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(54) Assembly and disassembly methods and apparatus.

(57) Assembly and disassembly methods and apparatus for a rotary machine (100). According to a first aspect of the present invention, methods and apparatus (200) are provided for assembling and disassembling a horizontal split stator housing (122) of the rotary machine (100), specifically a lower section (144) of the stator housing (122). According to a second aspect of the present invention, methods and apparatus (300) are provided for assembling and disassembling a rotor seal (124) and a disc end bearing (132) of the rotary machine (100). According to a third aspect of the present invention, methods and apparatus are provided for assembling and disassembling an impeller rotor (106) of the rotary machine (100).

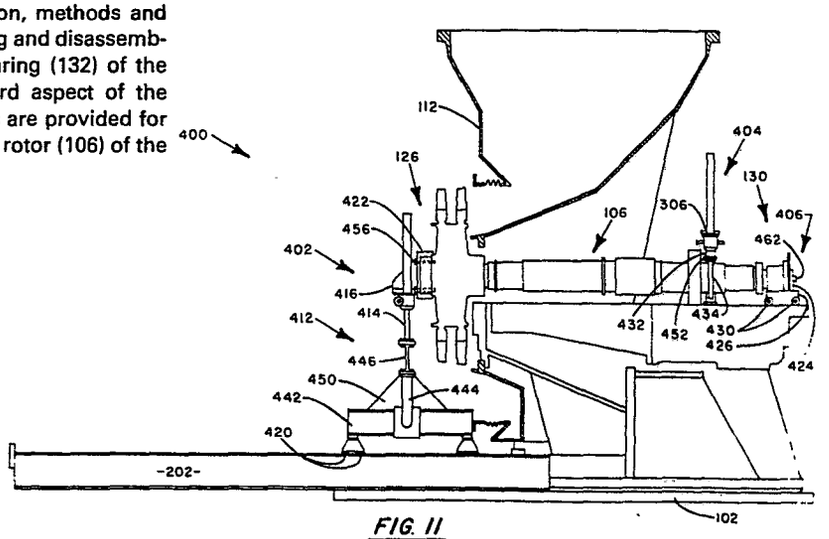

FIG. 11

EP 0 051 178 A1

Assembly and Disassembly Methods and Apparatus

This invention generally relates to rotary machines, and more specifically to assembling and disassembling rotary machines.

Occasionally, the impeller rotor and blades of a rotary machine such as a centrifugal compressor or expander must be removed from the machine for cleaning, maintenance, or replacement. For example, rotary machines are often used with fluids containing a significant amount of particulates or debris. Over a period of time, these particulates and debris tend to collect or accumulate on the impeller blade surfaces, necessitating periodic removal of the impeller rotor and blades from the machine to clean or replace the blade surfaces. Routine inspection and maintenance, for example to repair or realign a rotor seal or blade, may also require removal of the impeller rotor from the machine.

Typically, in order to remove an impeller rotor from a rotary machine, a large portion of the machine must be disassembled. Many of the parts which must be disassembled are large, heavy, and thus difficult to maneuver. Moreover, when reassembled, usually these parts must be accurately aligned relative to each other and to any equipment used with the rotary machine such as an electric motor or generator. As a result, disassembly and reassembly of a rotary machine requires skilled labor. Further, of course, the machine is inoperable and, hence, unproductive while being assembled and disassembled.

According to a first aspect of the present invention, methods and apparatus are provided for assembling and disassembling a horizontal split stator housing of a rotary machine, specifically a lower section of the stator housing. The stator housing assembly and disassembly apparatus includes rail means for supporting the lower section of the stator housing for horizontal movement toward and away from the rotary machine, and means for vertically moving

the lower section of the stator housing between the rail means and an assembled position.

According to a second aspect of the present invention, methods and apparatus are provided for assembling and disassembling a rotor seal and a disc end bearing of a rotary machine. The rotor seal and disc end bearing assembly and disassembly apparatus comprises axially extending carrier means for supporting the rotor seal for movement between seal lifted and seal disassembled positions and for supporting the disc end bearing for movement between bearing lifted and bearing disassembled positions. This assembly and disassembly apparatus further comprises means supporting the carrier means, means for moving the rotor seal between a seal assembled position and the seal lifted position, and means for moving the disc end bearing between a bearing assembled position and the bearing lifted position.

According to a third aspect of the present invention, methods and apparatus are provided for assembling and disassembling an impeller rotor of a rotary machine. The rotor assembly and disassembly apparatus comprises disc end fixture means disengagably connected to a disc end of the impeller rotor for moving the disc end thereof between a rotor assembled position and a rotor lifted position, and for horizontally moving the rotor through a fluid casing of the rotary machine between the rotor lifted position and a rotor disassembled position. The rotor assembly and disassembly apparatus further comprises coupling end fixture means for moving a coupling end of the impeller rotor between the rotor assembled and lifted positions, and coupling end carriage means supported by a frame of the rotary machine and supporting the coupling end of the rotor as the rotor moves between the rotor lifted and disassembled positions.

This invention will now be described by way of example, with reference to the accompanying drawings in which:

Figure 1 is a side view of a rotary machine with which the present invention may be employed;

Figure 2 is a side view of the rotary machine shown in Figure 1 with portions broken away to show internal parts of the machine;

Figures 3 and 4 are front views of the rotor and lower section of the stator housing of the machine shown in Figures 1 and 2 and of apparatus for assembling and disassembling the lower section of the stator housing, with Figure 3 showing the lower section of the stator housing in an assembled position and Figure 4 showing the lower section of the stator housing in a lowered position;

Figure 5 is a partial side view of the rotary machine shown in Figures 1 and 2 and of the assembly and disassembly apparatus shown in Figures 3 and 4, with the lower section of the stator housing of the rotary machine shown in the lowered position;

Figure 6 is a partial side view of the rotary machine shown in Figures 1 and 2 and of apparatus for assembling and disassembling a rotor seal and a disc end bearing of the rotary machine;

Figure 7 is an enlarged view of a section of Figure 6 showing the rotor seal and the disc end bearing in greater detail;

Figure 8 is an end view of portions of the rotary machine of Figures 1 and 2, and showing a coupling end frame of the assembly and disassembly apparatus of Figures 6 and 7;

Figure 9 is a side view of the rotor seal and portions of the fluid casing of the rotary machine shown in Figures 1 and 2;

Figure 10 is a side view similar to Figure 2 but with the rotary machine partially diasssembled;

Figure 11 is a side view of the partially disassembled rotary machine shown in Figure 10 and of apparatus for assembling and disassembling the rotor of the machine, with the rotor shown in a lifted position;

Figure 12 is a front view of a coupling end fixture of the rotor assembly and disassembly apparatus shown in Figure 11;

Figure 13 is a top view of the rotary machine and the rotor assembly and disassembly apparatus illustrated in Figure 11, with portions of the rotary machine fluid casing removed to more clearly shown the rotor assembly and disassembly apparatus;

Figure 14 is a front view of the rotary machine and the rotor assembly and disassembly apparatus illustrated in Figure 11;

Figure 15 is a rear view of the rotary machine and a coupling end carriage means of the rotor assembly and disassembly apparatus shown in Figure 11; and

Figure 16 is a side view similar to Figure 11, but with the rotor shown in a disassembled position.

Referring to Figures 1 and 2, there is illustrated rotary machine 100 with which the present invention may be employed. Generally, machine 100 includes base plate 102, machine frame 104, impeller rotor 106, bearing means 110, and fluid casing 112. Machine 100 also includes impeller blades 114, stator blades 116, diaphragm 120, stator housing 122, and rotor seal 124. Machine frame 104 rests on base plate 102, which preferably extends forward, to the left as viewed in Figure 1, of the machine frame. Impeller rotor 106, having disc end 126 and coupling end 130, axially extends along the top of machine frame 104 and is rotatably supported by bearing means 110 which, in turn, are supported by the machine frame. Preferably, bearing means 110 are of a conventional

horizontal split type including disc end bearing 132, intermediate bearing housing 134, and coupling end bearing 136, which are all bolted to the top of machine frame 104. Impeller blades 114 are rigidly secured to disc end 126 of rotor 106 and radially extend outward therefrom. Although two axially spaced sets of impeller blades 114 are shown in the drawings, it will be apparent to those skilled in the art that the present invention may be employed with a rotary machine having one or more sets of impeller blades.

Fluid casing 112 is secured to machine frame 104 and annularly extends around the machine frame and impeller rotor 106 rearward, to the right as viewed in Figures 1 and 2, of impeller blades 114. The top of fluid casing 112 defines discharge or outlet opening 140. Stator housing 122 is secured to the front end of fluid casing 112 and annularly extends around one or more impeller blades 114. Preferably, stator housing 122 is horizontally split, having upper section 142 and lower section 144, which preferably are bolted together along adjacent horizontal flanges.

Diaphragm 120 annularly extends around rotor 106 within stator housing 122; and the diaphragm also is horizontally split, including top half 146 and bottom half 150, which preferably are bolted together along adjacent horizontal flanges. Stator blades 116 are secured to diaphragm 120 and radially extend inward therefrom between rotor blades 114. Preferably a sealing member is secured to stator blades 116 and radially extends inward therefrom substantially to impeller rotor 106 to retard fluid flow through the area between the rotor and the stator blades.

Diaphragm 120 is radially spaced from stator housing 122, allowing radial expansion of the diaphragm.

Dowels 152 radially extend into generally concentric apertures 154 and 156 defined by diaphragm 120 and stator housing 122 respectively, preventing rotation of the diaphragm and stator

blades 116 relative to the stator housing. Preferably apertures 156 radially extend through stator housing 122, providing access to dowels 152 from the exterior of the stator housing. Caps 160 may be disengagably secured to stator housing 122, for example by being threaded into apertures 156, to align dowels 152 within apertures 156 and to cover the dowels, preventing undesired outward radial movement thereof.

Fluid casing 112 includes inside radial flange 162, which annularly extends above machine frame 104 and rotor 106. Rotor seal 124 is secured, preferably bolted, to machine frame 104 and fluid casing 112, specifically flange 162 thereof, covering the space between the machine frame, the fluid casing, and impeller rotor 106 to prevent leakage of a working fluid through this space. Rotor seal 124 defines a plurality of axially extending threaded apertures located near the peripheral edge of the rotor seal, and some of these apertures are aligned with axially extending threaded apertures defined by radial flange 162 for bolting the rotor seal thereto. Preferably, however, for reasons which will become apparent, some of the axial, threaded apertures defined by rotor seal 124 are located adjacent flat surfaces of radial flange 162.

To operate machine 100, inlet duct 164 is secured to the front of stator housing 122. Preferably, support means such as a stand (not shown) is secured to inlet duct 164 to support the duct and to provide additional support for stator housing 122 and the forward end of fluid casing 112. Once duct 164 is in position, a fluid is induced to flow through the inlet duct and past blades 114 and 116. If machine 100 is a compressor, then rotor blades 114 are rotated to compress the fluid flowing therepast. Alternately, if machine 100 is an expander, then the fluid causes rotation of blades 114. In either case, the fluid flows past blades 114 and 116 and through fluid casing 112, and the fluid is discharged from machine 100 via discharge opening 140.

As previously discussed, the impeller rotor of rotary machines of the general type described above are occasionally removed therefrom, and this usually requires disassembly of a large portion of the machine. In accordance with teachings of the present invention, machine 100 may be assembled and disassembled comparatively fast using methods and apparatus which are relatively inexpensive and simple to understand and operate. Figures 3 through 16 illustrate apparatus for assembling and disassembling machine 100 in accordance with a preferred embodiment of the present invention. More specifically, Figures 3 through 5 disclose apparatus for assembling and disassembling stator housing 122, specifically lower section 144 thereof, Figures 6 through 9 show apparatus for assembling and disassembling rotor seal 124 and disc end bearing 132, and Figures 10 through 16 illustrate apparatus for assembling and disassembling impeller rotor 106.

Turning first to Figures 3, 4 and 5, there is shown apparatus 200 for assembling and disassembling stator housing 122, specifically lower section 144 thereof. Preferably, apparatus 200 includes rails 202, screw jacks 204, posts 206, jack supports 210, guide rods 212, and wheels 214, 216, and 220. Apparatus 200 further includes flanges 222, which radially extend outward from stator housing section 144, and flanges 224, which are located at the top of posts 206. Jack supports 210 are fixed to posts 206. In turn, screw jacks 204 are mounted on supports 210. Screw jacks 204 extend through supports 210, and plates 226 are mounted on the tops of the screw jacks, above supports 210. With this arrangement, as is conventional, extension and retraction of screw jacks 204 move plates 226 upward and downward respectively relative to supports 210.

