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(54) **HYDRAULIC DISTRIBUTOR FOR TOP CHARGING A BLAST FURNACE**

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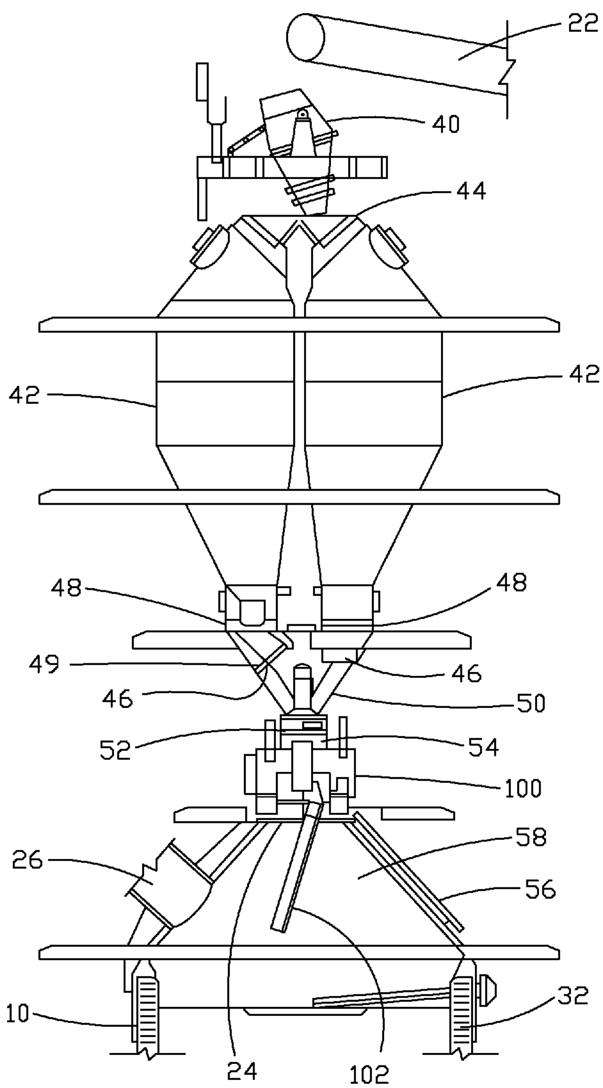
(57) **ABSTRACT**

A hydraulic distributor for safely and efficiently top charging a bell-less blast furnace. The hydraulic distributor includes a main housing, an inner ring, a trunnion, and an actuator ring, which act together to lift and rotate the distributor chute. Hydraulic tilt cylinders operatively coupled to the inner ring act to lift the distributor chute to change tilt. Rotational Drives operatively coupled to the trunnion act to rotate the distributor chute. The hydraulic distributor provides improved repeatability and precision control of the distributor chute, and hence the placement of burden materials within the blast furnace resulting in improved productivity and operation of the furnace. The hydraulic distributor provides a less complex design and construction resulting in reduced costs for manufacturing and maintenance.



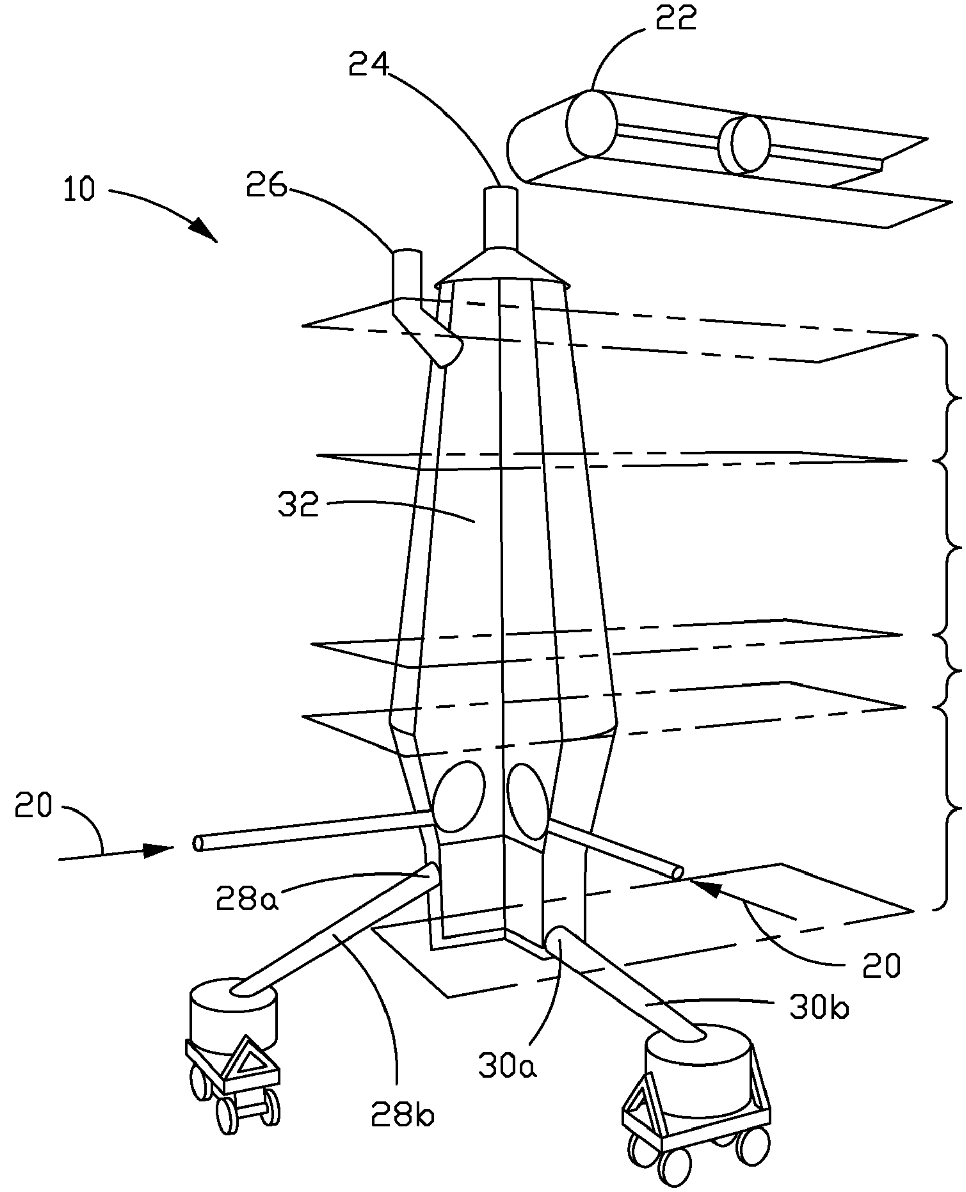


FIG. 1

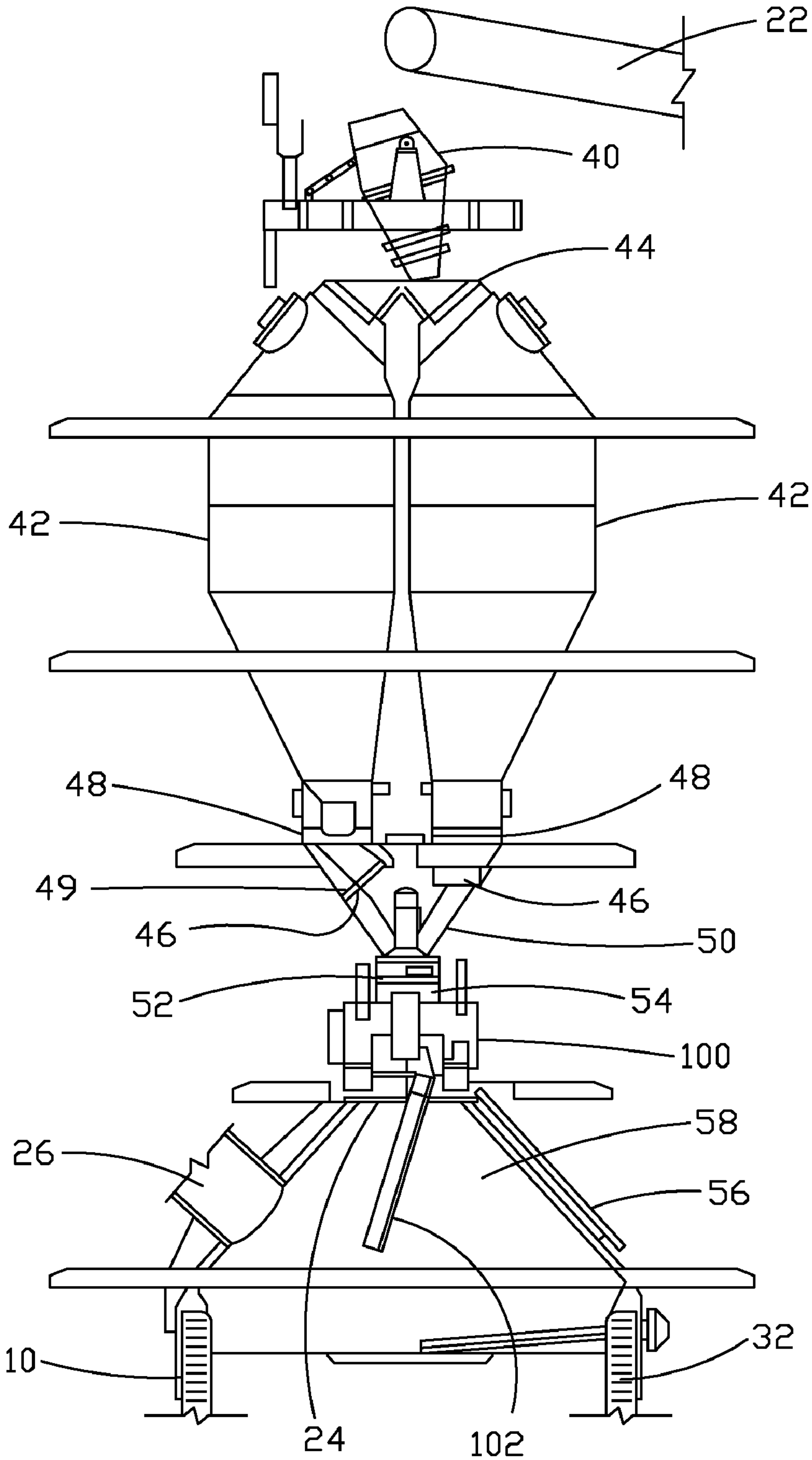


FIG. 2

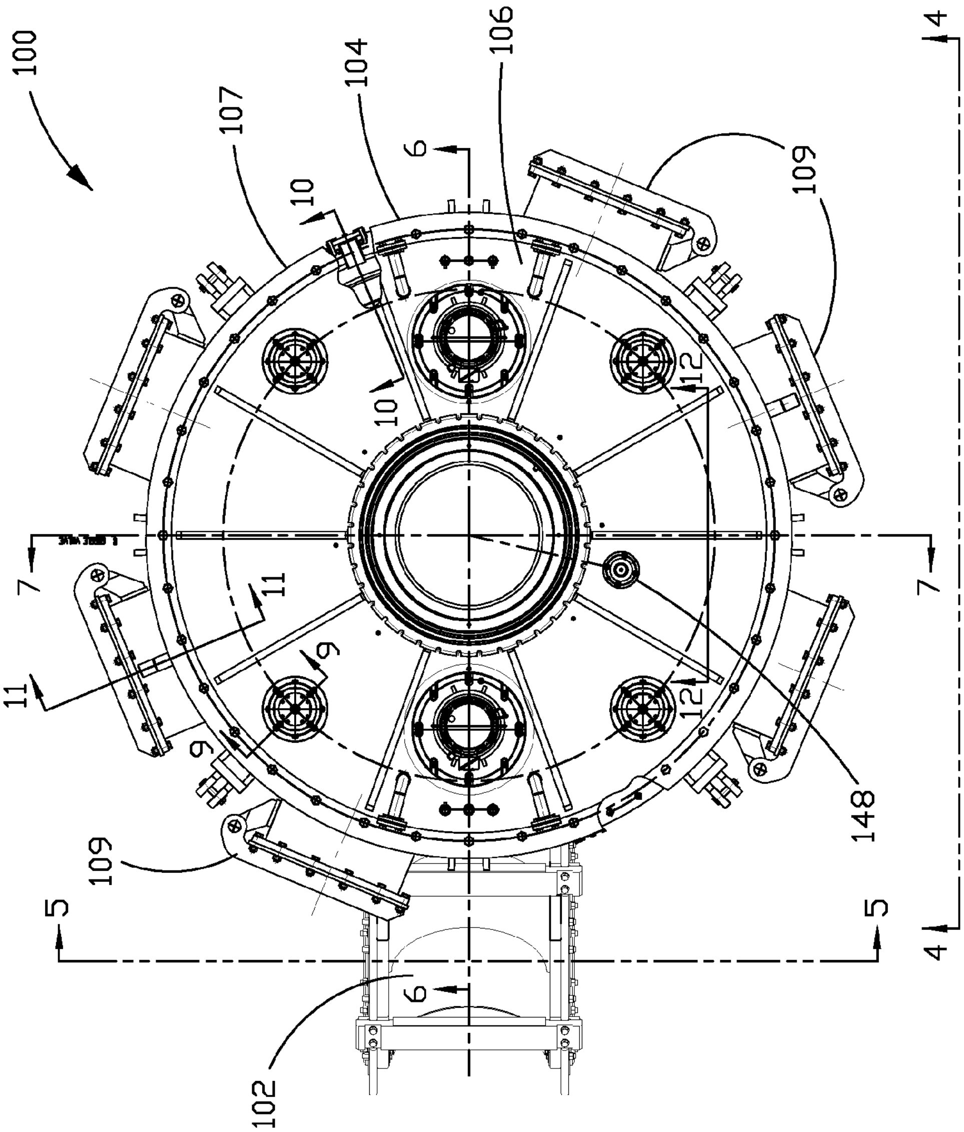
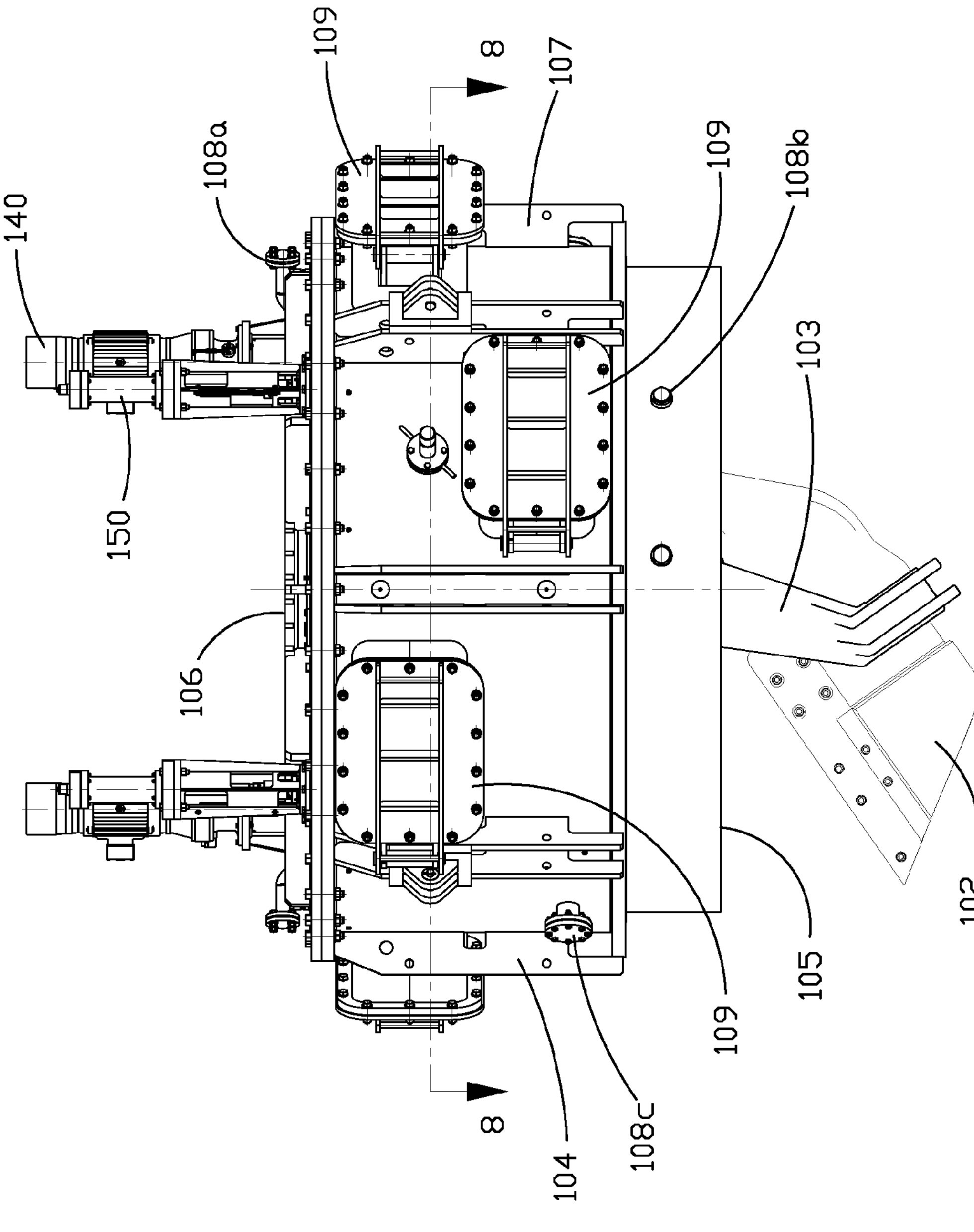


FIG. 3


140
150
108a
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108b
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108c
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FIG. 4

