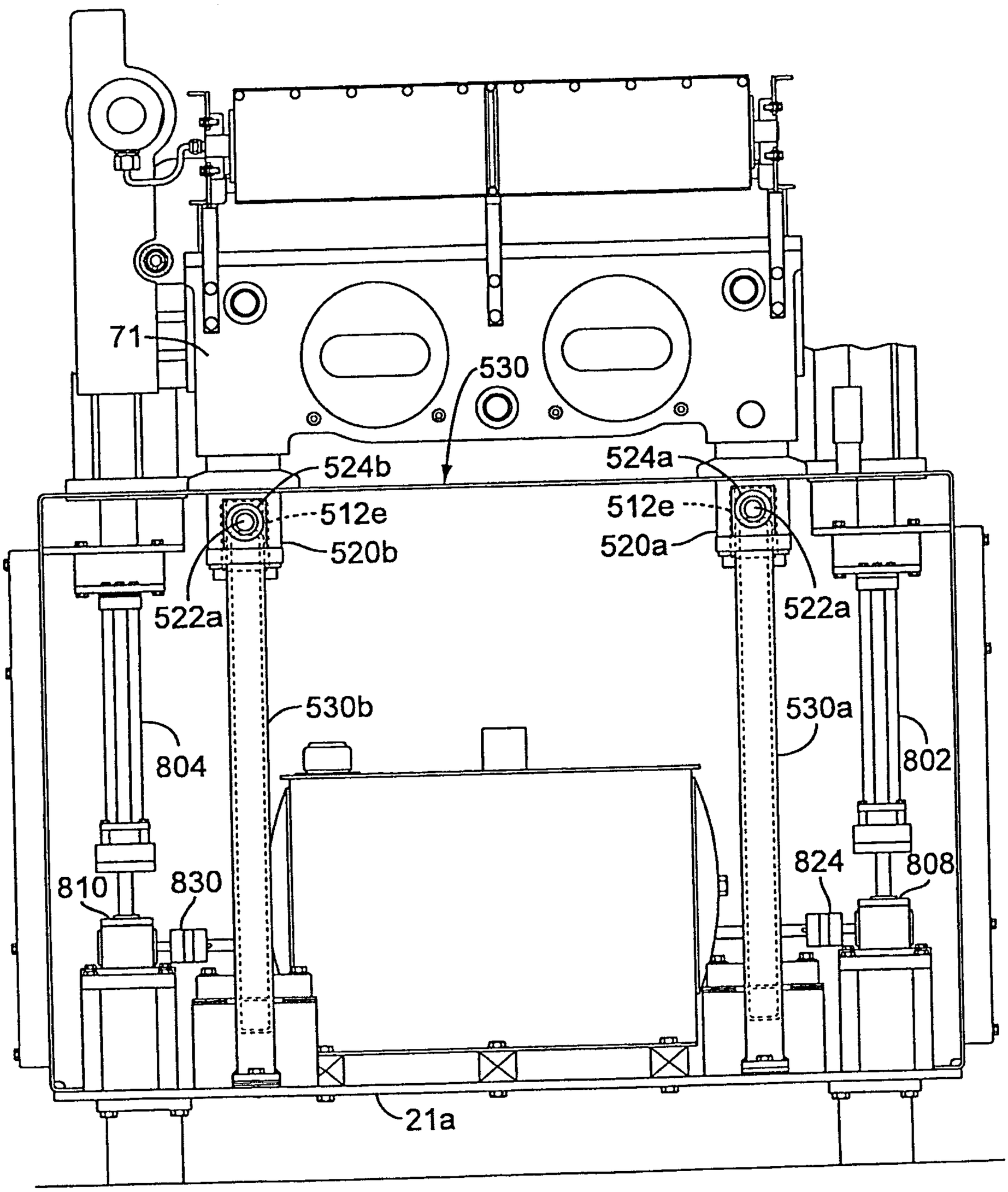

71
530
524b
524a
512e
512e
520b
520a
522a
522a
530b
530a
804
802
810
830
824
808
21a

FIG. 27

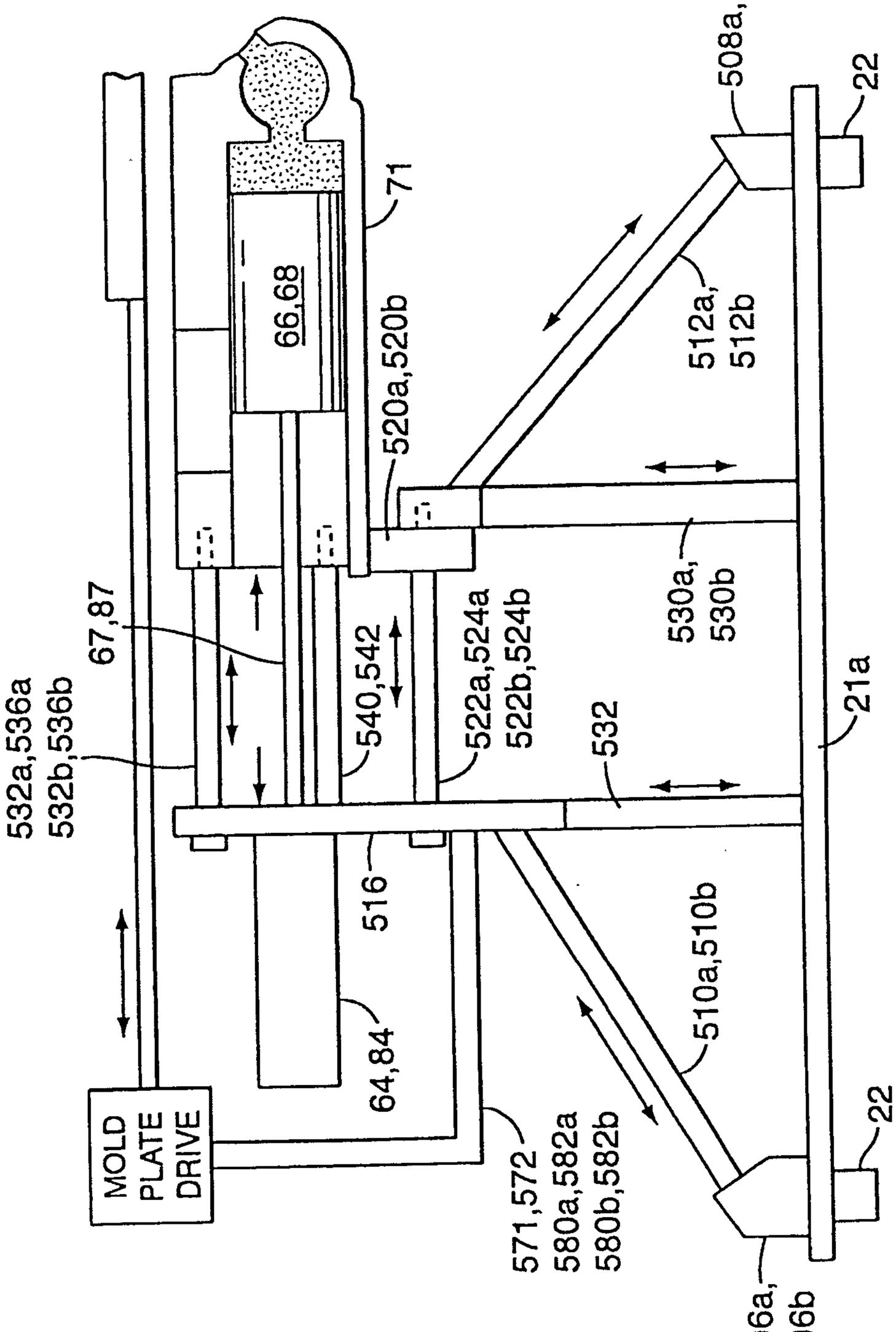

66,68
71
520a,520b
508a
22
512a,
512b
530a,
530b
524a
524b
522a,52
522b,52
532
21a
67,87
532a,536a
532b,536b
540,542
516
64,84
510a,510b
MOLD
PLATE
DRIVE
571,572
580a,582a
580b,582b
22
506a
506b

FIG. 28

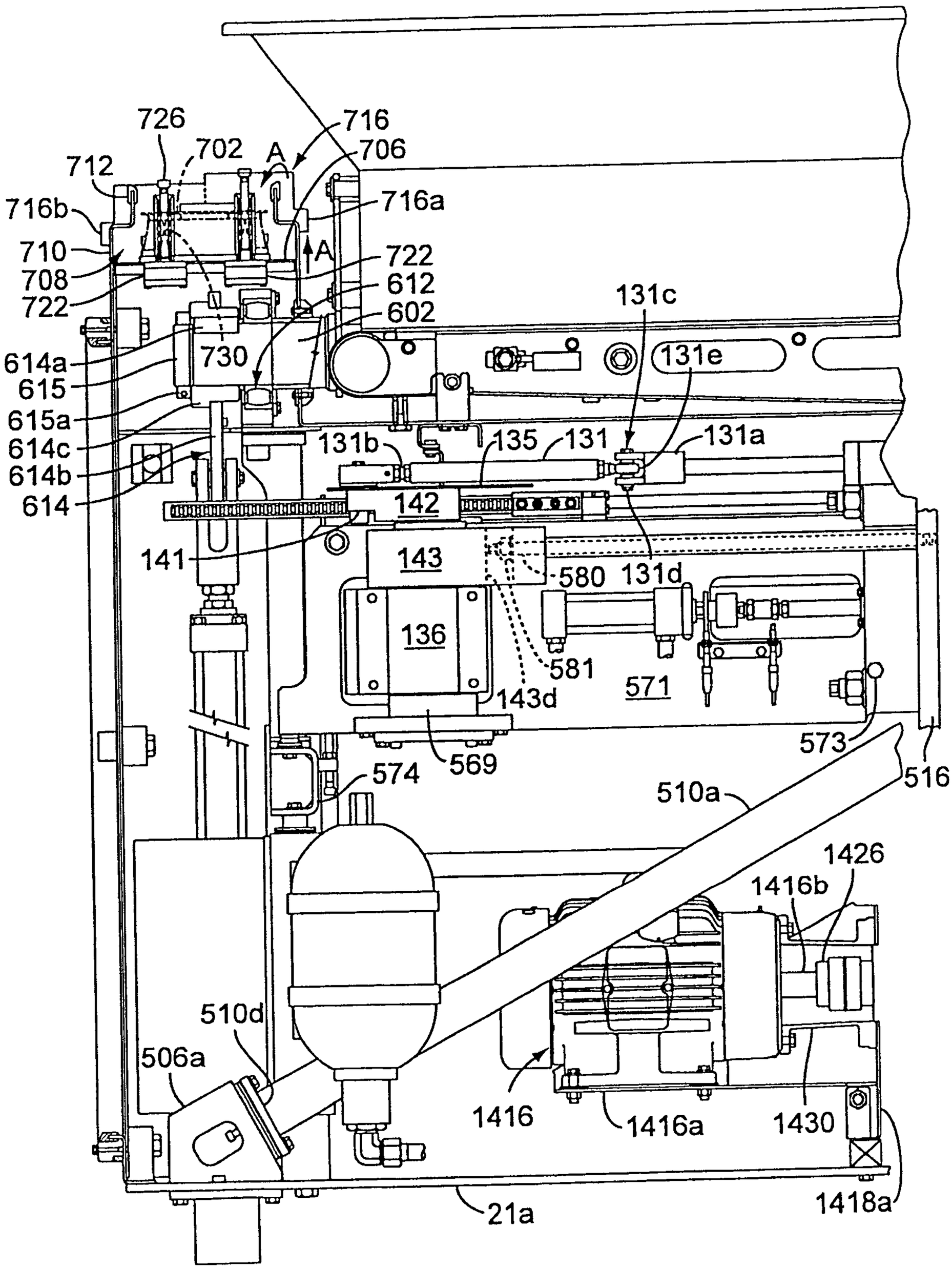

726
712
716b
710
708
722
614a
615
615a
614c
614b
614
141
702
A
716
706
716a
A
722
612
602
730
131c
131e
131b
135
131
131a
142
143
580
131d
136
581
571
143d
573
569
574
516
510a
1426
1416b
510d
506a
1416
1416a
1430
1418a
21a

