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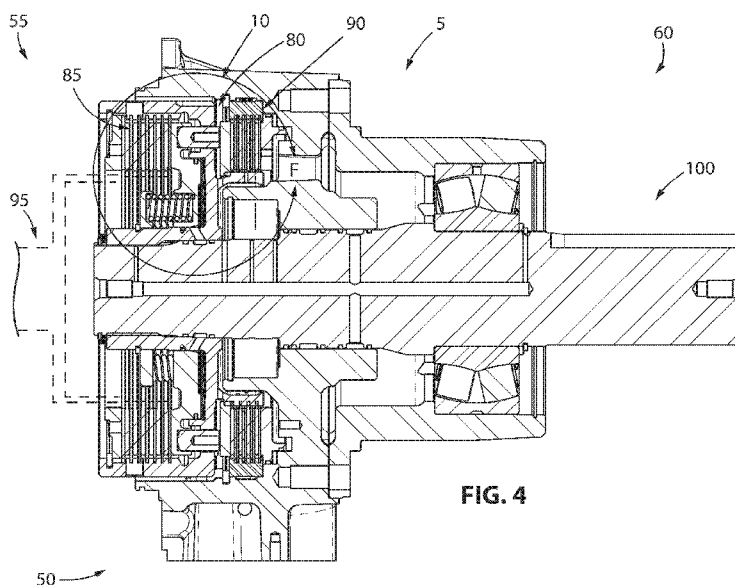


FIG. 4

(57) Abstract: A hydraulic power take-off is provided for use with industrial drives that deliver power to industrial equipment. The hydraulic power take-off has a brake disconnect system that can manually release a brake assembly to allow low-effort rotating of the industrial equipment components to facilitate servicing.



HYDRAULIC POWER TAKE-OFF WITH BRAKE DISCONNECT SYSTEM FOR INDUSTRIAL DRIVES

CROSS REFERENCE TO RELATED APPLICATIONS

[001] This application claims a benefit of priority under 35 USC § 119 to U.S. Provisional Patent Application No. 62/296,913 filed February 18, 2016, the entire contents of which are hereby expressly incorporated by reference into the present application.

BACKGROUND OF THE INVENTION

Field of the Invention

[002] The preferred embodiments are directed to industrial drives of industrial equipment and, more particularly, to a hydraulic PTO (power take-off) with a brake assembly that can be released or disconnected to allow low-effort rotating of drive components to facilitate servicing the equipment.

Discussion of the Related Art

[003] Industrial equipment like industrial chippers, shredders, grinders, and crushers having large rotating components that are driven with robust industrial drives. Suitable industrial drives include hydraulic PTOs with hydraulic clutches and brakes that automatically engage when the clutches are disengaged, providing a parking brake for the equipment.

[004] Industrial equipment is often serviced in the field, whether to clear jams in the equipment, change bits or other tools, or perform inspections. During such servicing for industrial equipment with large rotatable components, it is typically desirable to at least slightly rotate the rotatable components for alignment of components being replaced, to gain access to components, or to improve visibility for inspecting components. However the automatic parking brakes of hydraulic PTOs hold the rotatable components, preventing their rotation. One known solution is to apply a

separate hydraulic signal to hydraulically release the brake to at least some extent to allow for component rotation. But this approach requires a separate hydraulic kit which can be expensive and time-consuming since it needs to be connected to the hydraulic PTO.

[005] Overall, a hydraulic PTO for use in an industrial drive of a piece of industrial equipment allows for a cost-effective, quick, and manual release or disconnecting of a parking brake was desired.

SUMMARY AND OBJECTS OF THE INVENTION

[006] The preferred embodiments overcome the above-noted drawbacks by providing a hydraulic PTO (power take-off) for use with an industrial drive and by having a brake disconnect system that can manually release or disconnect a brake assembly to allow low-effort rotating of the industrial equipment components to facilitate servicing the equipment.

[007] In accordance with a first aspect of the invention, a hydraulic PTO is provided that includes a PTO housing mounted between a prime mover and a piece of driven industrial equipment. An output shaft extends from the PTO housing to selectively deliver power to the piece of driven equipment for driving rotation of a rotatable component of the piece of driven industrial equipment. A brake assembly is arranged within the PTO housing for slowing rotation of the output shaft. The brake assembly includes a brake ring radially spaced from the output shaft. A brake pack has interleaved brake plates and includes a first set of brake plates arranged to rotate in unison with the output shaft and a second set of brake plates rotationally fixed with respect to the brake ring. A disconnect lever assembly is movable between a locked position that prevents rotation of the brake ring and the second set of brake plates with respect to the PTO housing and an unlocked position that allows rotation of the brake ring and the second set of brake plates to rotate in unison with the first set of brake

plates and the output shaft. When the disconnect lever assembly is in the locked position, the brake assembly provides a relatively greater brake force to the output shaft. When the disconnect lever assembly is in the unlocked position, the brake assembly provides a relatively lesser brake force to the output shaft.

[008] In accordance with another aspect of the invention, a PTO is provided for use with industrial drives. The PTO includes a PTO housing mounted between a prime mover and a piece of driven industrial equipment. The PTO housing includes an input end for receiving power into the PTO and an output end with an output shaft for delivering power out of the PTO. A brake assembly is arranged within the PTO housing for slowing rotation of the output shaft. The brake assembly defines multiple use states. A non-parking brake state of the brake assembly allows rotation of the output shaft relative to the brake assembly and transmission of power through the PTO for delivering power to the piece of industrial equipment. A parking brake state of the brake assembly prevents rotation of the output shaft relative to the brake assembly when the piece of industrial equipment is not being used. A parking brake disconnected state of the brake assembly allows rotation of the output shaft and the brake assembly relative to the PTO housing when the piece of industrial equipment is not being used, for example, such as when the equipment is being serviced.

[009] These and other features and advantages of the invention will become apparent to those skilled in the art from the following detailed description and the accompanying drawings. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the present invention, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0010] Preferred exemplary embodiments of the invention are illustrated in the accompanying drawings in which like reference numerals represent like parts throughout and in which:
- [0011] FIG. 1 is a simplified schematic representation of a piece of industrial equipment with an industrial drive incorporating a hydraulic PTO (power take-off) with a multiple-force brake system;
- [0012] FIG. 2 is a pictorial view of the hydraulic PTO of FIG. 1;
- [0013] FIG. 3 is a side elevation view of a portion of the hydraulic PTO of FIG. 2;
- [0014] FIG. 4 is a longitudinal cross-sectional view of a portion of the hydraulic PTO of FIG. 2;
- [0015] FIG. 5 is a longitudinal cross-sectional view of a portion of the hydraulic PTO of FIG. 2 with the clutch assembly engaged and the brake assembly disengaged;
- [0016] FIG. 6 is a longitudinal cross-sectional view of a portion of the hydraulic PTO of FIG. 2 with the clutch assembly disengaged and the brake assembly in a high-energy brake engagement state;
- [0017] FIG. 7 is a longitudinal cross-sectional view of a portion of the hydraulic PTO of FIG. 2 with the clutch assembly disengaged and the brake assembly in a low-energy brake engagement state;
- [0018] FIG. 8 is a longitudinal cross-sectional view of a portion of the hydraulic PTO of FIG. 2, showing a disconnect system;

[0019] FIG. 9 is a transverse cross-sectional view of a portion of the hydraulic PTO of FIG. 2, showing the disconnect system of FIG. 8; and

[0020] FIG. 10 is a longitudinal cross-sectional view of a disconnect lever assembly of the disconnect system of FIG. 8.

[0021] In describing preferred embodiments of the invention, which are illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents, which operate in a similar manner to accomplish a similar purpose. For example, the words “connected”, “attached”, “coupled”, or terms similar thereto are often used. They are not limited to direct connection but include connection through other elements where such connection is recognized as being equivalent by those skilled in the art.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0022] Referring to the simplified schematic representation in FIG. 1, a hydraulic PTO (power take-off) 5 with a brake disconnect such as a manual brake disconnect system, explained in greater detail elsewhere herein, is shown implemented with a multiple-force brake system 10 in an industrial drive 15. The industrial drive 15 delivers power from a prime mover 20, which may be a high-power internal combustion engine to a piece of industrial equipment 25. Industrial drive 15 is shown here configured for side-load power delivery and includes a pulley arrangement 30 and belt(s) 35 that transmit power from hydraulic PTO 5 to a driven component(s) of the industrial equipment 25. The industrial equipment 25 may be, for example, a whole-tree chipper or other industrial wood chipper, a heavy-duty pump system, a grinder, a crusher, a dredge, a shredder, or a heavy-duty drill system that has a large rotating mass such as a rotatable component(s) 40 that establishes large inertial loads while rotating.