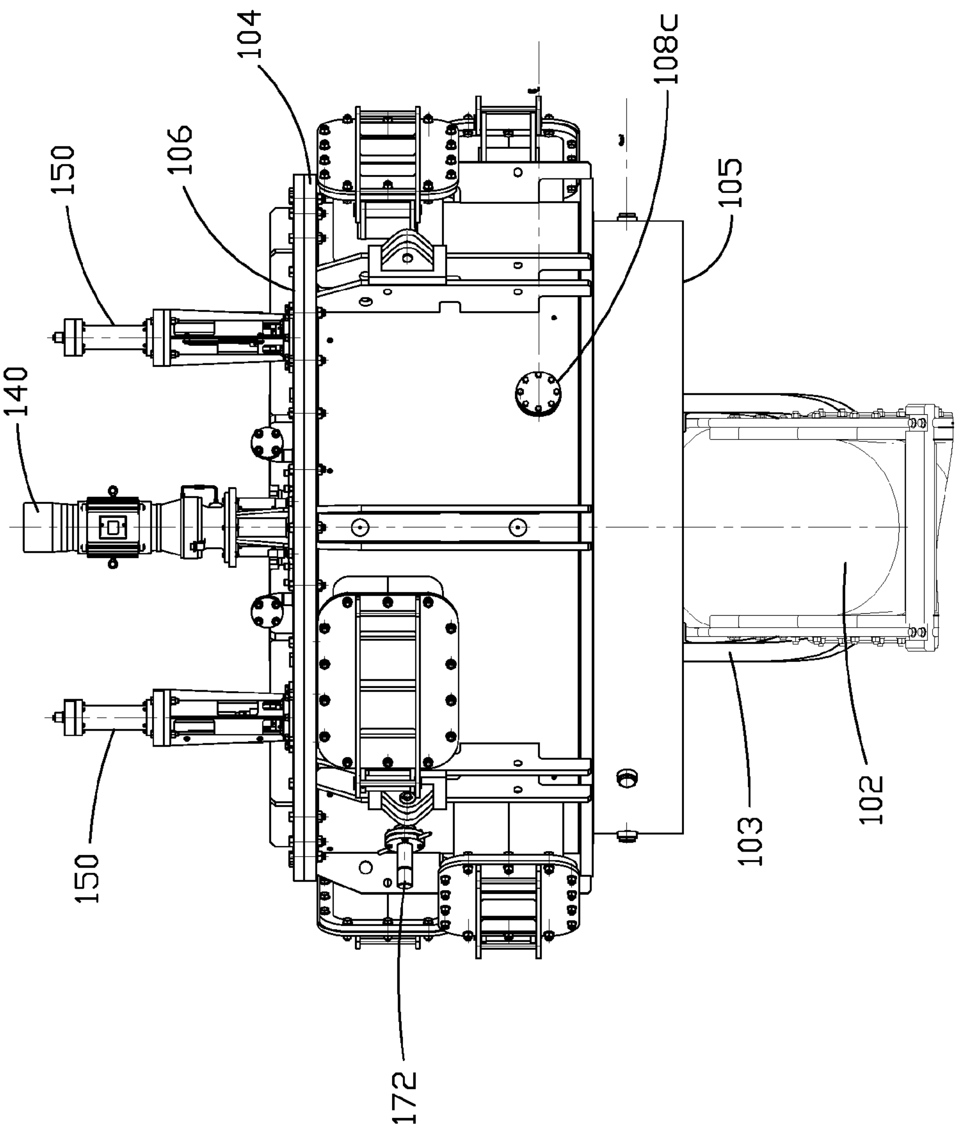

FIG. 5

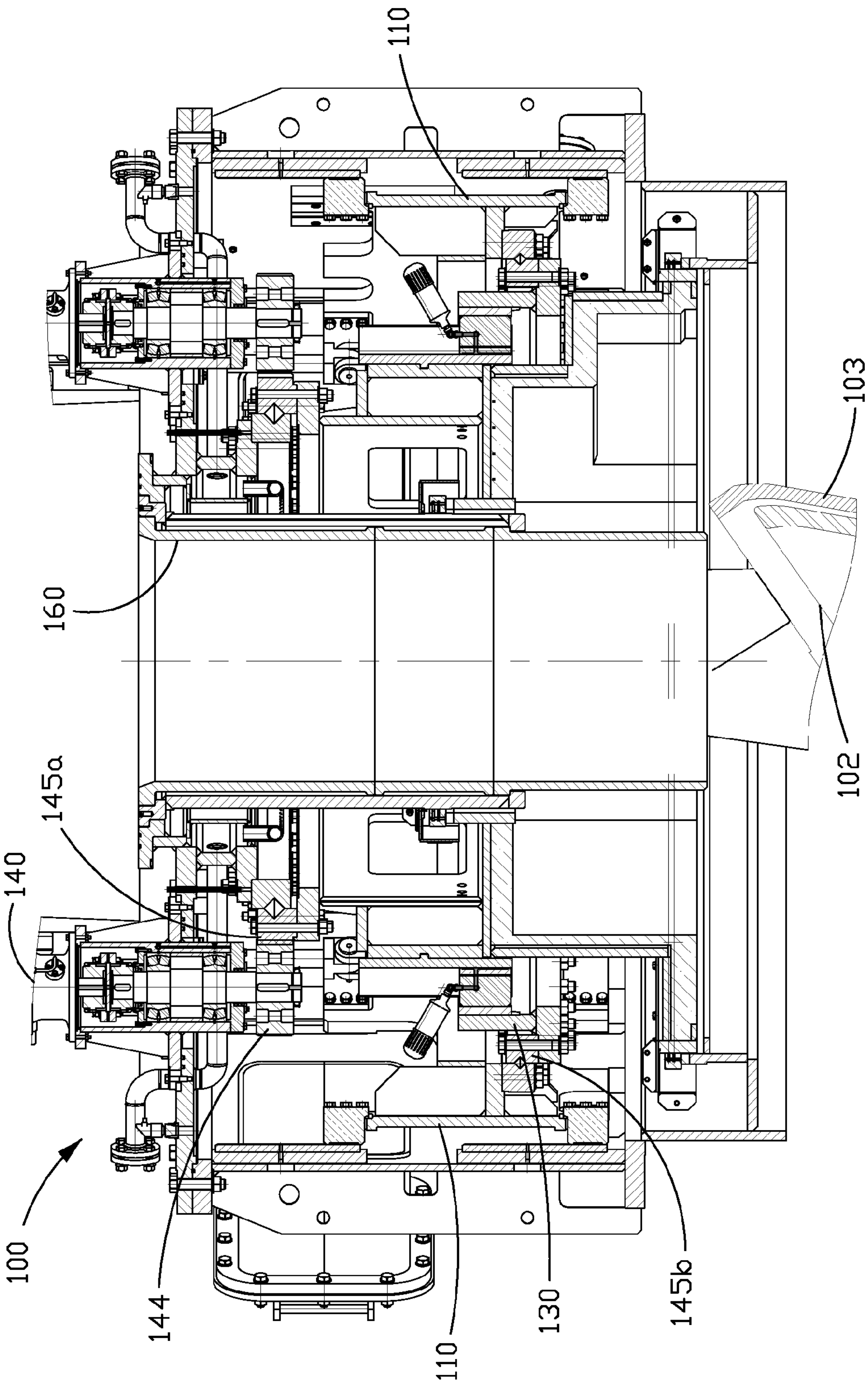

FIG. 6

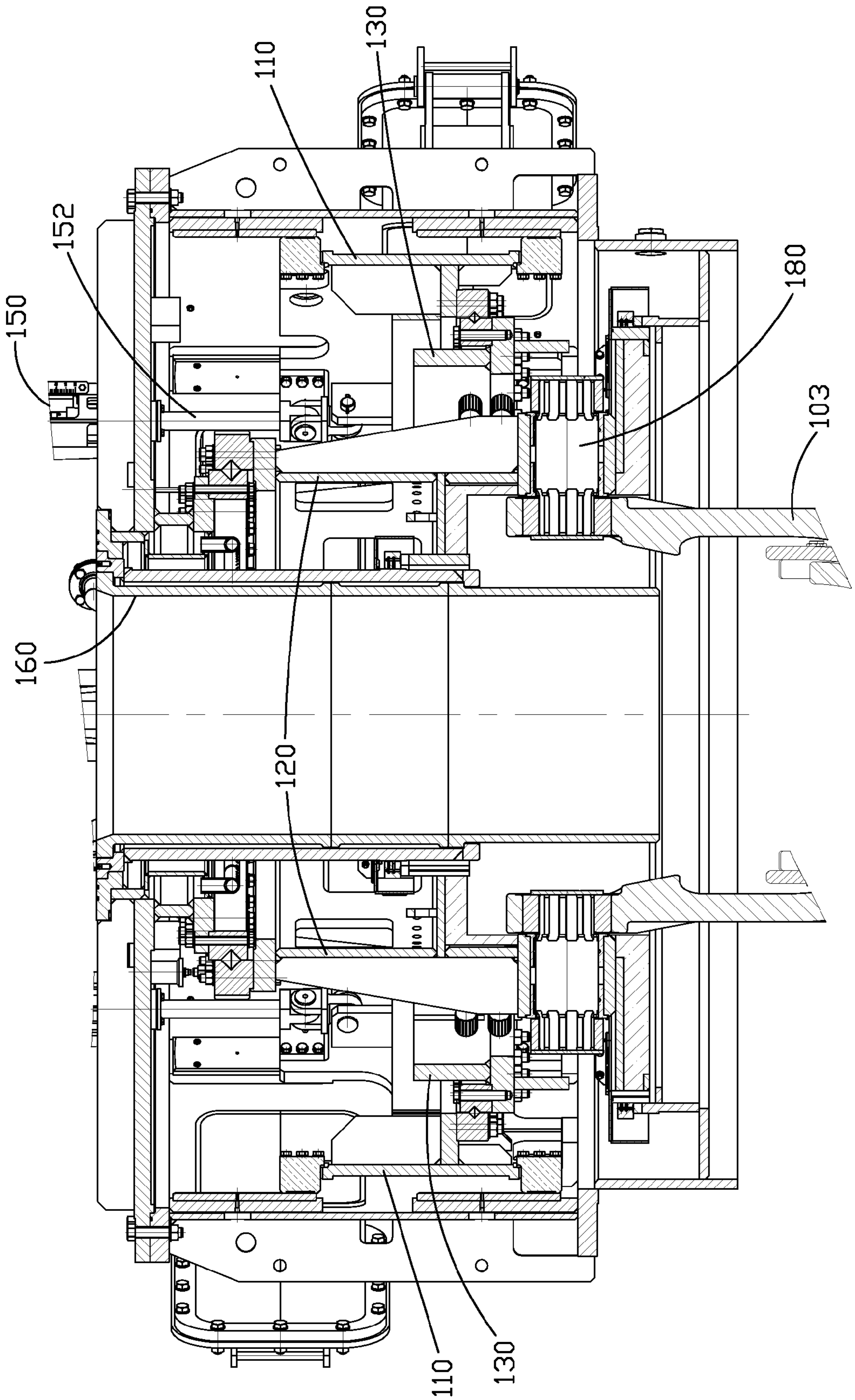

FIG. 7

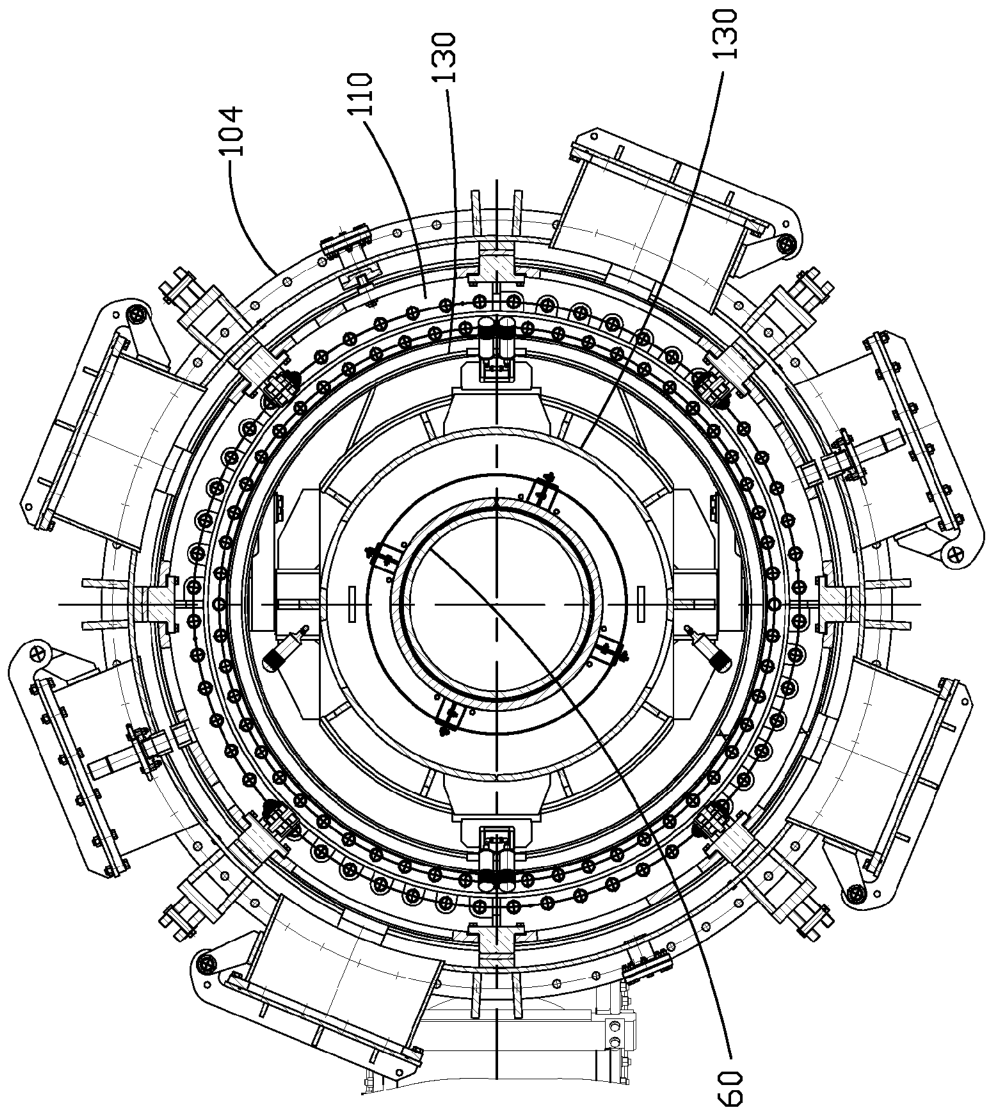

FIG. 8

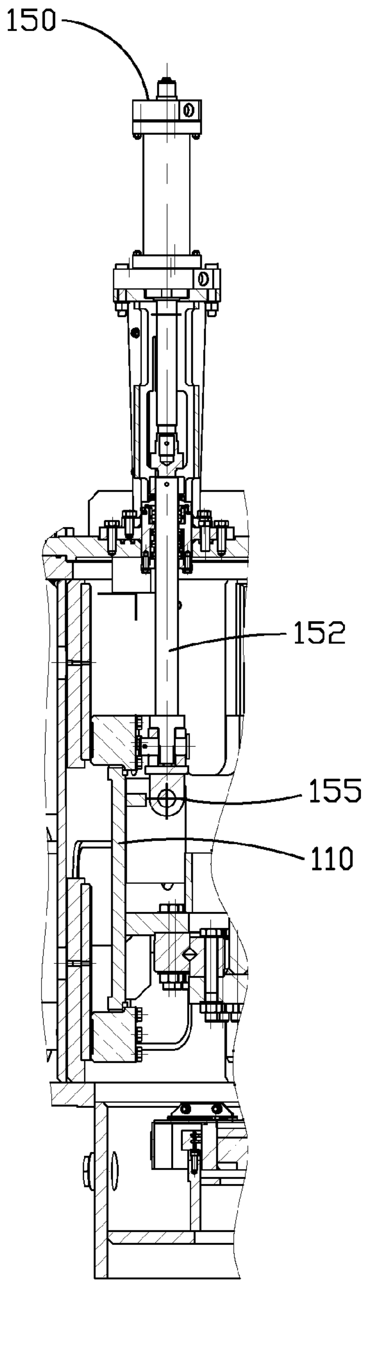

FIG. 9

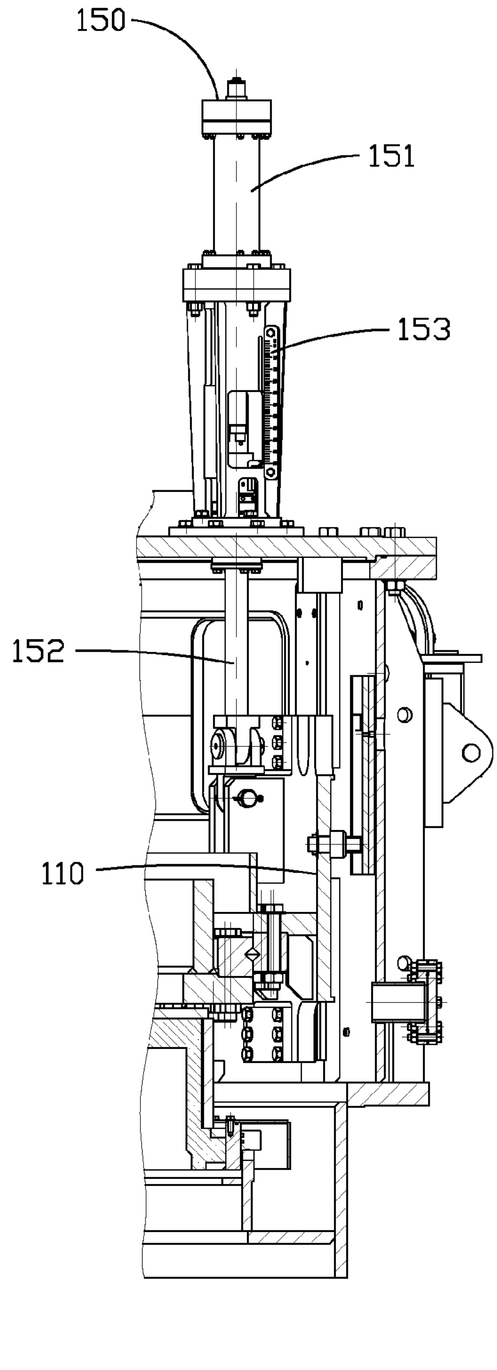

FIG. 10

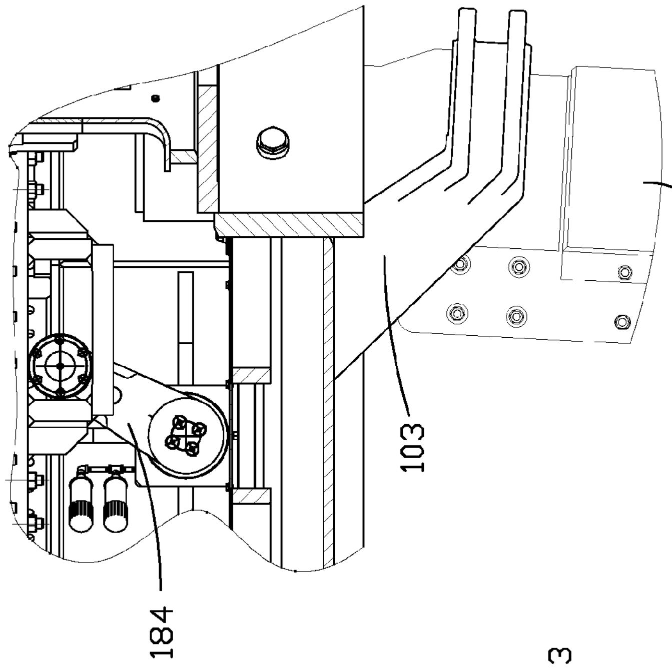

FIG. 12B

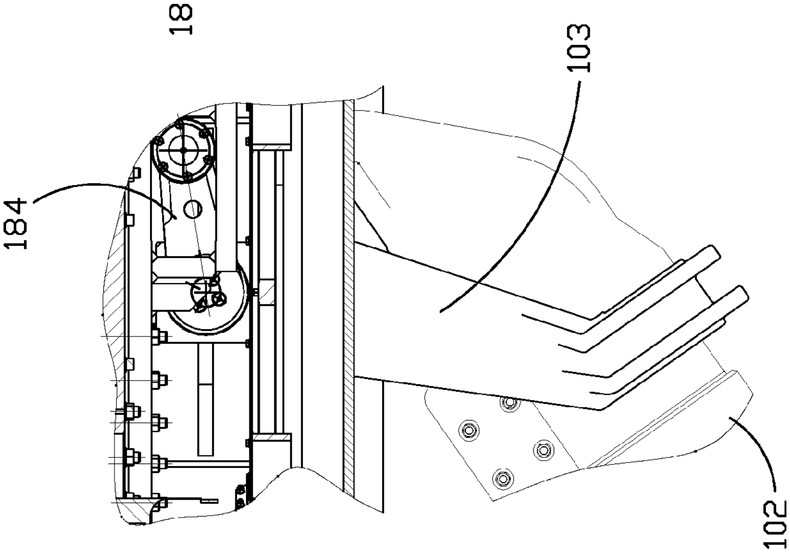

FIG. 12A

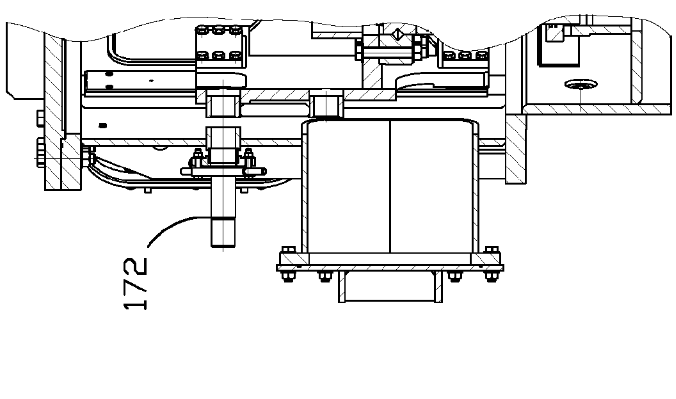

FIG. 11

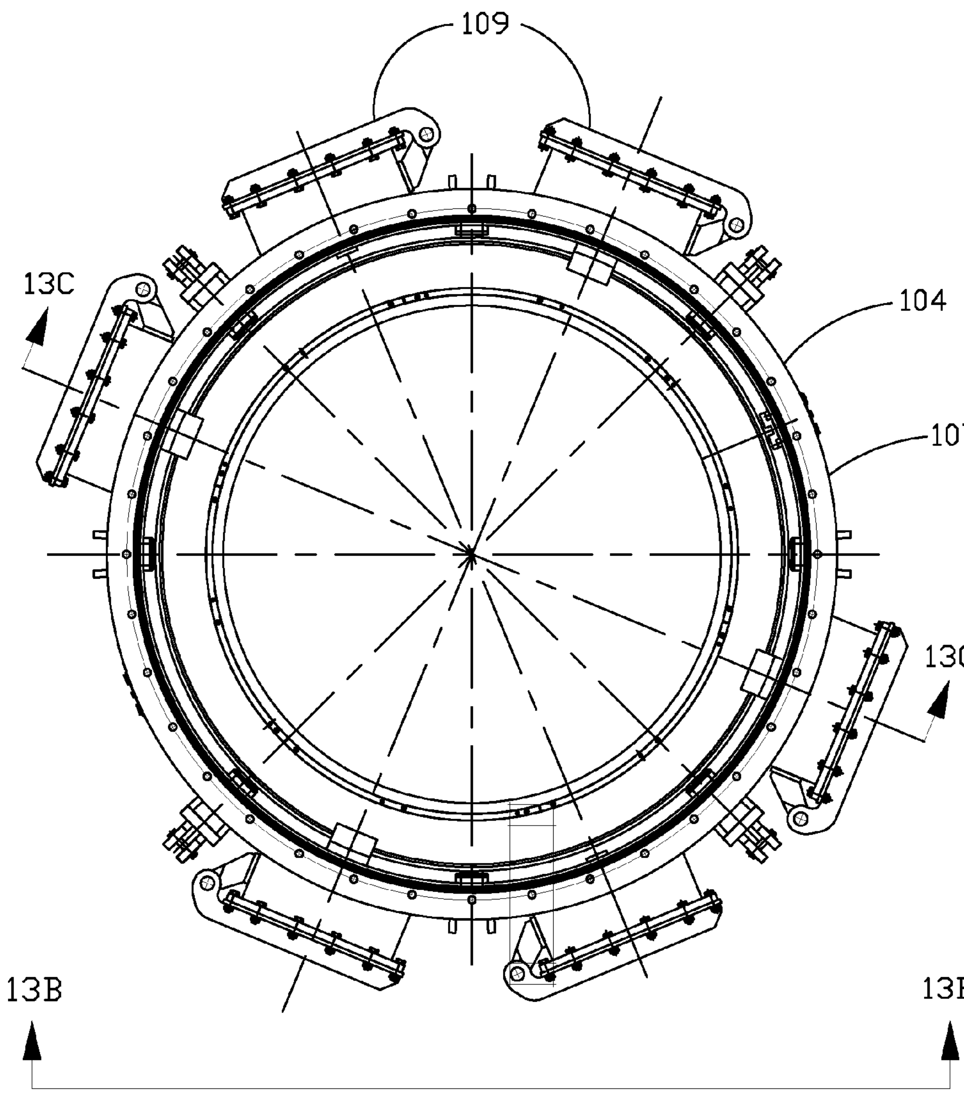

FIG. 13A

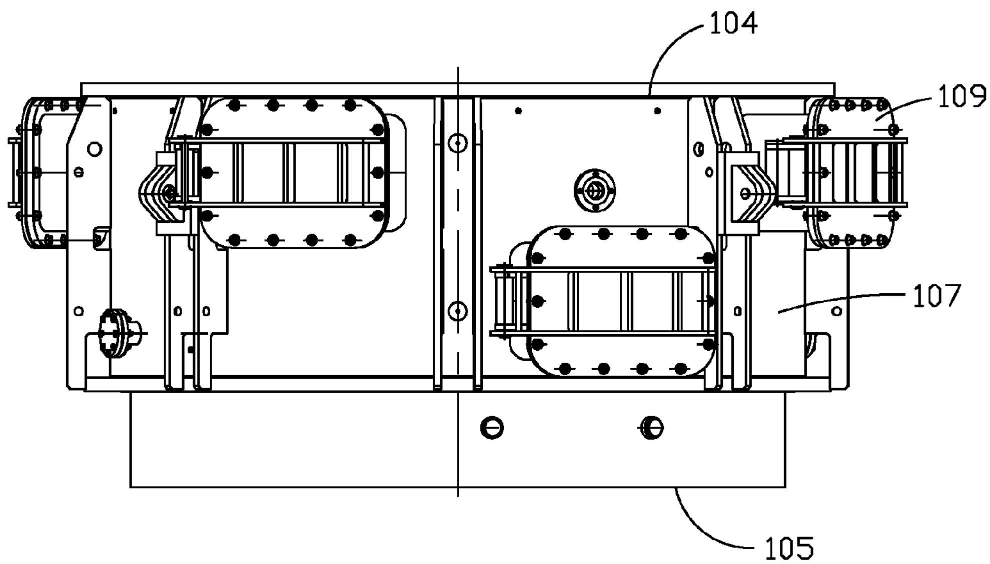

FIG. 13B

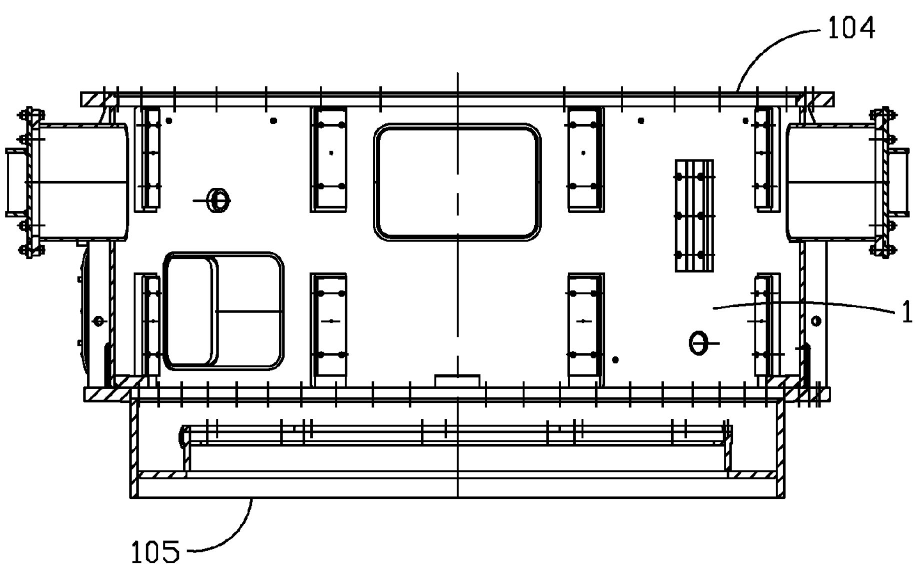

FIG. 13C

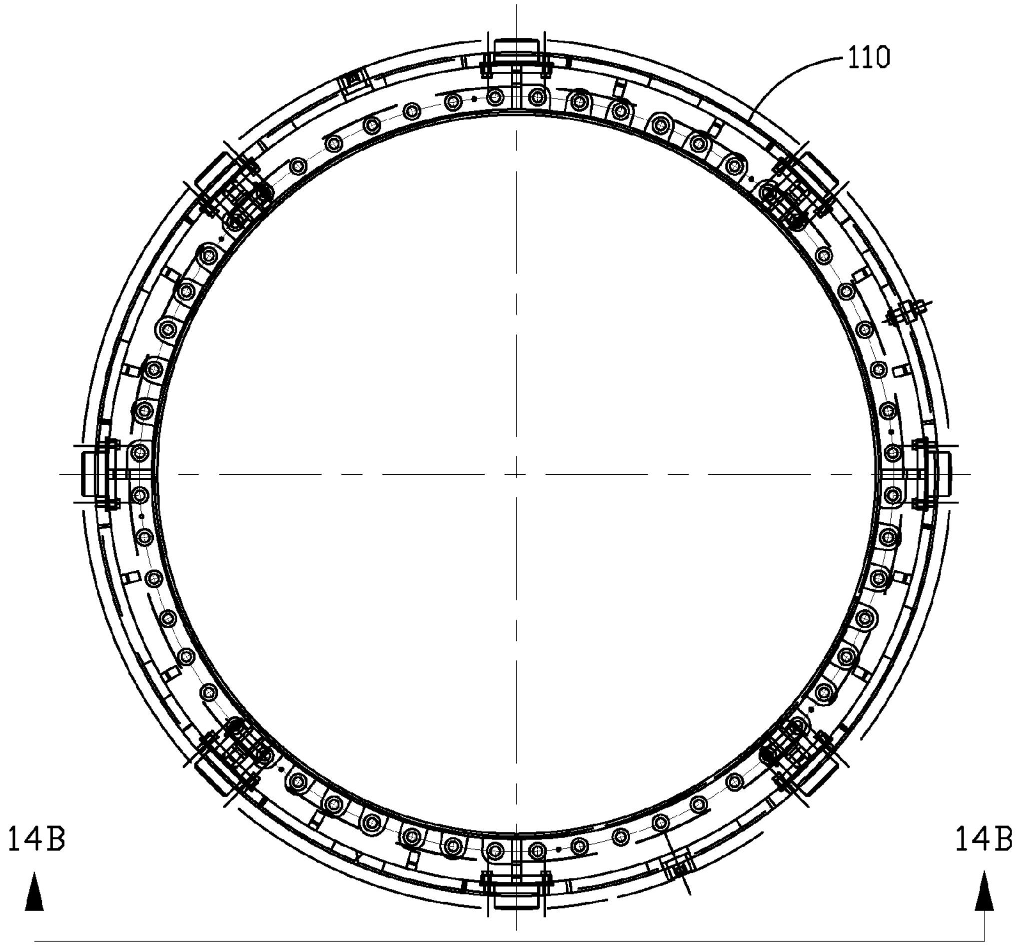

FIG. 14A

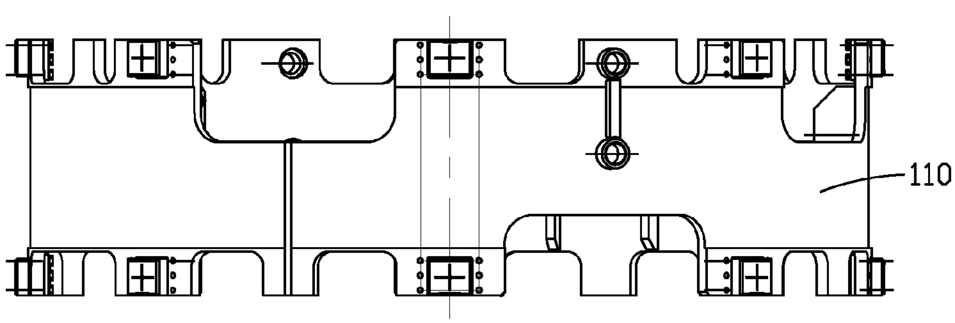

FIG. 14B

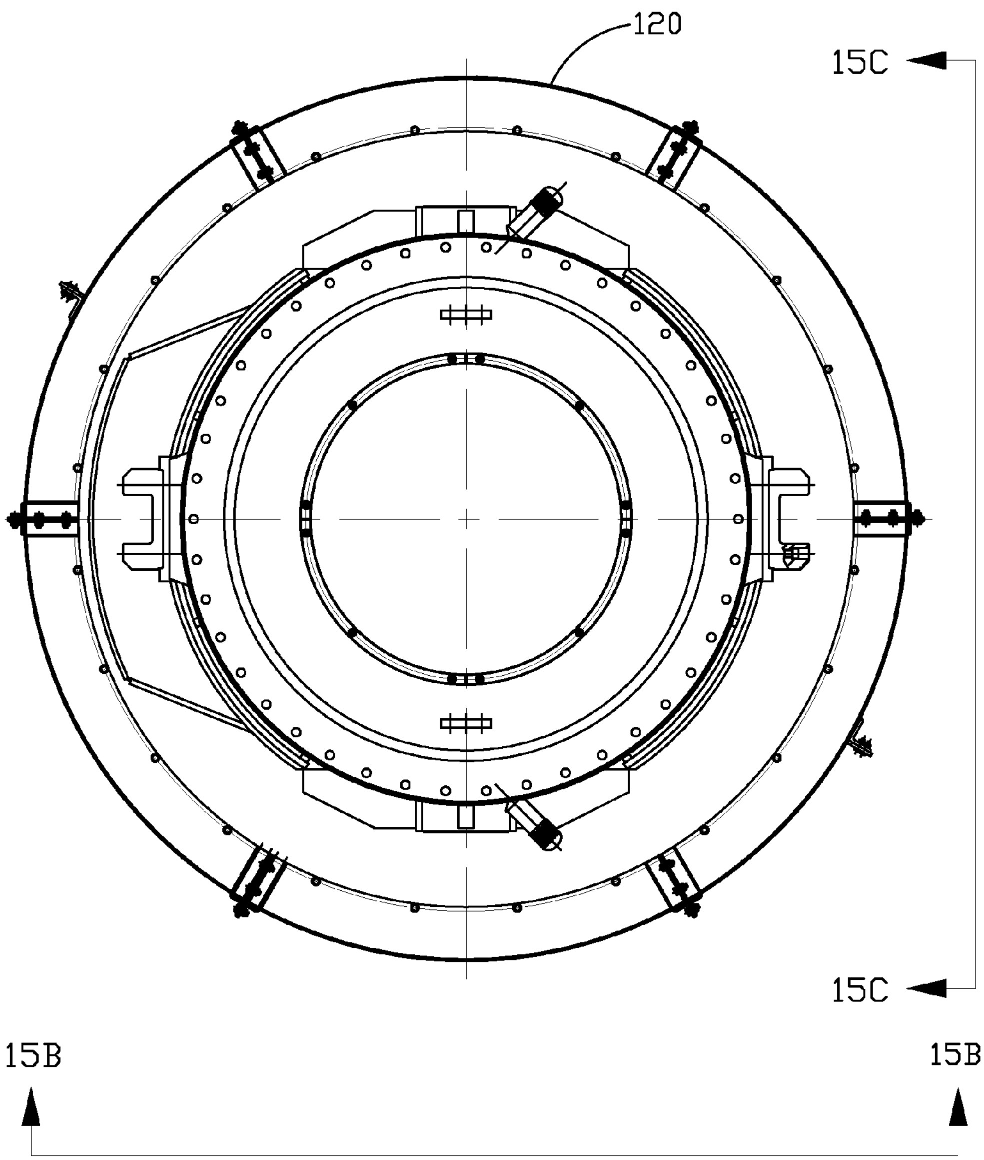

FIG. 15A

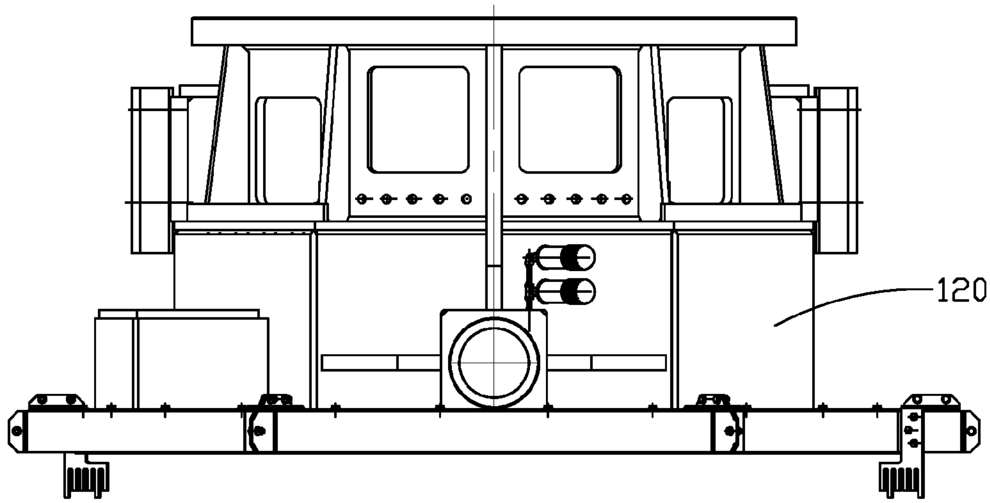

FIG. 15B

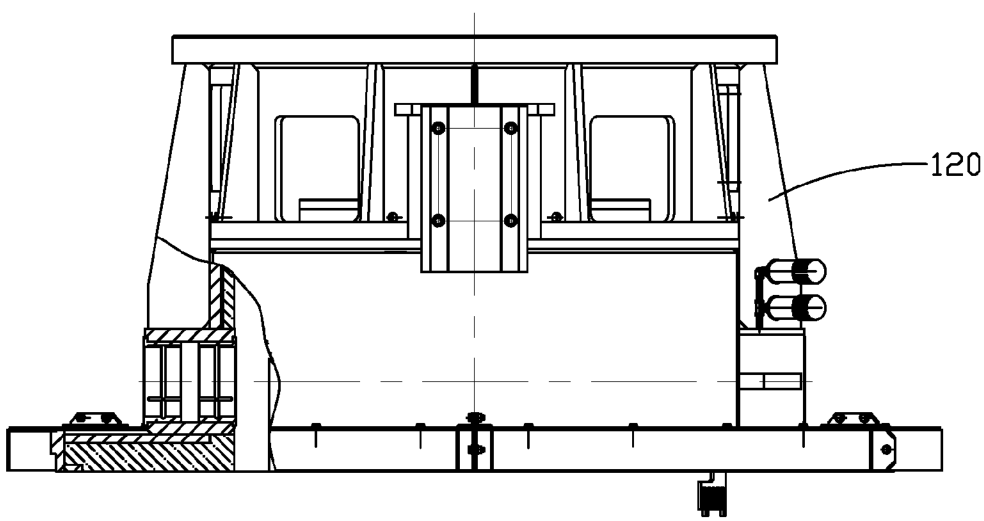

FIG. 15C

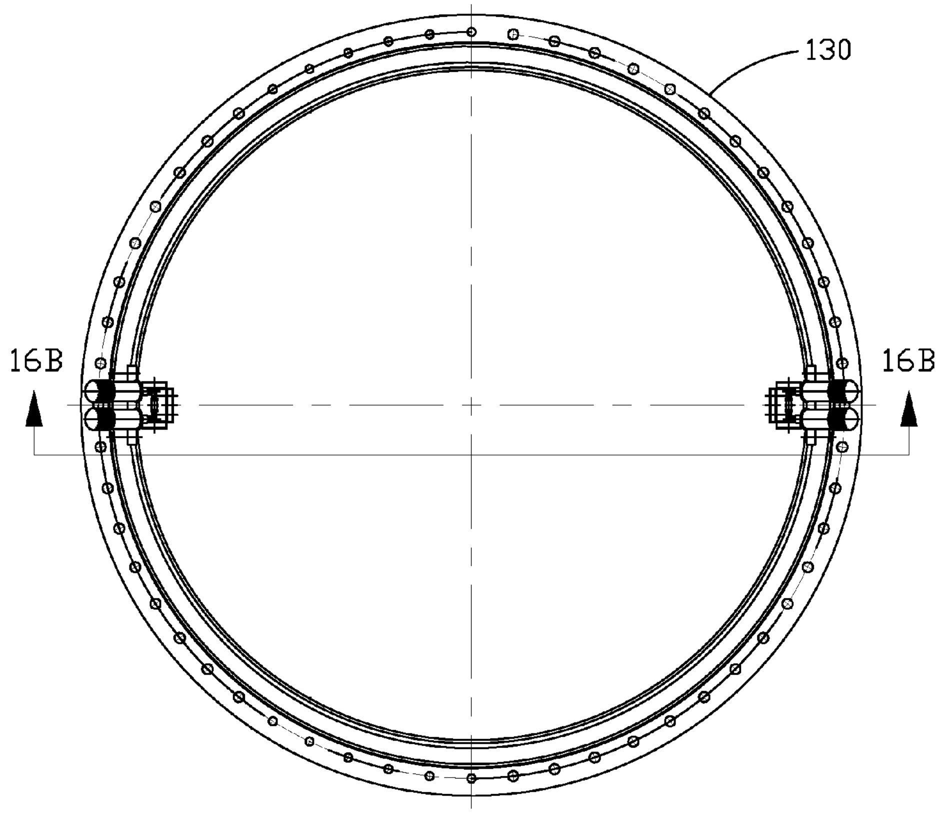

FIG. 16A

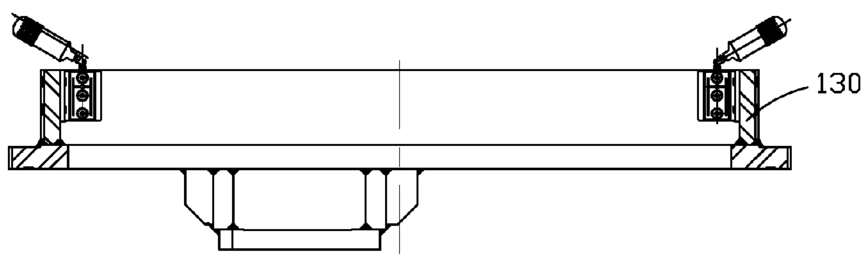

FIG. 16B

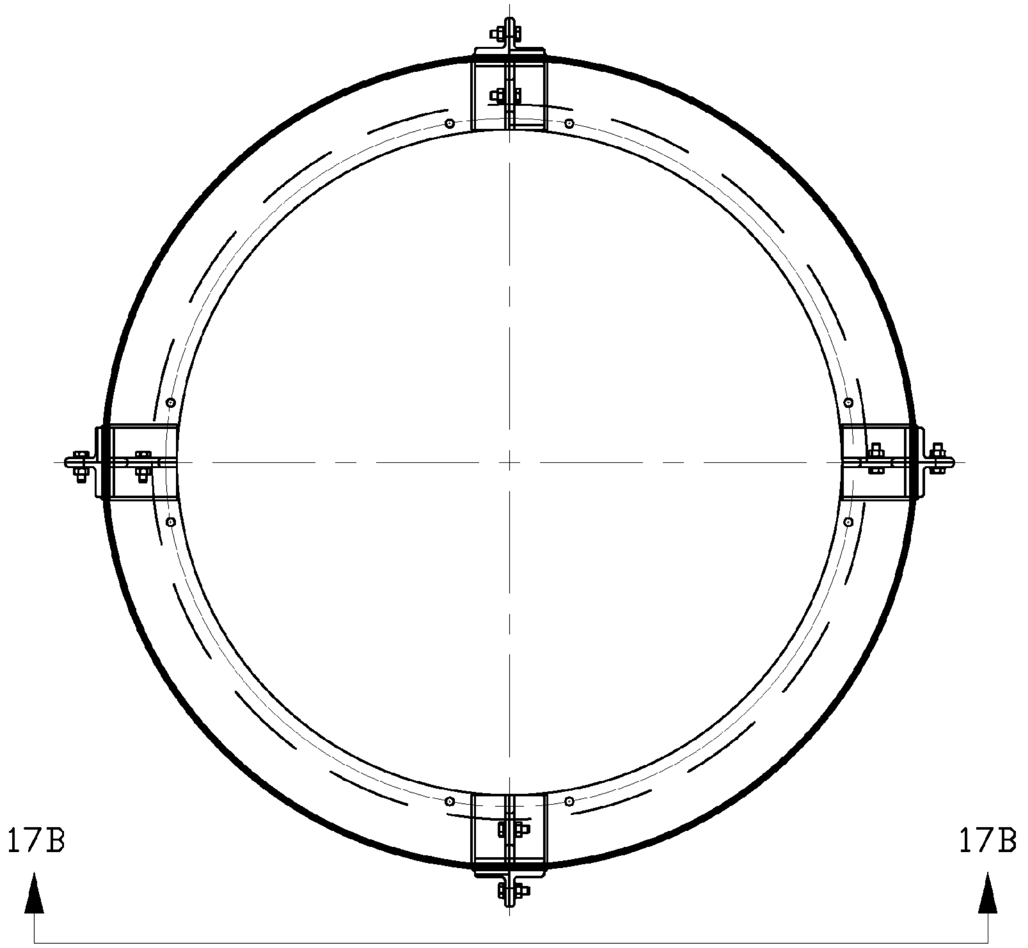

FIG. 17A

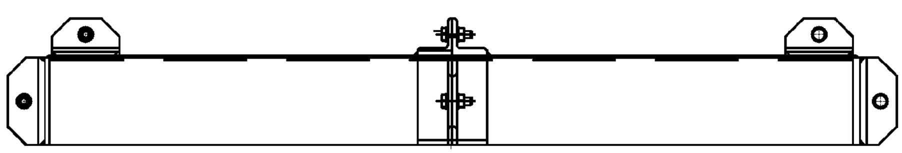

FIG. 17B

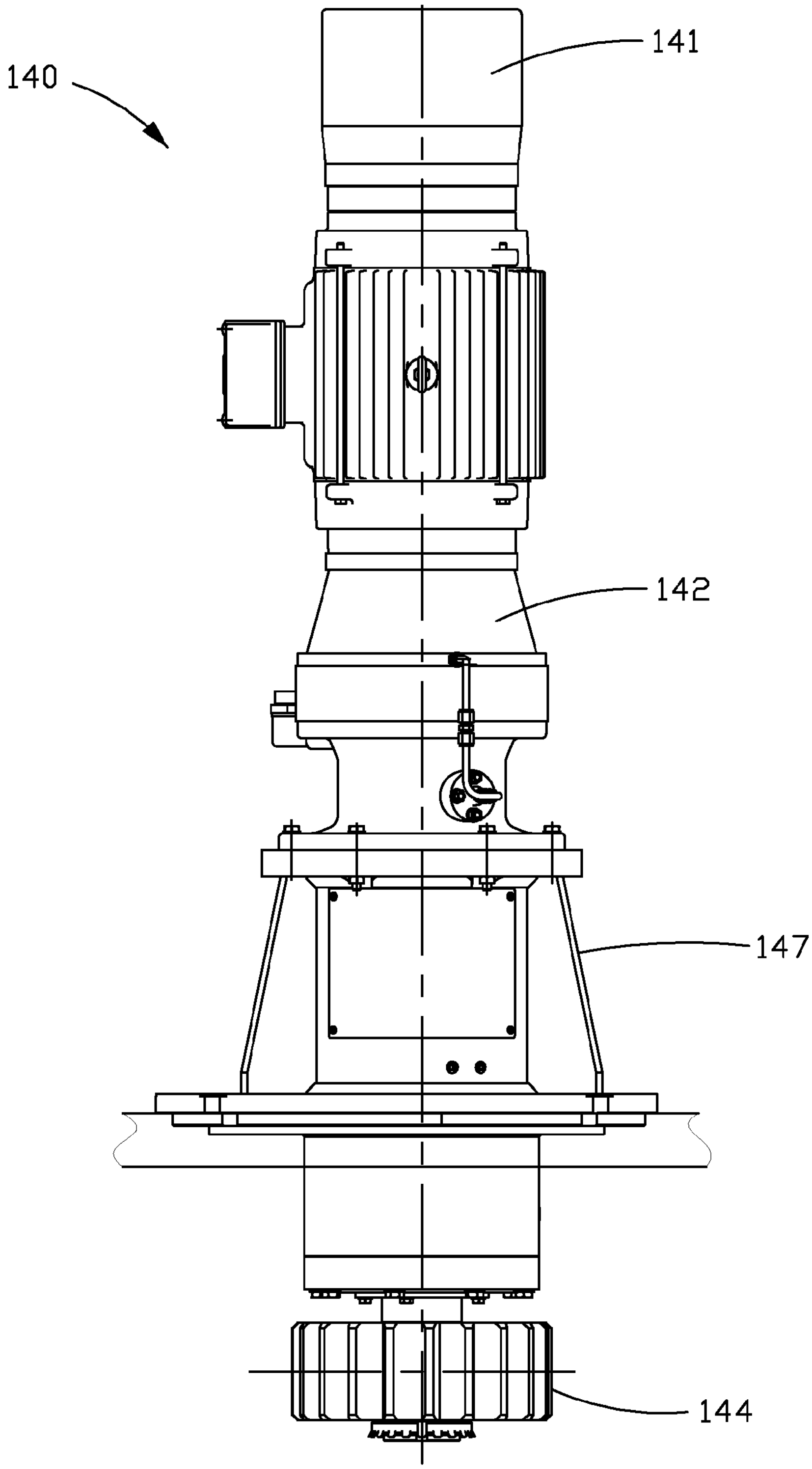

FIG. 18A

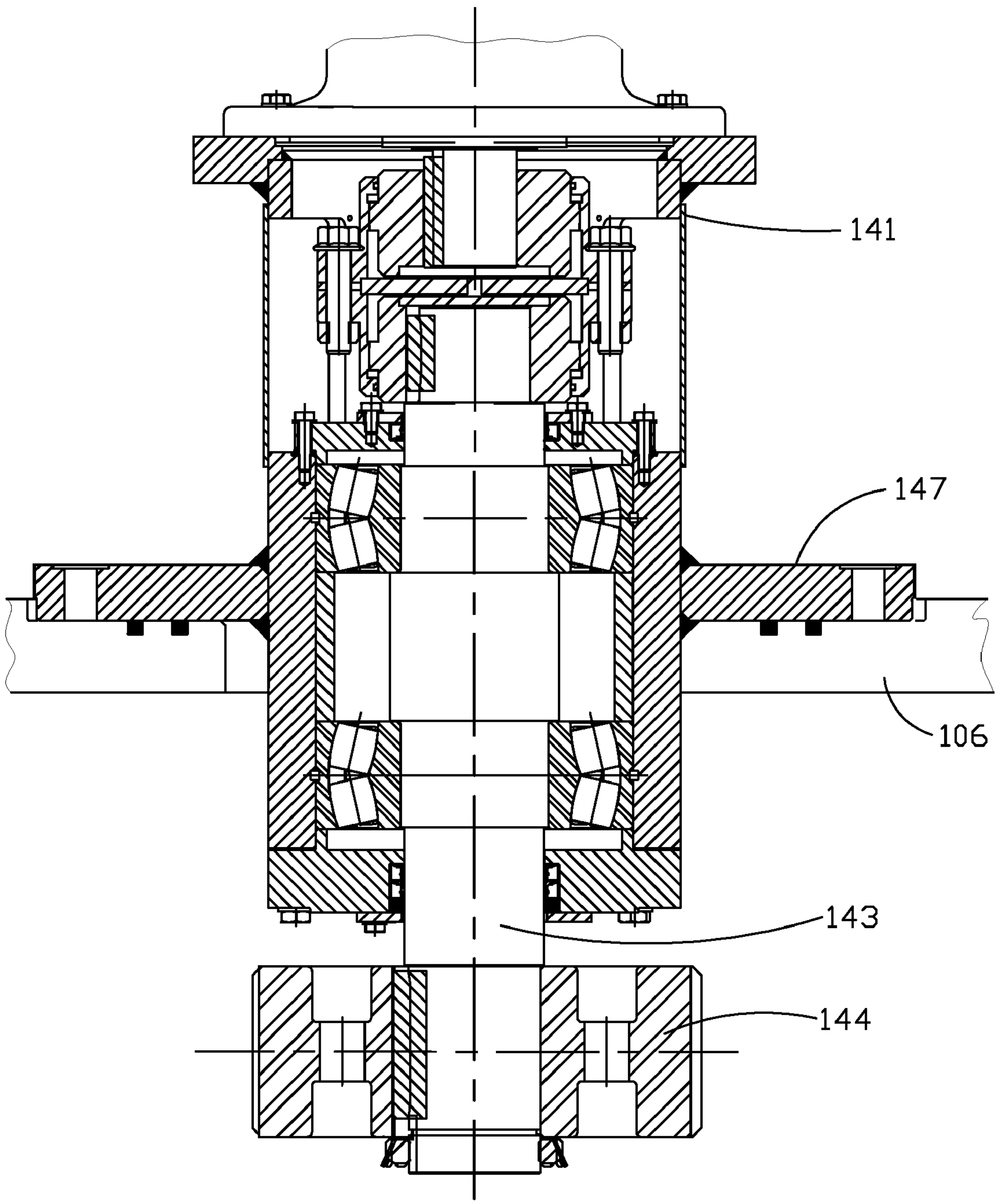

FIG. 18B

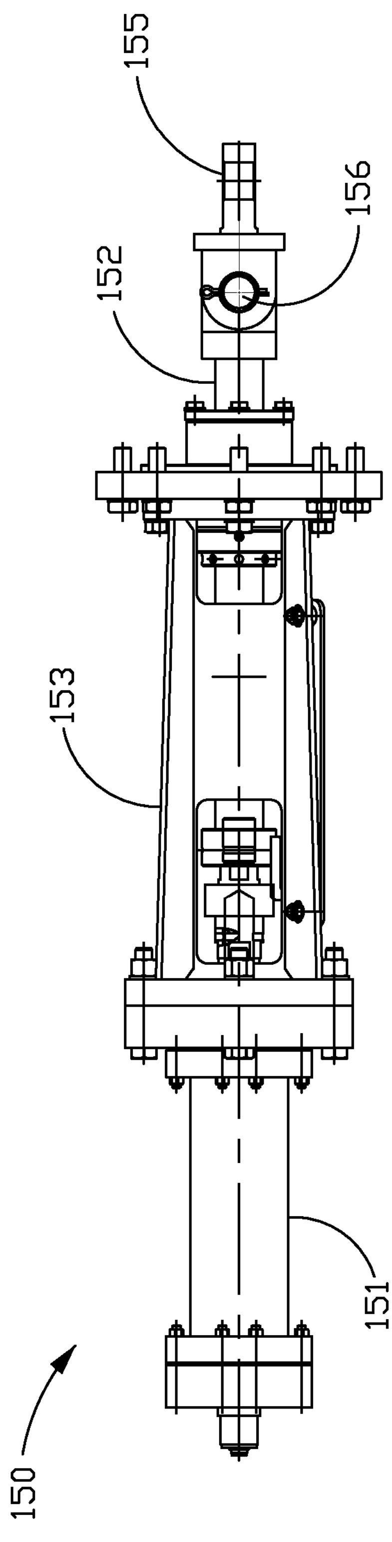

FIG. 19A

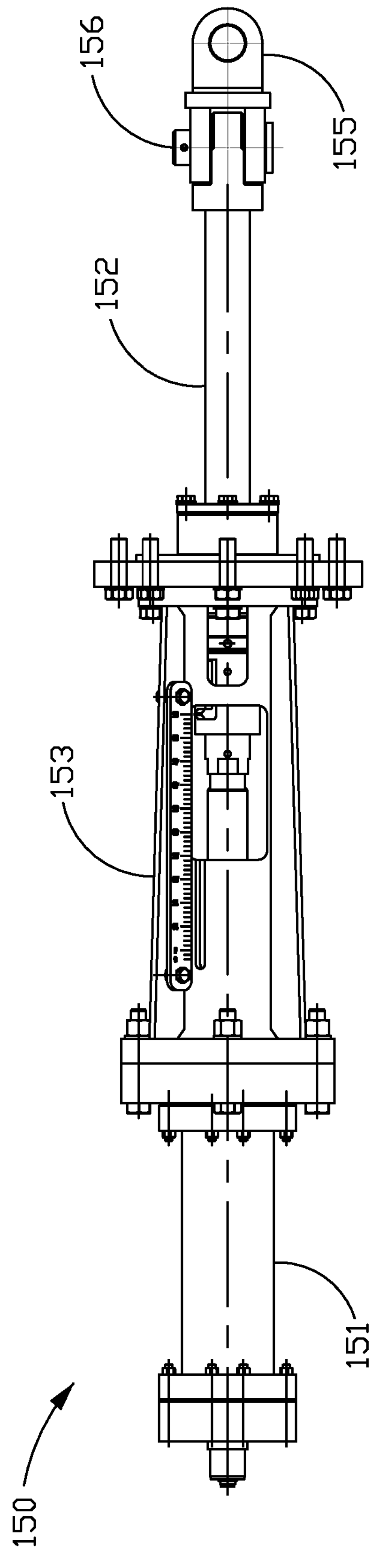

FIG. 19B

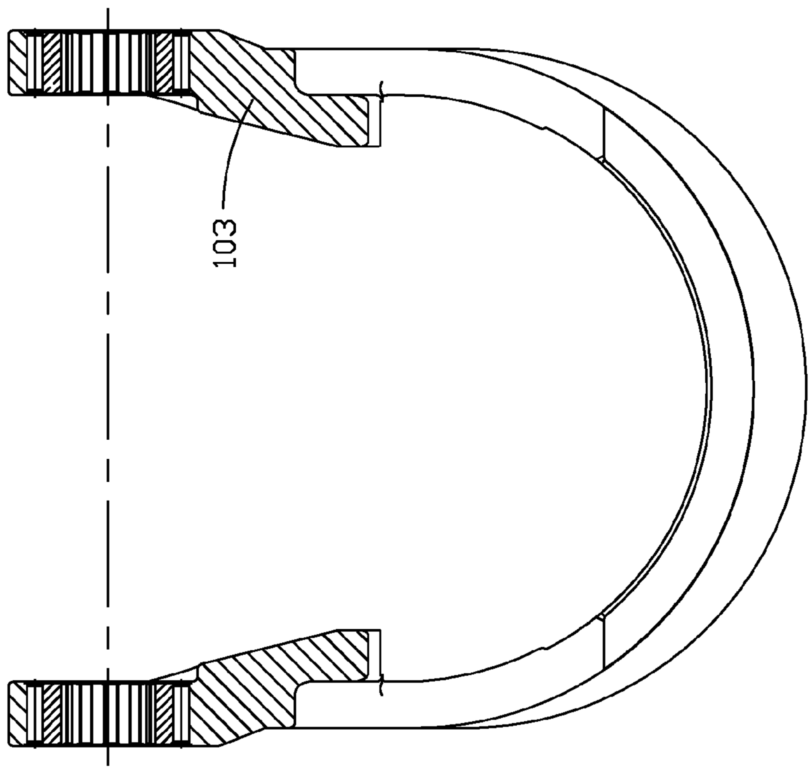

FIG. 20B

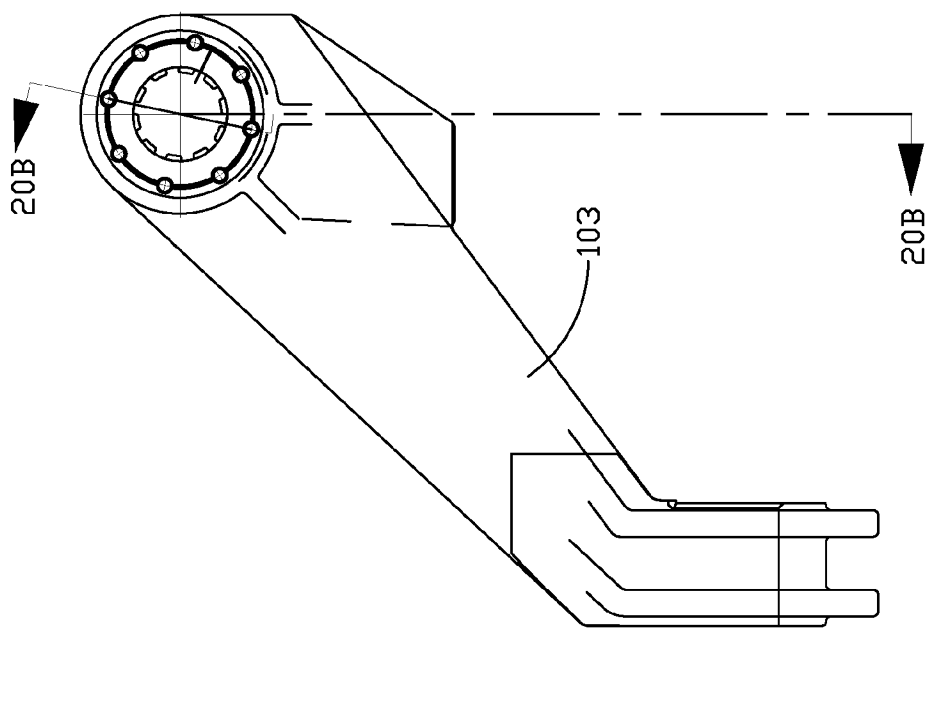

FIG. 20A

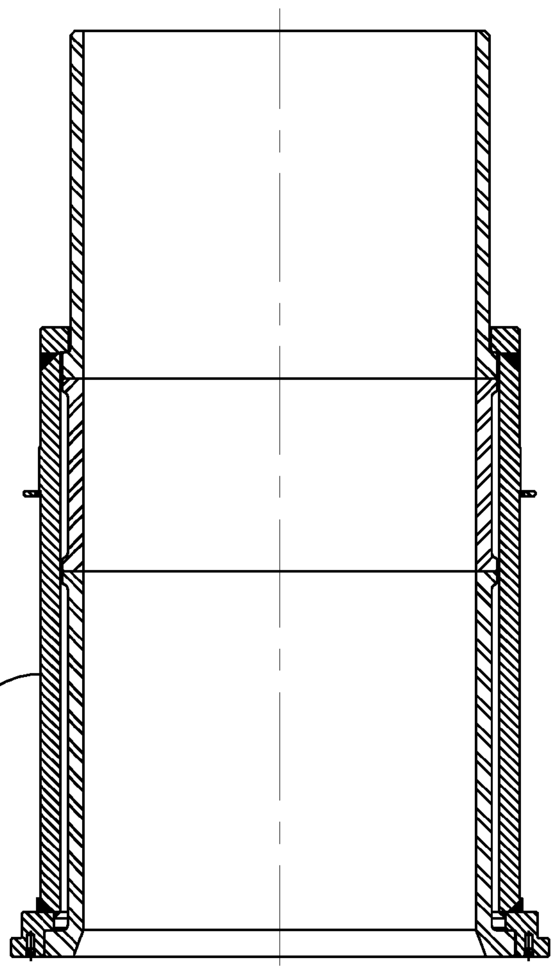

FIG. 21B

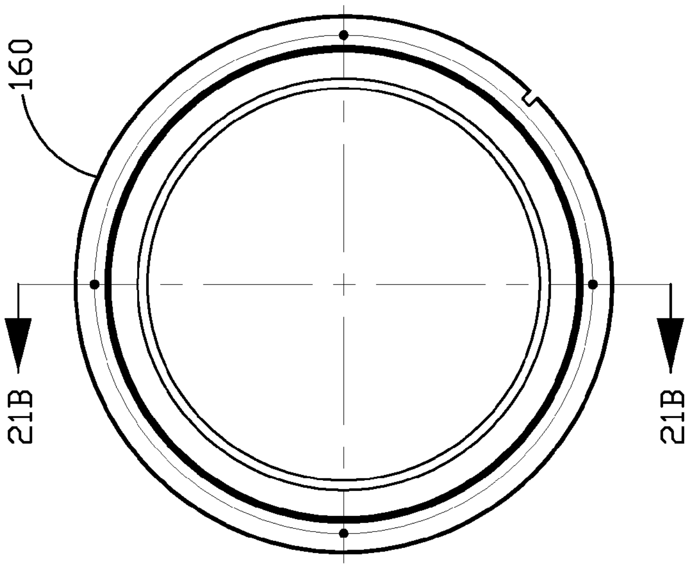

FIG. 21A

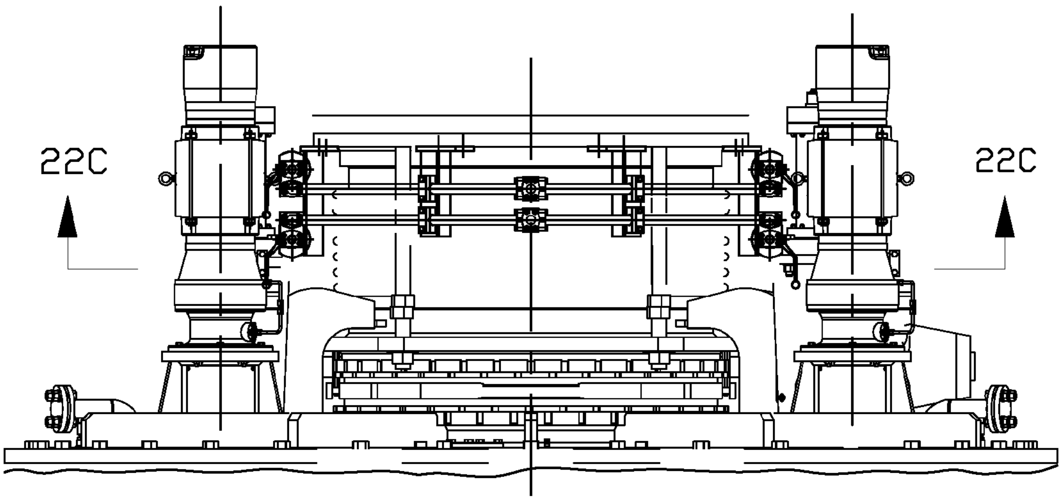

FIG. 22A

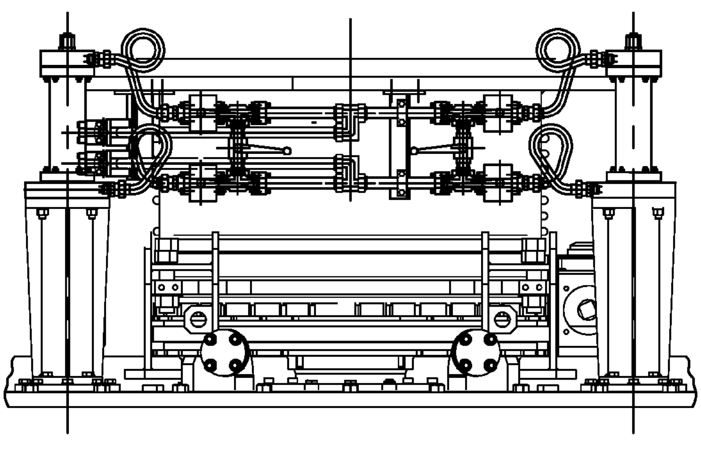

FIG. 22B

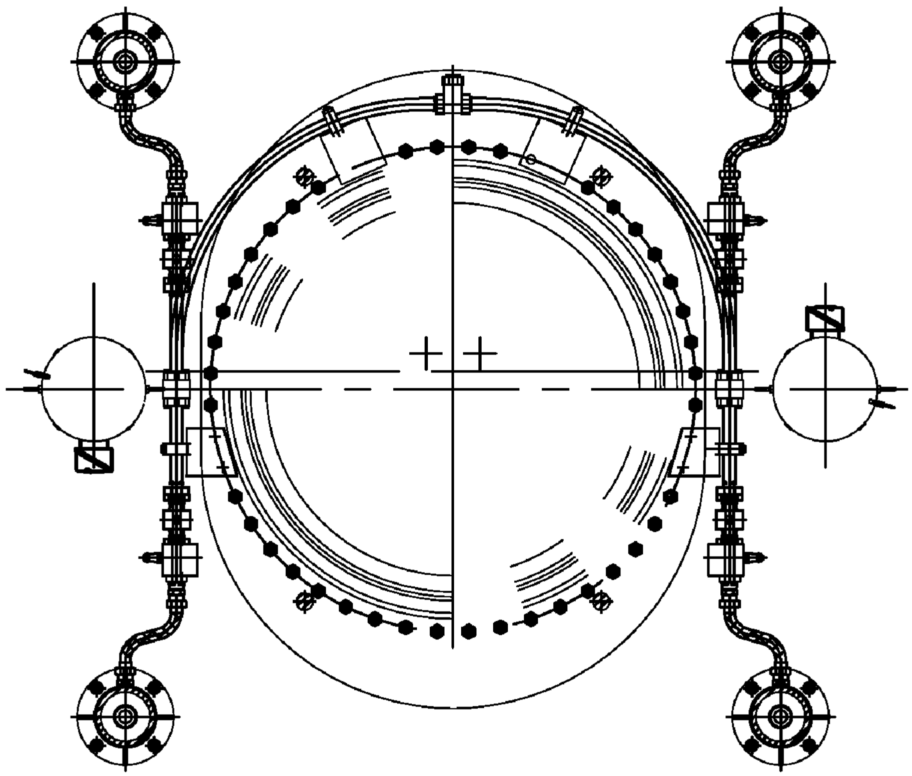

FIG. 22C

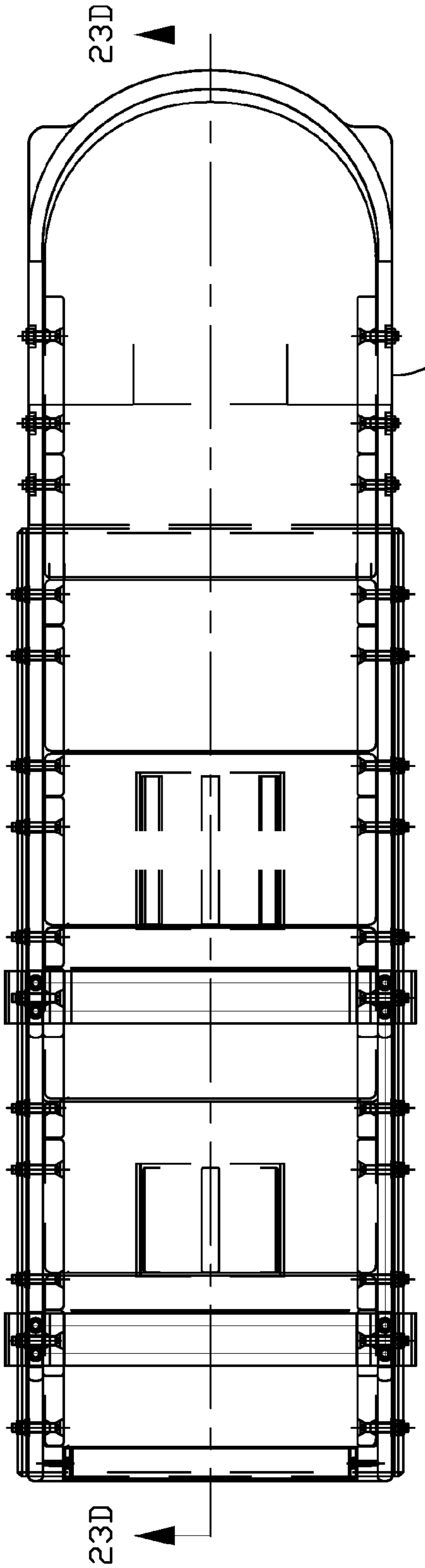

FIG. 23A

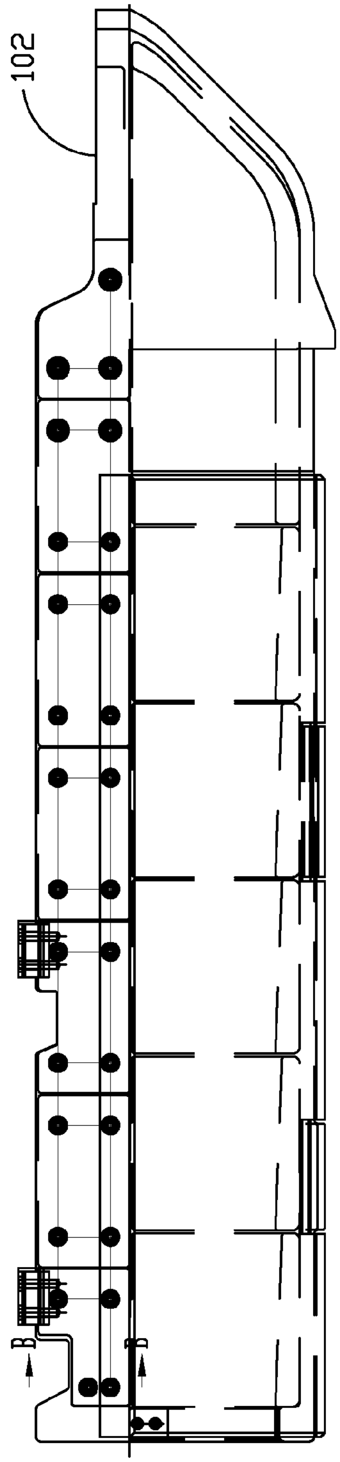

FIG. 23B

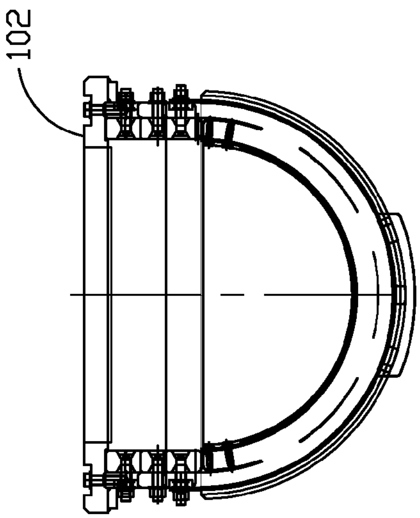

FIG. 23C

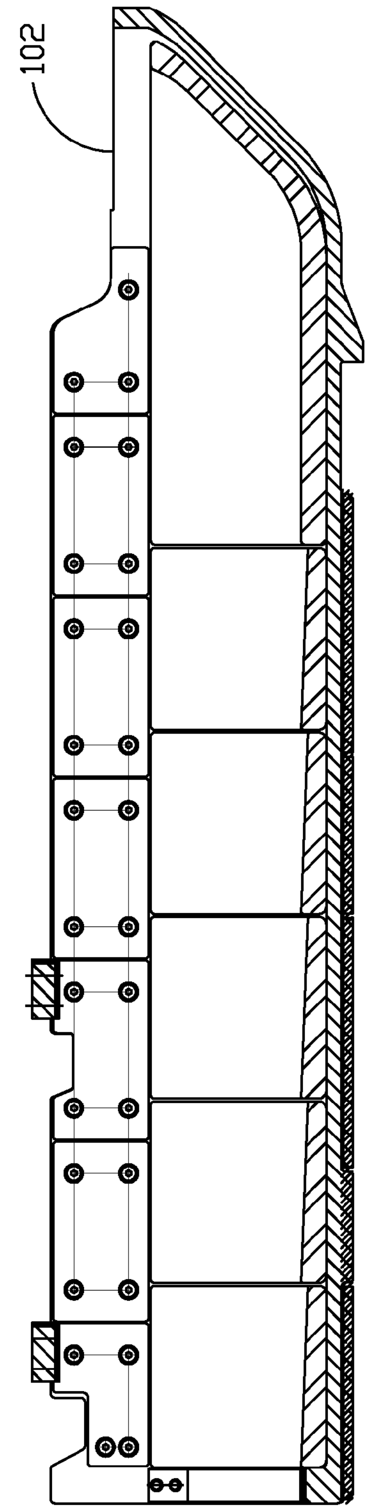

FIG. 23D

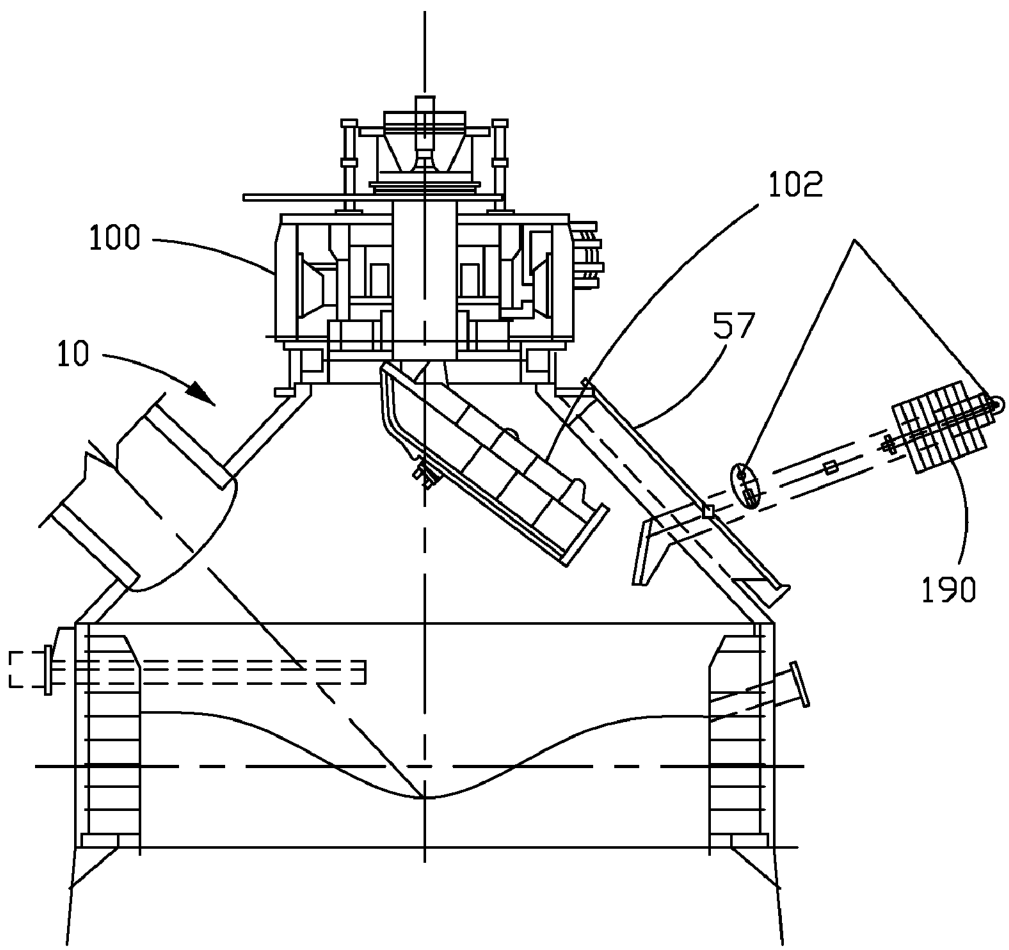

FIG. 24A

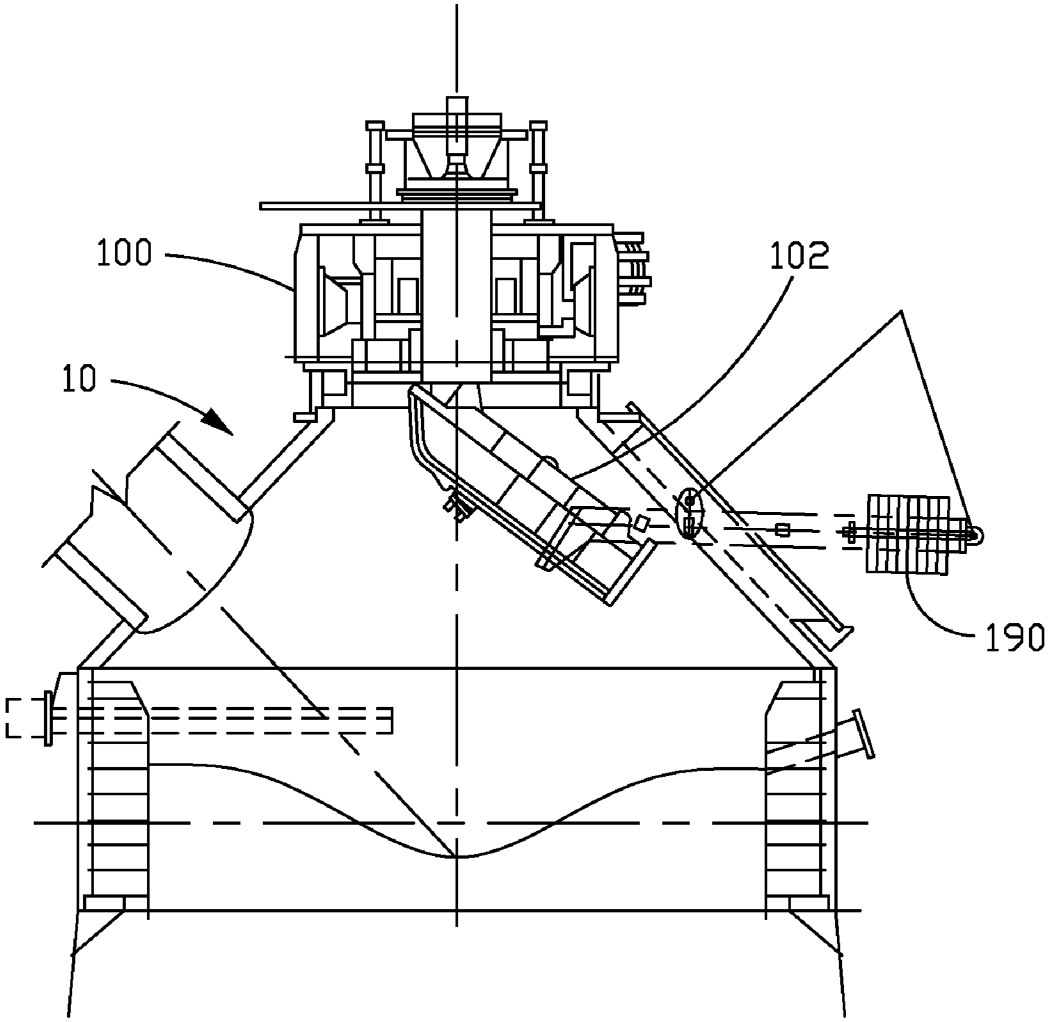

FIG. 24B

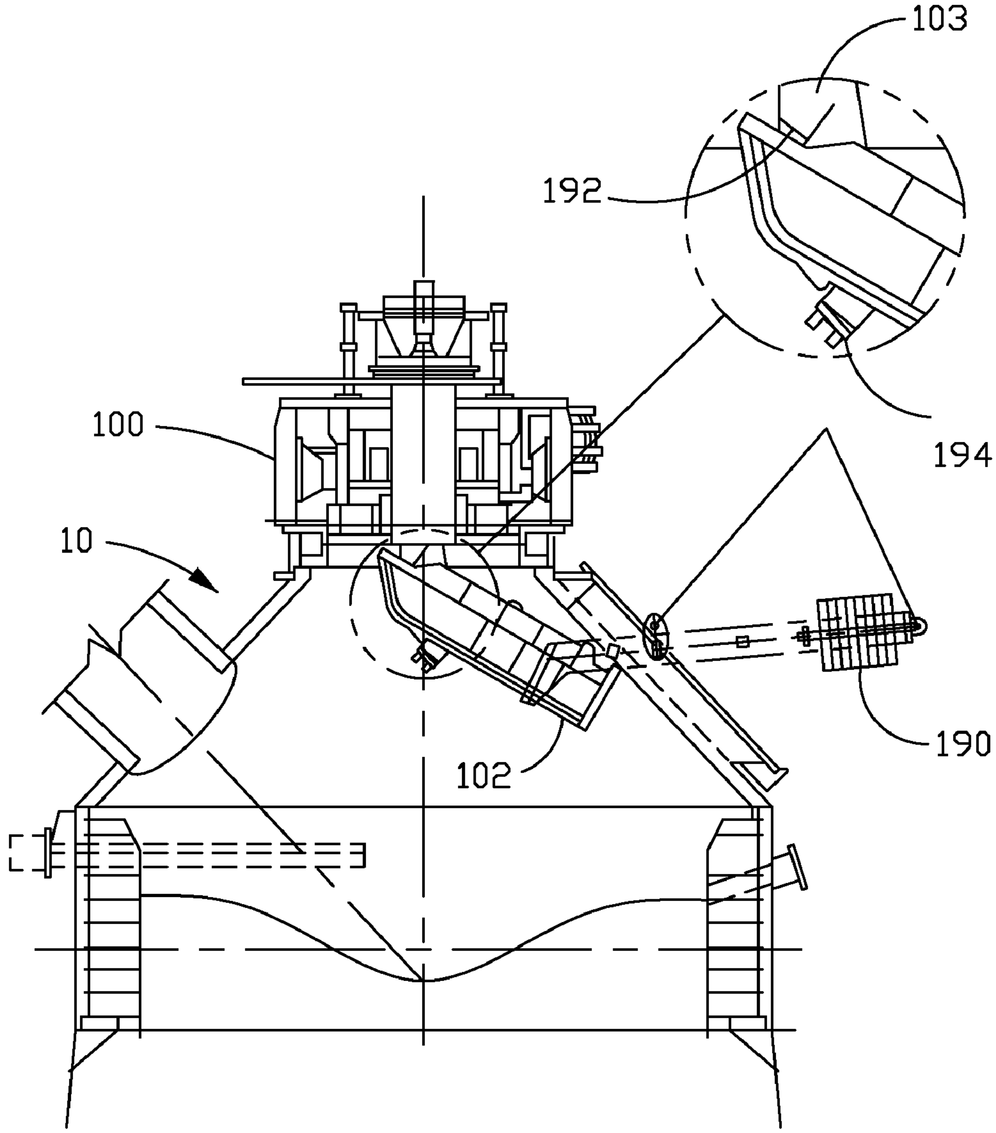

FIG. 24C

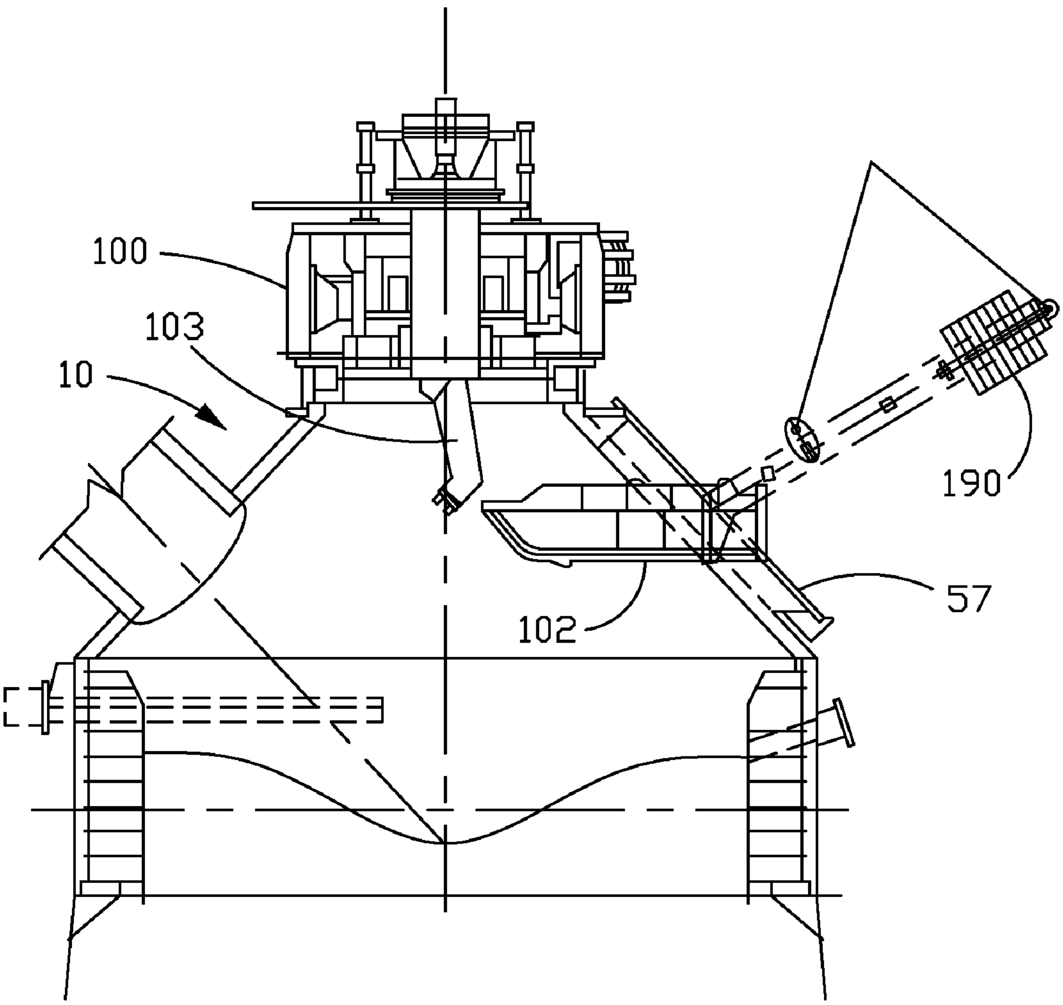

FIG. 24D

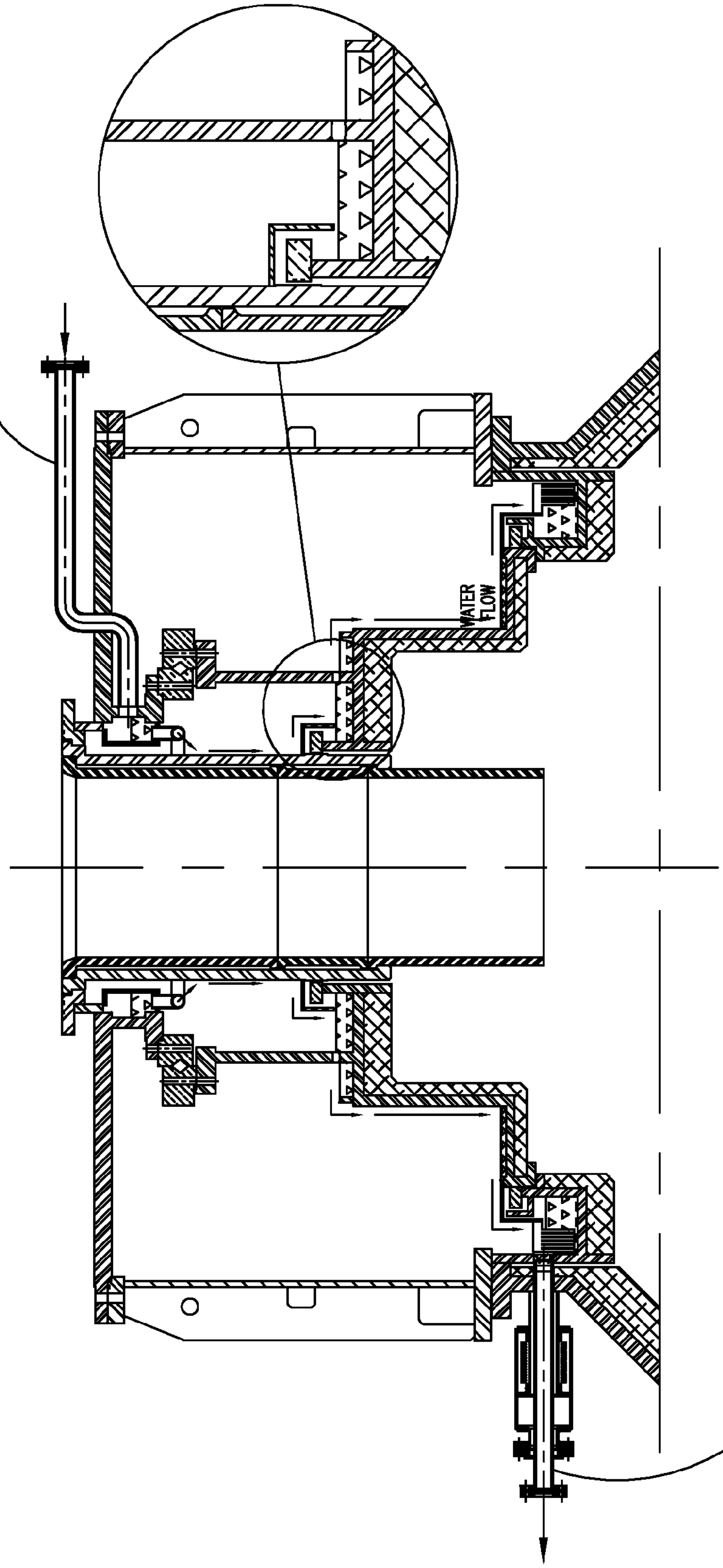

FIG. 25

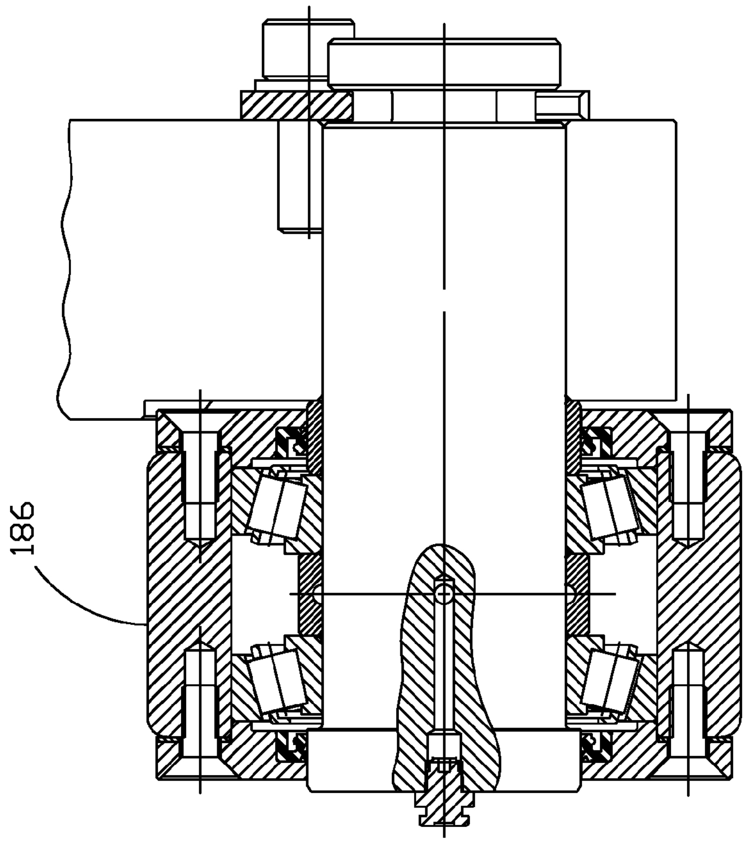

FIG. 26B

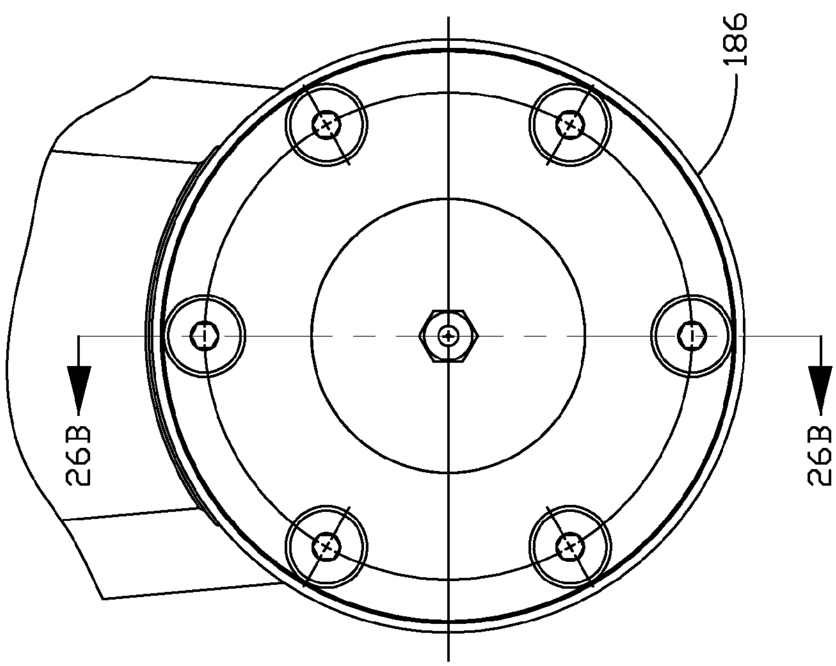

FIG. 26A

HYDRAULIC DISTRIBUTOR FOR TOP CHARGING A BLAST FURNACE

TECHNOLOGY FIELD

[0001] The present invention relates in general to blast furnaces, and more particularly, to a hydraulic distributor for top charging a blast furnace.

BACKGROUND