FIG. 29

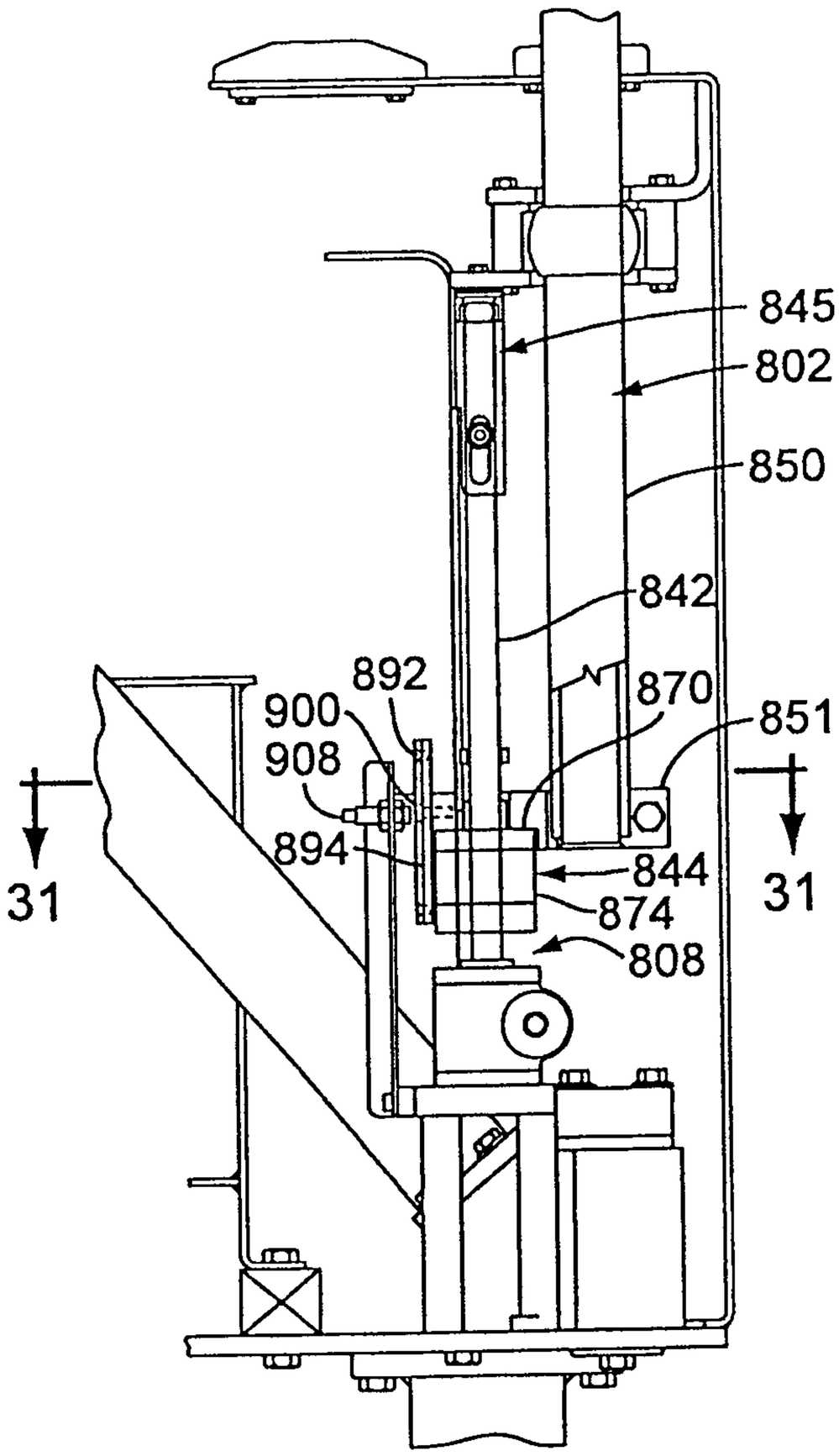

845
802
850
842
892
870
851
900
908
894
844
874
808
31
31

FIG. 30

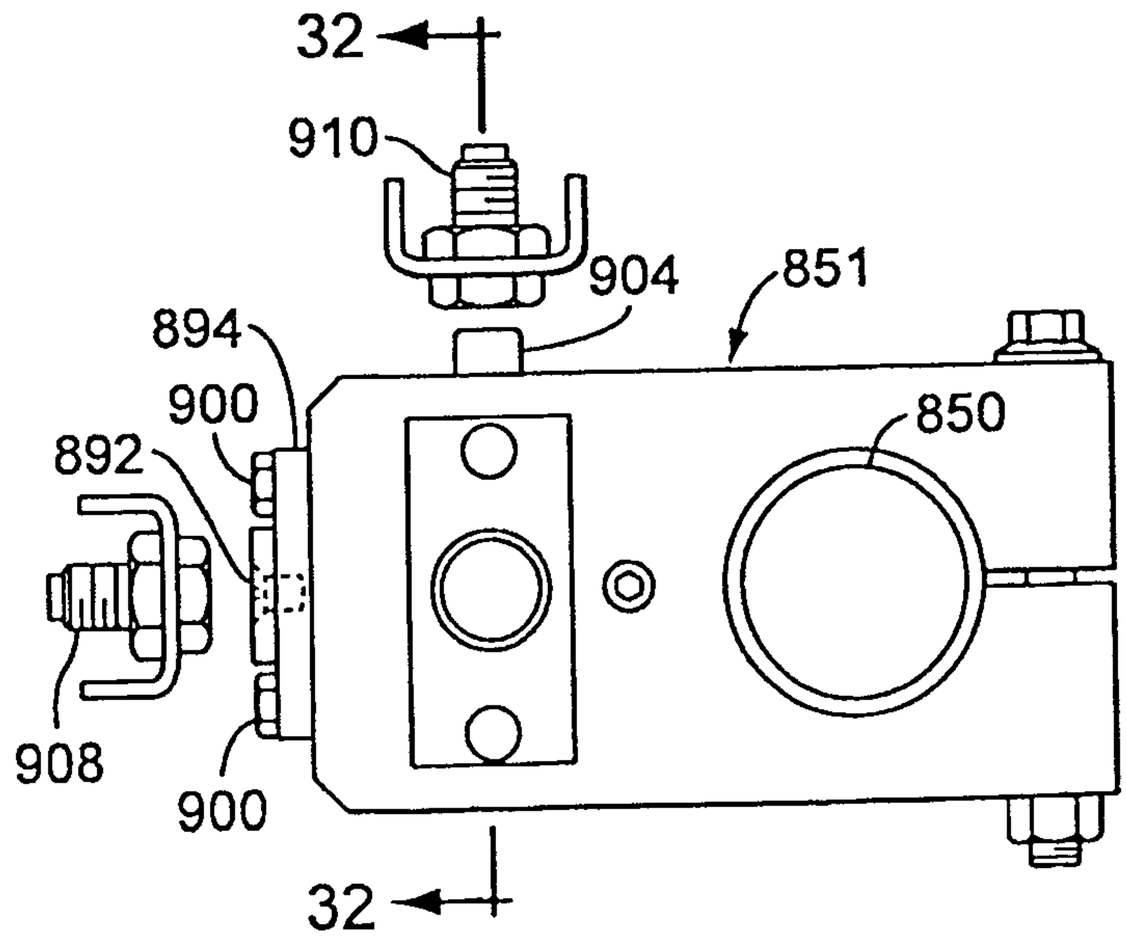

32
910
904
851
894
900
892
850
908
900
32

FIG. 31

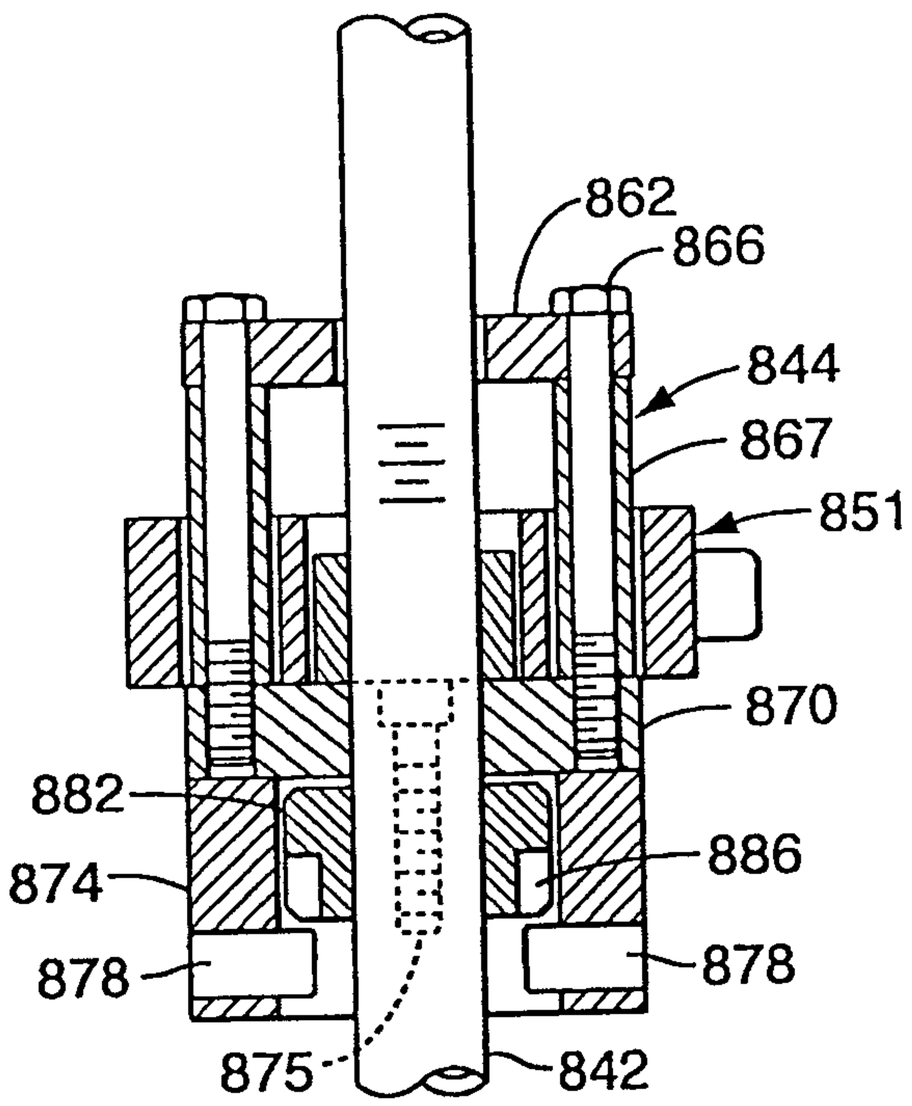

862
866
844
867
851
870
882
886
874
878
878
875
842

FIG. 32

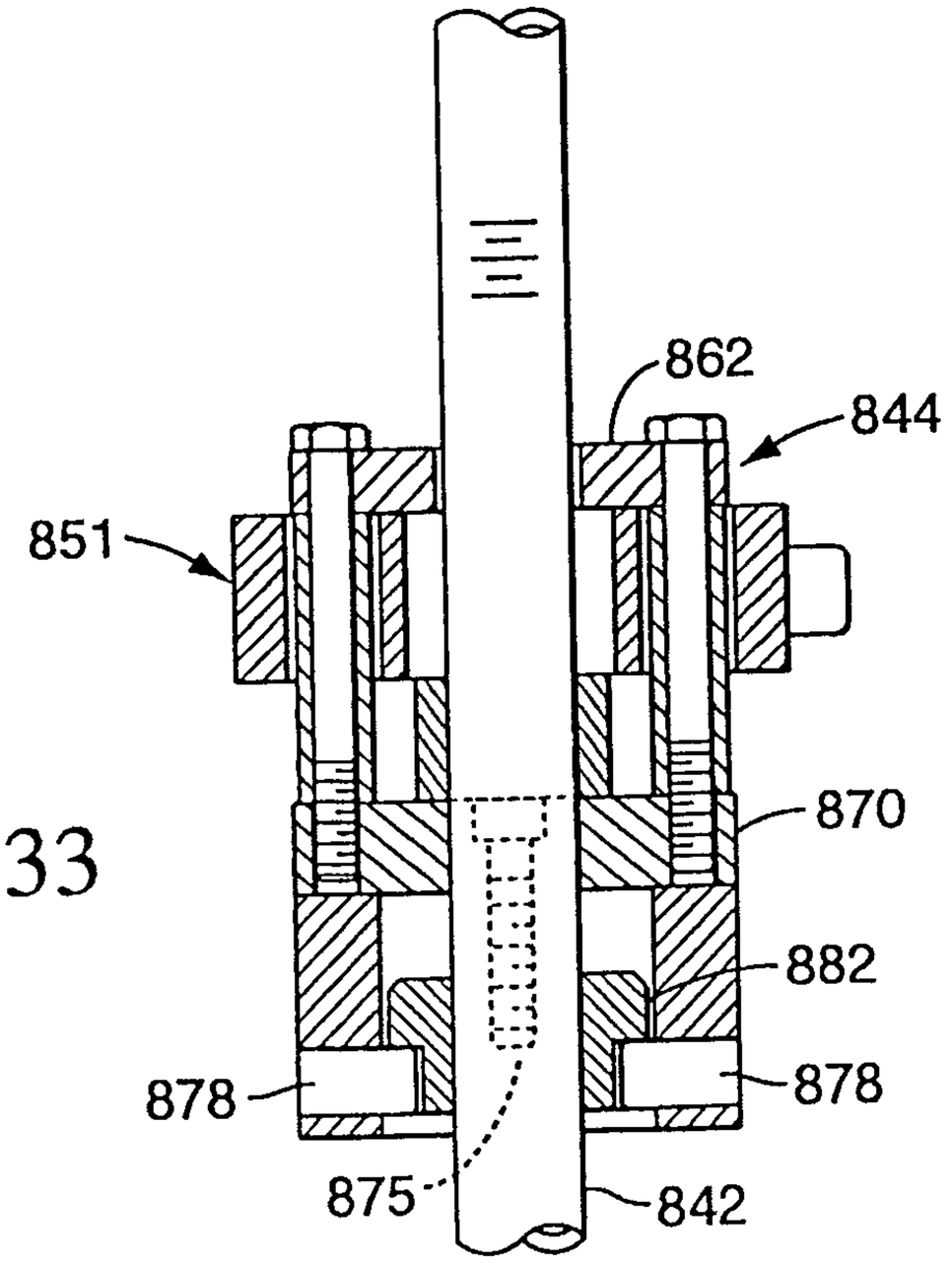

862
844
851
870
882
878
878
875
842

FIG. 33

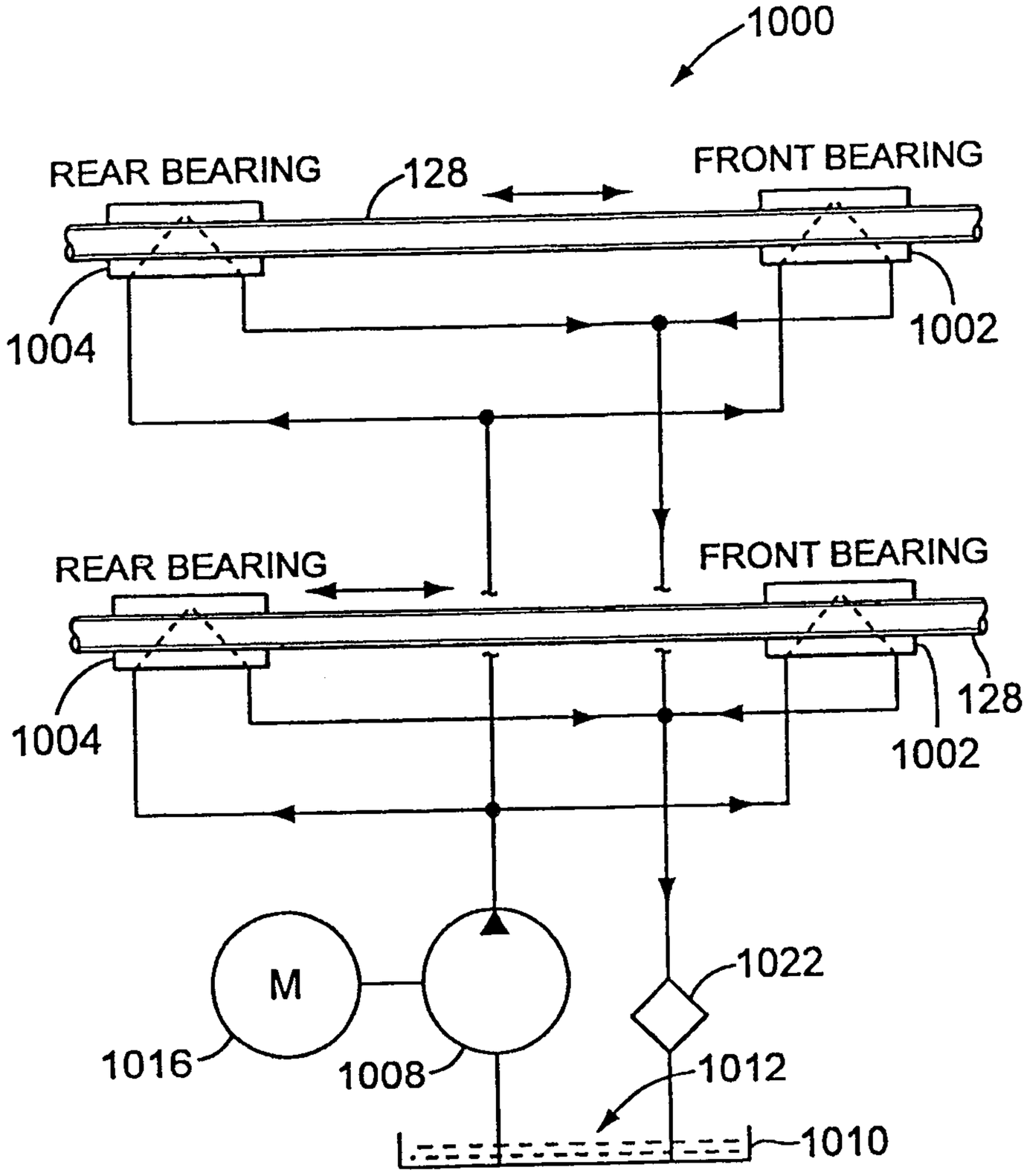