Referring to Figures 1 through 5, to remove stator housing 122, posts 206 are positioned adjacent thereto with flanges 224 of the posts overlaying flanges 222 of the stator housing, as shown in Figure 3. Flanges 222 and 224 are then secured together by any

conventional means wherein posts 206 provide additional support for stator housing 122. Preferably, flanges 222 and 224 define a plurality of vertically extending apertures (not shown) which are aligned as posts 206 are positioned adjacent to stator housing 122. Flanges 222 and 224 may then be secured together via bolts extending through aligned apertures. In addition, guide rods 212 may be lowered through aligned apertures of flanges 222 and 224 into abutting contact with support platforms 210 of posts 206 wherein the guide rods help to guide movement of stator housing section 144 as section 144 is vertically moved between the assembled position shown in Figure 3 and rails 202.

With posts 206 providing support for stator housing 122, inlet duct 164 is disengaged from the stator housing and removed in any suitable manner, for example by an overhead crane. Caps 160 and dowels 152 associated with upper stator housing section 142 are removed, freeing section 142 from upper diaphragm section 146. Upper section 142 of stator housing 122 is then disengaged from lower stator housing section 144 and fluid casing 112 and removed in any conventional manner, again for example by an overhead crane. Upper diaphragm section 146 is disengaged from lower diaphragm section 150, and the upper diaphragm section is lifted up and away from machine 100, preferably by an overhead crane. Rails 202 are then positioned on base plate 102 adjacent machine 100, between posts 206, and the rails are secured to the base plate by means such as bolts. If rails 202 extend forward of base plate 102 for any appreciable length, additional supports (not shown) may be provided for the rails. Preferably, rails 202 longitudinally extend parallel to the axis of rotor 106. Screw jacks 204 are then extended to move plates 226 into abutting contact with stator housing flanges 222.

Next, lower stator housing section 122 is disengaged from fluid casing 112, and flanges 222 are disengaged from flanges 224. Stator housing section 144 and diaphragm section 150 are now free

to move downward; and by retracting screw jacks 204, plates 226, stator housing section 144, and diaphragm section 150 are lowered toward rails 202. Before stator housing section 144 engages rails 202, wheels 214, 216, and 220 are secured to the lower stator housing section. Preferably, wheels 214 are located beside stator housing section 144, wheels 216 are positioned to the sides and forward of the lower stator housing section, and wheels 220 are disposed to sides and rearward of stator housing section 144. This arrangement provides a very stable support for lower stator housing section 144 and lower diaphragm section 150 as these parts move along rails 202.

As will be understood by those skilled in the arts, wheels 214, 216, and 220 may be secured to stator housing section 144 in any suitable manner. Preferably, particularly referring to Figure 5, wheels 214 are secured to stator housing section 144 via brackets 228, front wheels 216 are secured to the lower stator housing section via forwardly extending legs 230, plates 232, and flanges 222, and rear wheels 220 are secured to stator housing section 142 by means of rearwardly extending arms 234 and brackets 236.

When wheels 214, 216, and 220 are secured in place, screw jacks 204 are retracted to lower stator housing section 144 onto rails 202, as shown in Figures 4 and 5. With lower section 144 resting on rails 202, guide rods 212 are removed, freeing stator housing section 144 for movement along the rails. Preferably, posts 206 are carried away, thereby also removing screw jacks 204, supports 210, flanges 224, and plates 226. Stator housing section 144 and diaphragm section 150 are then manually moved along rails 202 away from machine 100 into a disassembled position where the stator housing section and the diaphragm section are easily accessible to a laborer or to material handling equipment such as a crane. Stator housing section 144 and diaphragm section 150 are then moved to a remote location. Preferably, rails 202 are kept in place

because, as subsequently explained, they are further used in the disassembly of machine 100.

Preferably, a selected rail 202 includes longitudinal flange 240 which cooperates with recess 242 defined by at least one wheel of assembly and disassembly apparatus 200 for guiding movement of lower section 144 along the rails. It should be noted that, with the preferred embodiment illustrated in the drawings, the axial orientation of lower stator housing section 144 is maintained as section 144 moves between the assembled and disassembled positions. That is, as stator housing section 144 moves between the assembled and disassembled positions, the axis of section 144 is maintained substantially parallel to the axis of section 144 as assembled in machine 100.

With inlet duct 164, diaphragm 120, and stator housing 122 removed, the next step in the disassembly of machine 100 is the removal of rotor seal 124, disc end bearing 132, intermediate bearing housing 134, and coupling end bearing 136. Coupling end bearing 136 and intermediate bearing housing 134 are easily removable in any conventional manner such as by means of a crane and cable which are maneuvered into the space directly above the coupling end bearing and the intermediate bearing housing. Accordingly, it is believed a detailed illustration and explanation of the removal of coupling end bearing 136 and intermediate bearing housing 134 are not necessary.

Referring to Figures 6 through 9, there is illustrated apparatus 300 for assembling and disassembling rotor seal 124 and disc end bearing 132 in accordance with a preferred embodiment of the present invention. Generally, apparatus 300 includes carrier rod 302, disc end bracket 304, coupling end frame 306, coupling end bracket 310, and turnbuckle 312. Apparatus 300 further includes axially extending hole 314 defined by rotor seal 124, vertically extending aperture 316 defined by disc end bearing 132, shaft 320

extending from turnbuckle 312, and cylindrical bearing means 322 and 324. Preferably, aperture 316 and shaft 320 define complimentary threads, the inside diameters of bearing means 322 and 324 are approximately equal to the diameter of carrier rod 302, and the outside diameter of bearing means 322 is substantially equal to the diameter of hole 314. It should be noted that when machine 100 operates, a plate (not shown) covers opening 314 of rotor seal 124 and is secured thereto for preventing the working fluid from passing through opening 314.

Particularly referring to Figure 7, disc end bracket 304 defines hole 326 and is disengagably secured to fluid casing 112, preferably to the forward radial surface of flange 162. Further, it is preferred that disc end bracket 304 be secured in place when machine 100 is originally assembled, before rotor seal 124 and disc end bearing 132 are initially positioned within the rotary machine. Now particularly referring to Figure 8, coupling end frame 306 includes feet 330, upwardly extending, spaced, parallel legs 332, top cross member 334 which extends between the legs, and braces 336. Coupling end bracket 310 defines hole 340, extends downward from cross member 334, and is secured thereto via means such as connecting plate 342 and bolts 344.

To remove rotor seal 124 and disc end bearing 132 from machine 100, coupling end frame 306 is secured to machine frame 104. More specifically, referring to Figures 6 and 8, coupling end frame 306 is positioned with feet 330 resting on transversely opposed sides of machine frame 104, with cross member 334 transversely extending over coupling end 130 of impeller rotor 106, and with hole 340 of coupling end bracket 310 axially aligned with hole 326 of disc end bracket 304. Feet 330, and thus support frame 306, are then secured to machine frame 104 by, for example, bolts 346.

The above-mentioned plate (not shown) covering hole 314 in rotor seal 124 is removed, the rotor seal is disengaged from casing 112

and machine frame 104, and disc end bearing 132 is disengaged from the machine frame. Then, with reference to Figure 9, threaded pull rods 350 (only one is seen in Figure 9) are threaded through axially extending apertures of rotor seal 124 into abutting contact with the rear surface of radial flange 162. Further rotation of the pull rods, as is well known in the art, axially pulls rotor seal 124 along the pull rods away from the assembled position of the rotor seal shown in Figure 2. Once rotor seal 124 is axially spaced from radial flange 162 a distance sufficient to permit slight upward movement of the rotor seal, threaded pull rods 352 are threaded through vertically extending apertures defined by the rotor seal into abutting contact with the top surface of machine frame 104. Further rotation of these pull rods lifts rotor seal 124 away from machine frame 104. Preferably, rotor seal 124 is lifted into the lifted position shown in Figures 6 and 7 wherein hole 314 of the rotor seal is aligned with holes 326 and 340 of disc and coupling end brackets 304 and 310 respectively.

Bearing means 322 is inserted into hole 314 of rotor seal 124 and connected thereto in any conventional manner for unitary axial movement therewith. For example, bearing means 322 may be connected to rotor seal 124 by snap ring 354, plate 356, and bolt 360. Turnbuckle 312 is secured to bearing means 324 via bolt 362. The forward end of carrier rod 302 is inserted through coupling end hole 340; and then bearing means 324, with turnbuckle 312 connected thereto, is slid onto the forward end of the carrier rod. Carrier rod 302 is then axially moved forward into fluid casing 112, through hole 314 of rotor seal 124, and through hole 326 of disc end bracket 304. Preferably at least the rear end of carrier rod 302 is threaded and nuts 364 and 366 are located on the rear end of carrier rod, one on each side of coupling end bracket 310. Once carrier rod 302 is properly positioned, nuts 364 and 366 are tightened against coupling end bracket 310, as shown in Figure 6, preventing inadvertent axial movement of the carrier rod.

With carrier rod 302 supporting rotor seal 124, pull rods 350 and 352 may be removed therefrom. Next, bearing means 324 and turnbuckle 312 are axially moved along carrier rod 302 until threaded shaft 320 is vertically aligned with aperture 316 of disc end bearing 132. Turnbuckle 312 is then extended, threading shaft 320 into aperture 316. Once shaft 320 securely engages disc end bearing 132, the disc end bearing is disengaged from machine frame 104 and turnbuckle 312 is retracted, lifting the disc end bearing from the assembled position shown in Figure 2 to the lifted position shown in Figures 6 and 7.

Disc end bearing 132 and rotor seal 124 are axially slid rearward along carrier rod 302 into a disassembled position where bearing 132 and seal 124 are easily accessible to a worker. Preferably, rotor seal 124 and disc end bearing 132 are moved completely outside of fluid casing 112. Once outside of casing 112 rotor seal 124 is provided with support independent of carrier rod 302. For example, rotor seal 124 may be manually supported or supported by an overhead crane. Nut 364 is loosened, and carrier rod 302 is axially pulled rearward through holes 326 and 314, freeing rotor seal 124 from the carrier rod. Rotor seal 124 may then be further carried away from machine 100 either manually or by additional, conventional material handling equipment.

With rotor seal 124 removed from carrier rod 302, bearing means 324 is slid off the forward end of the carrier rod, removing turnbuckle 312 and disc end bearing 132 therefrom. Bearing 324, turnbuckle 312, and disc end bearing 132 may then be transported to a remote location. Nut 364 is removed from carrier rod 302, and the carrier rod itself is pulled rearward through hole 340 and thence removed from machine 100. Next, disc end bracket 304 is manually disengaged from fluid casing 112 and carried away from machine 100. Coupling end bracket 310 is similarly unbolted from coupling end support frame 306 and carried away from rotary machine 100. Preferably, coupling end frame 306 is left secured in place

because, as explained below, it is used to remove rotor 106 from machine 100. Machine 100 is now in the partially disassembled position shown in Figure 10.

Thus, rotor seal 124 and disc end bearing 132 are quickly and easily removed from machine 100. Furthermore, with the preferred embodiment, the axial orientation of rotor seal 124 and disc end bearing 132 are maintained as the rotor seal and the disc end bearing move between their assembled and disassembled positions. More specifically, as rotor seal 124 moves between its assembled and disassembled positions, the longitudinal axis thereof, that is, the axis of the rotor seal which is parallel to the axis of impeller rotor 106 when both the impeller rotor and rotor seal are assembled in machine 100, is maintained substantially parallel to or colinear with the longitudinal axis of the rotor seal as assembled. Similarly, as disc end bearing 132 moves between its assembled and disassembled positions, the longitudinal axis thereof, that is, the axis thereof which is parallel to the axis of impeller rotor 106 when both the impeller rotor and the disc end bearing are assembled, is maintained substantially parallel to or colinear with the longitudinal axis of the disc end bearing as assembled.

Machine 100 is now prepared for the removal of impeller rotor 106. Turning to Figures 11 through 16, there is shown rotor assembly and disassembly apparatus 400. Apparatus 400 includes disc end fixture 402, coupling end fixture 404, coupling end carriage 406, rail means 202, and groove 410 (shown in Figure 13) defined by the top surface of machine frame 104. More specifically, disc end fixture 402 includes disc end frame 412, screw jack 414, bracket 416, wheels 420, and cap 422, which is designed to closely fit over and around disc end 126 of rotor 106. Coupling end carriage 406 includes support yoke 424, feet 426, and wheels 430; and coupling end fixture 404 includes coupling end frame 306 described above, screw jack 432, and lifting yoke 434, with yoke 434 comprising

separable top and bottom halves 436 and 440 (best seen in Figure 12).

Particularly referring to Figures 11 and 14, disc end frame 412 includes feet 442, spaced parallel legs 444, cross beam 446, and braces 450. Feet 442 are supported by wheels 420 which are rotatably connected thereto in any conventional manner. Legs 444 extend upward from feet 442 cross beam 446 is supported by and extends between the tops of the legs, and braces 450 extend between the feet and the cross beam to further support the cross beam. Screw jack 414 is secured to and extends upward from cross beam 446, bracket 416 is mounted on screw jack, and cap 422 is secured to bracket 416 wherein extension and retraction of the screw jack moves bracket 416 and cap 422 upward and downward respectively relative to disc end frame 412.