[0002] A blast furnace is a type of metallurgical furnace used for smelting to produce industrial metals. In a typical blast furnace, fuel and metal ore are continuously supplied through the top of the furnace and air is blown into the bottom of the chamber. Chemical reactions take place throughout the furnace as the material moves downward. The end products are typically molten metal and slag phases tapped from the bottom of the furnace, and flue gases exiting from the top of the furnace. One conventional use of a blast furnace is for smelting iron ore to produce pig iron, an intermediate material used in the production of commercial iron and steel.

[0003] Modern furnaces are equipped with an array of supporting facilities to increase efficiency. The various raw or burden materials are weighed to yield the desired hot metal and slag chemistry. The raw materials are introduced into the furnace through the top of the blast furnace. There are different ways in which the raw materials may be charged into the blast furnace. For example, some blast furnaces use a "double bell" system where two "bells" are used to control the entry of the raw material into the blast furnace. The purpose of the two bells is to minimize the loss of hot gases in the blast furnace. First the raw materials are emptied into the upper or small bell. The bell is then rotated a predetermined amount in order to distribute the charge more accurately. The small bell then opens to empty the charge into the large bell. The small bell then closes, to seal the blast furnace, while the large bell dispenses the charge into the blast furnace.

[0004] A more recent design is to use a "bell-less" system. A bell-less system uses multiple hoppers to contain each raw material, which is then discharged into the blast furnace through valves. The hopper system with valves are more accurate at controlling how much of each constituent is added, as compared to a conventional bell type system, thereby increasing the efficiency of the furnace. Further, some of these bell-less systems also implement a chute in order to precisely control where the charge is placed.

[0005] The charging procedure is an important means for influencing the gas distribution and performance of the furnace. Proper distribution of the burden materials entering the top of the blast furnace is essential to efficient operation of the furnace. Various designs exist for the burden charging process. For example: gimbal; top-charger; roto-charger; bell top, rotating chute, etc.

[0006] Conventional rotating chute designs use a complex and sensitive planetary gearbox for tilt and rotation. One such conventional electro/mechanical design is the Model PW bell-less top charging equipment. This conventional design includes multiple moving parts and is complicated to design and manufacture. Also, these conventional rotating chute designs have complex cooling systems. In addition, conventional rotating chute designs have sensitivity of tilting gearboxes for extreme positions and for lubrication. All this leads to higher cost for manufacturing and maintenance.