1000
REAR BEARING
128
FRONT BEARING
1004
1002
REAR BEARING
FRONT BEARING
1004
128
1002
M
1022
1016
1008
1012
1010

FIG. 34

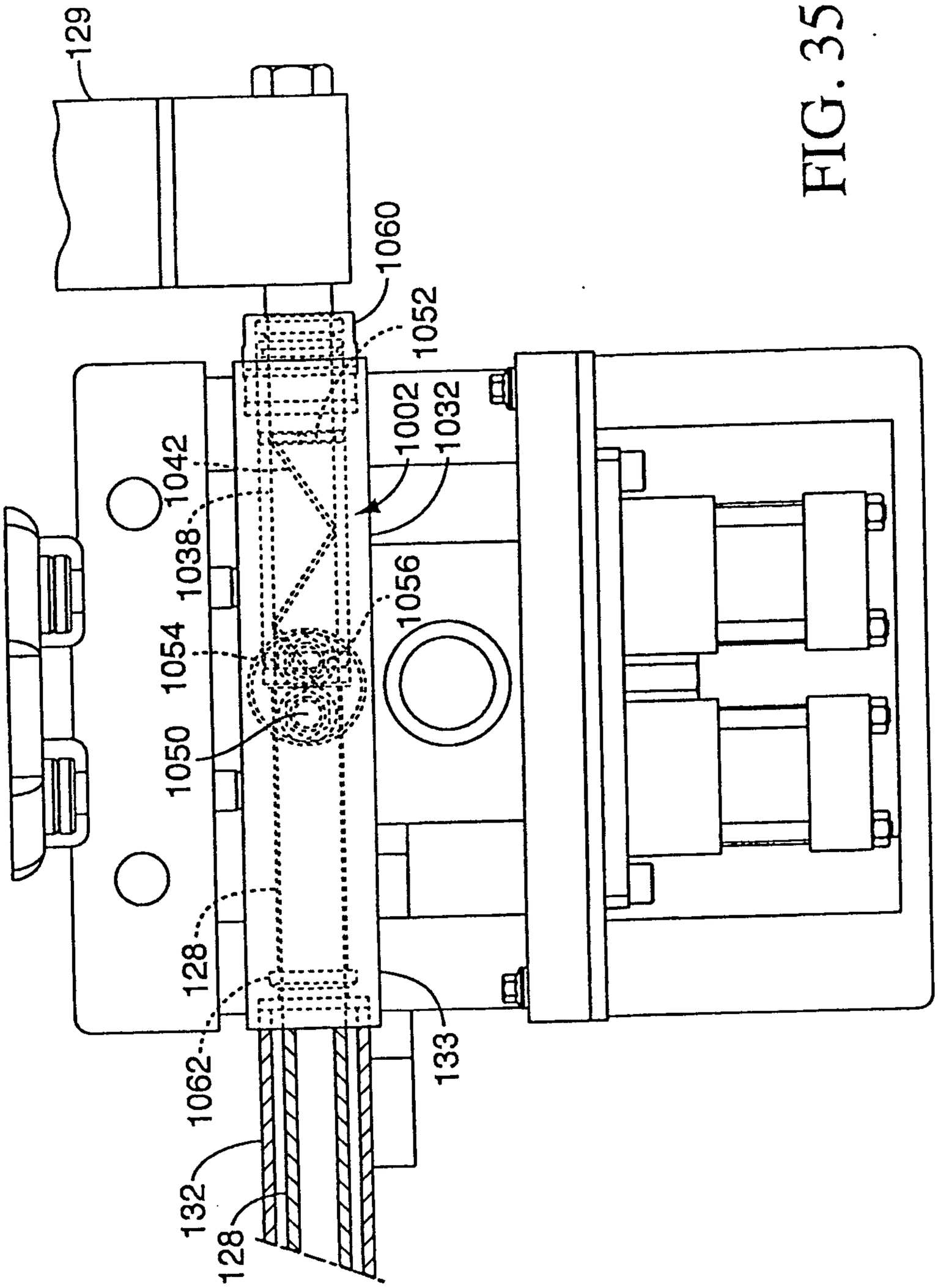

129
1060
1052
1002
1032
1042
1038
1056
1054
1050
128
1062
133
132
128

FIG. 35

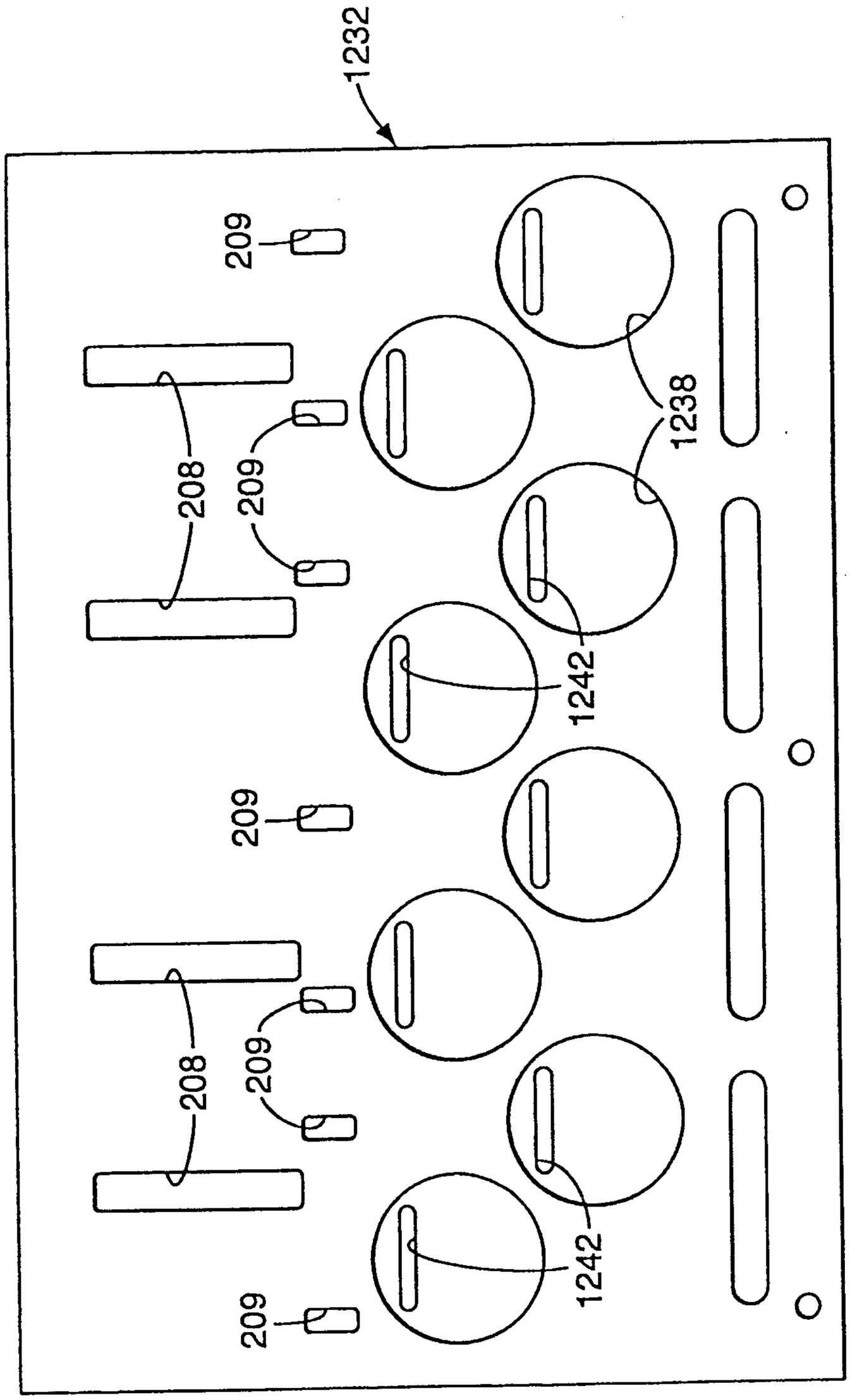


FIG. 36

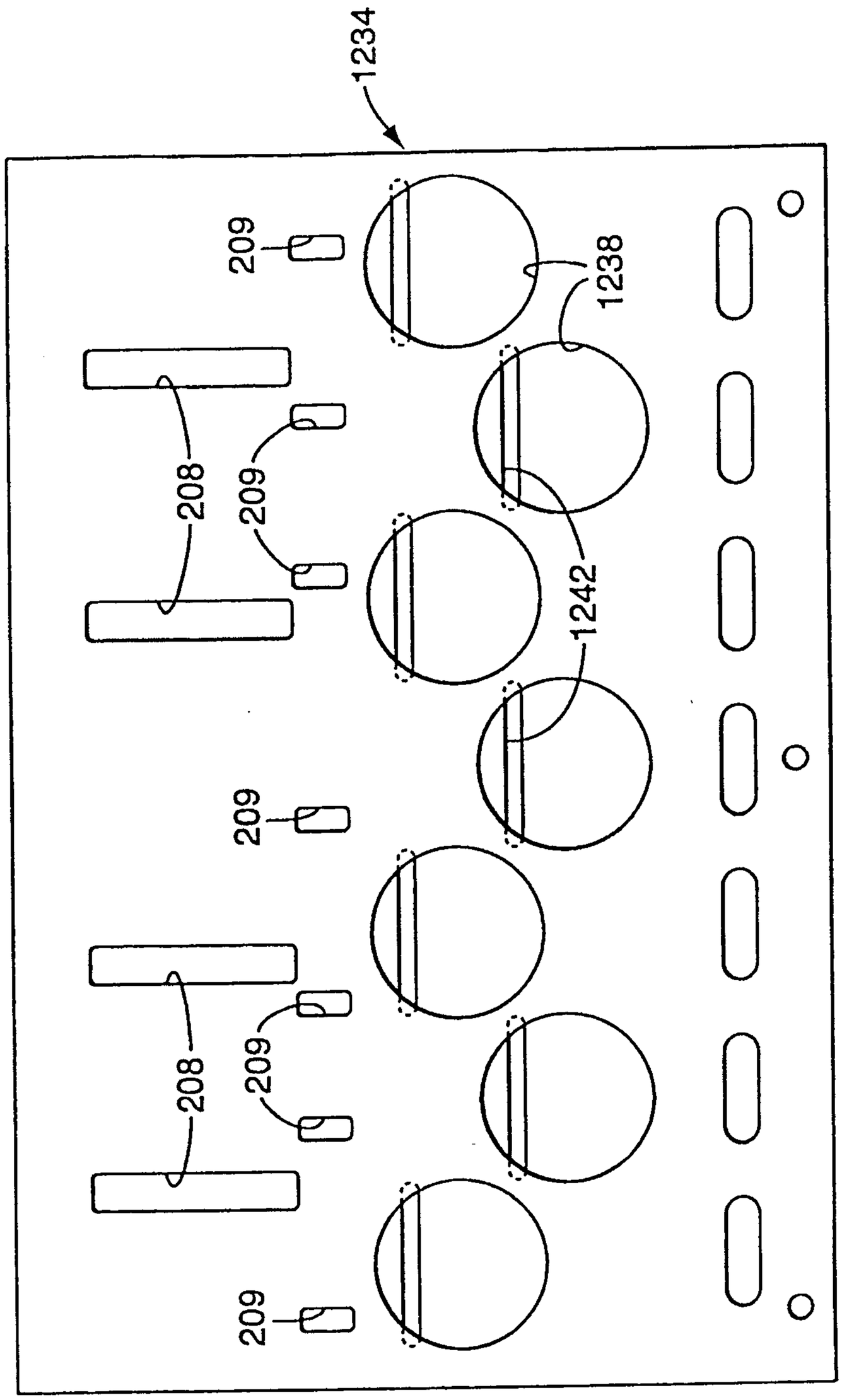


FIG. 37

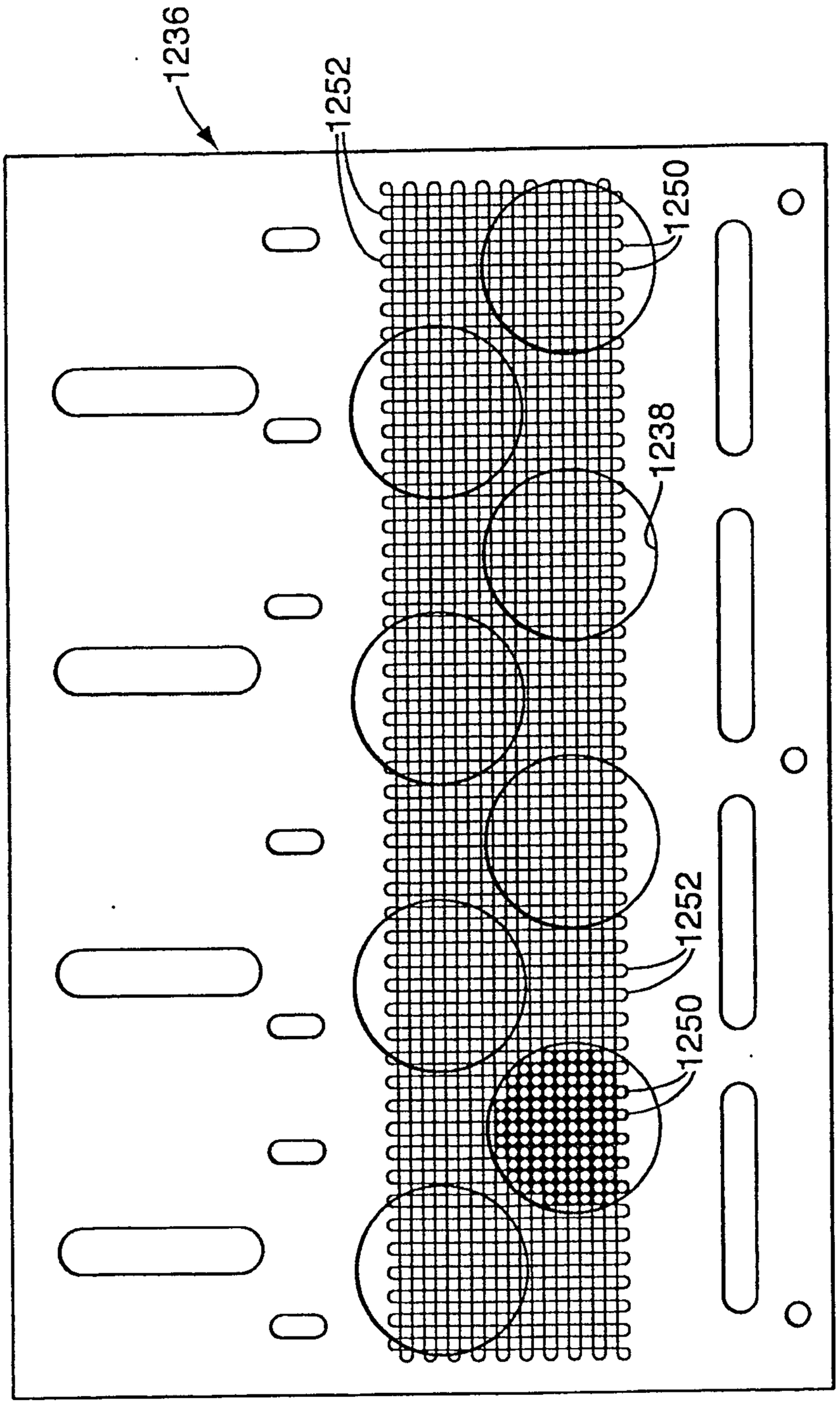


FIG. 38

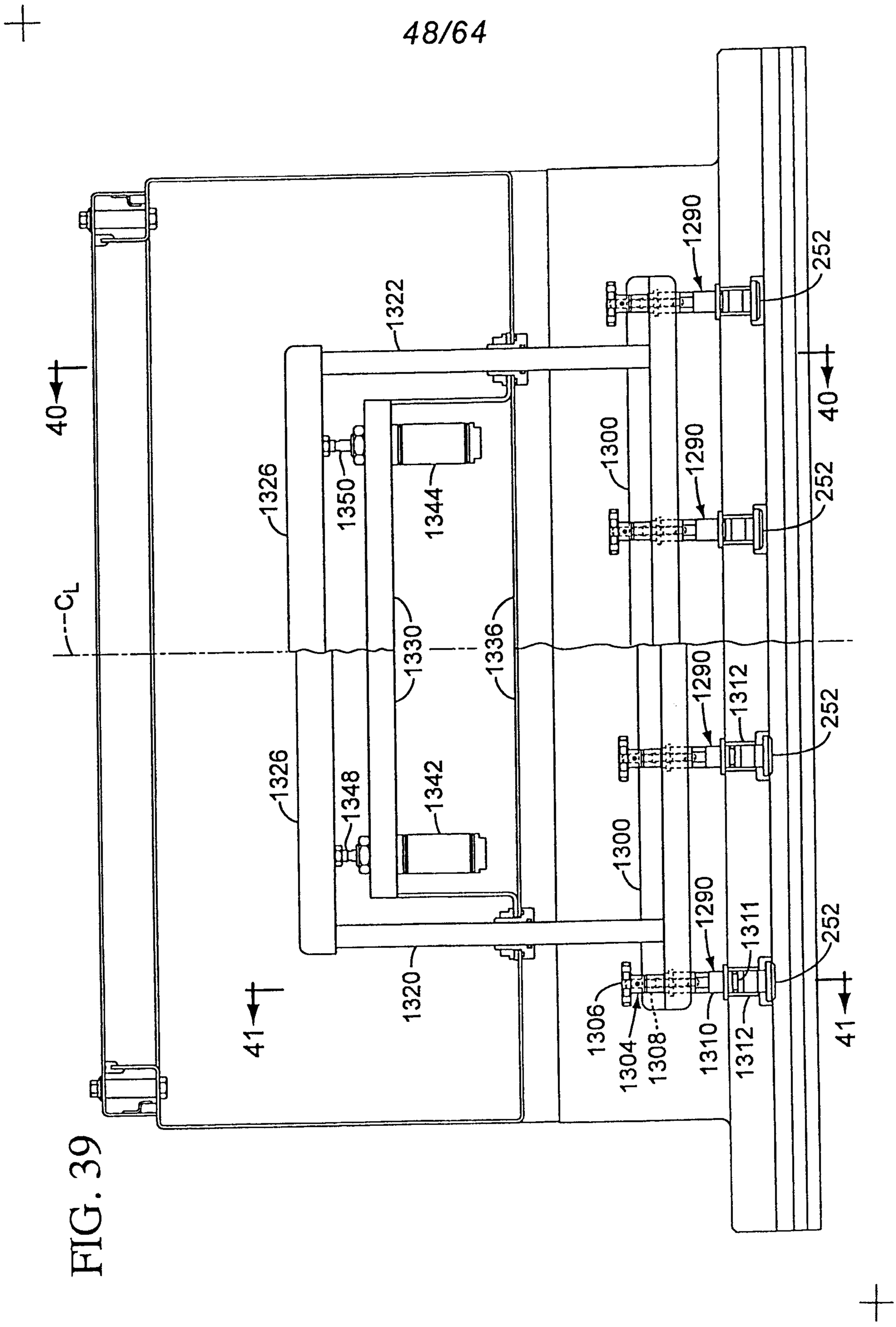