Referring to coupling end fixture 404 in greater detail, as best illustrated in Figures 11 and 12, screw jack 432 is mounted on coupling end frame 306, specifically cross member 334 thereof. Screw jack 432 extends downward through cross member 334, and a movable plate 452 of the screw jack is located below the cross member. Lifting yoke 434 is secured to plate 452 in any suitable manner for unitary, vertical movement therewith. With this arrangement, as will be appreciated by those skilled in the art, retraction and extension of screw jack 432 vertically raises and lowers, respectively, lifting yoke 434. Referring now to coupling end carriage 406 in greater detail, as best seen in Figures 11, 13, and 15, spaced, parallel feet 426 are supported by wheels 430, which are rotatably connected to the feet in any conventional manner. Support yoke 424 transversely extends between feet 426 and also is connected thereto in any conventional manner.

To remove rotor 106 from machine 100, disc end fixture 402 is positioned on rail 202 wherein the rails support the disc end fixture for limited movement toward and away from machine 100.

Preferably, a selected one or more wheels 420 of disc end fixture 402 defines recess 454 which cooperates with flange 240 of a selected rail 202 to guide movement of the disc end fixture along the rails. With disc end fixture 402 on rails 202, screw jack 414 is adjusted to position cap 422 at a height where it fits over and around disc end 126 of rotor 106. Disc end fixture 402 is then moved along rails 202 toward rotor 106 until cap 422 abuts against and fits over disc end 126 of the rotor. Cap 422 is then disengagably secured to disc end 126 by suitable means, for example bolts 456 extending through cap and into the disc end of rotor 106.

Coupling end fixture 404 is assembled. More particularly, bottom half 440 of lifting yoke 434 is annularly slid underneath coupling end 130 of impeller rotor 106, and top half 436 of the lifting yoke is positioned on the impeller rotor surface above the bottom half of the lifting yoke. Halves 440 and 436 of lifting yoke 434 are then joined together, as shown in Figure 12. Screw jack 432 is mounted on frame 306, with movable plate 452 of the screw jack located below cross member 334. Lifting yoke 434 is secured to screw jack 432, specifically plate 452 thereof.

Disc end fixture 402 and coupling end fixture 404 are now employed, respectively, to lift disc end 126 and coupling end 130 of impeller rotor 106 from the rotor assembled position shown in Figure 10 to the rotor lifted position shown in Figure 11. More specifically, screw jack 414 of disc end fixture 402 is extended, raising cap 422 and disc end 126 of rotor 106. At the same time, screw jack 432 of coupling end fixture 404 is retracted raising lifting yoke 434 and coupling end 130 of rotor 106.

With impeller rotor 106 in the lifted position, brace 460 (shown in Figures 14 and 16) is connected to cross beam 446 and to cap 422 of disc end fixture 402 to provide additional support for the cap and disc end 126 of rotor 106. Coupling end carriage 406 is positioned on machine frame 104 with support yoke 424 abutting against

coupling end 130 of rotor 106. Yoke 424 and, thus, coupling end carriage 406 are disengagably secured to rotor 106 by, for example, bolt 462 extending through the support yoke and into coupling end 130 of the rotor. Preferably, at least one of wheels 430 of carriage 406 extends into groove 410 to guide movement of the carriage and coupling end 130 of rotor 106 along machine frame 104. Once coupling end 130 of rotor 106 is supported by carriage 406, screw jack 432 is disengaged from lifting yoke 434 and from coupling end frame 306 and removed from machine 100.

Now, disc end fixture 402 is moved along rail 202 away from machine 100 to the position shown in Figure 16, pulling rotor 106 along the top of machine frame 104, through fluid casing 112, and into the disassembled position illustrated in Figure 16 wherein the rotor is easily accessible to a worker and to other rotor handling equipment. Thus, rotor 106 is simply and conveniently moved into a disassembled position where the rotor and rotor blades 114 may be inspected or repaired, or wherefrom the rotor and blades may be moved, after being disengaged from disc end fixture 402, to another location specifically equipped for rotor inspection or repair. Moreover, in the preferred embodiment, with, inter alia, flange 240 of rails 202 and groove 410 of machine frame 104 guiding movement of impeller rotor 106, the axial orientation thereof is maintained as the rotor moves between the assembled and disassembled positions. That is, as impeller rotor 106 moves between the assembled and disassembled positions, the axis of the rotor is maintained substantially parallel to the axis thereof when assembled in machine 100.

To reassemble machine 100, the above-described disassembly process is generally reversed. Coupling end carriage 406 is secured to coupling end 130 of rotor 106, lifting yoke 434 is fitted around the rotor, and the rotor is positioned, for example by an overhead crane, as shown in Figure 16, with carriage 406 resting on machine frame 104 and a selected one of wheel 430 extending into groove

410. Disc end fixture 402, including brace 460, is mounted on rails 202 and secured to disc end 126 of rotor 106 via cap 422. Any equipment employed to move rotor 106 into the position shown in Figure 16 is then disconnected from the rotor and removed therefrom. Disc end fixture 402 is then moved along rails 202 toward machine 100, pushing rotor 106 thereinto, with flange 240 of rail 202 and groove 410 of machine frame 104 guiding movement of the impeller rotor and maintaining the axial orientation thereof. When rotor 106 is in the lifted position shown in Figure 11, screw jack 432 is mounted on coupling end frame 306 and connected to lifting yoke 434, coupling end carriage 406 is removed, and brace 460 is removed from disc end fixture 402. Disc end screw jack 414 is retracted and coupling end screw jack 432 is extended, lowering rotor 106 into its assembled position. Once rotor 106 is so lowered, cap 422 is disengaged from disc end 126 of the rotor and screw jack 432 is disengaged from lifting yoke 434. Disc end fixture 402, screw jack 432 and lifting yoke 434 are then all removed from machine 100.

Next, rotor seal 124, disc end bearing 132, intermediate bearing housing 134, and coupling end bearing 136 are replaced. Referring to Figures 6 and 7, disc end bracket 304 is secured to radial flange 162 of fluid casing 112, and coupling end bracket 310 is secured to coupling end frame 306. The forward end of carrier rod 302 is inserted through hole 340 of coupling end bracket 310. Bearing means 324, with turnbuckle 312 and disc end bearing 132 connected thereto, is first slipped over the forward end of carrier rod 302, and then the forward end of the carrier rod is inserted through bearing means 322, with rotor seal 124 connected thereto. Carrier rod 302 is then axially inserted within fluid casing 112 and through hole 326 of disc end bracket 304.

Rotor seal 124 and disc end bearing 132 are then moved along carrier rod 302 to their lifted positions shown in Figures 6 and 7. Turnbuckle 312 is extended, lowering disc end bearing 132 into its

assembled position. Disc end bearing 132 is secured to machine frame 104, and turnbuckle 312 is retracted to disengage the disc end bearing therefrom. Threaded pull rods 352 are threaded through vertical openings defined by rotor seal 124. Pull rods 352 are threaded downward into abutting contact with the top surface of machine frame 104 to support rotor seal 124 independent of carrier rod 302. Carrier rod 302, bearing means 324, and turnbuckle 312 are then axially retracted and removed from machine 100.

Pull rods 352 are then rethreaded through the vertical apertures of rotor seal 124, lowering the rotor seal onto machine frame 104. These pull rods may then be removed. Similarly, bearing 322 and any means connecting this bearing to rotor seal 124 may also be removed. Rotor seal 124 is then axially moved along machine frame 104 into its assembled position. Guide rods may be extended through aligned axial apertures of rotor seal 124 and radial flange 162 of fluid casing 112 to guide axial movement of the rotor seal into its assembled position. Rotor seal 124 is secured to the machine frame 104 and to radial flange 162. A plate is employed to cover opening 314 of seal 124, and this plate is secured to the rotor seal. Coupling end frame 306, with coupling end bracket 310 secured thereto, is disengaged and removed from machine 100. Intermediate bearing housing 134 and coupling end bearing 136 are replaced in any conventional fashion.

Referring now to Figures 3, 4, and 5, the next steps in reassembling machine 100 involve replacement of stator housing 122. Lower stator housing section 144, with diaphragm section 150 and wheels 214, 216, and 220 connected thereto, is mounted on rails 202 and moved therealong to a position just forward of fluid casing 116. Posts 206, with screw jacks 204 mounted thereon, are located outside rails 202 adjacent lower stator housing section 144, with plates 226 directly below flanges 222, and with flanges 224 above and aligned with flanges 222. Guide rods 212 are inserted through top flanges 224 of posts 206 and radial flanges 222 of lower stator

housing section 144. Screw jacks 204 are then extended, lifting lower stator housing section 144 and lower diaphragm section 150 off rails 202. Wheels 214, 216, and 220 are removed from lower stator housing section 144. Screw jacks 204 are further extended, raising stator housing section 144 into its assembled position and bringing radial flanges 222 into abutting contact with top flanges 224.

Flanges 222 and 224 are joined together, guide rods 212 are removed, and lower stator housing section 142 is secured to fluid casing 112. Rails 202 may now be removed. Upper diaphragm section 146 and upper stator housing section 142 are returned to their assembled positions, for example by an overhead crane, and secured to, respectively, lower diaphragm section 150 and fluid casing 112. Caps 160 and dowels 152 associated with upper diaphragm section 146 and upper stator housing section 142 are replaced. After upper and lower stator housing sections 142 and 144 have been secured in place, inlet duct 164 is resecured to stator housing 122. Preferably, as previously discussed, support means (not shown) is secured to inlet duct 164 to support the inlet duct and to provide additional support for stator housing 122 and the forward end of fluid casing 112. With this additional support, flanges 224 of posts 206 are disengaged from flanges 222 of stator housing 122, and the posts and screw jacks 204 are removed from machine 100. Machine 100 is now reassembled and ready for operation.

With the above-discussed assembly and disassembly methods and apparatus, machine 100 is disassembled and reassembled comparatively quickly and simply. The use of guiding elements such as rails 202, groove 410, and carrier rod 302 to maintain axial orientation of various parts of machine 100 as these parts move between assembled and disassembled positions substantially facilitates realigning these many parts, significantly reducing the amount of human labor needed to realign the parts.

Moreover, the above-discussed assembly and disassembly processes do not require moving or disassembling any part of machine frame 104 of fluid casing 112, further simplifying and expediting disassembly and reassembly of machine 100 and, obviously, eliminating any requirement to reposition and realign these parts of the machine.

While it is apparent that the invention herein disclosed is well calculated to fulfill the objects above stated, it will be appreciated that numerous modifications and embodiments may be devised by those skilled in the art, and it is intended that the appended claims cover all such modifications and embodiments as fall within the true spirit and scope of the present invention.

Claims

1. Assembly and disassembly apparatus for use with a rotary machine having a machine frame, bearings supported by the machine frame and including a disc end bearing, an axially extending rotor rotatably supported by the bearing means, impeller blade means radially extending outward from the rotor, a fluid casing annularly extending around the rotor and machine frame, a rotor seal extending between the rotor, the machine frame, and the fluid casing, and a horizontal split stator housing secured to the fluid casing and encircling the impeller blade means, the assembly and disassembly apparatus characterized by rails (202) for supporting a lower section (150) of the stator housing (122) for horizontal movement toward and away from the rotary machine (100); means (204,212) for vertically moving the lower section (150) of the stator housing (122) between the rail means (202) and a stator housing assembled position; an axially extending carrier (302) for supporting the rotor seal (124) for movement between seal lifted and seal disassembled positions and for supporting the disc end bearing (132) for movement between bearing lifted and bearing disassembled positions; means (304,306) for supporting the carrier (302); means (350,352) for moving the rotor seal (124) between a seal assembled position and the seal lifted position; means (312) for moving the disc end bearing (132) between a bearing assembled position and the bearing lifted position; a disc end fixture (402) supported by the rails (202) and disengagably connected to a disc end (126) of the impeller rotor (106) for vertically moving the disc end (126) thereof between a rotor assembled position and a rotor lifted position, and for horizontally moving the rotor (106) through the fluid casing (112) between the rotor lifted position and a rotor disassembled position; a coupling end fixture (404) for moving a coupling end (130) of the impeller rotor (106) between the rotor assembled and lifted positions; and a coupling end carriage (406) supported by the machine frame (104) and supporting the coupling end (130) of the rotor (106) as the rotor (106) moves between the rotor lifted and disassembled positions.