[0023] A control system 45 includes a computer that executes various medium-stored programs while receiving inputs from, and sending commands to, the hydraulic PTO 5 to control the hydraulic PTO 5 and may further control other components of the industrial drive 15, prime mover 20, and/or other components of the industrial equipment 25. Control system 35 may include the TDEC-050 electronic control system available from Twin Disc, Inc. for controlling the hydraulic PTO 5 by controlling the various electronic, electromechanical, and hydraulic systems and/or other components of the hydraulic PTO 5 to control hydraulic fluid flow to actuate components to selectively engage and disengage components of multiple-force brake system 10. This may include toggling between high and low energy braking engagements during a stopping event, as explained in greater detail elsewhere herein.

[0024] Referring now to FIG. 2, hydraulic PTO 5 includes a housing 50 with an input end 55, an output end 60, and a pump tower 70 shown with two pump pads 75 arranged

between the input and output ends 55, 60. Referring to FIGS. 3 and 4, multiple-force brake system 10 is arranged inside of the housing 50. Referring now to FIG. 4, multiple-force brake system 10 includes a clutch and brake arrangement 80 having a clutch assembly 85 and brake assembly 90. Clutch assembly 85 receives power from an input shaft 95 toward the housing input end 55 and selectively delivers power to output shaft 100 toward the housing output end 60. Brake assembly 90 is shown here as a multi-disc or multi-plate wet brake system that is configured to slow the rotational speed of output shaft 100 by selectively using different clamping or braking forces as controlled by control system 45 (FIG. 1). FIGS. 5-7 show the multiple-force brake system 10 in different states of clutch engagement and braking force application.

[0025] Referring next to FIG. 5, multiple-force brake system 10 is shown with the clutch assembly 85 on or engaged and the brake assembly 90 off or disengaged to transmit power through the hydraulic PTO 5. A drum assembly 105 interconnects the clutch assembly 85 and brake assembly 90 by way of a clutch drum 110 and a brake collar 115 with a flange 120 that extends between and connects the clutch drum 110 and the brake collar 115 to each other. Clutch drum 110 is spline-mounted to output shaft 100 and has outer and inner circumferential clutch drum side walls 125, 130.

[0026] Still referring to FIG. 5, clutch assembly 85 has a clutch pack 135 with interleaved clutch plates 140. A first set of clutch plates 140 of clutch pack 135 is locked into rotational unison with clutch drum 110 through engagement of outwardly facing tabs of the clutch plates 140 with splined grooves of an inner surface of an outer clutch drum side wall 125. A second set of clutch plates 140 of clutch pack 135 is locked into rotational unison with input shaft 95 (FIG. 4) through engagement of inwardly facing tabs of the clutch plates 140 with splined grooves of an outer surface of the input shaft 95. A clutch piston assembly 150 with a clutch piston 155 that moves to compress the clutch plates 140 against each other and lock the clutch plates 140 into

rotational unison when hydraulic fluid is introduced into a clutch pressure cavity 160 is also provided. This engagement of clutch assembly 85 allows the clutch pack 135 to translate rotation of the input shaft 95 (FIG. 4) into rotation of the output shaft 100.

[0027] Still referring to FIG. 5, brake assembly 90 has a brake stack or brake pack 170 with interleaved brake plates 175. A first set of brake plates 175 of brake pack 170 is locked against rotation with respect to housing 50 through engagement of outwardly facing tabs of the brake plates 175 with inwardly facing splined grooves of an inner surface of housing 50 or, as shown here, a brake ring 180 so that the first set of brake plates 175 is rotationally fixed with respect to the brake ring 180. Brake ring 180 is configured to be selectively locked against rotation with respect to housing 50 or released and mechanically disconnected to allow the brake ring 180 to rotate with respect to housing 50, as explained in greater detail elsewhere herein. A second set of brake plates 175 of brake pack 170 has inwardly facing tabs that are received in outwardly facing splined grooves of an outer surface of brake collar 115 of drum assembly 105, which locks the second set of brake plates 175 into rotational unison with output shaft 100 through the drum assembly 105. The brake plates 175, brake ring 180, and brake collar 115 are shown with annular configurations, when viewed from end views, and concentrically arranged within an annular brake assembly opening of the PTO housing 50. A brake piston assembly 185 has a brake piston 190 that can be hydraulically actuated to move to compress the brake plates 175 against each other as supported by a back plate 195 and clutch piston assembly 150 when hydraulic fluid is introduced into a brake pressure cavity 200 for creating frictional drag between the fixed and rotating brake plates 175 to brake the output shaft 100. Back plate 195 floats like the other brake plates 175 and transfers the force of the clutch piston 155 when the clutch assembly 85 is not activated.

[0028] Referring again to FIGS. 5-7, a multiple-force spring system 205 allows the multiple-force brake system 10 to provide different braking forces of different

magnitudes at different times, as controlled by control system 45 (FIG. 1). Multiple-force spring system 205 includes multiple springs, shown here as high-strength springs 210 as a first set of springs, shown as clutch return springs, and low-strength springs 215 as a second set of springs, shown as brake piston springs. Each of high-strength springs 210 is supported at one end by a plate 220 held by a retainer 225 at the clutch drum 110 and, at a second end, engages and biases the clutch piston 155 away from clutch plates 140 to disengage clutch assembly 85. Each of low-strength springs 215 is supported at one end by housing 50 and, at a second end, engages and biases the brake piston 190 toward brake plates 175 to engage brake assembly 90. Pins 230 extend through openings 235 of the drum assembly flange 120. The pins 230 are configured to allow movement of the clutch piston 155 of clutch assembly 85 toward the drum assembly flange 120 to translate into movement of back plate 195 of brake assembly 90 away from the drum assembly flange 120 and toward the brake piston 190.

[0029] Referring again to FIG. 5, when the clutch assembly 85 is engaged, hydraulic pressure in the clutch pressure cavity 160 moves the clutch piston 155 to compress the clutch pack 135, which compresses the high-strength springs 210 and unloads pin 230 to allow the pin 230 to disengage from back plate 195 of the brake assembly 90. This simultaneously engages the clutch assembly 85 and disengages or turns off brake assembly 90 because low-strength springs 215 can remain fully extended and unloaded, with no resistance or stop provided by pins 230 because the pins 230 are slid out of engagement with back plate 195, which defines a clearance or gap 240. It is contemplated that back plate 195 could be attached to the pins 230 with screws or other fasteners to pull the back plate 195 away from the brake pack 170 during a clutch engagement.

[0030] Referring now to FIG. 6, multiple-force brake system 10 is shown with the clutch assembly 85 off or disengaged and the brake assembly 90 on or engaged to provide

braking of output shaft 100 with a relatively high-energy brake engagement. In the high-energy brake engagement state of multiple-force brake system 10, the high-strength springs 210 provide the braking pressure to the brake assembly 90. This is done by introducing oil into the brake pressure cavity 200 to create hydraulic pressure that pushes brake piston 190 toward the brake pack 170 until the brake piston 190 hits a stop provided by an abutment or engagement between the brake piston 190 and an end surface of the brake ring 180. The hydraulic pressure is maintained to hold the brake piston 190 against the stop at the brake ring 180. The clutch assembly 85 is turned off or disengaged by relieving hydraulic pressure from the clutch pressure cavity 160. The high-strength springs 210 push the clutch piston 155 away from the clutch pack 135, which axially loads and pushes pin 230 against back plate 195, with the movement permitted by a clearance or gap 245 and defined between clutch piston 155 and drum assembly flange 120. The translation of movement of the clutch piston 155 through the pin 230 to push against back plate 195 compresses brake pack 170 with a relatively high clamping force provided by high-strength springs 210, which provides a high-energy braking force.

[0031] Referring to FIG. 7, multiple-force brake system 10 is shown with the clutch assembly 85 off or disengaged and the brake assembly 90 on or engaged to provide braking of output shaft 100 with a relatively low-energy brake engagement. In the low-energy brake engagement state of multiple-force brake system 10, the low-strength springs 215 provide the braking pressure to the brake assembly 90. This is done by releasing hydraulic pressure from both the clutch and brake pressure cavities 160, 200. The high-strength springs 210 push the clutch piston 155 away from the clutch pack 135, against a stop provided by an abutment between the clutch piston 155 and a surface of the drum assembly flange 120. This holds the back plate 195 in a fixed position against which the low-strength springs 215 push the brake piston 190 to compress the brake pack 170, which creates a clearance or gap 250 between the brake

piston 190 and the brake ring 180. The compression of brake pack 170 provided by the low-strength springs 215 provides a low-energy braking force.