48/64
40
C_L
1322
1326
1350
1344
1330
1336
1348
1342
1320
41
1306
1304
1308
1310
1312
1311
1290
1300
252

FIG. 39

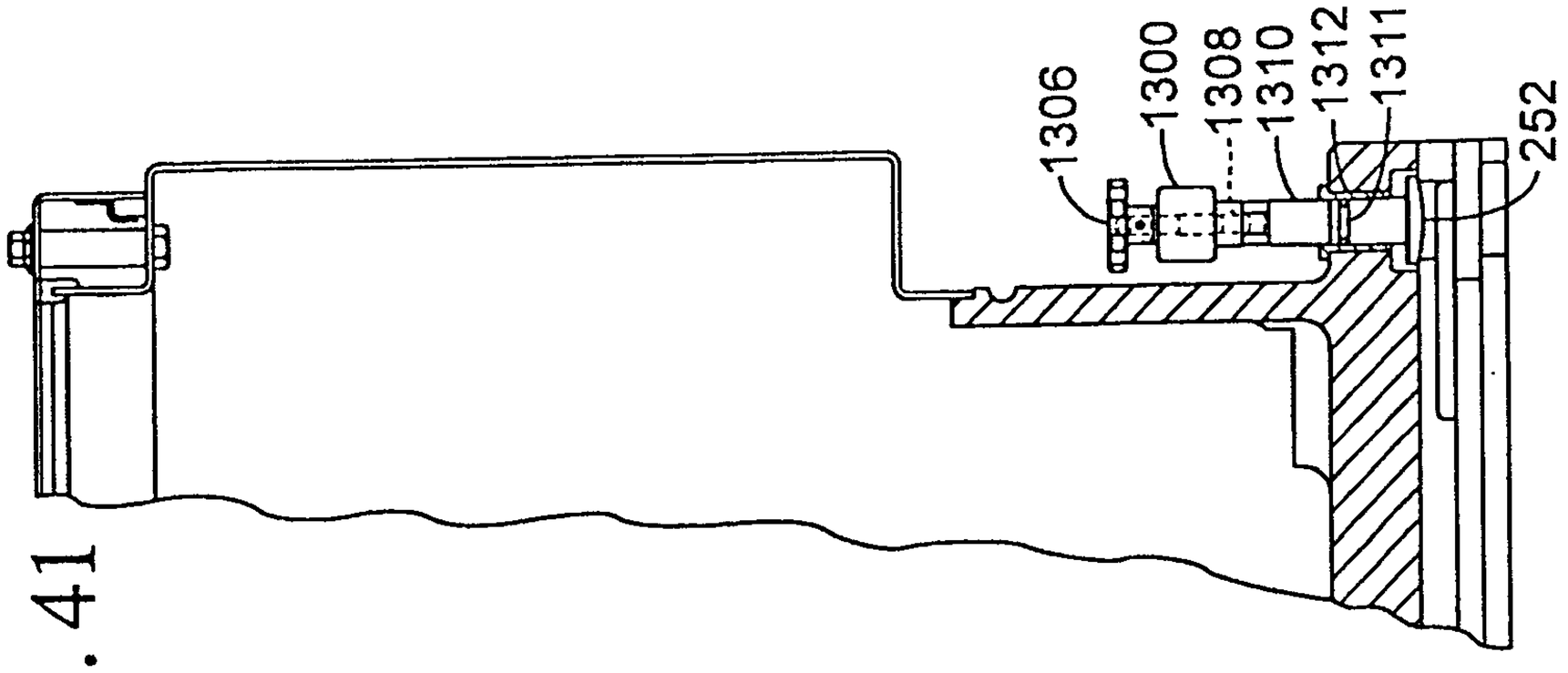


FIG. 41

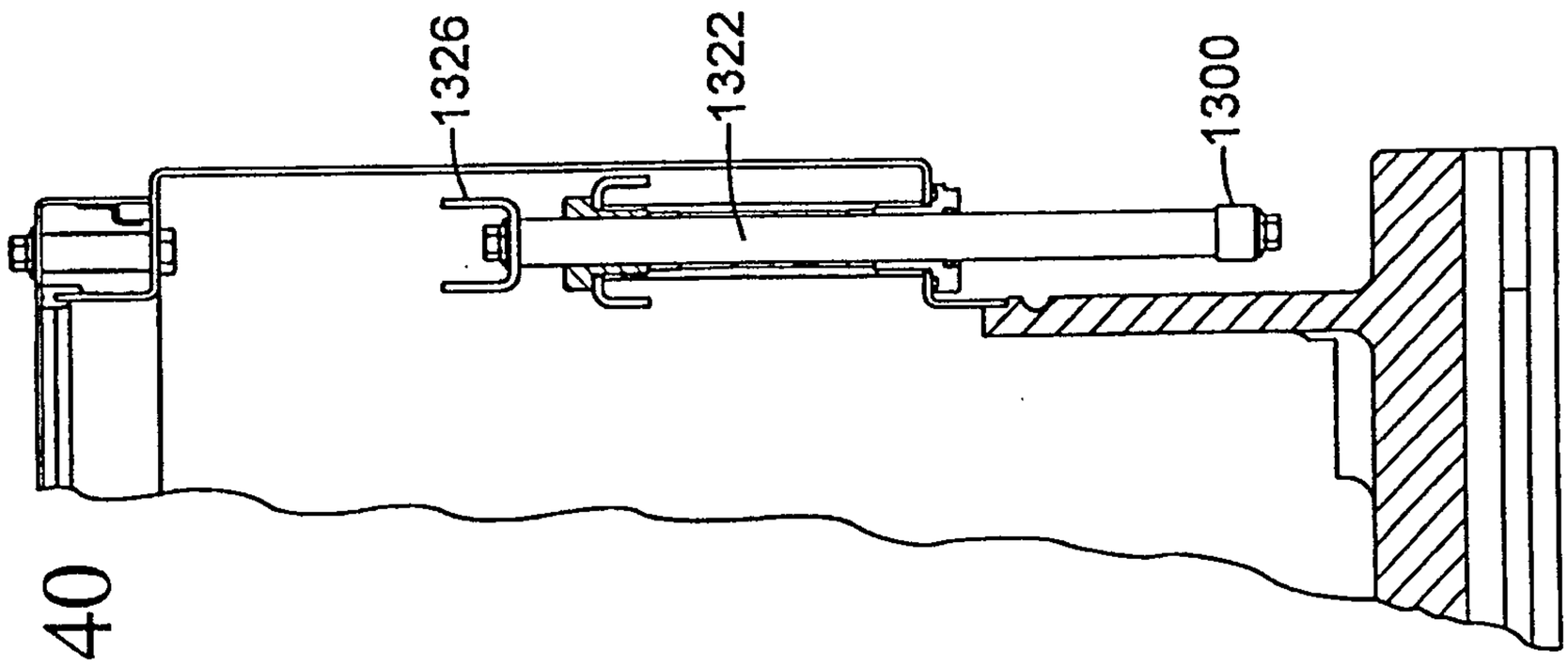


FIG. 40

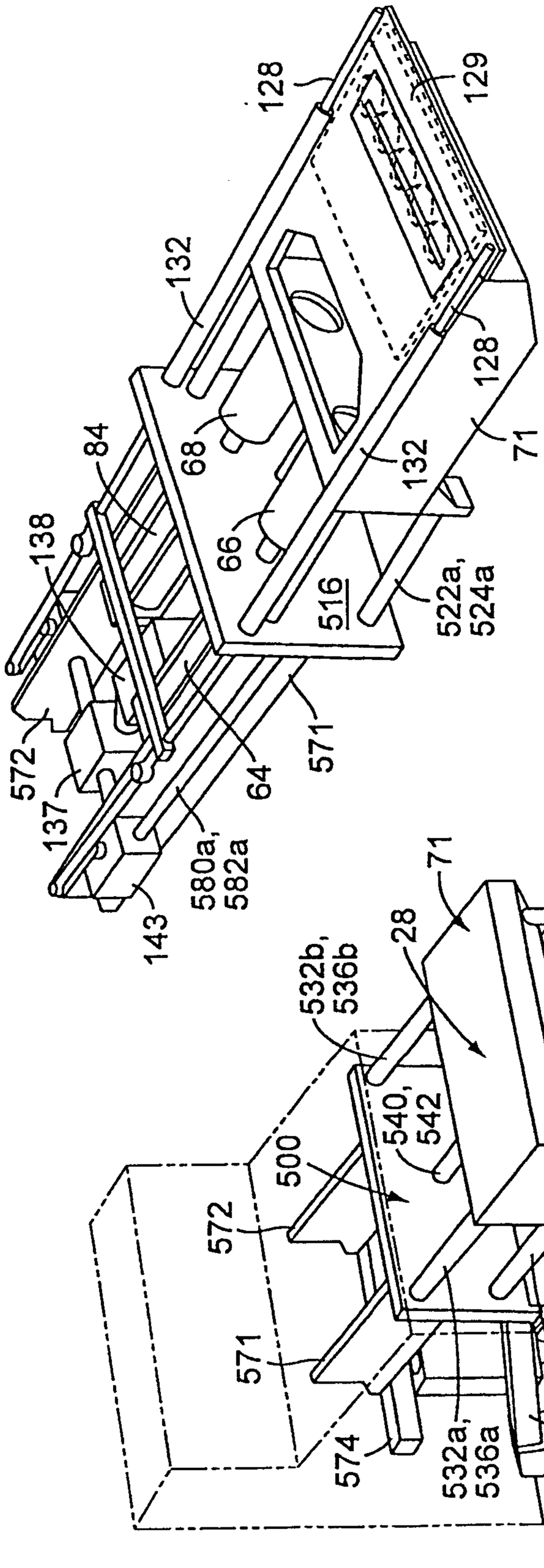

128
129
132
84
68
138
66
516
522a,
524a
71
572
137
64
571
580a,
582a
143
28
532b,
536b
540,
542
500
572
571
574
532a,
536a
510a
532
522a,
524a
530a
512a
530b
531a
21a
531b
512b