[0007] What is needed is a hydraulic distributor for a blast furnace that meets one or more of the following short comings in conventional blast furnaces: improves the control of the distribution of burden materials within a blast furnace; exceeds conventional gearbox capacities; improves repeatability and precision of chute positions; reduces complex components; reduces manufacturing and maintenance costs; improves bearing design; simplifies the chute change process; reduces refractory lined rotating mass; provides an efficient cooling system; and/or improves redundancy for rotation and tilt.

SUMMARY

[0008] Embodiments of the present invention address and overcome one or more of the above shortcomings and drawbacks, by providing devices, systems, and methods for safely and efficiently top charging a blast furnace. This technology is particularly well-suited for, but by no means limited to, a bell-less blast furnace. The hydraulic distributor for a blast furnace according to embodiments of the present invention provides an improvement over prior designs, including improved repeatability and precision control of the distributor chute and hence the placement of materials within the furnace. The hydraulic distributor provides a less complex design and construction, as compared to convention electro/mechanical gear designs, resulting in reduced costs for manufacturing and maintenance.

[0009] The hydraulic distributor of the present invention helps ensure proper distribution of the burden materials entering the top of the blast furnace thereby improving the performance and efficiency of the blast furnace operation. The hydraulic distributor provides for controlled, systematic charging resulting in improved productivity and operation of the furnace.

[0010] According to one embodiment of the invention, a hydraulic distributor for a bell-less top gearbox of blast furnace is provided. The hydraulic distributor includes a main housing or shell, an inner ring, a trunnion, and an actuator ring. The inner ring, trunnion, and actuator ring are located within the main housing and are operatively coupled to one another to effectuate rotation and tilt of a distributor chute coupled to the hydraulic distributor via a chute cradle. The inner ring acts to lift the distribution chute. The trunnion acts to rotate the distributor chute. The actuator ring acts to lift and rotate the distributor chute.