[0032] Referring again to FIGS. 5-7 and with further reference to FIG. 1, during use, control system 45 (FIG. 1) controls the multiple-force brake system 10 to actively brake rotation of the rotatable component(s) 40 (FIG. 1) of the industrial equipment 25 (FIG. 1). During a braking event, the control system 45 can toggle between applications of the high-energy and low-energy braking forces. The periodic applications of the high-energy braking forces provide substantial slowing of the rotatable component(s) 40 (FIG. 1), and the periodic applications of the low-energy braking forces provide some braking effect while allowing cooling of the oil and system components of the hydraulic PTO 5.

[0033] Referring next to FIGS. 8 and 9, hydraulic PTO 5 includes a manual service disconnect system, shown as disconnect system 255, to at least partially release the multi-disc wet brake system of brake assembly 90. This may be done by mechanically disconnecting the brake assembly 90 from its supporting components to allow rotation of the brake assembly 90 relative to PTO housing 50. When the industrial equipment 25 (FIG. 1) is in use, the brake assembly 90 is in a non-parking brake state to allow rotation of output shaft 100 (FIG. 4) relative to the brake assembly 90, such as rotation relative to the brake plates 175 that are rotationally fixed with respect to brake ring 180 and locked against rotation with respect to PTO housing 50, to deliver power to industrial equipment 25 (FIG. 1). When the industrial equipment 25 (FIG. 1) is not in use, the brake assembly 90 can be in a parking brake state, providing a parking brake effect by way of the low-energy braking force provided by the low-strength springs 215 (FIG. 5) against the multiple brake plates 175 in the brake pack 170 (FIG. 5). This prevents rotation of output shaft 100 (FIG. 4) relative to the brake assembly 90, such as relative to all of the brake plates 175 of brake pack 170 (FIG. 5). Disconnect system 255 is configured to manually release the parking brake to place

the brake assembly 90 in a parking brake disconnected state in which the brake assembly 90 is mechanically disconnected from its supporting structure of PTO housing 50 and allowed to rotate relative to the PTO housing 50. This allows rotating components of the industrial equipment 25 (FIG. 1) and/or output shaft 100 (FIG. 4) when the brake assembly 90 is in the parking brake disconnected state, as explained in greater detail elsewhere herein.

[0034] Still referring to FIGS. 8 and 9, disconnect system 255 includes brake ring 180 and disconnect lever assembly 260 that can selectively engage the brake ring 180 to lock and prevent rotation of brake ring 180 within the housing 50 during active braking or parking braking with the brake assembly 90. Disconnect lever assembly 260 can selectively release the brake ring 180 to allow rotation of brake ring 180 and rotation of output shaft 100. When the brake ring 180 is released and allowed to rotate in the housing 50, the brake assembly 90 applies a small fraction of the braking power compared to when the brake ring 180 is prevented from rotating within the housing 50. That is, because the brake ring 180 is allowed to rotate inside the housing 50, braking occurs at only a single frictional engagement surface between the outermost brake plate 175 and the piston 190, instead of multiple frictional engagements of multiple abutting surfaces of the adjacent interleaved brake plates 175 when the brake ring 180 is locked against rotation. By locking and releasing the brake ring 180 with the disconnect lever assembly 260, the disconnect system 255 converts the brake assembly 90 from a multi-plate configuration when in the parking brake state to effectively provide a single plate configuration that is substantially easier to rotate through when placed in the parking brake disconnected state.

[0035] Still referring to FIGS. 8 and 9, brake ring 180 has inner and outer circumferential surfaces 265, 270. Inner circumferential surface 265 supports the brake plates 175 with the outwardly facing tabs. Outer circumferential surface 270 faces outward toward an inwardly facing surface of a wall that defines an outer boundary of the

annular brake assembly opening of the PTO housing 50. Holes or brake ring pockets, shown as pockets 280, extend into the outer circumferential surface 270 of brake ring 180 and are circumferentially spaced from each other. Disconnect lever assembly 260 includes handle 315 with a plunger 290 that extends into pocket(s) 280 to lock the brake ring 180 and is withdrawn out of pocket 280 to release and allow the brake ring 180 to rotate. Plunger 290 is arranged for sliding concentrically in a bore 295 of cylindrical lever body 300 that is attached to housing 50, extending through a bore 305 of the housing 50 that is aligned with the brake ring 180 and the pockets 280.

[0036] Referring now to FIG. 10, pin 310 is connected to and extends outwardly from plunger 290 through bore 292, and a handle 315 extends perpendicularly from an upper end of pin 310. A slot 320 extends through a sidewall 325 of the cylindrical lever body 300. The slot 320 is configured to receive the handle 315 so that the handle 315 is advanced downwardly in the slot 320 to define a first position of handle 315 when the plunger 290 is seated in pocket 280. To withdraw the plunger 290 out of pocket 280, the handle 315 is withdrawn from the slot 320 and rotated to sit on an upper end 330 of the cylindrical lever body 300 to define a second position of handle 315, as shown in dashed outline in FIG. 10. A spring 335 is arranged concentrically between pin 310 and sidewall 325 of the cylindrical lever body 300. A lower end 340 of spring 335 sits against an upper surface 345 of plunger 290. An upper end 350 of spring 335 sits against an internal shoulder 355 of the cylindrical lever body 330. Spring 335 is a compression spring that biases the plunger 290 toward brake ring 180 so that if handle 315 is aligned with slot 320, the plunger 290 automatically falls into a pocket 280 that rotates into alignment with the plunger 290 when the brake ring 180 rotates.

[0037] Referring again to FIG. 9, a sensor shown as switch 360 is configured to detect when the brake ring 180 is in a home position in which the disconnect lever assembly 260 locks the brake ring 180 with respect to the housing 50. Switch 360 is shown as a

plunger-style switch with a switch button that remains in an extended position by extending into a pocket 280 when the brake ring 180 is in the home position, such as the position shown in FIG. 9. When the brake ring 180 is not in the home position, the button of switch 360 engages the outer circumferential surface 270 of brake ring 180, which pushes the switch button into the switch 360 as a retracted position. Switch 360 delivers a signal to control system 45 (FIG. 1) indicating whether the button is extended out indicating that the brake ring 180 is in the home position or pushed in as the retracted position indicating that the brake ring 180 is not in the home position as an indicator of the position of the brake ring 180, which may correspond to the state of the disconnect lever assembly 260 in its locked or unlocked position(s). Control system 45 (FIG. 1) evaluates whether the brake ring 180 is in the home position to make operational choices, such as requiring the brake ring 180 to be in the home position to allow normal operation of the hydraulic PTO 5 for delivering power to the industrial equipment 25 (FIG. 1).

[0038] Although the best mode contemplated by the inventors of carrying out the present invention is disclosed above, practice of the above invention is not limited thereto. It will be manifest that various additions, modifications, and rearrangements of the features of the present invention may be made without deviating from the spirit and the scope of the underlying inventive concept.

CLAIMS

We claim:

1. A hydraulic PTO (power take-off) for use with industrial drives, the hydraulic PTO, comprising:

a PTO housing mounted between a prime mover and a piece of driven industrial equipment;

an output shaft extending from the PTO housing to selectively deliver power to the piece of driven equipment for driving rotation of a rotatable component of the piece of driven industrial equipment;

a brake assembly arranged within the PTO housing for slowing rotation of the output shaft, the brake assembly including,

a brake ring radially spaced from the output shaft;

a brake pack having interleaved brake plates including a first set of brake plates rotationally fixed with respect to the brake ring and a second set of brake plates arranged to rotate in unison with the output shaft; and

a disconnect lever assembly movable between a locked position preventing rotation of the brake ring and the first set of brake plates with respect to the PTO housing and an unlocked position permitting rotation of the brake ring and the first set of brake plates to rotate in unison with the second set of brake plates and the output shaft.

2. The hydraulic PTO of claim 1, wherein when the disconnect lever assembly is in the locked position, the brake assembly provides a first brake force to the output shaft and when the disconnect lever assembly is in the unlocked position, the brake assembly provides a second brake force to the output shaft, wherein the first brake force is greater than the second.

3. The hydraulic PTO of claim 2, wherein the PTO housing defines an annular brake assembly opening with the brake assembly arranged concentrically within the annular brake assembly opening.
4. The hydraulic PTO of claim 2, wherein the first set of brake plates includes outwardly facing tabs and the brake ring has an inner surface with inwardly facing grooves and where the outwardly facing tabs of the first set of brake plates are received in the grooves of the brake ring inner surface to prevent rotation of the first set of brake plates with respect to the PTO housing when the disconnect lever assembly is in the locked position.
5. The hydraulic PTO of claim 2, further comprising a drum assembly in rotational unison with the output shaft and having a brake collar with outwardly facing grooves and wherein the second set of brake plates includes inwardly facing tabs that are received in the brake collar outwardly facing grooves.
6. The hydraulic PTO of claim 2, wherein the brake ring has an outer circumferential surface and multiple brake ring pockets that are spaced from each other and extend into the brake ring outer circumferential surface.
7. The hydraulic PTO of claim 6, wherein the disconnect lever assembly further comprises a plunger configured to selectively extend into one of the multiple brake ring pockets for establishing the locked position of the disconnect lever assembly.
8. The hydraulic PTO of claim 7, wherein the unlocked position of the disconnect lever assembly is defined when the plunger is withdrawn from the respective one of the multiple brake ring pockets.