FIG. 43

FIG. 42

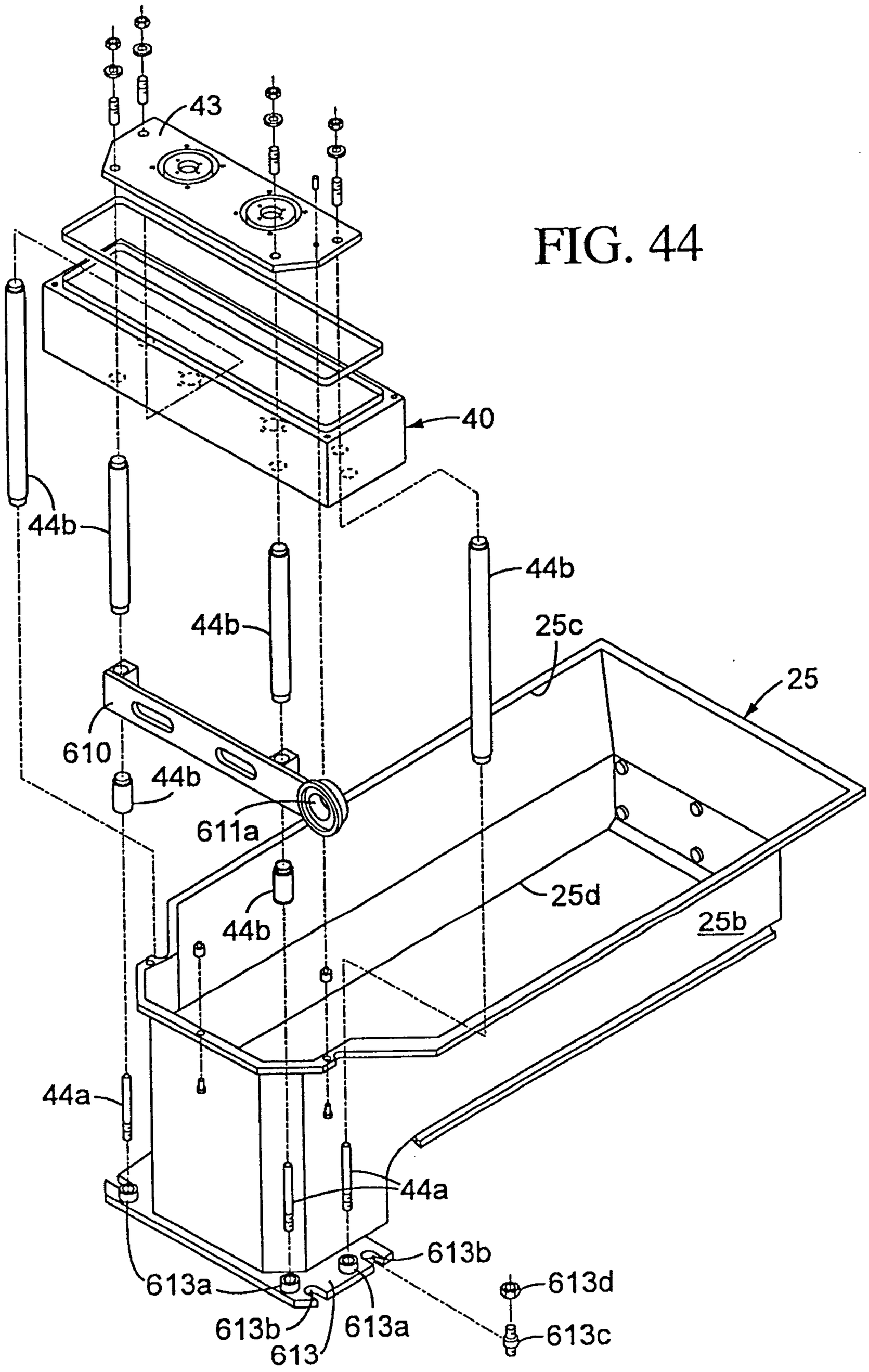

43
40
44b
44b
44b
44b
25c
25
610
44b
611a
44b
25d
25b
44a
44a
613b
613d
613a
613b
613
613a
613c

FIG. 44

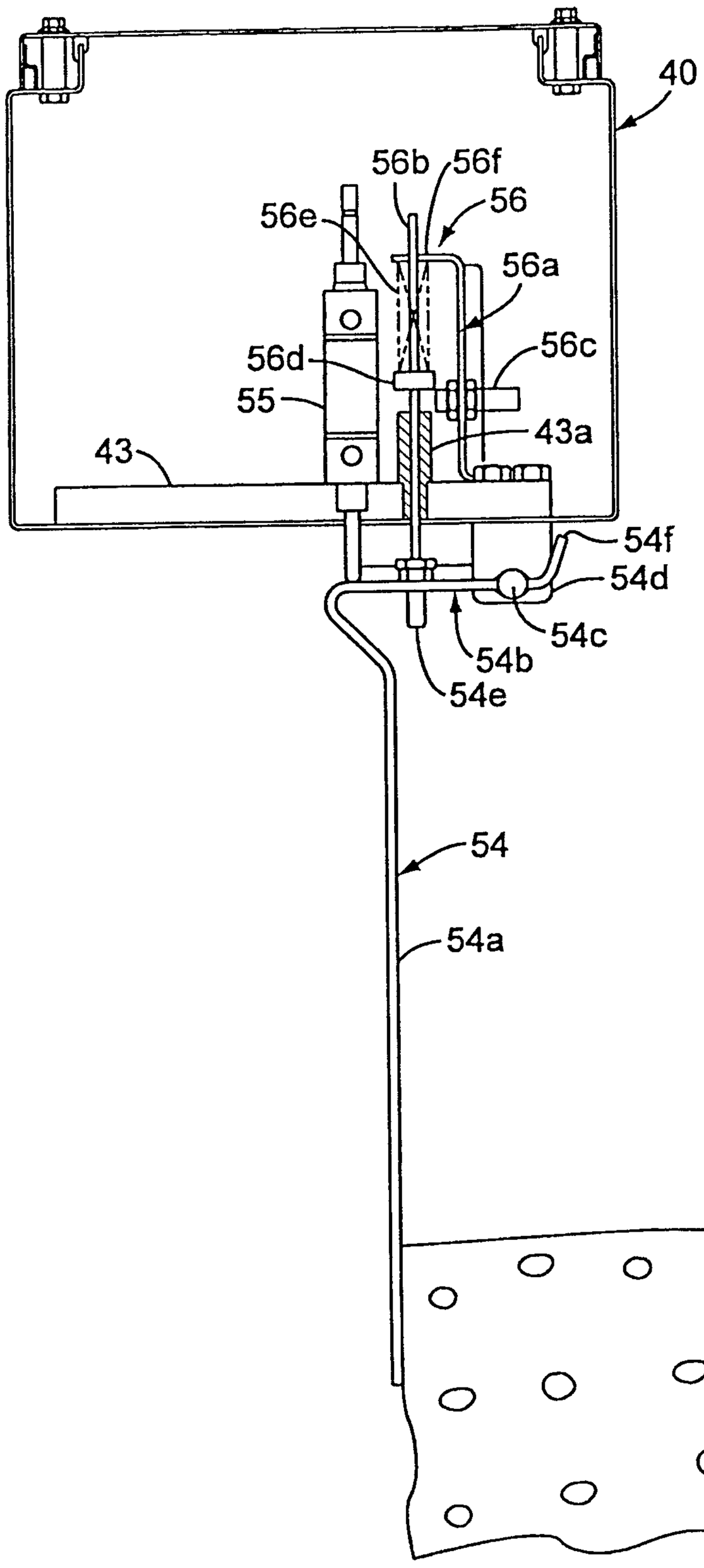


FIG. 45

53/64

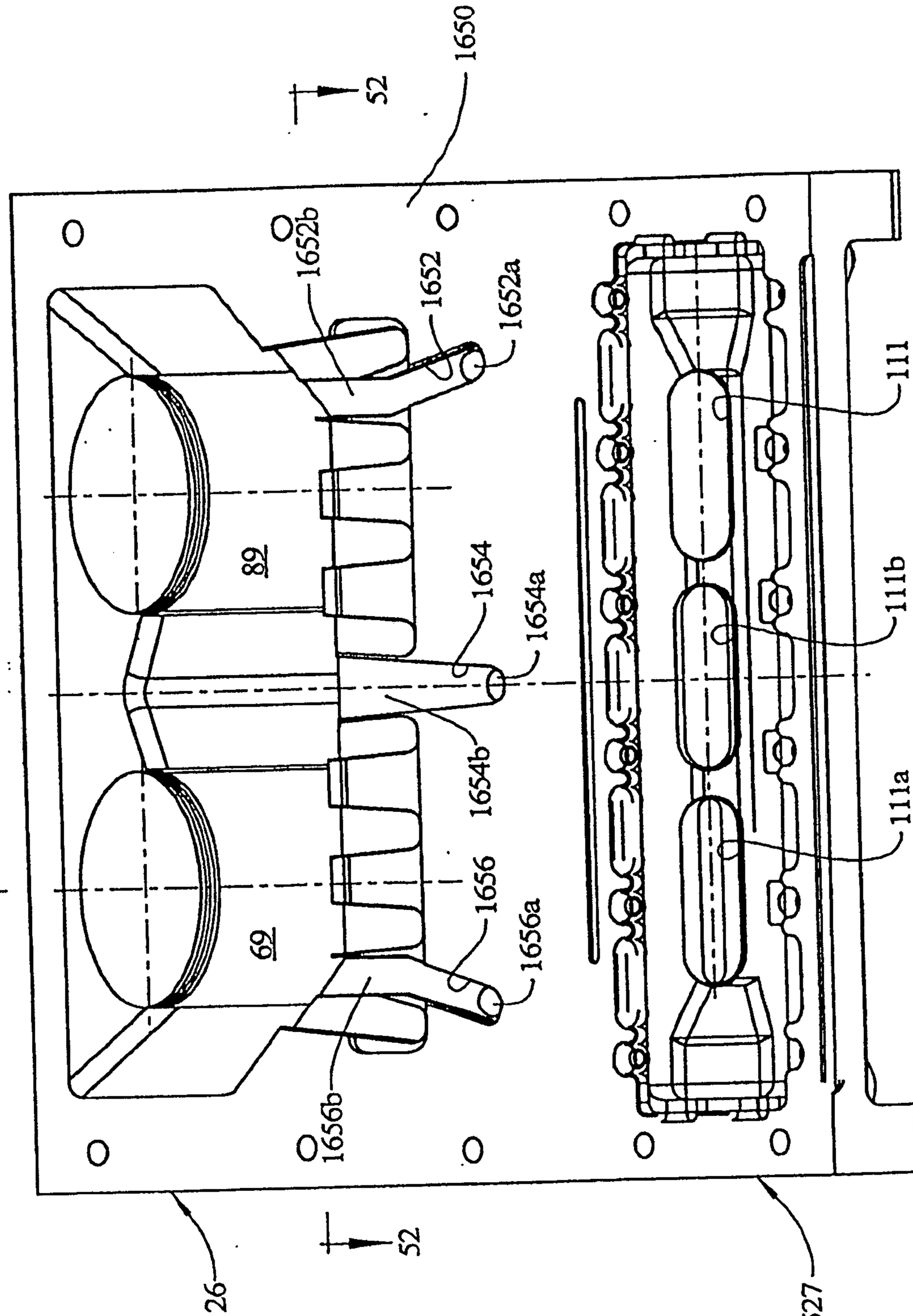

1650
52
1652b
1652
1652a
89
1654
1654a
1654b
1656
1656a
1656b
69
111
111b
111a
47
47
52
26
527