2. Assembly and disassembly apparatus as defined by claim 1 further characterized by means (206) for supporting the lower section (150) of the stator housing (122) in the stator assembled position; and wherein the means (304,306) for supporting the carrier (302) includes a disc end bracket (304) secured to the fluid casing (112) and extending radially inward therefrom for supporting a first end of the carrier (302), and a coupling end frame (306) supported by the machine frame (150) for supporting a second end of the carrier (302); the means (312) for moving the disc end bearing (132) between the bearing assembled and bearing lifted positions includes means (312) supported by the carrier means (302) for raising and lowering the disc end bearing (132); the disc end fixture (402) includes a disc end frame (412) supported by the rails (202) for limited movement toward and away from the rotary machine (100); a cap (422) disengagably connected to the disc end (126) of the impeller rotor (106), and adjustable means (414,416) connecting the cap (422) to the disc end frame (412) for varying the height of the cap (422) and the disc end of the impeller rotor; and the coupling end fixture (404) includes a lifting yoke (434) extending below the coupling end (130) of the impeller rotor (106), and lifting means (432) connecting the lifting yoke (434) to the coupling end frame (306) for vertically moving the lifting yoke (434) and the coupling end (130) of the impeller rotor (106); and the coupling end carriage (406) includes a support yoke (424) disengagably connected to the coupling end (130) of the impeller rotor (106), and a plurality of wheels (430) supporting the support yoke (424) and supported by the machine frame (104) for movement therealong.

3. Apparatus for assembling and disassembling a stator housing of a rotary machine characterized by rails (202) for supporting a lower section (150) of the stator housing (122) for horizontal movement toward and away from the rotary machine (100); and means (204,212) vertically moving the lower section (150) of the stator housing (122) between the rails (202) and an assembled position.

4. Apparatus as defined by claim 3 further characterized in that the means (204,212) for vertically moving the lower section (150) of the stator housing (122) includes means (204,206) for raising and lowering the lower section (150) of the stator housing (122) between the rail means (202) and the assembled position; guide rods (212) for vertically guiding movement of the lower section (150) of the stator housing (122) between the rail means (202) and the assembled position.

5. Apparatus as defined by claim 4 further characterized by means (206,222) to support the lower section (150) of the stator housing (122) in the assembled position, the support means including flanges (222) radially extending outward from the lower section (150) of the stator housing (122); and posts (206) disengagably secured to the flanges (222) to support the flanges (222) and the lower section (150) of the stator housing (122).

6. Assembly and disassembly apparatus for use with a rotary machine having a machine frame, bearings supported by the machine frame and including a disc end bearing, an axially extending rotor rotatably supported by the bearing means, a fluid casing annularly extending around the rotor and machine frame, and a rotor seal extending between the machine frame, the rotor, and the fluid casing,the assembly and disassembly apparatus characterized by a carrier (302) axially extending within the fluid casing (112) for supporting the rotor seal (124) for movement between seal lifted and seal disassembled positions and for supporting the disc end bearing (132) for movement between bearing lifted and bearing disassembled positions; means (304,306) supporting the carrier (302); means (350,352) for moving the rotor seal (124) between a seal assembled position and the seal lifted position; and means (312) for moving the disc end bearing (132) between a bearing assembled position and the bearing lifted position.

7. Assembly and disassembly apparatus as defined by claim 6 further characterized in that the means (304,306) supporting the carrier (302) includes a disc end bracket (304) secured to the fluid casing (112) and extending inward therefrom.

8. Assembly and disassembly apparatus as defined by claim 7 further characterized in that the means (304,306) supporting the carrier (302) further includes a coupling end frame (306) supported by the machine frame (104) rearward of the fluid casing (112).

9. Assembly and disassembly apparatus as defined by claim 6 further characterized in that the means (312) for moving the disc end bearing (132) between the bearing assembled and bearing lifted positions includes means (312) supported by the carrier (302) for raising and lowering the disc end bearing (132).

10. Assembly and disassembly apparatus for use with a rotary machine having an axially extending, rotatable impeller rotor, a fluid casing annularly extending around the rotor, and a machine frame supporting the rotor and casing, the assembly and disassembly apparatus characterized by a disc end fixture (402) disengagably connected to a disc end (126) of the impeller rotor (106) for vertically moving the disc end (126) thereof between a rotor assembled position and a rotor lifted position and for horizontally moving the rotor (106) through the fluid casing (112) between the rotor lifted position and a rotor disassembled position; a coupling end fixture (404) for vertically moving a coupling end (130) of the impeller rotor (106) between the rotor assembled and lifted positions; and a coupling end carriage (406) supported by the machine frame (104) and supporting the coupling end (130) of the rotor (106) as the rotor (106) moves between the rotor lifted and disassembled positions.

11. Assembly and disassembly apparatus as defined by claim 10 further characterized by rails (202) positioned adjacent to the

rotary machine (100) substantially parallel to the rotor axis for guiding movement of the disc end fixture (402) toward and away from the rotary machine (100); and a groove (410) defined by a surface of the machine frame (104) and extending substantially parallel to the rotor axis for guiding movement of the coupling end carriage (406) along the machine frame (104).

12. Assembly and disassembly apparatus as defined by claim 11 further characterized in that the disc end fixture (402) includes a disc end frame (412) movable toward and away from the rotary machine (100) a connecting cap (422) disengagably connected to the disc end of (126) of the impeller rotor (106); and adjustable means (414,416) joining the connecting cap (422) to the disc end frame (412) for adjusting the height of the connecting cap (422) and the disc end (126) of the impeller rotor (106).

13. Assembly and disassembly apparatus as defined by claim 10 further characterized in that the coupling end fixture (404) includes a coupling end frame (306) supported by the machine frame (104); a lifting yoke (434) encircling the coupling end (130) of the impeller rotor (106); and lifting means (432) connecting the lifting yoke (434) to the coupling end frame (306) for vertically moving the lifting yoke (434) and the coupling end (130) of the impeller rotor (106).

14. Assembly and disassembly apparatus as defined by claim 10 further characterized in that the coupling end carriage (406) includes a plurality of spaced feet (426); a support yoke (434) connected to and extending between the feet (426); means (462) disengagably connecting the support yoke (424) to the coupling end (130) of the impeller rotor (106); and a plurality of wheels (430) rotatably connected to the feet (426) and supported by and movable along the machine frame (104).

15. A method of disassembling a horizontal split stator housing from a rotary machine characterized by the steps of removing a top section (142) of the stator housing (122); vertically moving a lower section (144) of the stator housing (122) from an assembled position to a lowered position; horizontally moving the lower section (144) of the stator housing (122) from the lowered position to a disassembled position; and maintaining axial orientation of the lower section (144) of the stator housing (122) during movement from the assembled position to the disassembled position.

16. A method of disassembling a rotor seal and a disc end bearing from a rotary machine including the steps of moving the rotor seal from a seal assembled position to a seal lifted position; moving the disc end bearing from a bearing assembled position to a bearing lifted position; and moving the rotor seal and the disc end bearing from their lifted positions to disassembled positions; and characterized by the step of maintaining axial alignment of the rotor seal (124) and disc end bearing (132) during movement between their lifted and disassembled positions.

17. A method of disassembling an axially extending rotor from a rotary machine having a fluid casing annularly extending around the rotor, a machine frame supporting the rotor and fluid casing, and a rotor seal extending between the rotor, the machine frame, and the fluid casing, the method including the step of removing the rotor seal, and characterized by the steps of vertically raising the impeller rotor (106) to a lifted position; horizontally moving the impeller rotor (106) through the fluid casing (112) from the lifted position to a disassembled position; and maintaining axial orientation of the impeller rotor (106) as the rotor (106) moves from the assembled position to the disassembled position.

18. A method of disassembling a rotary machine having a machine frame, bearings supported by the machine frame and including a disc end bearing, an axially extending rotor rotatably supported by the

bearing means, impeller blade means radially extending outward from the rotor, a fluid casing annularly extending around the rotor and the machine frame, a rotor seal extending between the rotor, the machine frame, and the fluid casing, and a horizontal split stator housing secured to the fluid casing and encircling the impeller blade means, the disassembling method including the steps of moving the rotor seal from a seal assembled position to a seal lifted position; moving the disc end bearing from a bearing assembled position to a bearing lifted position; and moving the rotor seal and the disc end bearing from the lifted positions thereof to seal and disc end bearing disassembled positions; and characterized by the steps of removing a top section (142) of the stator housing (122); vertically moving a lower section (144) of the stator housing (122) from a stator housing assembled position to a lower section lowered position; horizontally moving the lower section (144) of the stator housing (122) from the lower section lowered position to a lower section disassembled position; maintaining axial orientation of the lower section (144) of the stator housing (122) during movement from the stator housing assembled position to the lower section disassembled position; maintaining axial orientation of the rotor seal (124) and the disc end bearing (132) as the seal (124) and bearing (132) move between the assembled and disassembled positions thereof; raising the impeller rotor (106) to a rotor lifted position; moving the impeller rotor (106) through the fluid casing (112) from the rotor lifted position to a rotor disassembled position; and maintaining axial orientation of the impeller rotor (106) as the rotor (106) moves between the assembled and disassembled positions thereof.