9. The hydraulic PTO of claim 8, wherein the disconnect lever assembly further comprises a handle movable between a first position and a second position, and wherein the handle in the first position defines the locked position of the disconnect lever assembly and the handle, and the second position defines the unlocked position of the disconnect lever assembly.

10. The hydraulic PTO of claim 9, wherein the disconnect lever assembly further comprises a pin that extends between the handle and the plunger and a spring that biases the plunger outward toward the locked position of the disconnect lever assembly.

11. The hydraulic PTO of claim 9, wherein the brake assembly further comprises a switch with a switch button that is movable between an extended position and a retracted position for indicating a state of the disconnect lever assembly that corresponds to the locked and unlocked positions of the disconnect lever assembly.

12. The hydraulic PTO of claim 11, wherein the disconnect lever assembly and the switch are arranged with respect to each other so that when the disconnect lever assembly is in the locked position with the plunger in a first one of the multiple brake ring pockets, the switch button is in the extended position and extends into a second one of the multiple brake ring pockets.

13. A PTO (power take-off) for use with industrial drives, the PTO, comprising:
a PTO housing mounted between a prime mover and a piece of driven industrial equipment, wherein the PTO housing includes an input end for receiving power into the PTO and an output end with an output shaft for delivering power out of the PTO;
a brake assembly arranged within the PTO housing for slowing rotation of the output shaft, the brake assembly defining:

a non-parking brake state allowing rotation of the output shaft relative to the brake assembly and transmission of power through the PTO for delivering power to the piece of industrial equipment during use of the piece of industrial equipment;

a parking brake state preventing rotation of the output shaft relative to the brake assembly during nonuse of the piece of industrial equipment; and

a parking brake disconnected state allowing rotation of the output shaft and the brake assembly relative to the PTO housing during nonuse of the piece of industrial equipment.

14. The PTO of claim 13, wherein the brake assembly comprises:

a brake ring arranged within the PTO housing and wherein,

the brake ring is fixed relative to the PTO housing when the brake assembly is in each of the non-parking brake state and the parking brake state;

the brake ring can rotate relative to the PTO housing when the brake assembly is in the parking brake disconnected state;

a brake pack supported by the brake ring so that the brake pack can rotate relative to the PTO housing when the brake assembly is in the parking brake disconnect estate.

15. The PTO of claim 14, wherein when the brake assembly is in the parking brake state, the brake assembly provides a first brake force to the output shaft, wherein when the brake assembly is in the parking brake disconnected state, the brake assembly provides a second brake force to the output shaft, and wherein the first brake force is greater than the second.

16. The PTO of claim 14, wherein the brake assembly further comprises a disconnect lever assembly movable between a locked position that fixes the brake ring relative to the PTO housing and an unlocked position that allows rotation of the brake ring relative to the PTO housing.

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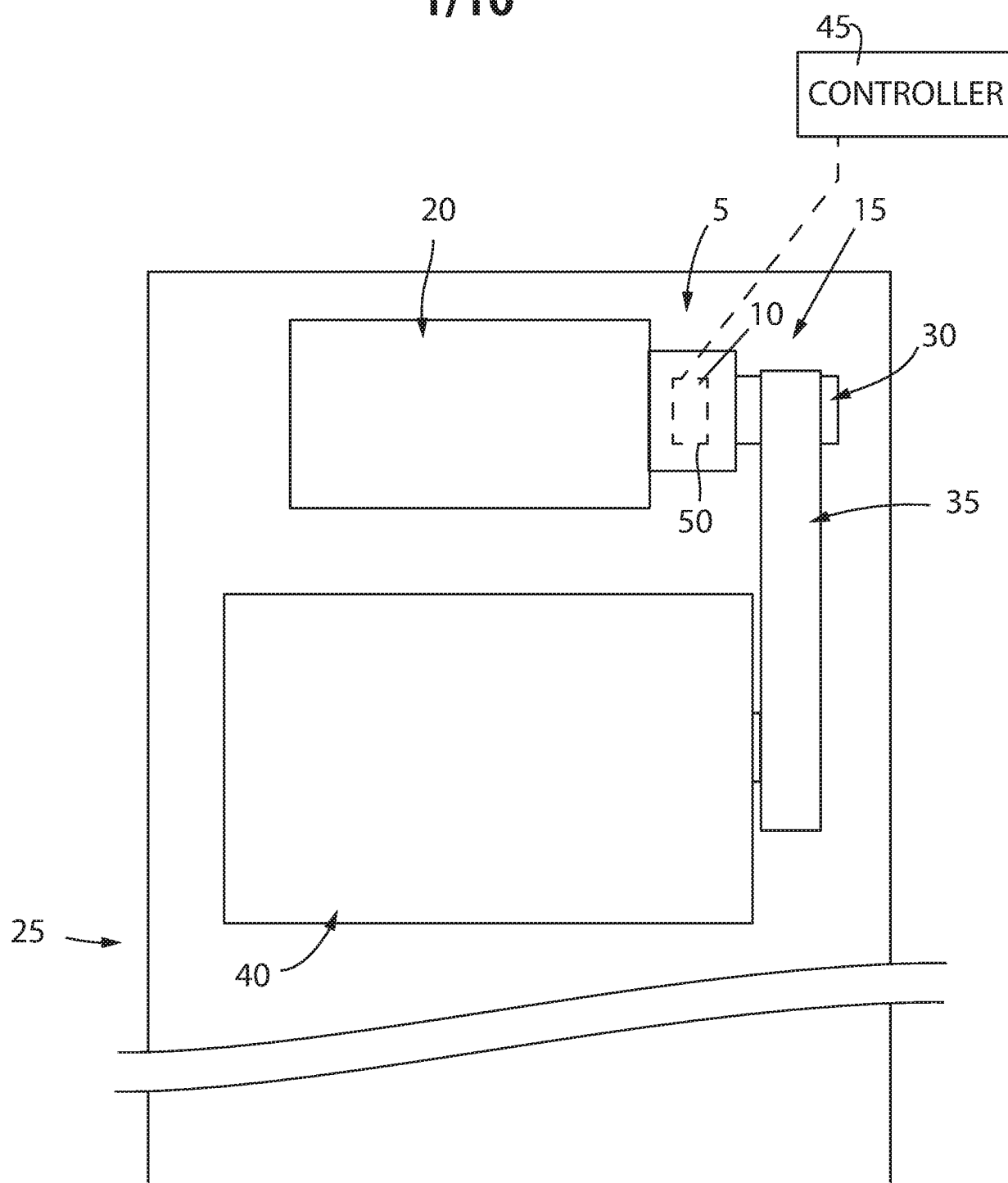