FIG. 46

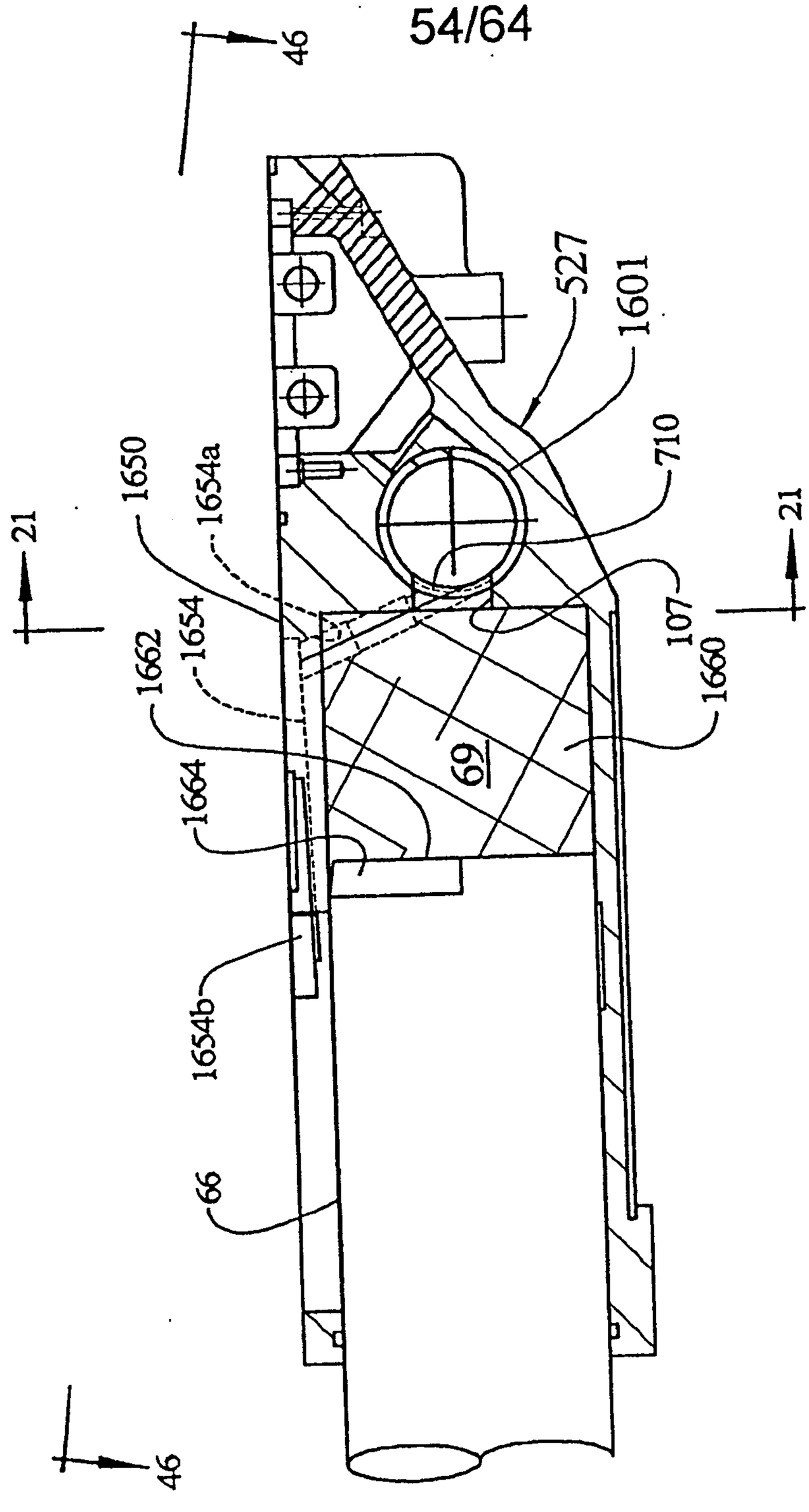

46
527
1601
710
21
1650
1654a
1654
1662
1664
69
107
1660
21
1654b
66
46

FIG. 47

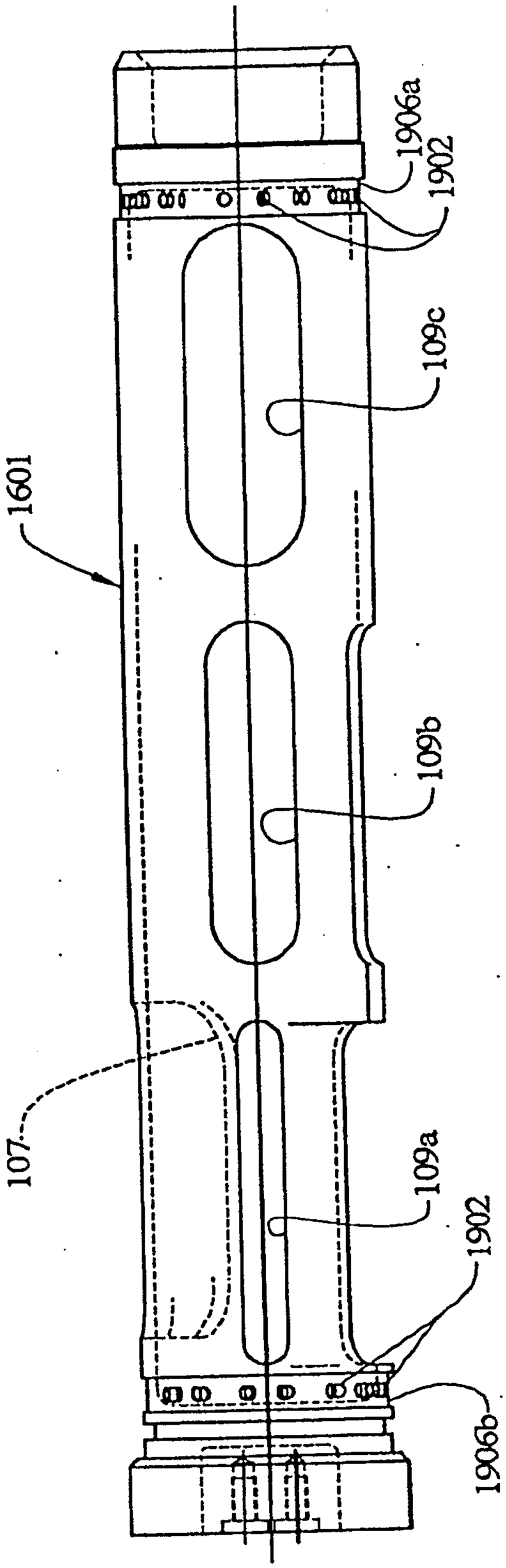

1601
107
109a
1902
1906b
109b
109c
1902
1906a

FIG. 48

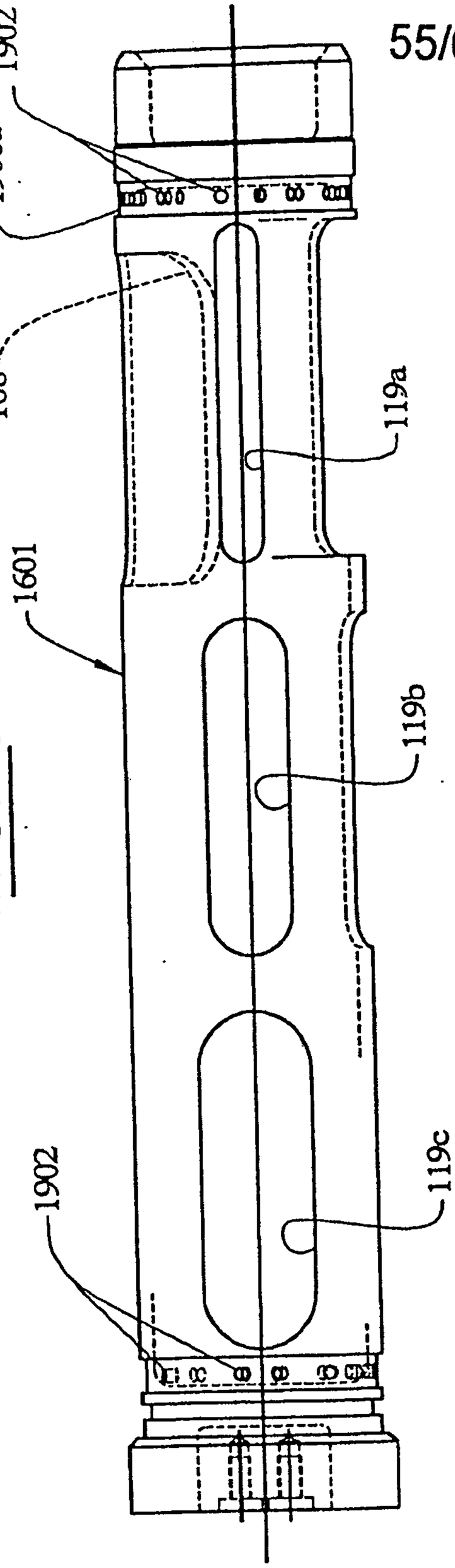

1601
108
1902
1906a
119a
119b
119c
1902

FIG. 49

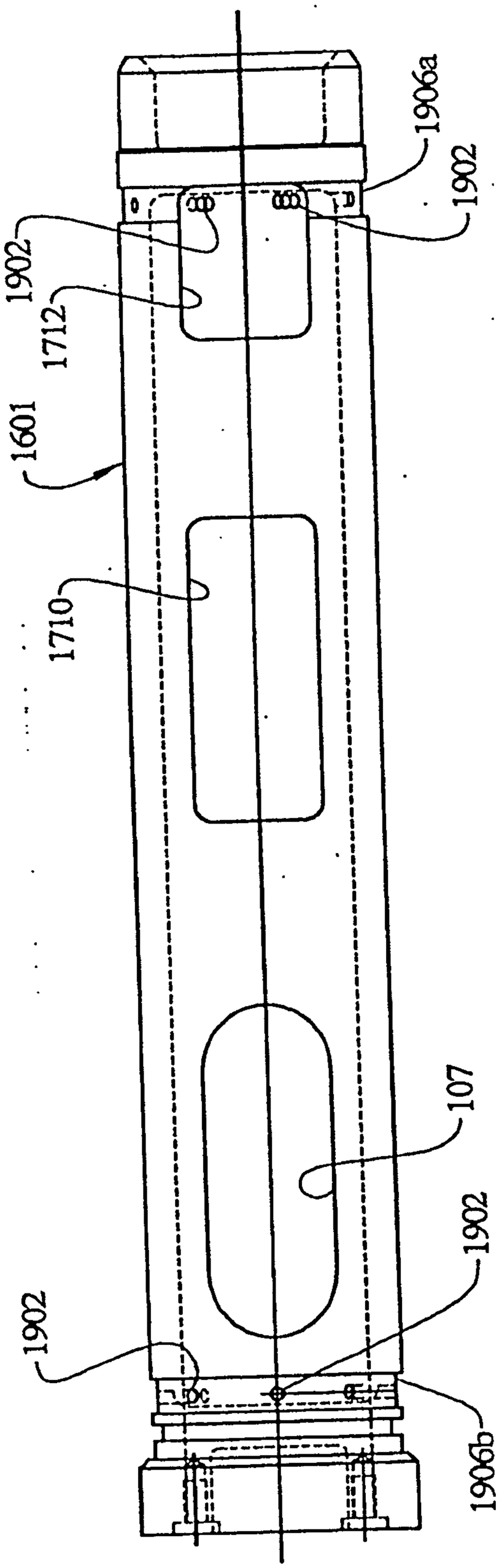

1906a
1902
1902
1712
1601
1710
107
1902
1902
1906b

FIG. 50

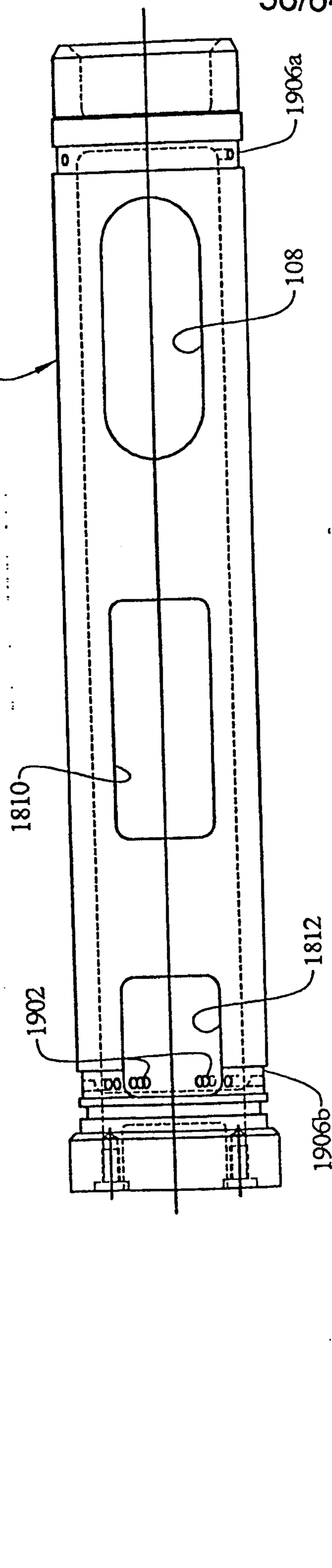

1906a
108