[0011] A control system, electronics and hydraulics are provided to control the operation of the hydraulic distributor. For example, the control system controls the electronics and hydraulics to manipulate the movement of the inner ring **110**, trunnion **120**, and actuator ring **130**, which in turn cause tilt and rotation the distributor chute **102**, as desired. For example, the control system may be programmed with a burden distribution model for a particular blast furnace (or smelting process) to precisely control the placement of burden material within the furnace.

[0012] Hydraulic tilt cylinders assemblies are provided to control the angle (or tilt) of the distribution chute. The angle (or tilt) of the distributor chute may be controlled by hydraulic cylinder stroke. Linear transducers in the hydraulic cylinders give a precise location of the cylinder stroke. This position dictates the angle of the distribution chute. The hydraulic tilt cylinders provide repeatability of the same angle at the correct position.

[0013] The hydraulic tilt cylinders are mounted to the top and outside of the hydraulic distributor housing and connecting rods extend into the main housing to link the hydraulic cylinders to the inner ring. The hydraulic cylinders extend and retract causing the inner ring to move down and up, respectively.

[0014] In one embodiment, the inner ring is connected to the actuator ring through a connection using a roller slewing bearing. The bearing connect is designed to allow the actuator ring the ability to rotate in a continuous 360 degree motion and move up and down based on the movements of the inner ring. The actuator ring is then connected to pivoting crank shafts by utilizing appropriate linkage, crank arms, and roller assemblies. The rollers and crank arms force the crank shafts to pivot as the actuator ring moves up or down. This crank arms to crank shaft connection transfers the vertical motion, up and down, into a horizontal rotation motion that in turn tilts the distribution chute up or down. In one embodiment, the crank shafts pivot on a set of bearings located in the trunnion ring with a fixed connection to the cradle. The other end of the crank shafts may be connected to the actuator ring. The distribution chute is connected to the distribution chute cradle. As the crank shafts tilt the distribution chute cradle, the cradle tilts the distribution chute.

[0015] Rotational drive assemblies control the rotation of the chute. Chute rotation may be accomplished with a gear motor and pinion that drives a geared slewing bearing at a constant RPM. An encoder internal to the rotation drive motor may be used to determine and control chute rotation angle.