FIG.1

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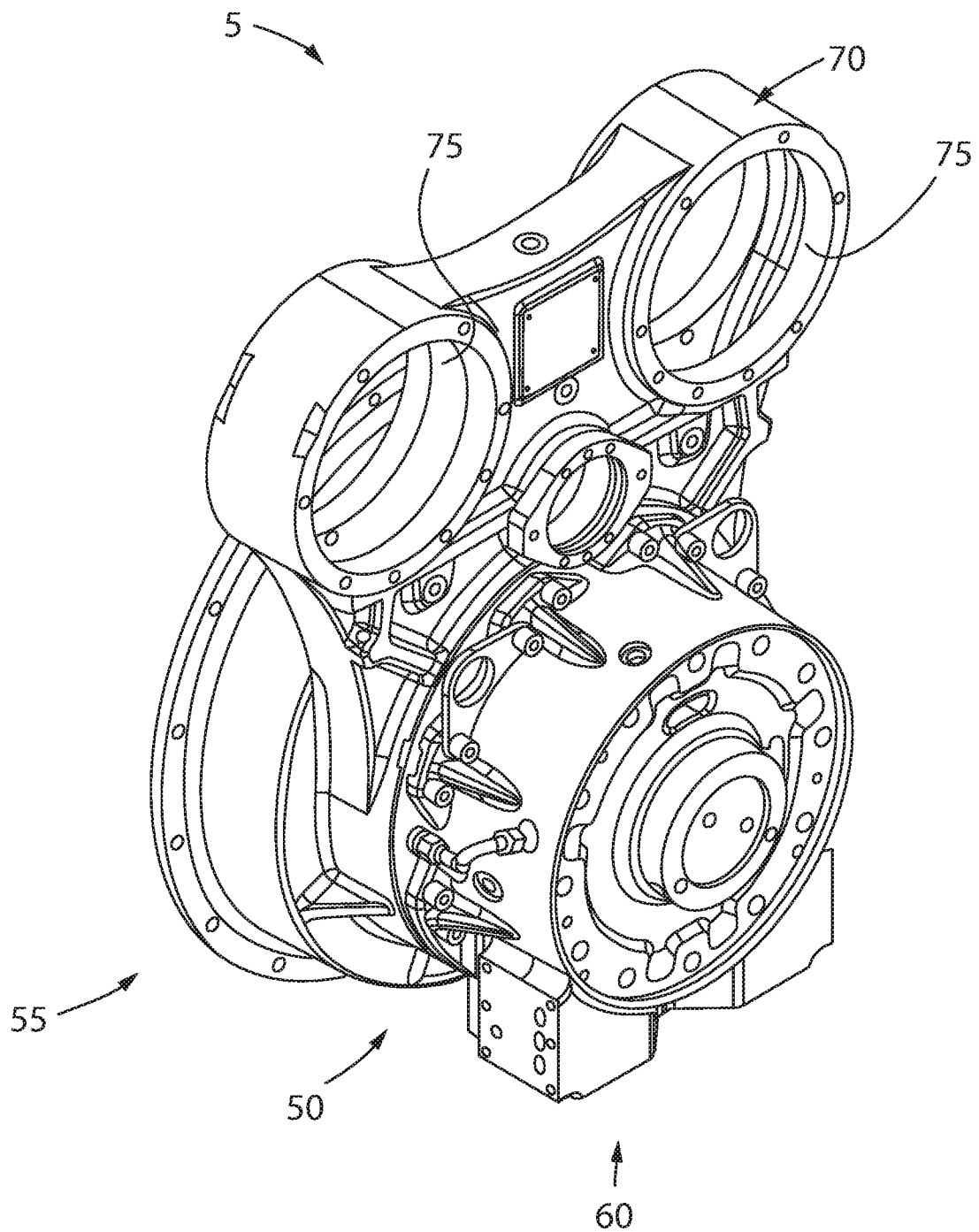