1601
1810
1812
1902
1906b

FIG. 51

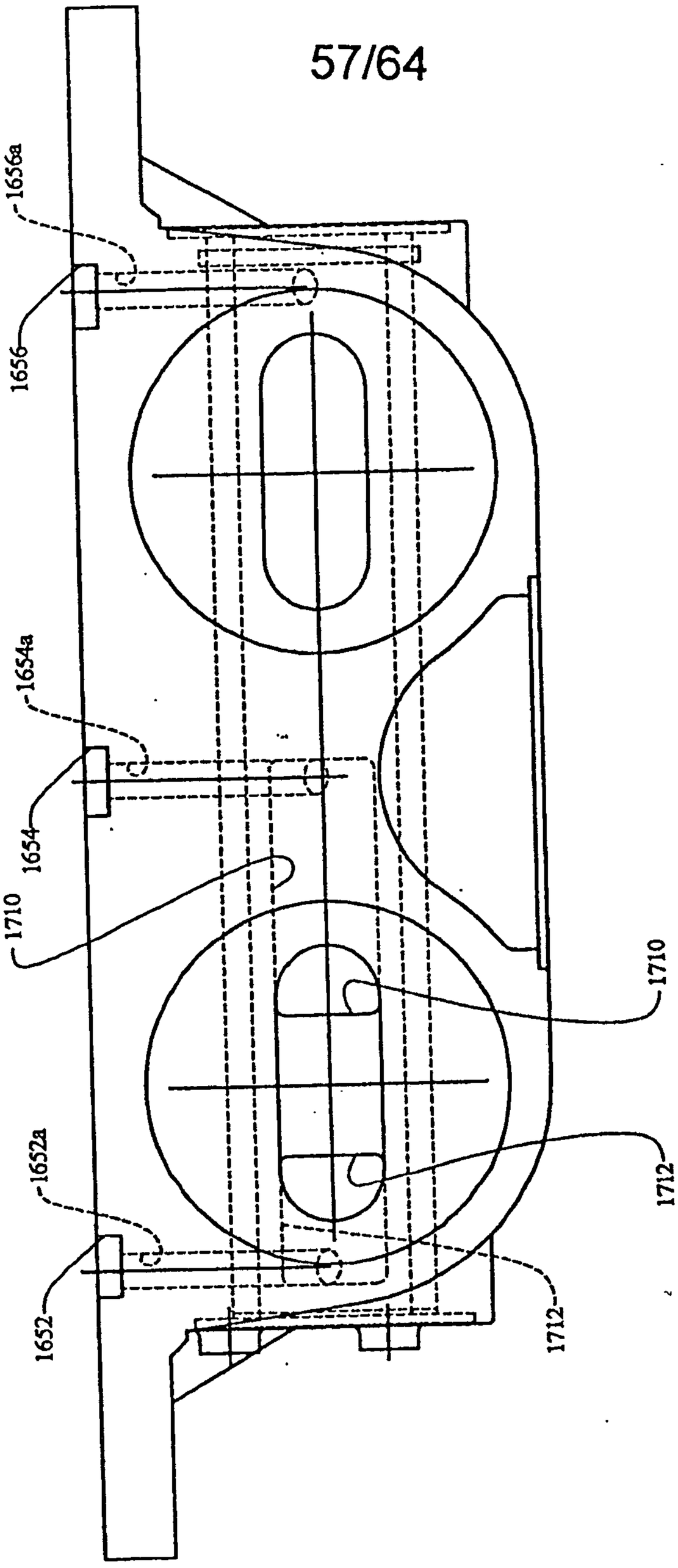


FIG. 52

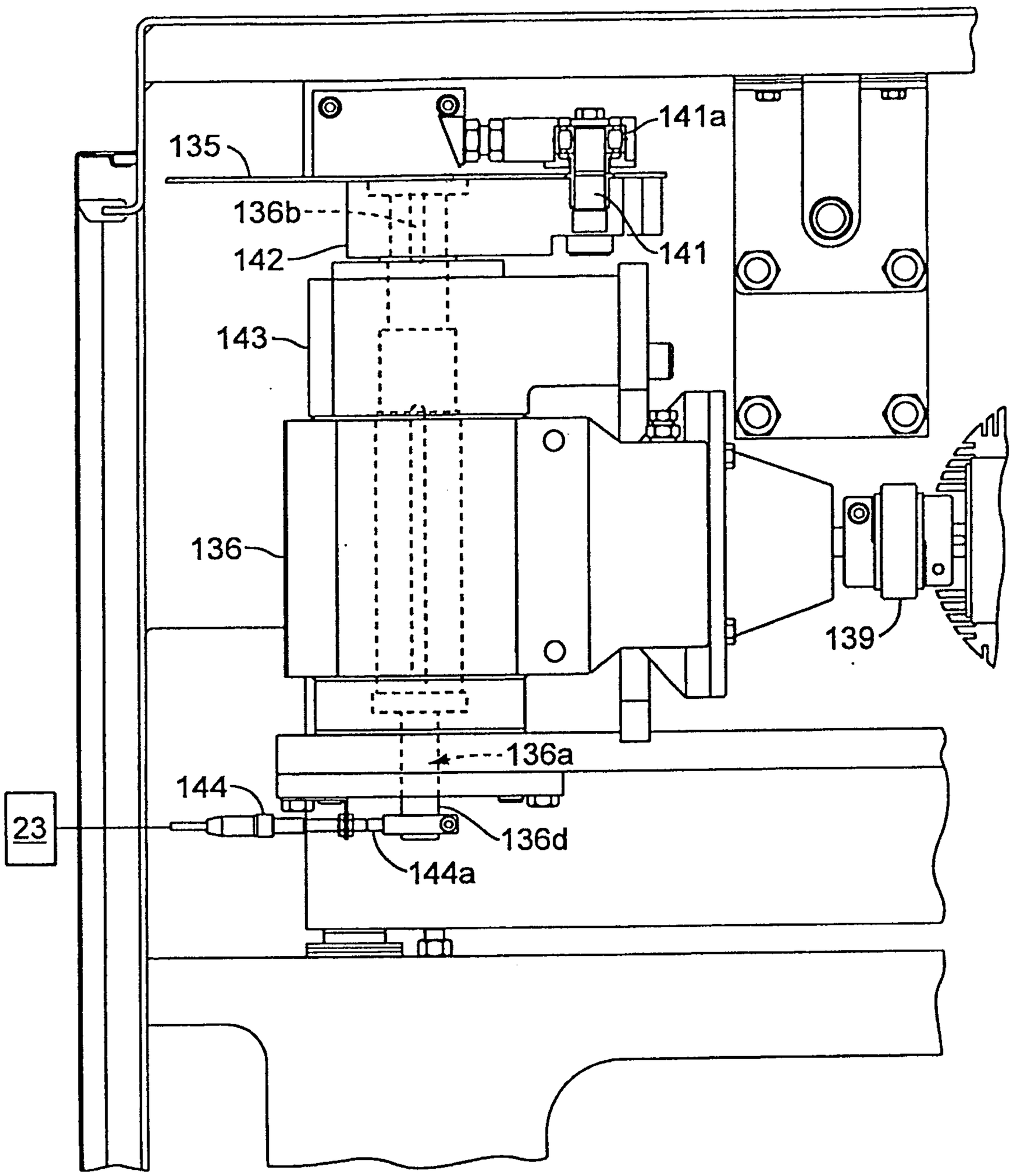


FIG. 53

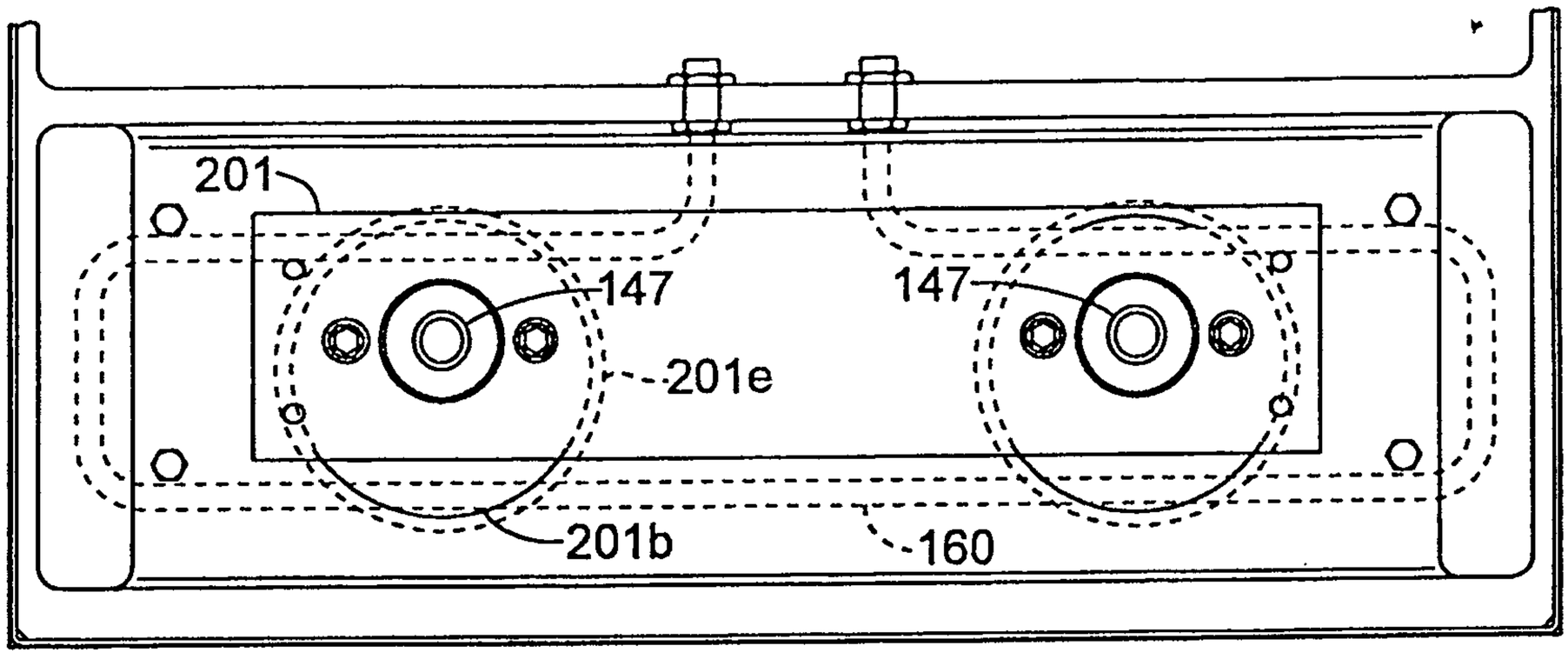


FIG. 54A

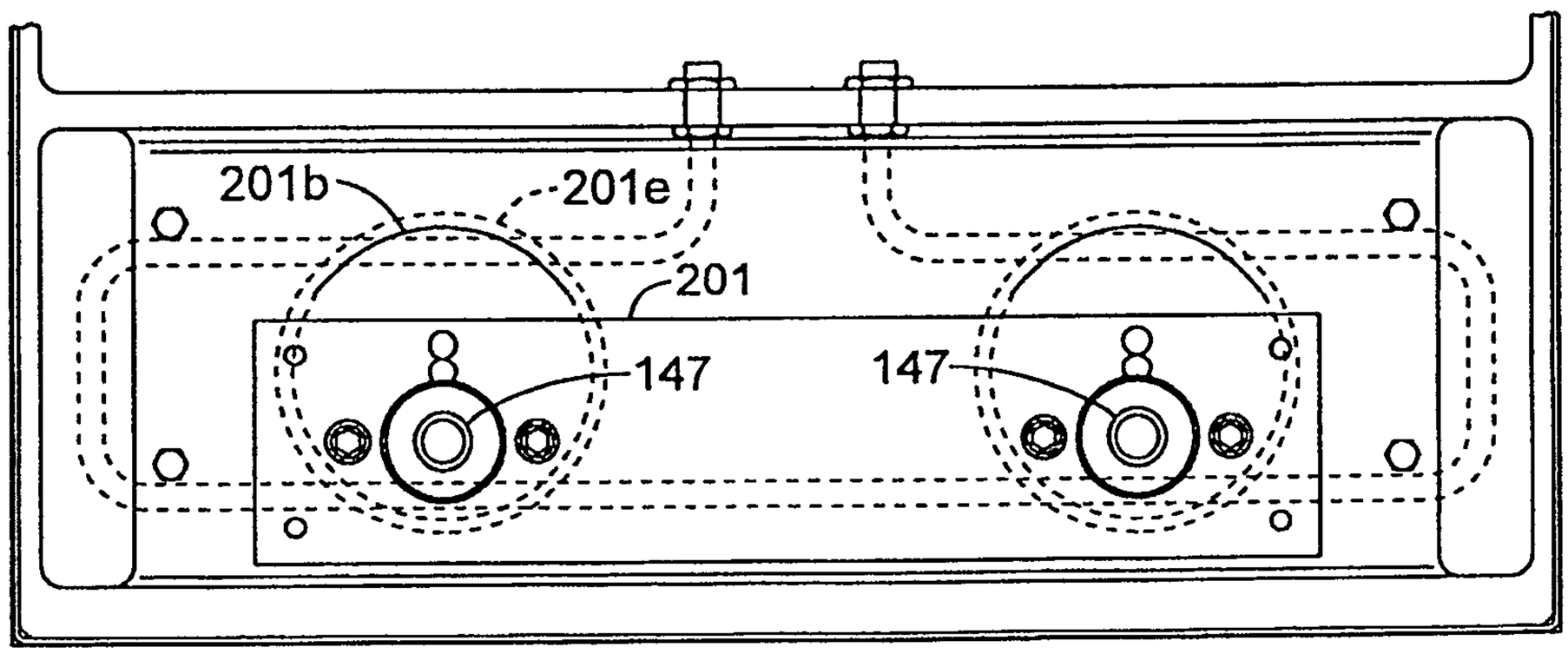


FIG. 54B

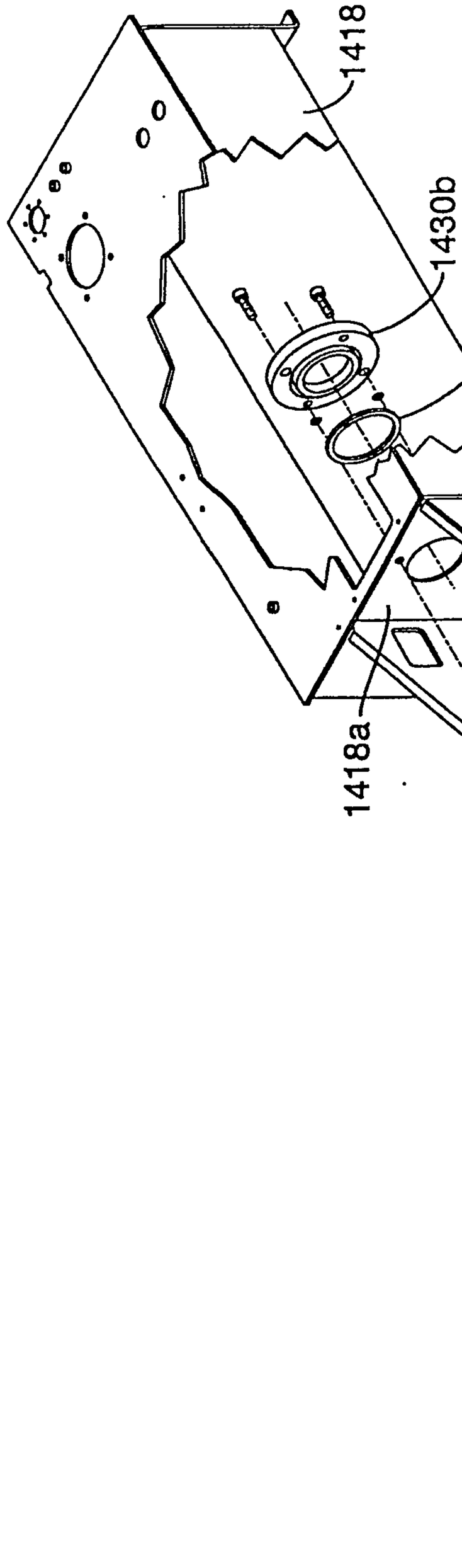
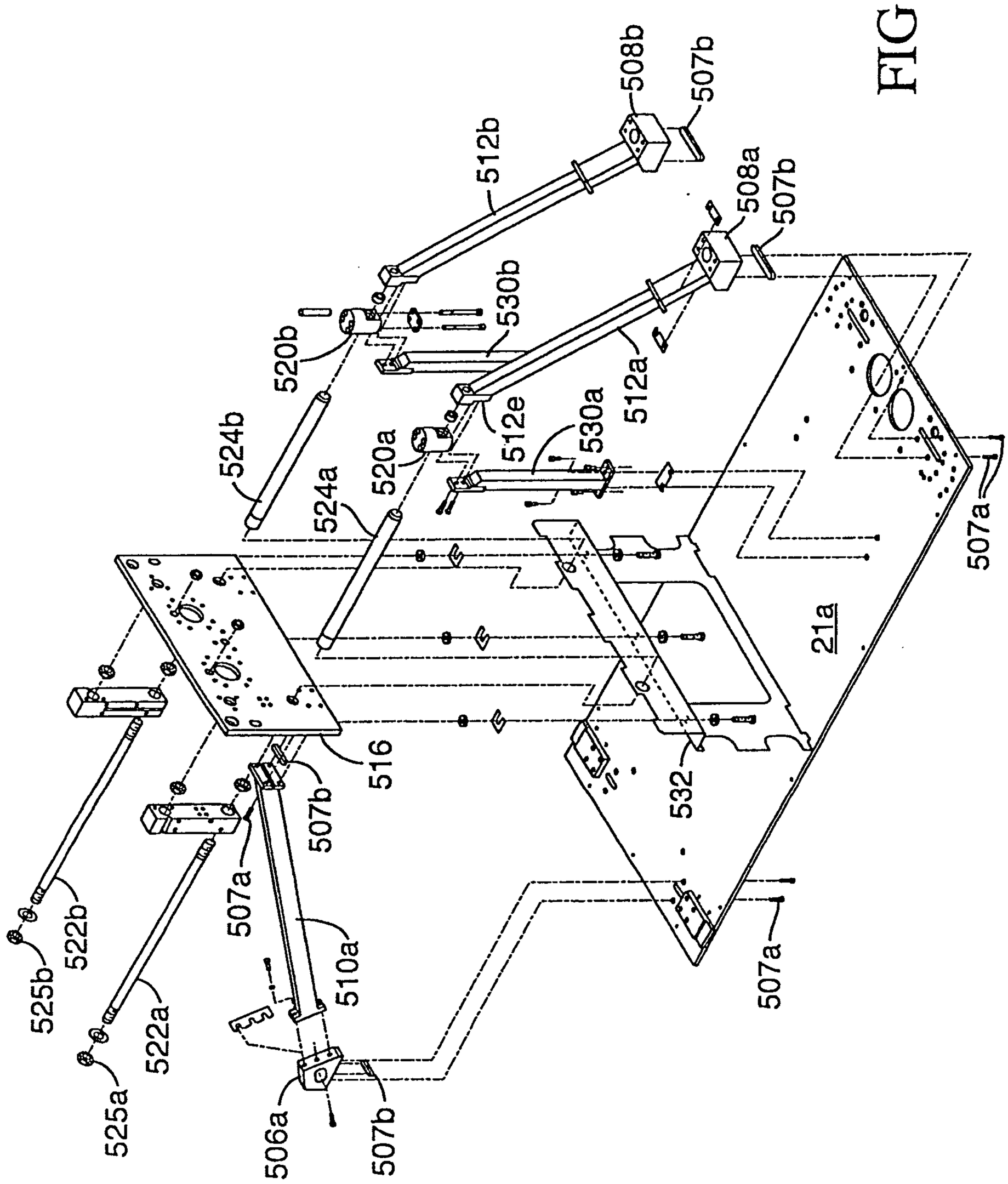


FIG. 55

FIG. 56


508b
507b
512b
508a
507b
530b
520b
512a
524b
512e
530a
520a
524a
21a
516
507b
507a
532
522b
507a
510a
525b
522a
507a
525a
506a
507b