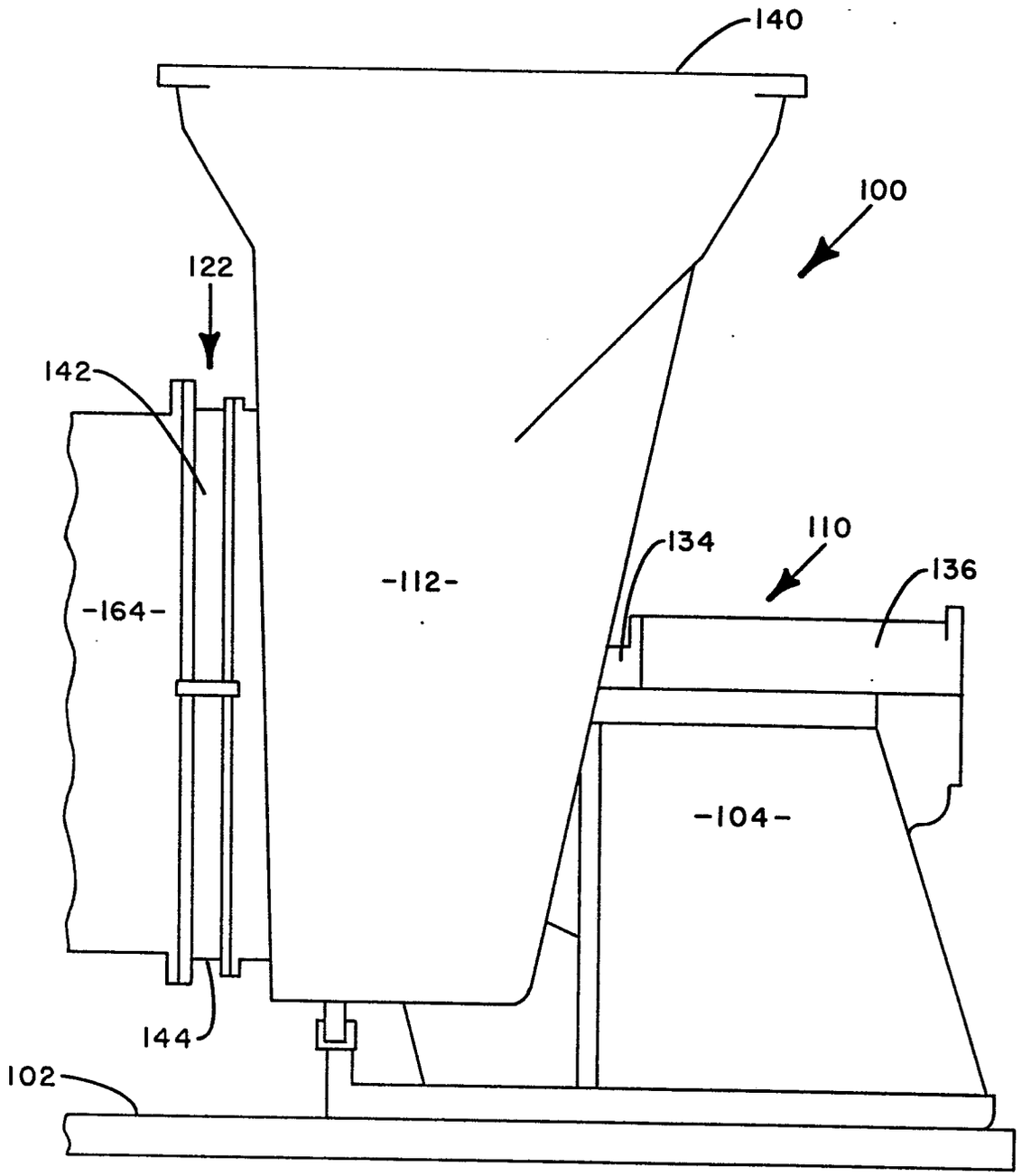

FIG. 1

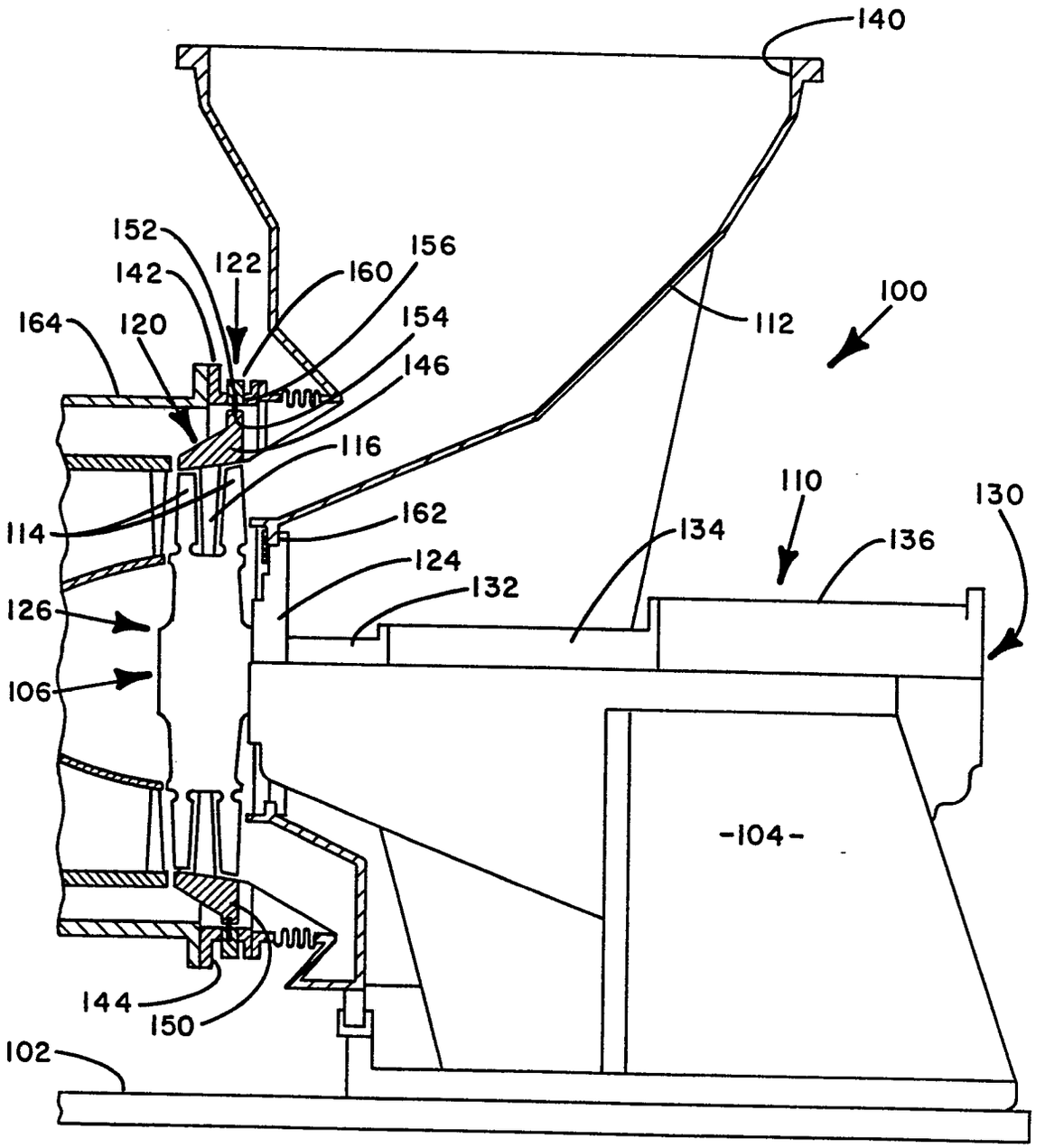
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FIG. 2

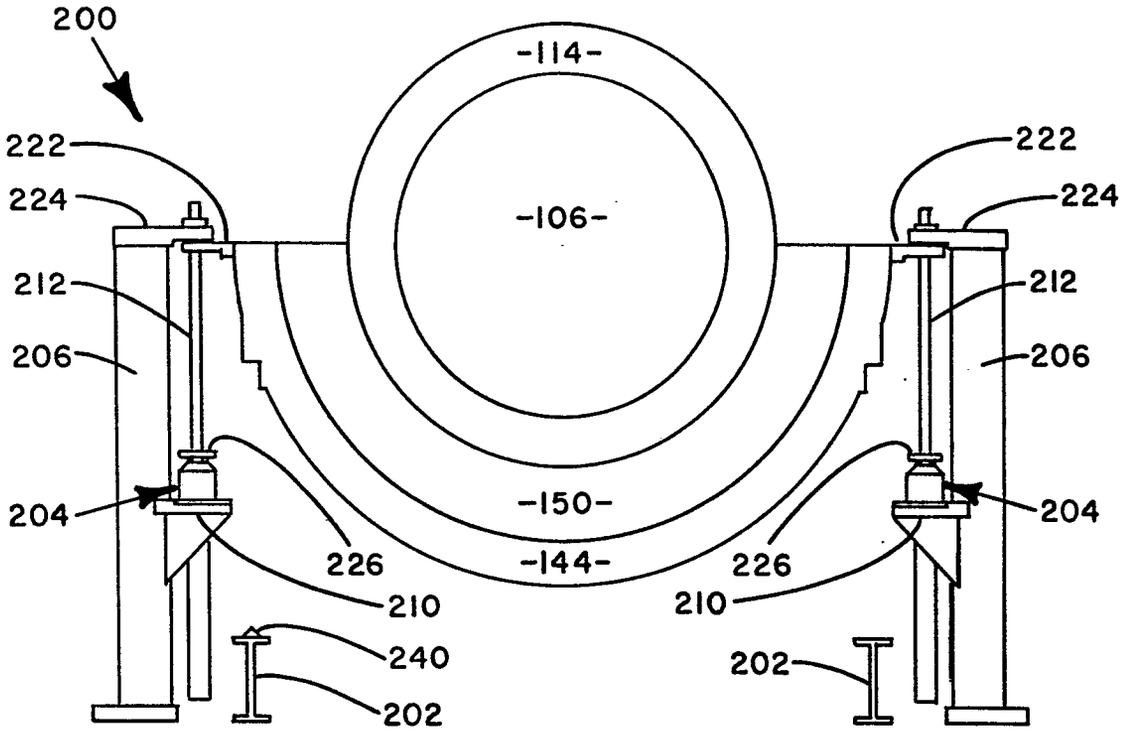
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FIG. 3

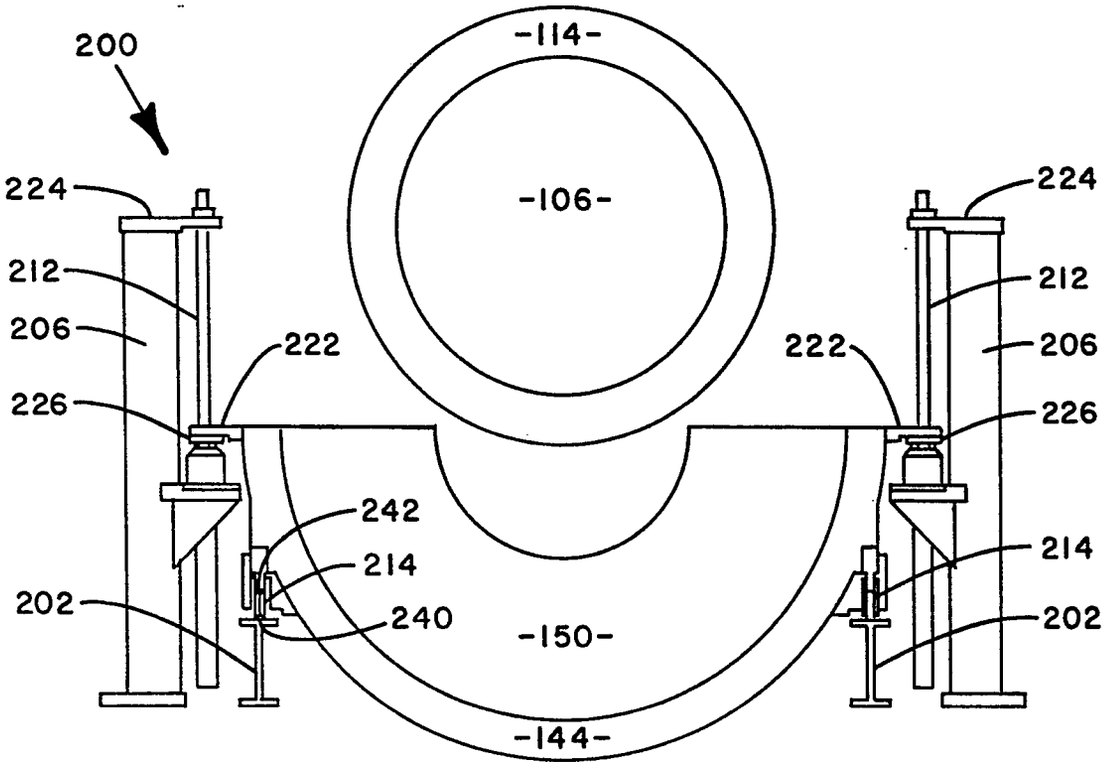
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FIG. 4

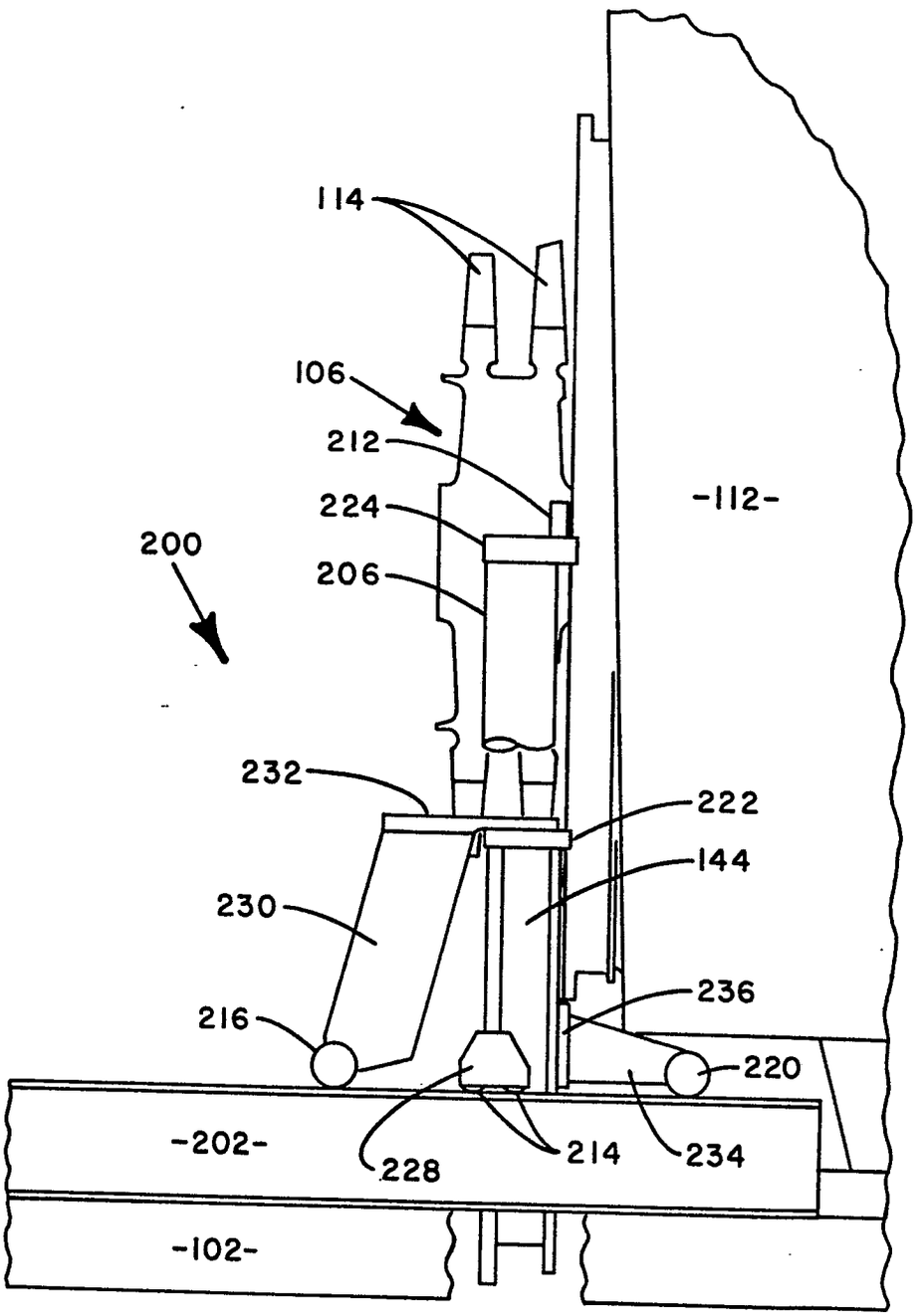
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FIG. 5