[0016] The rotation drives are is mounted to the top and outside of the hydraulic distributor housing. In one embodiment, the rotation drive **140** has a motor **141** that may be operatively coupled to a gear reducer. The gear reducer may be coupled to a shaft with a drive pinion keyed to the shaft that extend into the housing. The drive pinion rotates an externally geared roller slewing bearing. The trunnion may be bolted to the outside externally geared race of the slewing bearing. The bearing connection transfers the rotation motion from the rotation drive to the trunnion. The inside race of the slewing bearing is stationary and may be bolted to the hydraulic distributor housing.

[0017] As the trunnion rotates, the crank shafts mounted through the trunnion then rotate about the vertical centerline of the hydraulic distributor. The crank shafts may be connected to the distribution chute cradle. As such, the distribution chute cradle rotates as the crank shafts are rotating about the vertical centerline of the hydraulic distributor. Rotation of the distribution chute cradle rotates the distribution chute.

[0018] According to one aspect of the invention, the hydraulic distributor provides for redundancy of operation. For example, the hydraulic distributor may include multiple and redundant rotational drive assemblies for rotating the chute. For example, the hydraulic distributor may include multiple and redundant hydraulic cylinder assemblies for tilting the chute.

[0019] According to another aspect of the invention, the ease of maintenance. For example, rotational drive assemblies are mounted to the top cover plate of the hydraulic distributor allowing for ease of access and/or replacement. For example, hydraulic cylinder assemblies are mounted to the top cover plate of the hydraulic distributor allowing for ease of access and/or replacement. Further, the location of the hydraulic cylinder assemblies on the outside of the hydraulic distributor also facilitates easier calibration of the hydraulic cylinders.

[0020] According to another embodiment of the invention, the hydraulic distributor simplifies the chute change process. For example, the distribution chute may include an improved chute cradle design and chute access door in a top portion of the blast furnace to allow the chute to be repaired or replaced without having to enter the hydraulic distributor. Also, the distribution chute may be designed to simply insert into the cradle, so that no pins are required. Also, tilt lockout pins may be provided to lock the chute in position and prevent tilt movement.