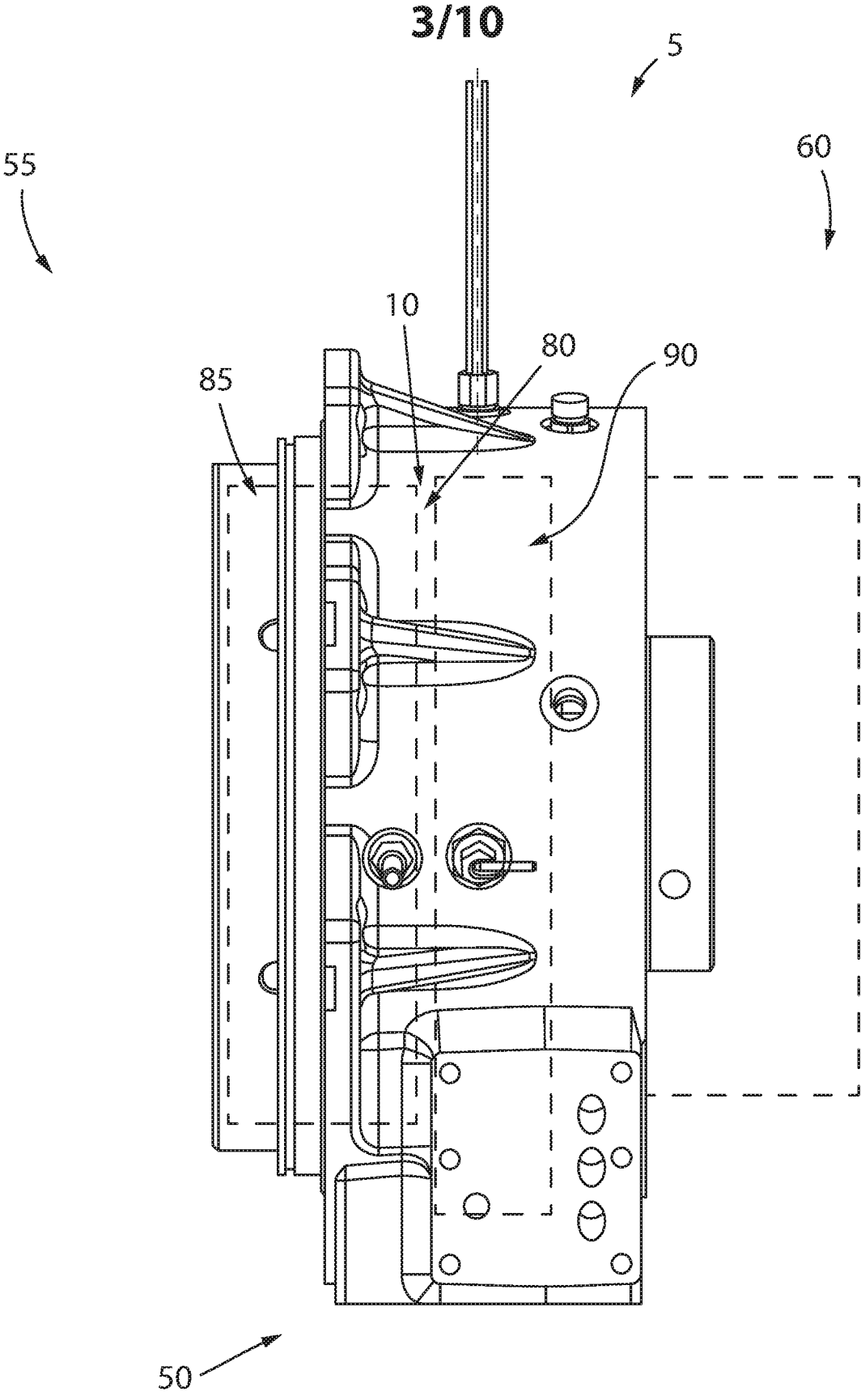
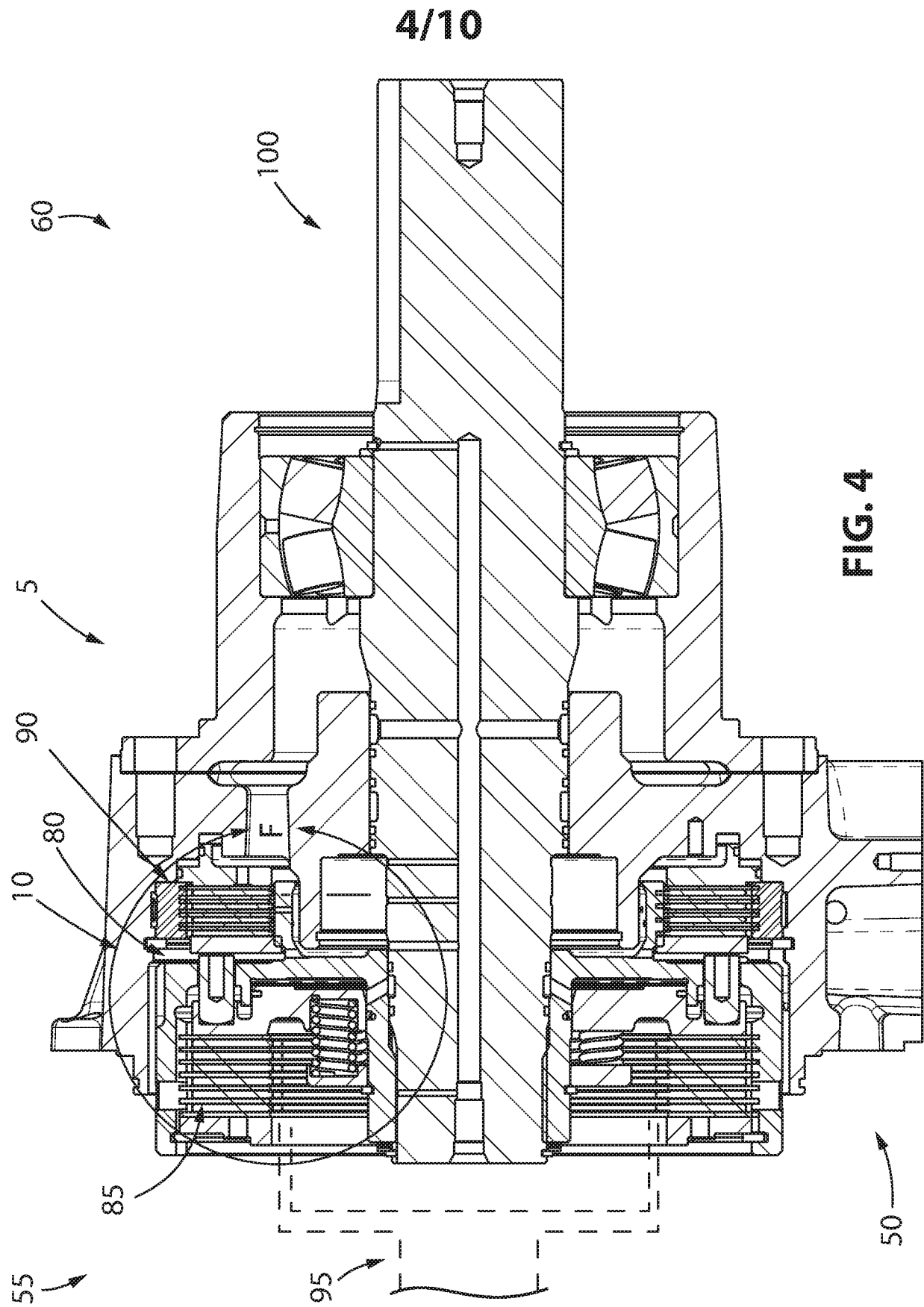
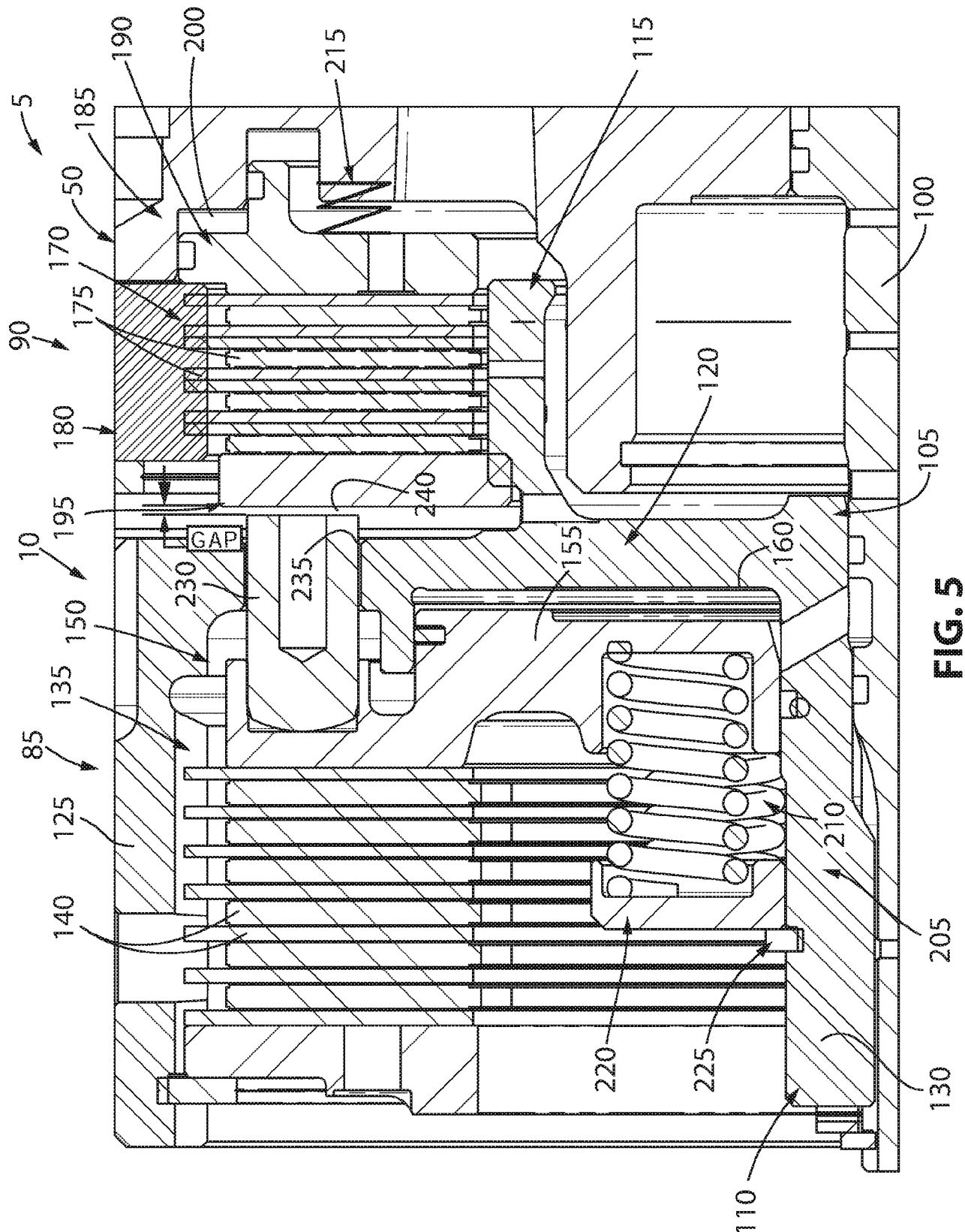