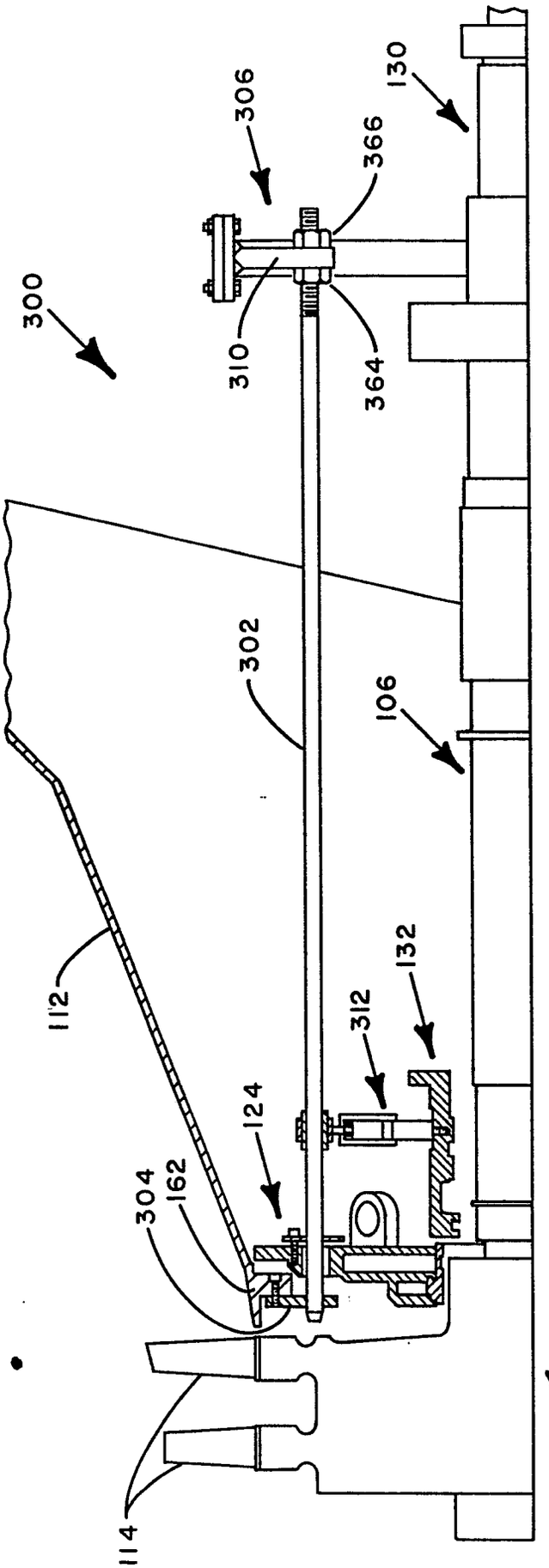

FIG. 6

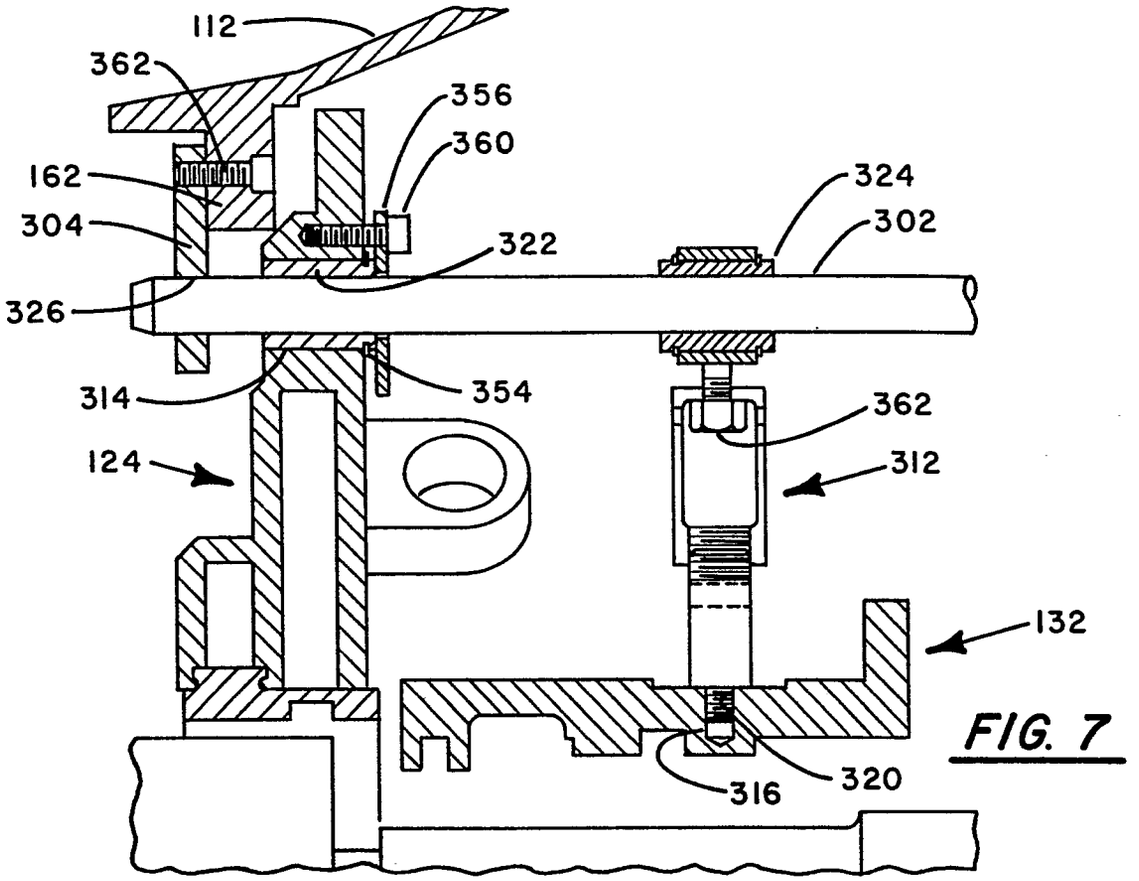
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FIG. 7

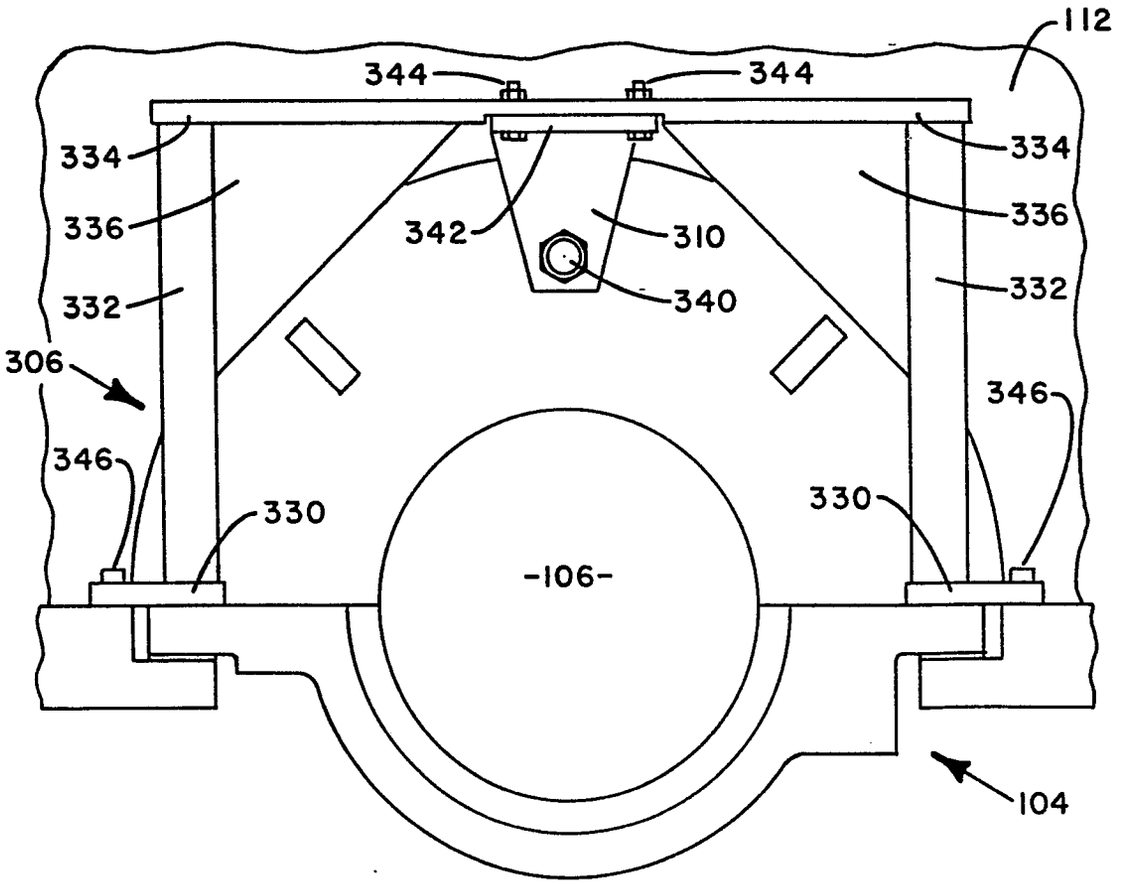
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FIG. 8