[0021] In some embodiments of the invention, the hydraulic distributor is manufactured using substantially all fabrication techniques. In other embodiments, the hydraulic distributor is designed and manufactured as a standard unit (e.g., standard size and dimensions). A standardized design allows the hydraulic distributor to easy replace a conventional gearbox and allows the hydraulic distributor to be placed in the identical same location as a conventional gearbox in which it is replacing. A standardized hydraulic distributor also provides the advantage of having substantially the same burden distribution characteristics as the gearbox it is replacing.

[0022] In some embodiments of the invention, the hydraulic distributor includes an improved and more reliable cooling system. The cooling system may include a simple once through water system. The cooling system may include a shower cooled system.

[0023] In some embodiments of the invention, the hydraulic distributor includes an improved and more reliable nitrogen system. The nitrogen system may include nitrogen that is injected at a regulated pressure into the hydraulic distributor housing at a pressure higher than the top pressure of the blast furnace to prevent blast furnace gas from entering the hydraulic distributor. In emergency situations, the nitrogen system may be used as an emergency backup for cooling the hydraulic distributor.

[0024] Additional features and advantages of the invention will be made apparent from the following detailed description of illustrative embodiments that proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The foregoing and other aspects of the present invention are best understood from the following detailed description when read in connection with the accompanying drawings. For the purpose of illustrating the invention, there is shown in the drawings embodiments that are presently preferred, it being understood, however, that the invention is not limited to the specific instrumentalities disclosed. Included in the drawings are the following Figures:

[0026] FIG. **1** shows an exemplary blast furnace on which embodiments of the hydraulic distributor of the present invention may be used;

[0027] FIG. **2** shows an exemplary hydraulic distributor installed over a blast furnace in accordance with one embodiment of the invention;

[0028] FIG. **3** is a top view showing the general arrangement of an exemplary hydraulic distributor;

[0029] FIG. **4** is a side view taking along line **4-4** of FIG. **3**;

[0030] FIG. **5** is a side view taking along line **5-5** of FIG. **3** and rotated 90 degrees from the view of FIG. **4**;

[0031] FIG. **6** is a cross-sectional view taking along line **6-6** of FIG. **3**;

[0032] FIG. **7** is a cross-sectional view taking along line **7-7** of FIG. **3** and rotated 90 degrees from the view of FIG. **6**;

[0033] FIG. **8** is a cross-sectional view taking along line **8-8** of FIG. **4**;

[0034] FIG. **9** is a partial cross-sectional view taking along line **9-9** of FIG. **3** showing an exemplary hydraulic tilt cylinder;

[0035] FIG. **10** is a partial cross-sectional view taking along line **10-10** of FIG. **3** showing exemplary alignment key travel;

[0036] FIG. **11** is a partial cross-sectional view taking along line **11-11** of FIG. **3** showing an exemplary lock-out pin in the unlocked position;

[0037] FIGS. **12**A and **12**B are partial cross-sectional views taking along line **12-12** of FIG. **3** showing the distribution chute at maximum angle and minimum angle, respectively;

[0038] FIGS. **13**A, **13**B, and **13**C are top, side and cross-sectional views, respectively, of an exemplary shell assembly;

[0039] FIGS. **14**A and **14**B are top and side views, respectively, of an exemplary inner ring assembly;

[0040] FIGS. **15**A, **15**B, and **15**C are top and two side views, respectively, of an exemplary trunnion assembly;

[0041] FIGS. **16**A and **16**B are top and cross-sectional views, respectively, of an exemplary actuator ring assembly;

[0042] FIGS. **17**A and **17**B are top and side views, respectively, of an exemplary deflector ring assembly;

[0043] FIGS. **18**A and **18**B show an exemplary rotational drive assembly and details thereof;

[0044] FIGS. **19**A and **19**B show an exemplary hydraulic tilt cylinder assembly in the retracted and extended positions, respectively;

[0045] FIGS. **20**A and **20**B are side and cross-sectional views, respectively, of an exemplary distributor chute cradle;

[0046] FIGS. **21**A and **21**B are top and cross-sectional views, respectively, of an exemplary feeder spout assembly;

[0047] FIGS. **22**A, **22**B, and **22**C are top, side and cross-sectional views, respectively, of an exemplary hydraulic distributor hydraulic piping arrangement;

[0048] FIGS. **23**A, **23**B, **23**C, and **23**D are top, side, end and cross-sectional views, respectively, of an exemplary distributor chute;

[0049] FIGS. **24**A-**24**D show a jig tool and exemplary method for replacing the chute;

[0050] FIG. **25** shows an exemplary water cooling system; and

[0051] FIGS. **26**A and **26**B show an exemplary roller assembly.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0052] The above problems in the prior art have motivated the creation of a hydraulic distributor for a blast furnace that solves one or more of the above-identified problems or shortcomings of conventional blast furnaces. The hydraulic distributor receives and distributes burden material (also referred to as raw material) inside a blast furnace. In particular, the hydraulic distributor, according to embodiments of the invention, precisely distributes burden material in a specific area within the furnace, which makes the process work better. This is accomplished through the improved control of the rotation and tilt of the distributor chute.

[0053] In some embodiments, the hydraulic distributor is for a bell-less top gearbox of a blast furnace. The hydraulic distributor eliminates the complex planetary gear box for lift and rotation of the distributor chute and provides one or more advantages over conventional gear box designs. For example, the hydraulic distributor improves repeatability of chute positions for charging ring locations. For example, the hydraulic distributor improves revolution speed of chute position changes. For example, the hydraulic distributor provides redundancies for rotation and tilt. For example, the hydraulic distributor improves bearing configuration. For example, the hydraulic distributor is easier to maintain than conventional gearboxes. For example, the hydraulic distributor reduces maintenance costs though reduced complexity and ease of access of components. For example, the hydraulic distributor provides externally mounted hydraulic cylinders. For example, the hydraulic distributor provides externally mounted rotational drives. For example, the hydraulic distributor provides for external tilt angle calibration. For example, the hydraulic distributor simplifies the water cooling system. For example, the hydraulic distributor allows for a heavier distribution chute. For example, the hydraulic distributor simplifies the chute change or replacement. For example, the hydraulic distributor has an improved ability to withstand top temperature and pressure requirements under normal blast furnace operations and during excursions.

[0054] To achieve the requirements for reliability, repeatability and low maintenance cost the hydraulic distributor design of the present invention uses hydraulic technology in place of conventional electro-mechanical technology. Use of hydraulic technology to control the distribution chute position (e.g., rotation and tilt) provides a number of advantages in comparison to the conventional gearbox design that utilizes complex mechanical gearing and mechanical brakes.

[0055] The hydraulic distributor comprises a future generation of blast furnace charging systems. Essentially, the hydraulic operation results in a stronger more compact design with a more reliable operation that produces more accurate and repeatable chute positions with less maintenance. Also, the hydraulic distributor does not have to rely on limit switches at the end positions of travel, since this position is dictated by the cylinder stroke. A limitation of conventional non-hydraulic designs is that if limit switches do not work, the device runs through the end positions resulting in mechanical damage to the equipment.

[0056] The angle (or tilt) of the distribution chute may be controlled by hydraulic cylinder stroke. Linear transducers in the hydraulic cylinders give a precise location of the cylinder stroke. This position dictates the angle of the distribution chute. This hydraulic distributor system results in the repeatability of the same angle at the correct position. Also, the design of the hydraulic valve system holds this position and provides a fast response to changes in chute positions. The hydraulic distributor design eliminates relying on brakes to stop the chute and eliminates differences from chute angle due to gear wear. In addition, the hydraulic cylinders are located on the exterior of the hydraulic distributor thereby allowing the chute angles to be calibrated without stopping the furnace by determining the stroke position of the cylinders.

[0057] The rotation of the chute may be accomplished with a gear motor and pinion that drives a geared slewing bearing at a constant RPM. In some embodiments, the hydraulic distributor may be supplied with two rotation drive assemblies, one operating and one standby. An encoder internal to the rotation drive motor may be used to determine and control chute rotation angle.

[0058] FIG. **1** shows an exemplary blast furnace **10**. As shown, the blast furnace **10** may include a preheating zone **12**, a first reduction zone **14** (e.g., for the reduction of ferric oxide), a second reduction zone **16** (e.g., for the reduction of ferrous oxide), and a melting zone **18**. One or more sources of hot blasts **20** are provided. For example, BF stoves may supply hot blasts to the melt zone **18**. A feeder **22** supplies raw materials into the top opening **24** of the blast furnace **10**. The feeder **22** may include, for example, a belt, a conveyor, a conduit, tracks with cars, rails with hoppers, a bridge, transfer cars, and the like. During operation, exhaust gases collect in a top portion or dome of the furnace and an uptake **26** may be provided for the removal of gases from the blast furnace **10**. Taps **28***a*, **28***b* and conduits **30***a*, **30***b* may be provided for the removal of slag and molten metal (e.g., pig iron), respectively, from the furnace **10**.

[0059] For example, an iron making blast furnace may comprise a tall chimney-like structure lined with refractory brick **32**. Coke, limestone flux, and iron ore (iron oxide) may be charged into the top of the furnace in a precise filling order which helps control gas flow and the chemical reactions inside the furnace. Uptakes **26** allow the hot, dirty gas to exit the furnace dome, while bleeder valves (not shown) may protect the top of the furnace from sudden gas pressure surges. The coarse particles in the gas may settle in the dust catcher (not shown) and may be discharged from the furnace for disposal, while the gas itself may flow through a venturi scrubber (not shown) and a gas cooler (not shown) to reduce the temperature of the cleaned gas.

[0060] A casthouse **34** at the bottom half of the furnace may include the bustle pipe, tuyeres and the equipment for casting the liquid iron and slag. One or more tapholes may be drilled through the refractory clay plug(s) allowing liquid iron and slag to flow down a trough through a skimmer opening, separating the iron and slag. Modern, larger blast furnaces may have multiple tapholes and casthouses. Once the pig iron and slag has been tapped, the taphole is again plugged with refractory clay, or other suitable material.

[0061] Tuyeres may be used to implement a hot blast, which may be used to increase the efficiency of the blast furnace. The hot blast is directed into the furnace through water-cooled copper nozzles called tuyeres near the base. Oil, tar, natural gas, powdered coal and oxygen can also be injected into the furnace at tuyere level to combine with the coke to release additional energy which is necessary to increase productivity.

[0062] FIG. **2** is a general arrangement view showing the hydraulic distributor **100** installed over a blast furnace, such as the exemplary blast furnace **10** shown and described with reference to FIG. **1**. As shown in FIG. **2**, the hydraulic distributor **100** is installed over the top opening **24** of the blast furnace **10**. The hydraulic distributor **100** is used to lift and rotate a distributor chute **102** in order to control the feed and distribution of raw materials into the furnace **10**.

[0063] As shown in FIG. **2**, raw materials (not shown) may flow from the feeder **22** and may gravity feed into a feed hopper **40** positioned below the feeder to receive the raw materials. One or more material hoppers (e.g., lock hoppers) **42** may be positioned below feed hopper **40** to receive the raw materials. Two material hoppers **42** are shown in FIG. **2**. Feed hopper **40** may be movable to selectively discharge raw materials into a top opening **44** of one of the material hoppers **42**. Each material hopper **42** also includes a bottom opening **46** for allowing the raw materials to exit the material hoppers **42**. A material gate **48** and lower seal valve **49** may be provided at each bottom opening **46** to control the flow of raw materials exiting each material hopper **42**. The lower seal **49** may be located in a lower seal valve housing **50**. As shown, an expansion joint **52** and a shut off or goggle valve **54** may also be located between the material hoppers **42** and the hydraulic distributor **100**. A chute access door **56** is also provided in a top portion **58** of the blast furnace **10** for maintenance and replacement of the chute.

[0064] FIGS. **3-8** show one embodiment of the hydraulic distributor **100**. As shown in the figures, the hydraulic distributor **100** includes a housing or shell **104**, an inner ring **110**, a trunnion **120**, and an actuator ring **130**. As shown, the inner ring **110** may be located in housing **104** and serves to lift the distribution chute **102**. As shown, the trunnion **120** may be positioned concentrically within the inner ring **110** and is operatively coupled to the actuator ring **130**. The trunnion **120** serves to rotate the distributor chute **102**. Also as shown, the actuator ring **130** may be positioned concentrically with the trunnion **120** and is operatively coupled to the trunnion **120**. The actuator ring **130** serves to lift and rotate the distributor chute **102**. The movement of the inner ring **110**, trunnion **120**, and actuator ring **130** may be used to tilt and rotate the distributor chute **102**, as desired, based upon, for example, the burden distribution model of the blast furnace.

[0065] As shown in FIGS. **3-5** and **13**A-**13**D, the main housing **104** includes a bottom **105**, a top cover plate **106**, and a sidewall **107** extending between the bottom **105** and the top cover plate **106**. Water inlet ports **108***a* and water outlet ports **108***b* may be provided in housing **104**. Nitrogen ports **108***c* may also be provided in housing **104**.

[0066] Access doors **109** are provided for allowing access to the components housed in main housing **104**. The access doors **109** may include a hinged pivot, bolted flange connection and a packing seal to provide quick open or closing action of the access doors **109**. As shown, the upper access doors may provide access to: the hydraulic tilt cylinder **150**/inner ring **110** connections; rotation drive pinions **144** and the top slewing bearing **145***a* and actuator ring grease reservoirs. As shown, two lower doors may provide access to: crank shafts **180**; crank arms **184**; rollers assemblies **186** (see FIGS. **26**A and **26**B); crank shaft bushing grease reservoirs (not shown); bottom slewing bearing **145***b*; and bottom water trough.

[0067] As shown in FIGS. **3-7** and **9-10**, the hydraulic distributor **100** may include a number of openings in and mounting flanges on the top cover plate **106**. For example, four hydraulic tilt cylinder openings and flanges for mounting the hydraulic tilt cylinder assemblies **150** and two rotor drive openings and flanges for mounting the rotor drive assemblies **140**. In the illustrated embodiment, the hydraulic tilt cylinders **150** and rotor drives **140** are bolted to the respective mounting flanges.

[0068] As shown in FIGS. **3**, **6**, **7**, **8**, and **21**A-**21**B, the hydraulic distributor **100** also includes a feeder spout assembly **160**. The feeder spout assembly **160** extends through the center region of the hydraulic distributor **100**. Raw materials are fed through the top opening of the feeder spout assembly **160**, pass through the hydraulic distributor **100**, and flow out of the feeder spout assembly **160** and into the chute **102**.

[0069] As shown in FIGS. **3**, **6**, **7**, **8**, and **21**A-**21**B, the distribution chute **102** is mounted to the cradle **103**, which rotates and lifts the distribution chute **102**. The chute shell may be lined with liner plate. These liner plates may comprise cast manganese steel. The liner plates are a normal wear item and the distribution chute typically needs to be replaced over time. To increase life of liner plates, the chute rotation direction can be change from a CW to a CCW rotation, or visa-versa, periodical so wear is even on all sides.

[0070] As shown in the figures, the hydraulic distributor **100** also includes one or more rotational drive assemblies **140** and one or more hydraulic tilt cylinder assemblies **150**. The rotational drive assemblies **140** act to rotate the distributor chute **102**. The hydraulic tilt cylinder assemblies **150** act to lift the distributor chute **102**.

[0071] Multiple rotational drive assemblies **140** may be provided. As shown, two rotational drive assemblies **140** may be positioned 180 degrees apart from one another and may be mounted to the top cover plate **106** of the main housing **104**. Mounting of the rotational drive assemblies **140** allows for ease of maintenance or replacement of rotational drives without entering the hydraulic distributor shell **104**.

[0072] As shown in FIGS. **6** and **18**, each rotational drive **140** includes a motor **141** connected to the hydraulic distributor **100** via a base housing **147**. An output shaft of the gear motor **141** drives a motor drive pinion **144** through a gear reducer **142** and pinion drive shaft **143**.

[0073] In one embodiment, the rotational drive **140** may be powered by a 10 HP AC, 480V, 3-phase, 1,800-RPM electrical motor with an encoder internal to the motor. This encoder is used by the control system (e.g., the PLC) to determine chute rotation angle.

[0074] Multiple hydraulic tilt cylinder assemblies **150** may be provided. As shown, four hydraulic tilt cylinder assemblies **150** may be positioned 90 degrees apart from one another and may be mounted to the top cover plate **106** of the main housing **104**. In one embodiment shown in FIGS. **9**-**12**B and **19**A-**19**B, the hydraulic tilt cylinder assemblies **150** may include a 3,000-PSI mill duty type cylinder with a 4-inch bore×2-inch rod and 13-inch stroke. Each hydraulic cylinder may have a linear transducer incorporated into the blind end head. The linear transducer may be used by the control system to determine chute tilt angle. The hydraulic cylinders **150** may be mounted on the top cover plate **106**, which allows for ease of maintenance or replacement of cylinders without entering the hydraulic distributor shell **104**.

[0075] As shown in FIGS. **7**, **9**, **10**, **19**A and **19**B, each hydraulic tilt cylinder includes a hydraulic cylinder **151**, an intermediate rod **152**, and a cylinder stand **153**. The hydraulic cylinder **151** is connected to a source of hydraulic pressure (not shown) and causes extension and retraction of the intermediate rod **152**. The cylinder stand **153** is used to mount the hydraulic cylinder **151** to the hydraulic distributor **100**. As shown, the hydraulic cylinder rod is attached to an intermediate rod **152** and a clevis **155**. A pin may be used to connect clevis **155** to inner ring **110**.

[0076] The hydraulic distributor **100** uses two types of motion to control the distribution chute **102**—tilt and rotation. The following is an explanation of how an exemplary hydraulic distributor controls tilt and rotation in one embodiment of the invention.

[0077] The distribution chute tilt motion may be achieved as follows:

[0078] 1. The tilt motion is achieved by utilizing hydraulic cylinders **150** to precisely locate and hold the chute position. The cylinders are mounted to the top cover plate **106** and are outside of the hydraulic distributor shell **104** to provide easy access and maintenance to the cylinders.

[0079] 2. Connecting rods **152** link the hydraulic cylinders **150** to the inner ring **110** inside the hydraulic distributor shell **104**. The inner ring **110** moves in an up and down motion as the hydraulic cylinders **150** extend and retract.

[0080] 3. The inner ring **110** is then connected to an actuator ring **130** through a connection using an X style roller slewing bearing **145***b* (bottom slewing bearing). The bearing connection is designed to allow the actuator ring **130** the ability to rotate in a continuous 360 degree motion and move up and down based on the movements of the inner ring **110**.

[0081] 4. The actuator ring **130** is then connected to two (2) pivoting crank shafts **180** by utilizing linkage, crank arms **184** and roller assemblies **186**. The rollers **186** and crank arms **184** force the crank shafts to pivot as the actuator ring **130** moves up or down. This crank arms **184** to crank shaft **180** connection transfers the vertical motion, up and down, into a horizontal rotation motion that in turn tilts the distribution chute **102** up of down. See FIGS. **7**, **12**A, and **12**B.

[0082] 5. The crank shafts **180** pivot on a set of bushings located in the trunnion inner most ring. The other end of the crank shafts **180** may be connected to the distribution chute cradle **103** using, for example, a spline connection.

[0083] 6. The distribution chute **102** is connected to the distribution chute cradle **103**. As the crank shafts tilt the distribution chute cradle **103**, the cradle **103** tilts the distribution chute **102**. See FIGS. **4**-**7** **12**A, **12**B, **20**A, **20**B, **26**A and **26**B.

[0084] See FIGS. **3**, **7**, **9**-**12**B, and **19**A-**19**B.

[0085] In some embodiments, the minimum distribution chute angle is about 3 degrees (offset from vertical). In some embodiments, the maximum distribution chute angle is about 55 degrees (offset from vertical). In some embodiments, the distribution chute tilt angle change speed is about 3 degrees per second.

[0086] The distribution chute rotational motion may be achieved as follows:

[0087] 1. A rotation drive **140** is mounted to the top cover plate **106** located outside and on top of the hydraulic distributor shell **104**. Once again this provides for easy maintenance to the rotation drive assembly **140**, if needed. The rotation drive **140** has a motor **141** (e.g., a 10 HP electrical motor) that may be operatively coupled to a gear reducer **142** (e.g., a vertical Cyclo gear reducer). The gear reducer **142** may be coupled to a shaft **143** with a drive pinion **144** keyed to the shaft **143**.

[0088] 2. The drive pinion **144** rotates an externally geared X style roller slewing bearing **145***a* (upper slewing bearing). The trunnion **120** may be bolted to the outside externally geared bearing of the slewing bearing. The bearing connection transfers the rotation motion from the rotation drive **140** to the trunnion **120**. The inside race of the slewing bearing is stationary and is bolted to the top cover plate **106**.

[0089] 3. As the trunnion **120** rotates, the crank shafts **180** mounted through the trunnion **120** then rotate about the vertical centerline of the hydraulic distributor **100**.

[0090] 4. These crank shafts **180** may be spline connected, for example, to the distribution chute cradle **103**.

As such, as the crank shafts **180** are rotating about the vertical centerline of the hydraulic distributor **100** the distribution chute cradle **103** rotates as well.