FIG. 2

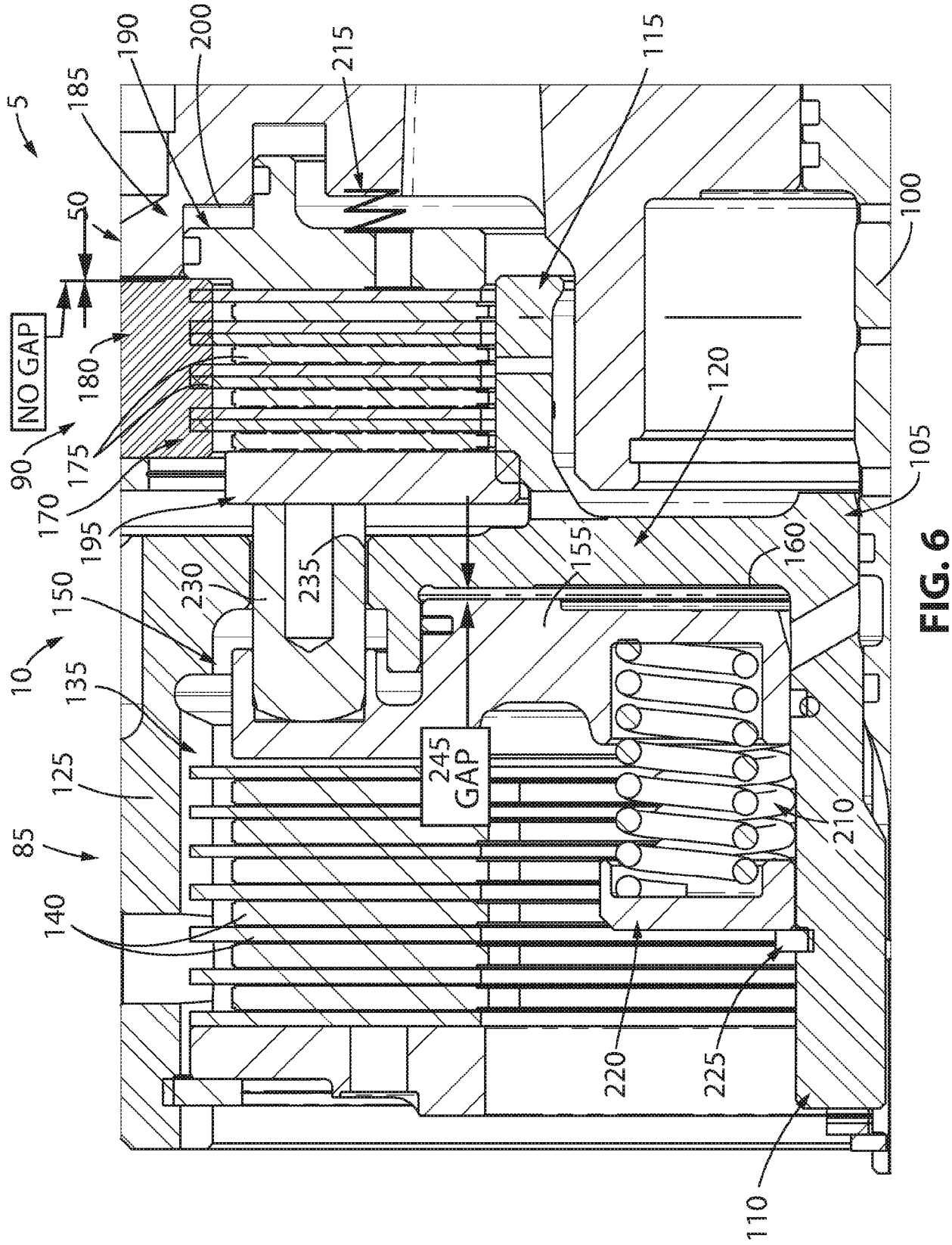




5/10



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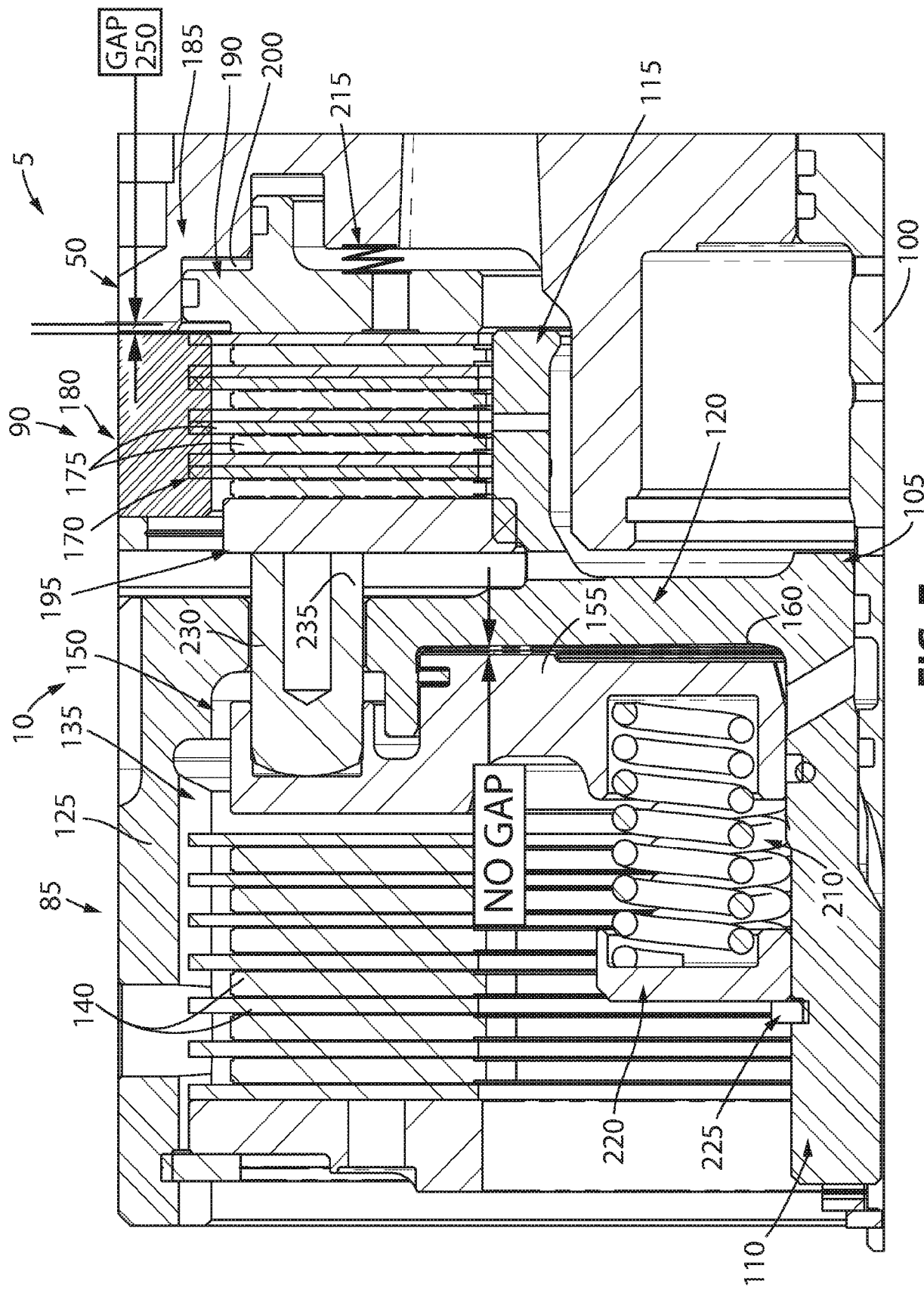