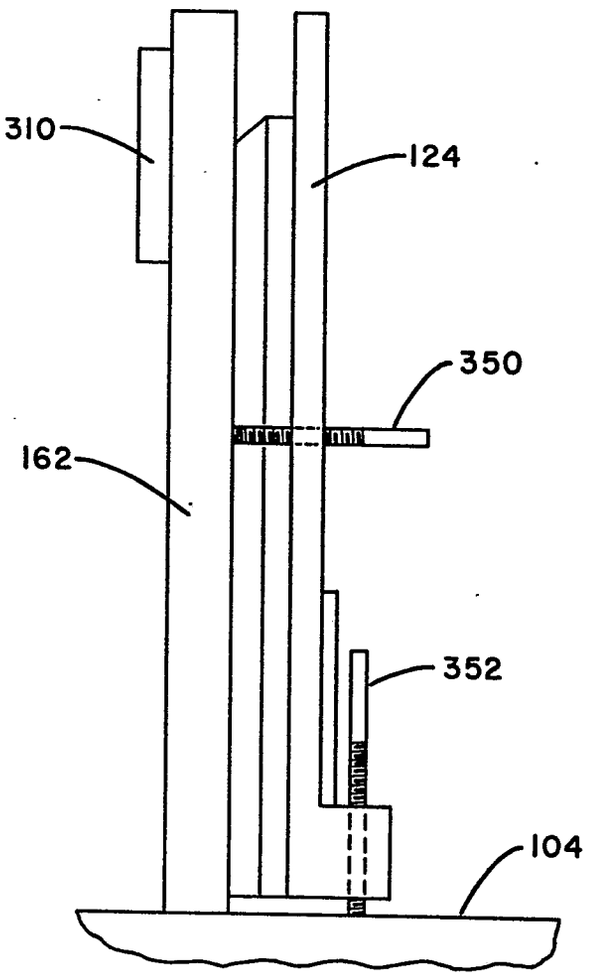

FIG. 9

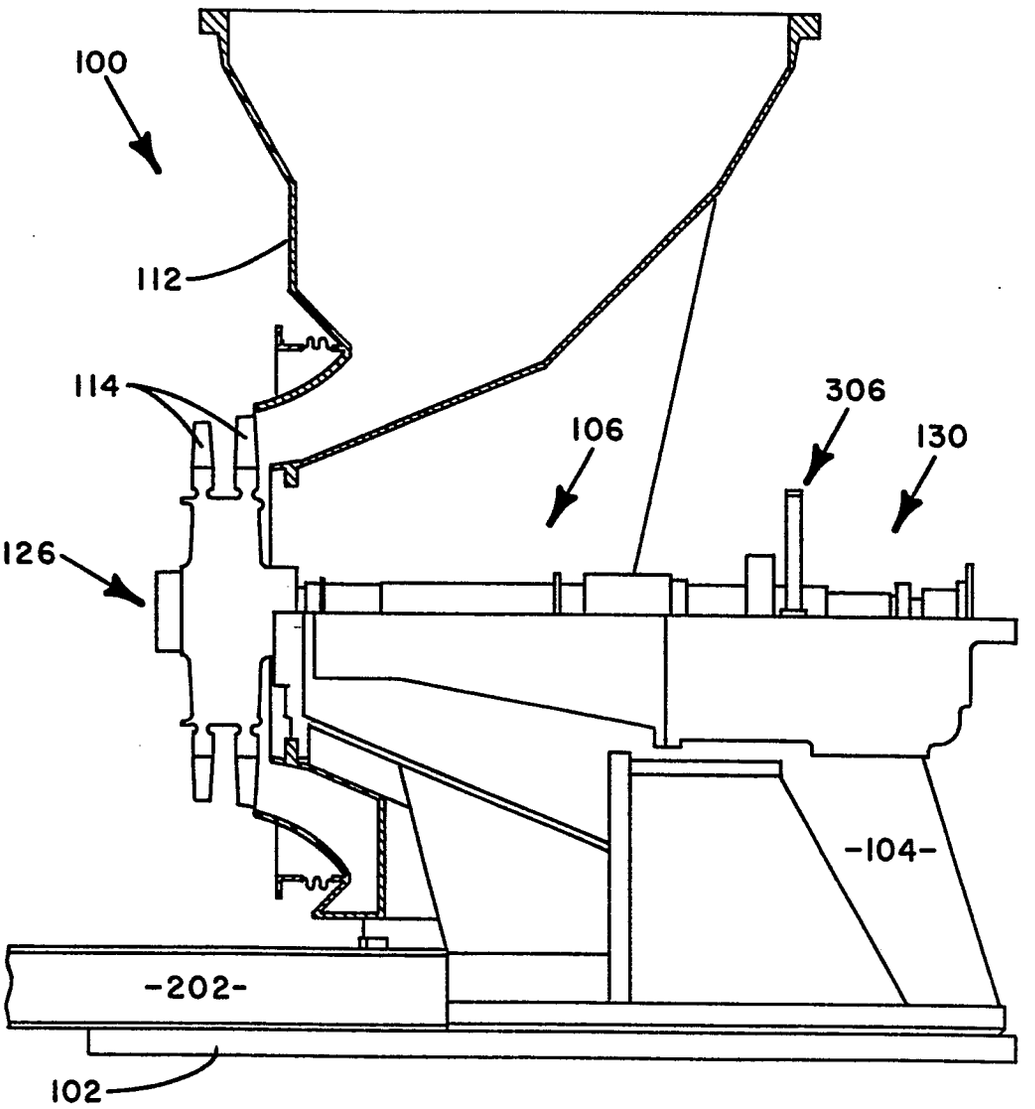

FIG. 10

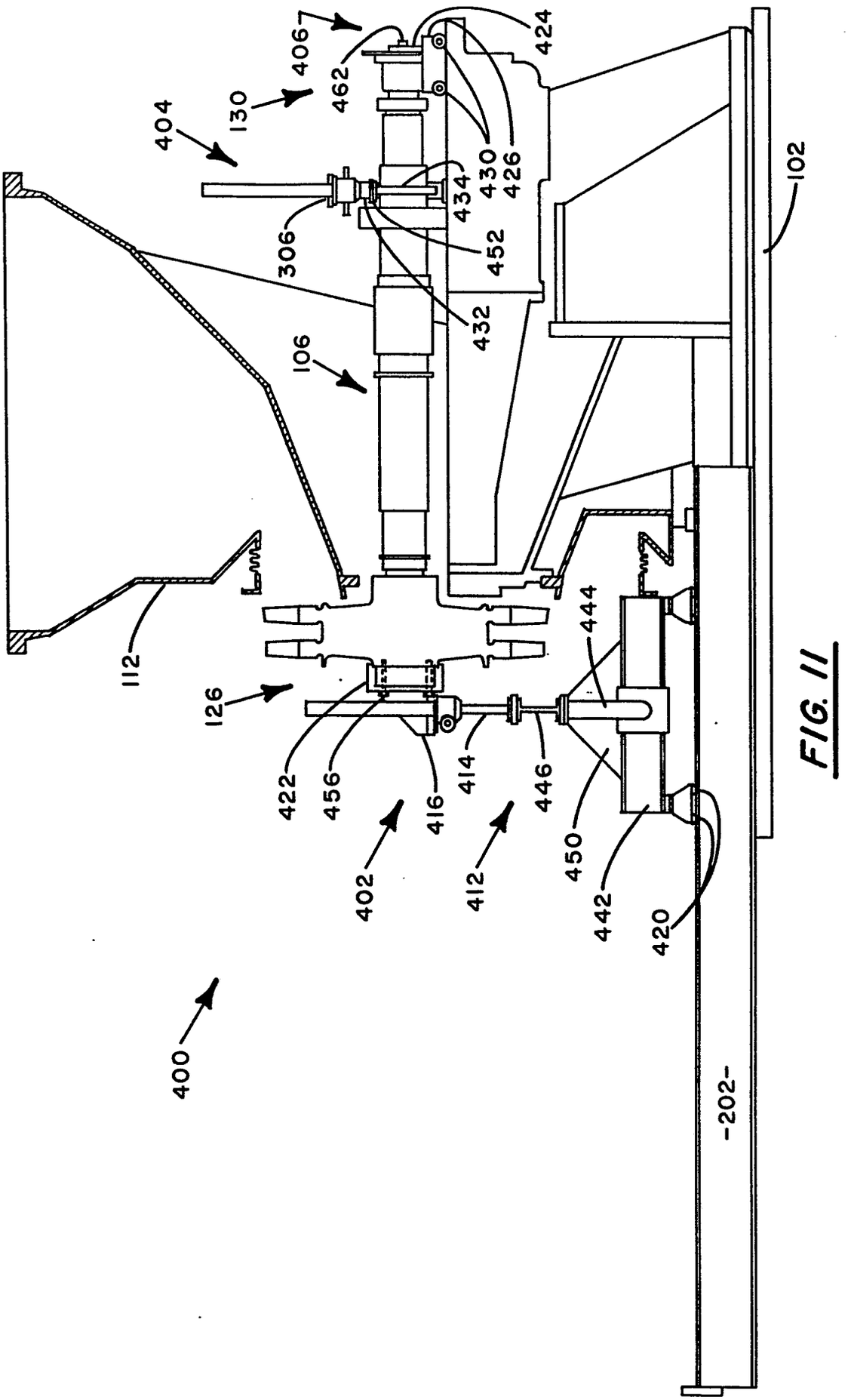
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FIG. 11

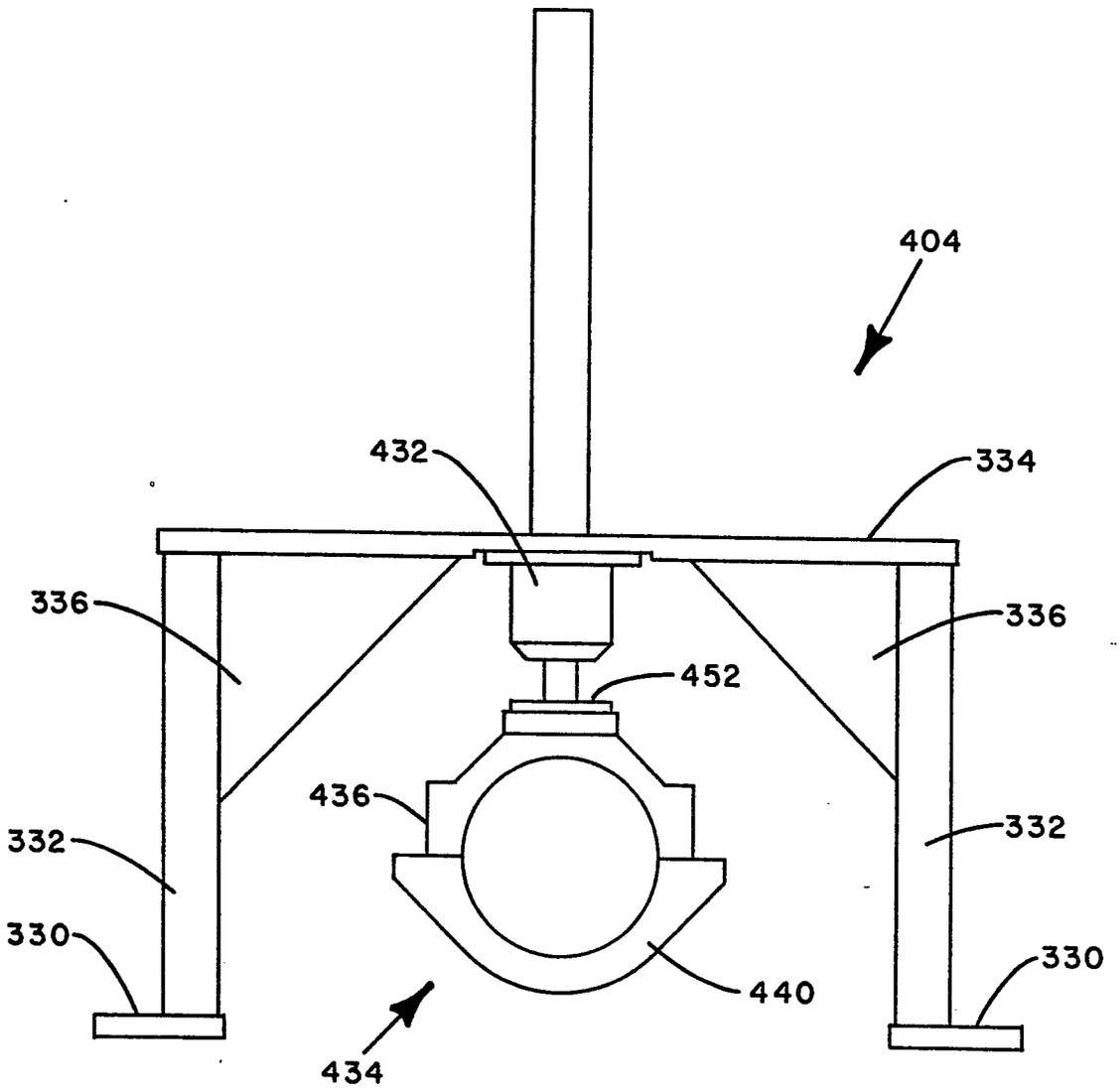

FIG. 12

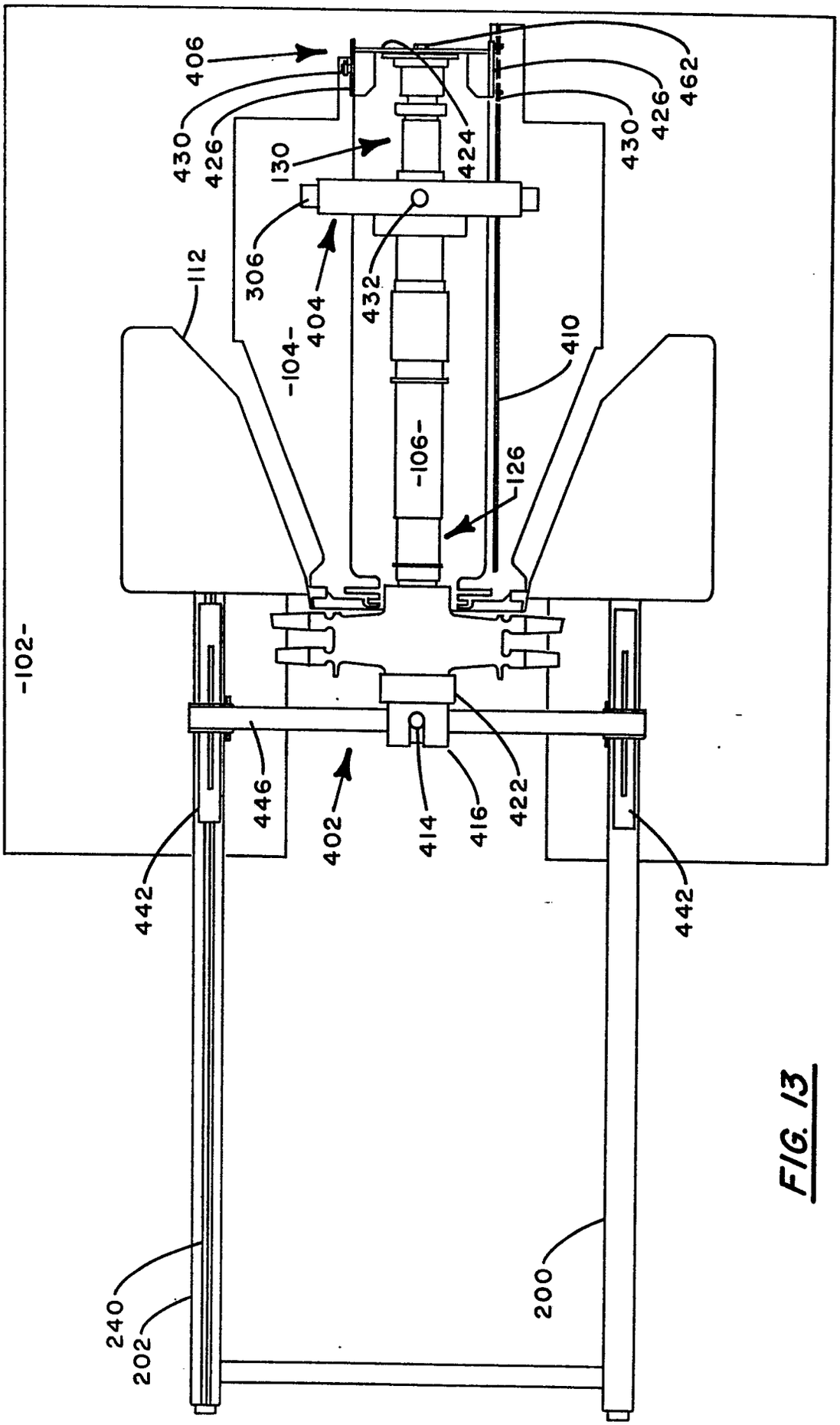
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FIG. 13