[0091] 5. The distribution chute **102** is connected to the distribution chute cradle **103**, so as the cradle **103** rotates the distribution chute **102** rotates as well.

[0092] See FIGS. **3**, **6**, and **7**.

[0093] In the illustrated embodiment, there are two chute rotation drives **140**, each with a motor **141** and an integral gearbox **142**, but only one rotational drive is in service at any time. The second rotational drive is a spare and is mechanically disengaged. In one embodiment, the functioning chute rotation motor and gearbox drive the chute with an effective overall gear reduction of approximately 217:1. The chute rotation motor may be powered via a variable frequency drive (VFD). In one embodiment, the Accel/Decel ramps in the VFD may be set at about 5 seconds; and during normal operation, the chute may rotate at constant speed of about 8 RPM.

[0094] When homing, the chute may rotate at a slow speed, approximately 0.1-0.8 RPM (which may be set via the HMI). The normal operating speed and the homing speed can both be set from the HMI. The direction of rotation may be selected through the HMI. In normal operation, the direction of rotation may be reversed periodically.

[0095] The hydraulic distributor includes a rotating chute with chute slope control capabilities. A control system may be provided to control the operation of the hydraulic distributor through primarily hydraulics and electronics. Hydraulics are generally used to move mechanical components while the electronics are generally used to control the components. The control system may control components of the hydraulic valve stand, the hydraulic distributor, and a Human-Machine Interface (HMI). In a typical blast furnace operation, rotational speed (e.g., motor speed) is constant, and the angle (lift and tilt) of the distribution chute and the flow rate of material may be adjusted.

[0096] In one embodiment the hydraulic distributor control system may include a controller (e.g., an Allen-Bradley® ControlLogix PLC with I/O) and two variable-frequency drives (VFDs) (e.g., Allen-Bradley® Powerflex 700 VFDs). The PLC may communicate with the Powerflex 700 VFD via a control network (e.g., Controlnet).

[0097] The I/O may be controlled by a PLC which in turn may communicate with the existing control system and the HMI via a suitable communications protocol (e.g., Ethernet/IP). The I/O reads all field devices and the logic may be solved in the PLC. The rotational motor may include an encoder, which may be wired to a VFD. The encoder data may be read by the PLC via the Controlnet connection to the PLC.

[0098] In certain embodiments, for example retrofit application, the status of all the I/O on the control system may be displayed on the existing HMI and, to the extent possible, the appearance and functionality of all icons and operator interactions may be unchanged from the existing system. Certain functions and instruments on the hydraulic distributor may also be added to the HMI displays. The HMI thereby displays the status of all the I/O devices associated with the hydraulic distributor. Alternatively, in new installations a new HMI may be provided that includes all of the necessary I/O devices associated with the hydraulic distributor.

[0099] A proximity switch assembly **148** (See e.g., FIG. **3**) may be provided and used by the PLC to indicate home position for chute rotation. The home position is when the distribution chute **102** is lined up with the chute change door **56**. See FIGS. **2**, **3** and **7**.

[0100] Also, embodiments of the distribution chute may include an improved cradle design to allow the chute to be exchanged without having to open the hydraulic distributor doors or enter the hydraulic distributor case. In such embodiments, the chute change door **56** on the blast furnace **10** is the only portal opening required to exchange the chute **102** (see FIG. **2**). Preferably, there are not any pins to pull as this distribution chute **102** is designed to simply insert into a cradle **103**. As the chute **102** is tilted into its rest position in the cradle **103**, it may be locked into position.

[0101] Tilt lock-out pins **172** may be provided for locking out tilt function during maintenance (see e.g., FIGS. **4**, **5**, **8** and **11**). The lock pins **172** may include a flange connected to the hydraulic distributor shell **104** and pin though the inner ring **110** to prevent tilt movement during maintenance. The hydraulic distributor **100** can be pinned, for example, at a minimum distribution chute angle and a maximum distribution chute angle. FIG. **11** shows the lock-out pins **172** in the unlocked position.

[0102] FIGS. **24**A-**24**D show an exemplary chute exchange process and chute counter weight jig **190**. As shown in FIG. **24**A, the chute access door **56** may be removed, the chute **102** may be rotated to its maximum angle. Jig **190** enters the furnace **10** through the chute access door opening **57**. As shown in FIG. **24**B, the jig **190** may be connected to the chute **102**. FIG. **24**C shows the jig **190** rotating the chute **102** to release it from chute locking surfaces **192** and **194** of cradle **103**. One of the advantageous of this design is that there is no need to open or access the hydraulic distributor **100**. As shown in FIG. **24**D, the jig may continue to rotate the chute **102** to horizontal and the chute **102** may be removed from the furnace **10** through the chute access door opening **57**.

[0103] In some embodiments, the cooling system of the hydraulic distributor is a simple once through water system—instead of closed loop cooling which would increase the capital and operating cost of the system. In some embodiments, such as the embodiment illustrated in FIG. **25**, the water cooling of the hydraulic system may include a shower cooled system that has water coverage on every internal portion of the distributor that may conduct heat from the blast furnace. The hydraulic distributor has a small rotational mass to support the distribution chute and an external trough ring that is stationary which also has refractory insulation. This portion is not subject to vibration due to the rotation of the chute. The refractory in this area is very stable and has a long life.

[0104] In the illustrated embodiment, the hydraulic distributor includes four 2" water inlet pipes **108***a*. These pipes connect to an enclosed trough located inside the top cover **106**. The trough discharges into a shower ring-pipe below the trough. The internal shower ring-pipe has holes in it which are positioned to directly spray the cooling water onto the feeder spout bushing. The water cascades down the feeder spout bushing and onto the top of the trunnion **120**. The water collects in a shallow pool on top of the trunnion horizontal surface. The water then overflows a weir wall to cascade down the trunnion's vertical surface and is collected in a trough located at the bottom of the hydraulic distributor shell **104**. Once in the bottom trough, two paddles connected to the rotating trunnion continually rotate to keep the water stirred up and prevent settlement from falling out of the water and building an insulating layer of debris in the bottom of the hydraulic distributor. Further, in order to provide additional heat protection to the hydraulic distributor, refractory may be applied to all surfaces exposed to the inside of the blast furnace.

[0105] In some embodiments, nitrogen may be injected at a regulated pressure into the hydraulic distributor housing at, for example, two nitrogen inlet ports **108***c* (See e.g., FIG. **4**) located 180° apart, to provide a pressure that is higher than the blast furnace top pressure. This positive pressure prevents dirty blast furnace gas from entering the hydraulic distributor unit.

[0106] In an emergency situation, such as loss of cooling water, the nitrogen regulating valve may open to allow nitrogen (e.g., about 1500-2000 SCFM of nitrogen) into the hydraulic distributor for emergency cooling. In an exemplary embodiment, one of the two inlets may be reversed to become an exhaust to prevent pressure from building too high in the hydraulic distributor shell. This emergency cooling is only intended to provide short term cooling to protect the hydraulic distributor.

[0107] Preferably, redundancy is provided for both the tilt and rotation motions. For example, multiple hydraulic cylinders may be provided in some embodiments of the hydraulic distributor such that the distribution chute tilt is able to continue to operate even if one of the multiple hydraulic cylinders fails. Also, embodiments of the hydraulic distributor may be designed such that a cylinder can be easily replaced. For example, the cylinder may be mounted outside the hydraulic distributor housing. In addition, embodiments of the hydraulic distributor may include distribution chute rotation redundancy by featuring a complete spare drive assembly which may be, for example, mounted on the top cover plate 180 degrees away from the other rotation drive on the outside of the hydraulic distributor housing. Further, the rotation drives may be designed with an eccentric mounting flange. This design allows for a quick change over from the primary to the backup drive.

[0108] The hydraulic distributor according to embodiments of the present invention is built using substantially all fabrication techniques—as opposed to casting techniques. Further, the hydraulic distributor according to embodiments of the present invention may be standard (e.g., standard size and dimensions) so that it may replace a conventional gearbox (e.g., a PW electro/mechanical gearbox). The standardized hydraulic distributor may be set in the identical same location as a conventional gearbox it is replacing without requiring any modifications to it or the furnace. This provides an improvement over conventional designs that were custom built to a particular furnace or application. A standard hydraulic distributor results in ease of installation, reduced down time, and cost savings when replacing a gearbox.

[0109] In addition, a standard hydraulic distributor having substantially the same dimensions as the gearbox it is replacing will also result in the distribution chute distributing burden material exactly the same and in the same locations as the gear box it is replacing. This may have a big impact on costs. The reason for this is that each blast furnace has a specific burden distribution model. A burden distribution model controls the distribution of burden material so as to optimize and improve performance. For example, burden distribution model dictates the rotation and lift of the distribution chute to precisely locate material within the furnace. If a hydraulic distributor is not standard or the same as the gearbox it is replacing, then all the burden distribution models have to be updated or new burden distribution models must be generated. With a standard hydraulic distributor that fits identically in the same location as the gearbox it is replacing, the hydraulic distributor will distribute material in the same location and the existing burden distribution models may be used.

[0110] Chute rotation calibration may be accomplished as follows:

[0111] 1. With all alarms acknowledged or reset, the operator may put the system into maintenance mode and then initiate the homing operation. The operator should wait for the homing operation to complete before attempting any other control actions.

[0112] 2. During homing, the following actions may occur:

[0113] a) If not at the home position, the chute will move toward the home position switch at slow speed (set via the HMI).

[0114] b) When the home position switch is reached, the chute will stop, reverse direction and then move off the home position switch until the first marker pulse of the encoder is detected.

[0115] c) This is the home position. The system is now homed and ready for operation.

[0116] In some embodiments, the chute slope is mechanically limited to a range of 3-55 degrees. The chute slope may be controlled by the operator through the HMI. In the illustrated embodiment, there are four hydraulic tilt cylinders that control the chute slope. The hydraulic tilt cylinders extend to raise the chute and retract to lower it. The hydraulic tilt cylinders may be controlled by a hydraulic valve stand (described in more detail below), and the position of each hydraulic tilt cylinder may be sensed by a feedback device, such as a linear transmitter. The four linear transmitters may generate an analog signal which may be an input to the PLC of the control system. The position of each cylinder may be displayed on the HMI. The chute slope may be determined by the PLC based upon a calculation from the four linear transmitters.

[0117] Chute slope calibration may be accomplished as follows:

[0118] 1) The hydraulic tilt cylinders may extend until the chute hits a mechanical stop. In some embodiments, the feedback devices may read 55 degrees in the extended position. If the feedback device output does not indicate 55 degrees, the feedback device output may be re-calibrated to 55 degrees.

[0119] 2) The hydraulic tilt cylinders may retract until the chute hits a mechanical stop. In some embodiments, the feedback devices may read 3 degrees in the retracted position. If the feedback device output does not indicate 3 degrees, the feedback device output may be re-calibrated to 3 degrees.

[0120] 3) If the feedback from one of the hydraulic tilt cylinders is out of the allowable variance, the PLC may disregard the signal from that device and an alarm may be set. If only two units are in agreement then the chute position system is faulted and the system should be inspected to determine the cause of the mismatched outputs in order to prevent damage to the inner workings of the hydraulic distributor.

[0121] The hydraulic tilt cylinders may be designed to have extra stroke at both the min and max positions of the chute, e.g., 3 degrees and 55 degrees. Stop blocks (not shown) may be provided to prevent the hydraulic tilt cylinders from being able to stroke past the min and max degree positions. When the hydraulic tilt cylinders stroke to the extreme positions, the inner ring, which the hydraulic cylinders lift and lower, comes up against these stop blocks. The purpose of this design is to make it quick and easy to replace a hydraulic tilt cylinder. There is no need to spend time shimming or adjusting the cylinder to get the chute at exactly 55 degrees when the cylinders are completely extended or at exactly 3 degrees when the cylinders are completely retracted since there is extra stroke in the cylinders.

[0122] The PLC program may be zeroed as follows:

[0123] 1. Retract the cylinders until the inner ring comes up against the top set of stop blocks.

[0124] 2. Check that the chute is at 3 degrees.

[0125] 3. Set the PLC program to a 0.000 stroke value, even though the cylinder is at about 0.25-inch as explained above with respect to extra stroke. The control system may then display that the chute is at 3 degrees based on the 0.000 stroke value.

[0126] 4. Extend the cylinders until the inner ring comes up against the bottom set of stop blocks.

[0127] 5. Check to make sure the liner transducers are reading approximately 12.3-inch, which the PLC may then calculate the chute angle as being 55 degrees.

[0128] FIGS. **22**A and **22**B show piping assembly **190**, which may be used to control the chute slope position functions. As shown, the assembly **190** may include appropriate piping, hoses, pressure sensor and/or indicators. A remote hydraulic manifold, including pressure reducers, filters, relief valves, solenoid valves, closed-loop control network, reservoir, and the like, may supply a control hydraulic fluid to the hydraulic tilt cylinders in order to cause the cylinder rods to extend and retract. In one embodiment, the system hydraulic pressure may be set to about 2500 psi.

[0129] The following lists basic operating data and parameters of an exemplary hydraulic distributor:

minimum distribution chute angle	3°
maximum distribution chute angle	55°
tilt cylinders (qty. 4)	Bore-4 inch diameter
(with cushion at both ends)	Rod-2 inch diameter
	Stroke-13.0 Inches
hydraulic design pressure	3,000 PSI
hydraulic operating pressure	2,200 PSI
hydraulic flow rate required	13 GPM
tilt angle change speed	3° per second
Rotation Speed	8 RPM
Rotation E-Motor	10 HP; 460 VAC; 60 Hz; 3-Phase

[0130] Although the invention has been described with reference to exemplary embodiments, it is not limited thereto. Those skilled in the art will appreciate that numerous changes and modifications may be made to the preferred embodiments of the invention and that such changes and modifications may be made without departing from the true spirit of the invention. It is therefore intended that the appended claims be construed to cover all such equivalent variations as fall within the true spirit and scope of the invention.

What is claimed:

1. A hydraulic distributor comprising:

a housing comprising a top cover plate, a bottom and a sidewall extending between the top cover plate and the bottom;

an inner ring located in the housing;

a trunnion located with the housing and concentrically inward from the inner ring, and

an actuator ring located with the housing and concentrically between the inner ring and the trunnion;

a hydraulic tilt cylinder mounted to the top cover plate of the housing; the hydraulic tilt cylinder comprising a hydraulic cylinder, a cylinder stand and a cylinder rod, the cylinder rod extending into the housing and operatively coupled to the inner ring;

a rotational drive mounted to the top cover plate of the housing; the rotational drive comprising a motor, a pinion drive shaft, and a drive pinion, the pinion drive shaft and drive pinion extending into the housing and operatively coupled to the trunnion;

a distributor cradle operatively coupled to the inner ring, the trunnion, and the actuator ring;

a distribution chute mounted to the distributor cradle

wherein linear movement of the hydraulic tilt cylinder serves to lift and control tilt of the distribution chute and wherein rotational movement of the rotational drive serves to rotate the distributor chute.

2. The hydraulic distributor of claim **1**, further comprising four hydraulic tilt cylinders positioned about 90 degrees apart from one another.

3. The hydraulic distributor of claim **1**, wherein the inner ring is connected to the actuator ring using a lower roller slewing bearing, the lower bearing connection allowing the actuator ring to rotate in a continuous 360 degree motion and move up and down based on the movements of the inner ring.

4. The hydraulic distributor of claim **3**, wherein the actuator ring is connected to one or more pivoting crank shafts having linkage, crank arms and roller assemblies, wherein the rollers and crank arms force the crank shafts to pivot as the actuator ring moves up or down, this crank arms to crank shaft connection transferring the vertical motion into a horizontal rotation motion that in turn tilts the distribution chute up of down.

5. The hydraulic distributor of claim **4**, wherein the crank shafts pivot on a set of bushings located in a trunnion inner most ring, the other end of the crank shafts connected to the distribution chute cradle.

6. The hydraulic distributor of claim **1**, further comprising two rotational drives positioned about 180 degrees apart from one another, wherein during normal operations one rotational drive is operating and the other rotational drive is in stand-by.

7. The hydraulic distributor of claim **1**, wherein the rotational drive pinion is coupled to the trunnion via an upper geared slewing bearing, the trunnion is bolted to an outside externally geared race of the slewing bearing, an inside race of the slewing bearing is connected to the hydraulic distributor housing and is stationary, the upper bearing connection transferring the rotation motion from the rotation drive to the trunnion.

8. The hydraulic distributor of claim **7**, wherein as the trunnion rotates, crank shafts mounted through the trunnion rotate about the vertical centerline of the hydraulic distributor, the crank shafts are connected to and rotate the distribution chute cradle.

9. The hydraulic distributor of claim **1**, further comprising a control system for controlling rotation and tilt of the hydraulic distributor.

10. The hydraulic distributor of claim **9**, wherein the hydraulic tilt cylinder further comprises a linear transducer, wherein the linear transducer provides a precise location of the cylinder rod stroke to the control system.

11. The hydraulic distributor of claim **9**, wherein rotational drive further comprises an encoder internal to the motor, wherein the encoder is used by the control system to determine distributor chute rotation angle.

12. The hydraulic distributor of claim **9**, further comprising a source of hydraulic pressure in fluid communication with the hydraulic cylinder of the hydraulic tilt cylinder, wherein the source of hydraulic pressure is controlled by the control system to cause extension or retraction of the hydraulic tilt cylinder and control lift of the distributor chute.

13. The hydraulic distributor of claim **1**, further comprising electronics electrically connected to the rotational drive, wherein the electronics are controlled by the control systems to activate the rotational drive to control rotation of the distributor chute.

14. The hydraulic distributor of claim **1**, further comprising a linear transducer in each of the hydraulic cylinders that provide a precise location of the cylinder stroke, wherein the location of the cylinder stroke dictates the angle of the distribution chute.

15. The hydraulic distributor of claim **1**, further comprising an encoder in the rotational drive motor that provides precise location of the rotation drive, wherein the location of the rotation drive dictates a rotational angle of the distribution chute.

16. A method of controlling the rotation and tilt of a distributor chute of a hydraulic distributor comprising:

controlling distribution chute rotational motion by:

utilizing a rotation drive having a motor;

energizing the motor to rotate an output shaft of the motor;

operatively coupling a gear reducer to the motor output shaft;

coupling a shaft to the gear reducer, the shaft having a drive pinion keyed to the shaft, wherein the gear reducer transmits the rotation of the motor output shaft to cause rotation of the drive pinion;

rotating an upper roller slewing bearing that is operatively coupled to the drive pinion;

connecting a trunnion to the slewing bearing, wherein the bearing connection transfers the rotation motion from the rotation drive to the trunnion;

as the trunnion rotates, rotating crank shafts mounted through the trunnion about a vertical centerline of the hydraulic distributor;

connecting a distribution chute cradle the crank shafts;

rotating the distribution chute cradle as the crank shafts rotate about the vertical centerline of the hydraulic distributor;

connecting a distribution chute to the distribution chute cradle, so as the cradle rotates the distribution chute rotates as well;

controlling distribution chute tilt motion by:

utilizing hydraulic cylinders connected to a source of hydraulic pressure;

connecting the hydraulic cylinders to an inner ring inside a hydraulic distributor housing via connecting rods;

extending and retracting the hydraulic cylinder to move the inner ring in a vertical up and down motion;

connecting the inner ring to an actuator ring through a connection using a lower roller slewing bearing, wherein the bearing connect is designed to allow the actuator ring the ability to rotate in a continuous 360 degree motion and move up and down based on the movements of the inner ring;

connecting the actuator ring to two pivoting crank shafts utilizing linkage, crank arms and rollers, the rollers and crank arms force the crank shafts to pivot as the actuator ring moves up or down, this crank arms to crank shaft connection transferring the vertical motion, up and down, into a horizontal rotation motion that in turn tilts the distribution chute up or down.

17. The method of claim **16**, wherein the upper slewing bearing is an externally geared X style roller slewing bearing, and further comprising;

connecting the trunnion to an outside externally geared race of the slewing bearing; and

connecting an inside race of the slewing bearing to the hydraulic distributor housing.

18. The method of claim **16**, further comprising pivoting the crank shafts on a set of bushings located on the trunnion, and the other end of the crank shafts being connected to the distribution chute cradle.

19. The method of claim **16**, further comprising connecting the inner ring to the actuator ring using a lower roller slewing bearing, the lower bearing connection allowing the actuator ring to rotate in a continuous 360 degree motion and move up and down based on the movements of the inner ring.

20. The hydraulic distributor of claim **19**, further comprising connecting the actuator ring to one or more pivoting crank shafts having linkage, crank arms and roller assemblies, wherein the rollers and crank arms force the crank shafts to pivot as the actuator ring moves up or down, this crank arms to crank shaft connection transferring the vertical motion into a horizontal rotation motion that in turn tilts the distribution chute up of down.

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