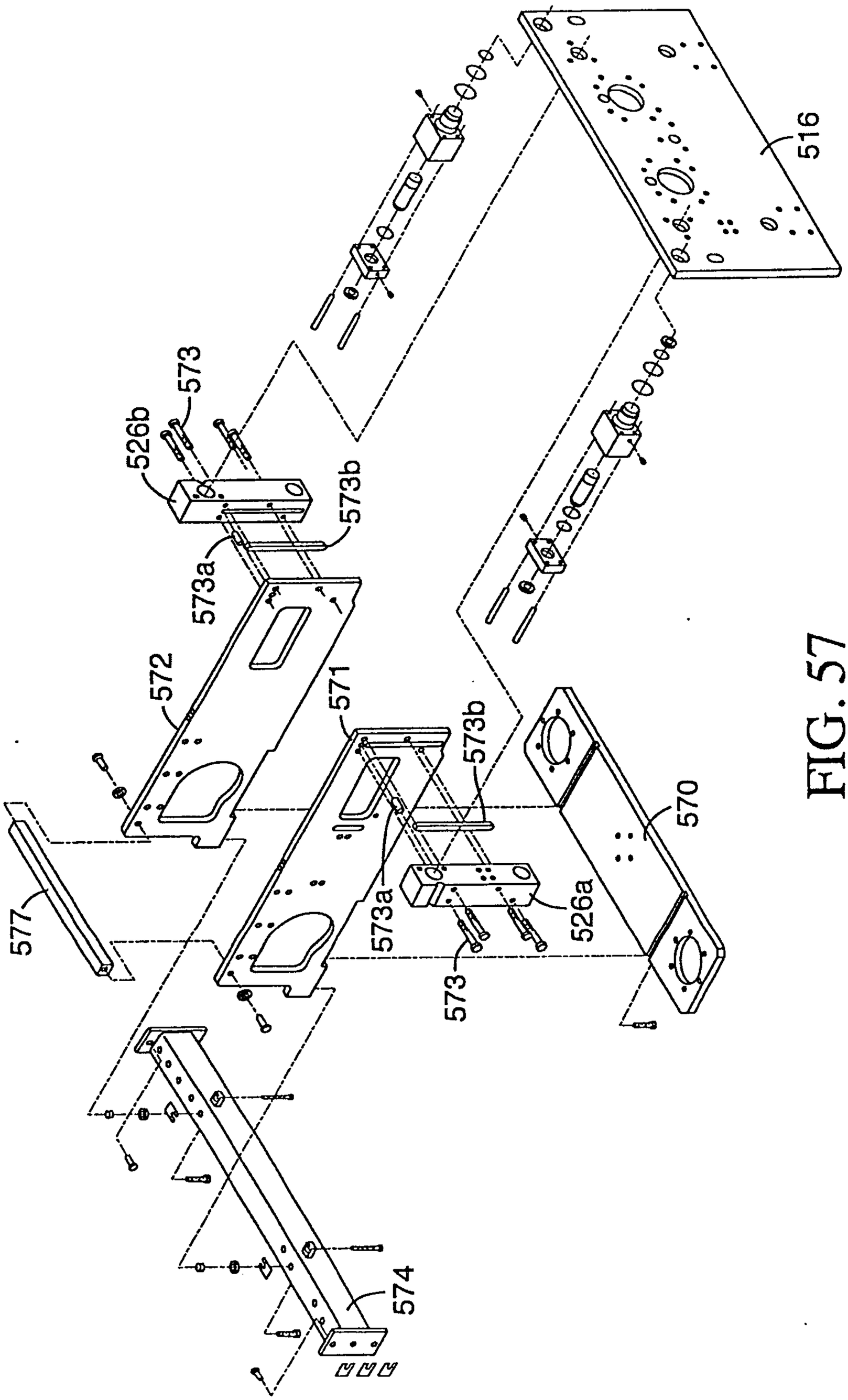


FIG. 57

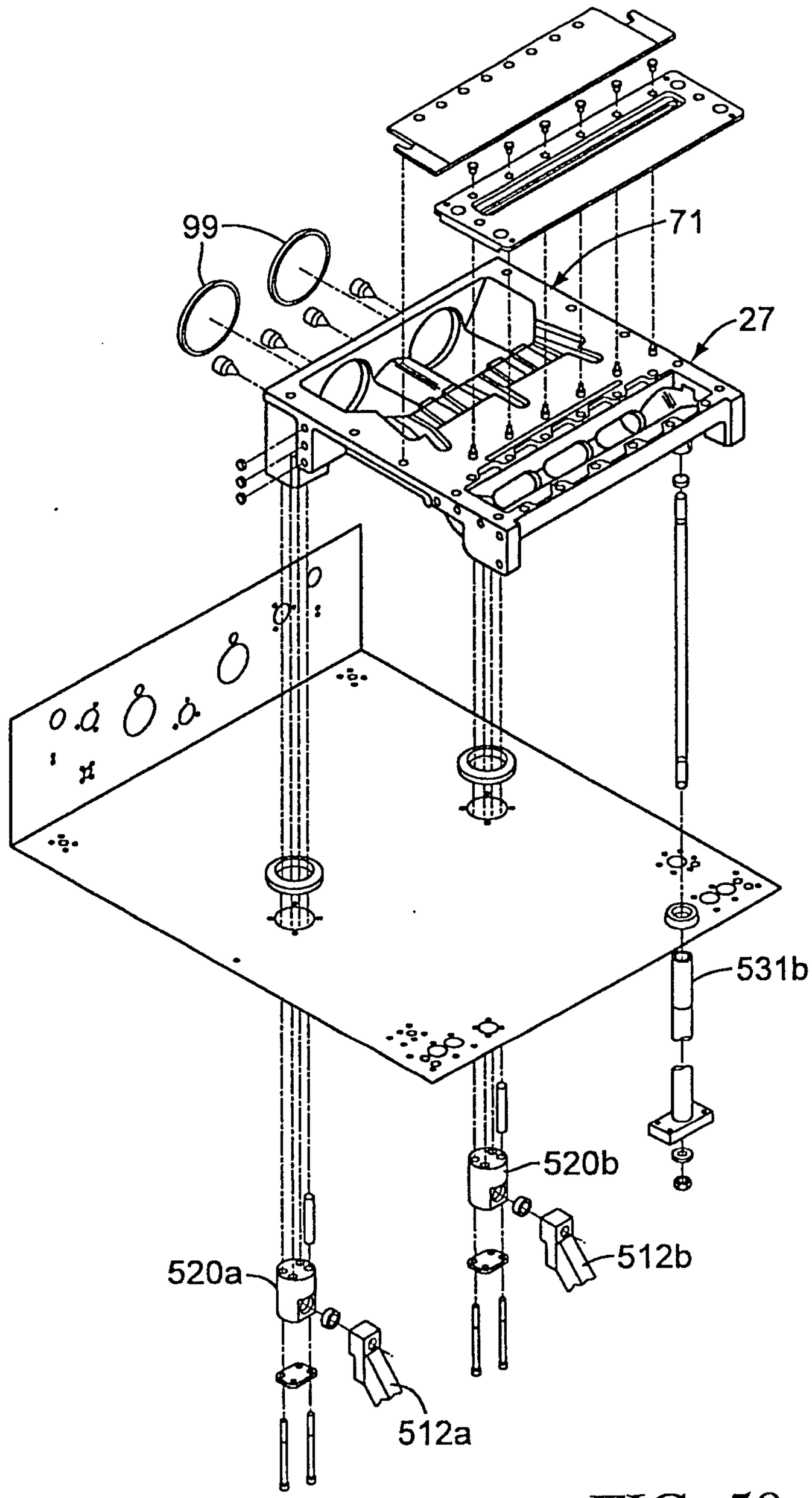


FIG. 58

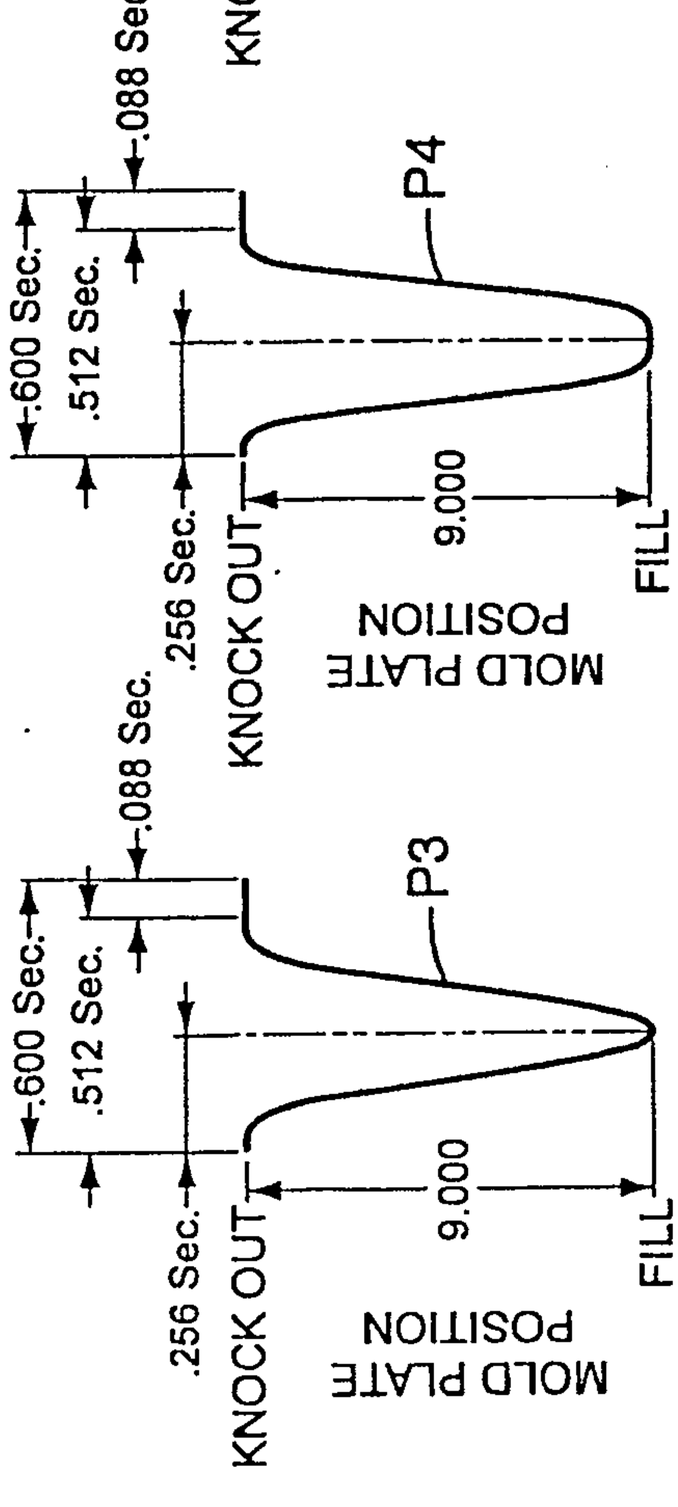


FIG. 63

FIG. 62

FIG. 61

FIG. 60

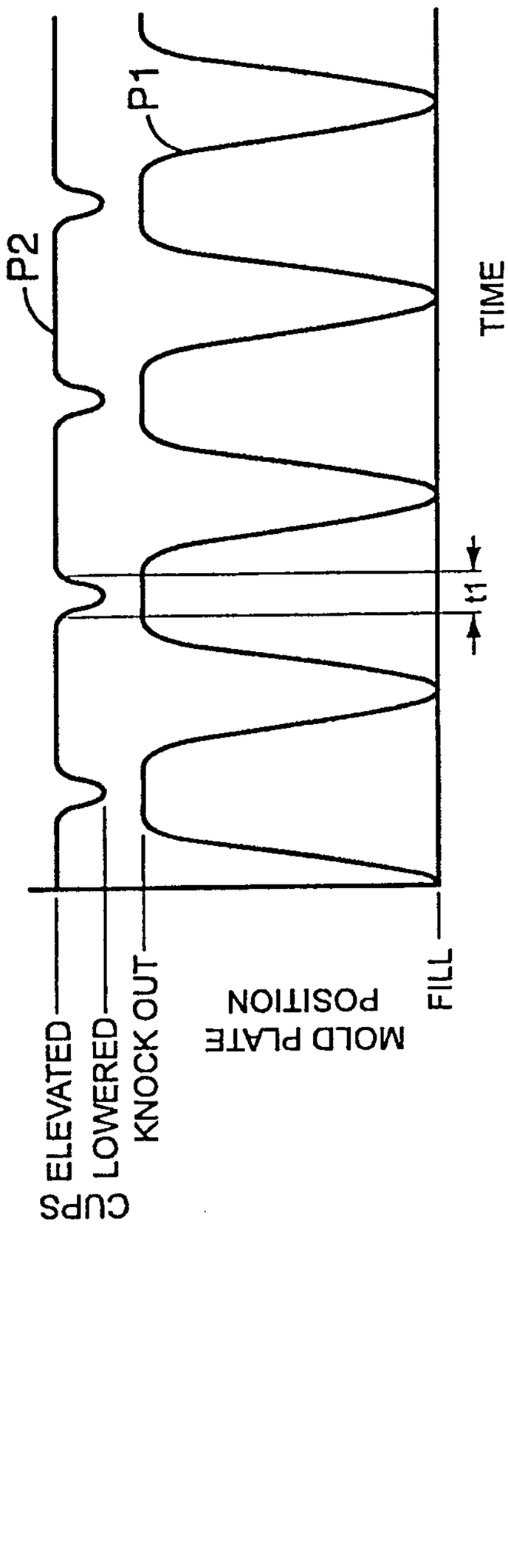
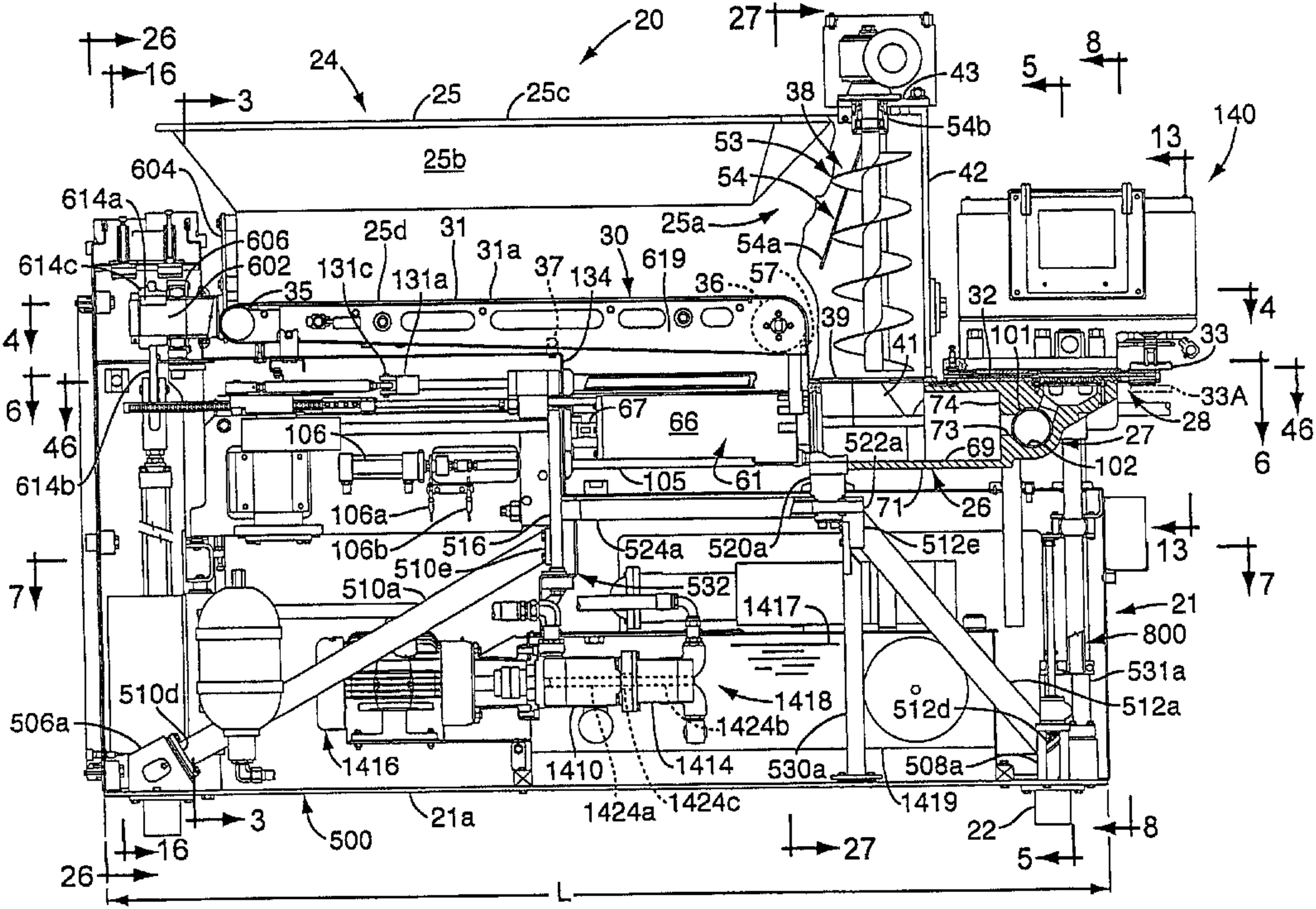


FIG. 59


20
24
25
25c
25b
25a
25d
26
16
3
27
43
38
5
8
54b
53
54
42
140
13
604
614a
606
602
614c
35
131c
131a
31
31a
37
134
30
619
36
57
54a
39
32
101
33
4
6
46
614b
67
66
106
105
61
74
73
69
522a
33A
28
27
102
71
26
106a
106b
516
510e
510a
524a
520a
532
1417
512e
21
800
531a
512a
510d
506a
1418
1424b
512d
1416
1410
1414
530a
508a
1419
1424a
1424c
21a
500
22
L