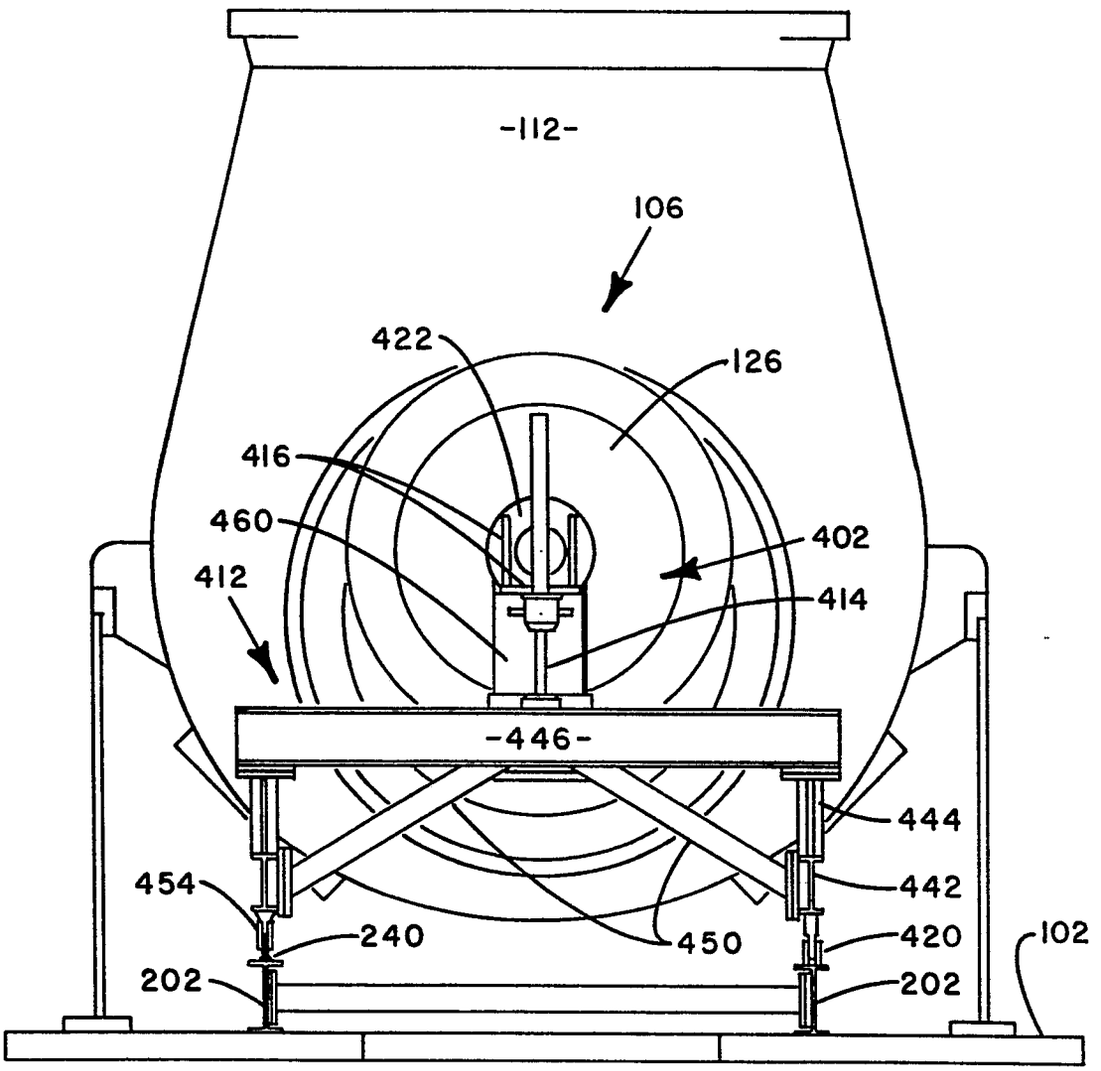
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FIG. 14

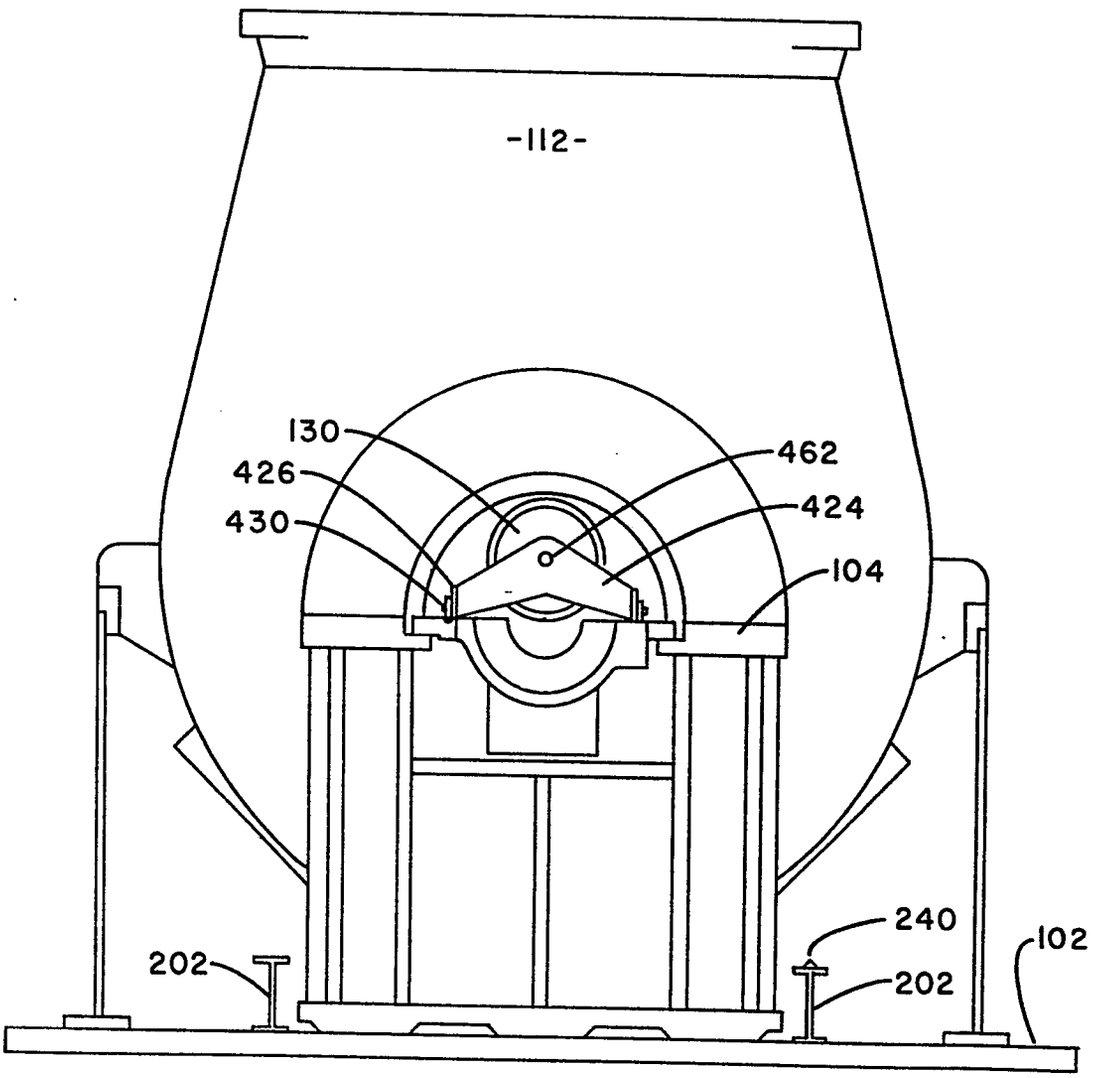

FIG. 15

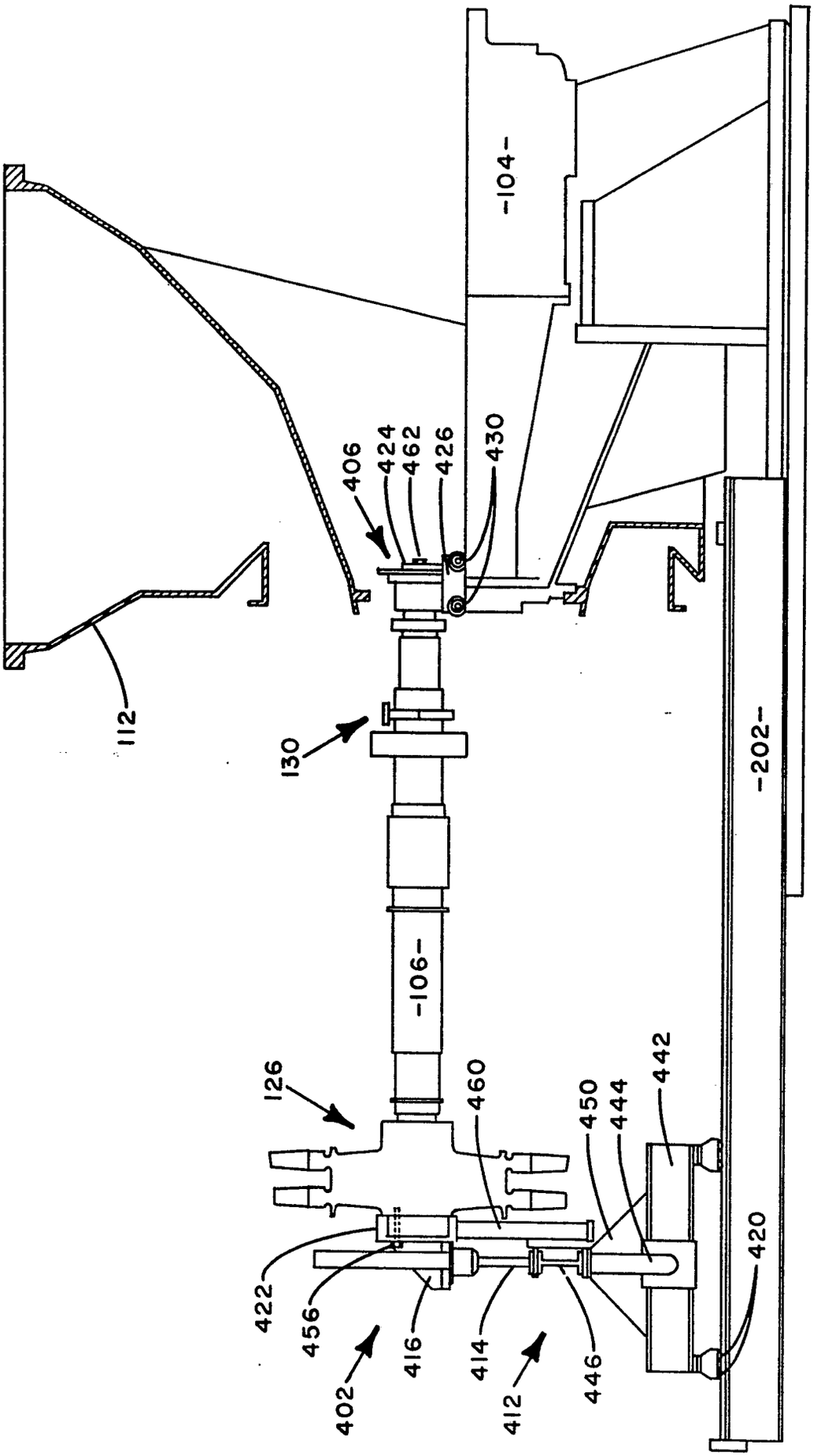
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FIG. 16

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 10 8316

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
A	US - A - 1 991 761 (McHUGH)	
A	FR - A - 802 529 (BEAUDREY)	
A	DE - A - 2 026 915 (TURNBULL)	

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

F 04 D 29/64
F 01 D 25/28

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

F 04 D
F 01 D

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same category
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	02.02.1982	DE SCHEPPER