FIG. 7

8/10

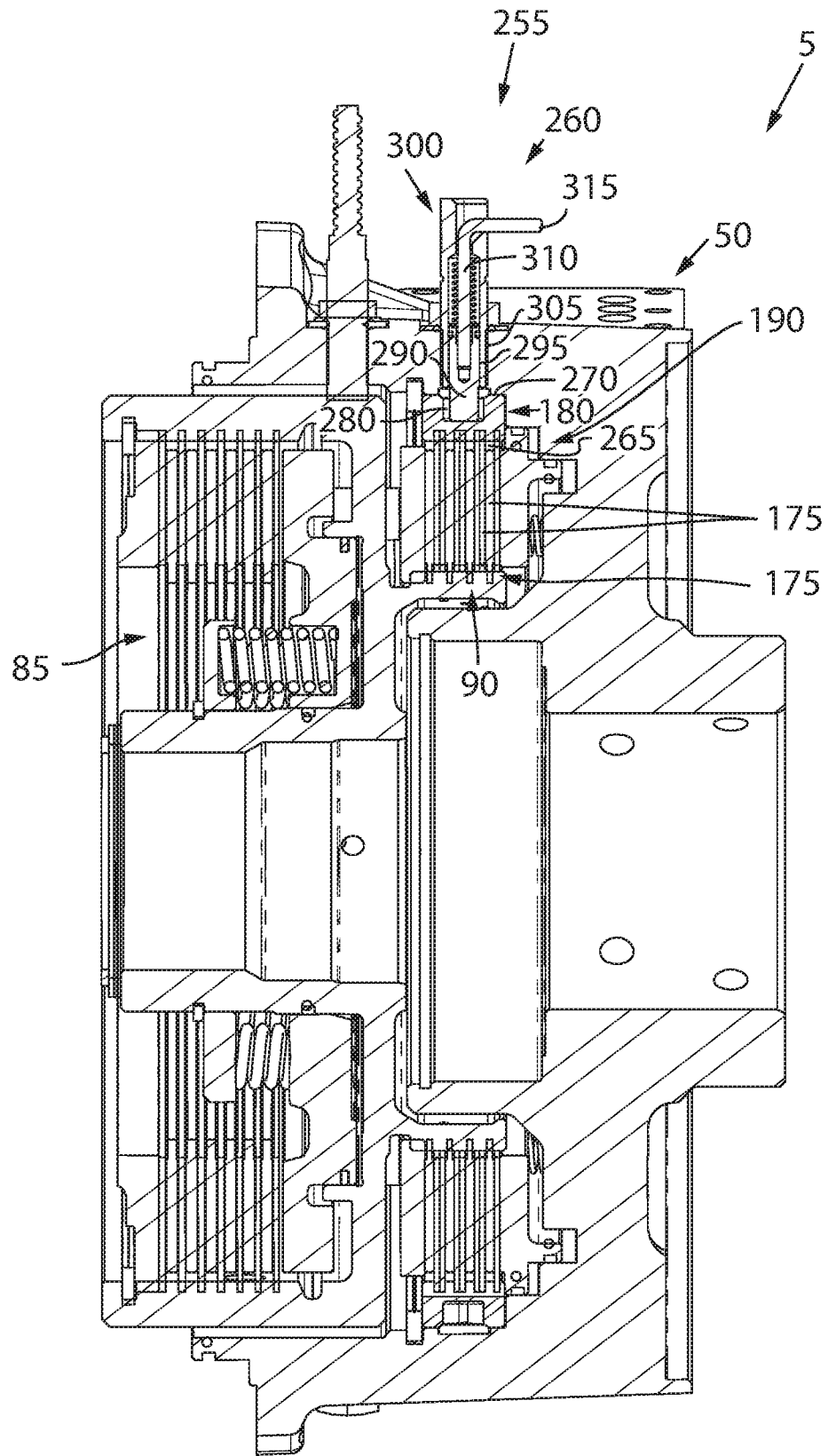


FIG. 8

9/10

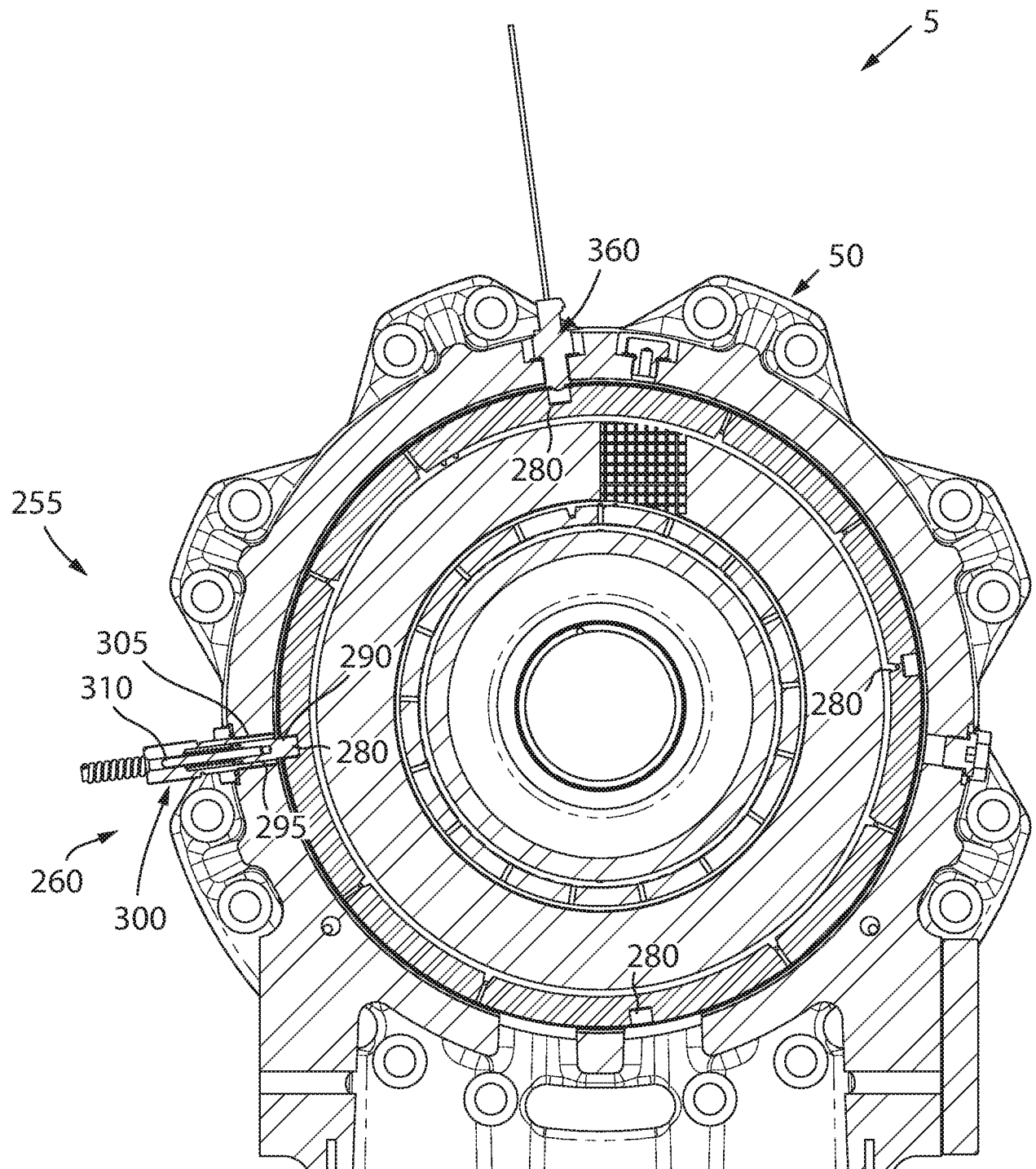


FIG. 9

10/10

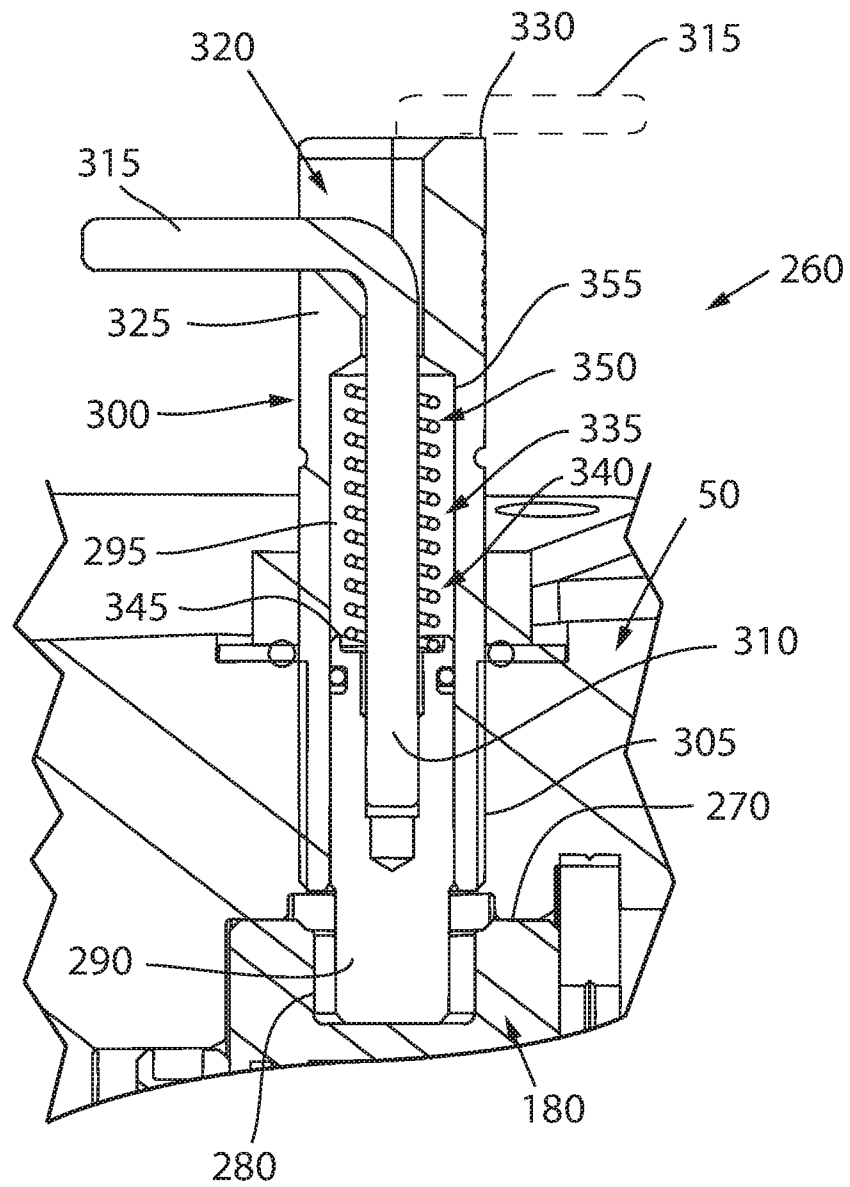


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/018041**A. CLASSIFICATION OF SUBJECT MATTER****B60K 17/28(2006.01)i, F16D 65/02(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60K 17/28; F16D 67/02; F16D 25/06; B60K 41/24; B23B 31/12; F16D 67/06; B60K 25/02; F16D 41/06; F16D 65/02

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: hydraulic, PTO, brake, ring, pack, plate, disconnect, lever

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 9221336 B1 (HYDRO-GEAR LIMITED PARTNERSHIP) 29 December 2015 See column 1, line 31 - column 3, line 24; column 4, line 29 - column 6, line 14; claim 11; and figures 1, 3-4.	1-16
Y	US 4671395 A (DOBBERPUHL et al.) 09 June 1987 See column 4, lines 19-33; claim 5; and figures 1-4.	1-16
A	US 2007-0227849 A1 (MAEZAWA et al.) 04 October 2007 See paragraphs [0032]-[0039]; and figures 4-5.	1-16
A	WO 2014-095148 A1 (AGCO INTERNATIONAL GMBH) 26 June 2014 See page 4, line 10 - page 5, line 31; and figures 3-4.	1-16
A	US 2007-0187908 A1 (PUZIO, DANIEL) 16 August 2007 See paragraphs [0022]-[0050]; and figures 2-5.	1-16



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

10 May 2017 (10.05.2017)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

International Application Division

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189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/018041

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9221336 B1	29/12/2015	None	
US 4671395 A	09/06/1987	EP 0153725 A2 EP 0153725 B1 JP 60-193748 A	04/09/1985 19/10/1988 02/10/1985
US 2007-0227849 A1	04/10/2007	JP 2007-269061 A JP 2007-270975 A JP 4758800 B2 JP 4820198 B2 KR 10-0814522 B1 KR 10-0814524 B1 US 7854281 B2	18/10/2007 18/10/2007 31/08/2011 24/11/2011 17/03/2008 17/03/2008 21/12/2010
WO 2014-095148 A1	26/06/2014	EP 2934935 A1 EP 2934935 B1 US 2015-0291028 A1 US 9434252 B2	28/10/2015 17/08/2016 15/10/2015 06/09/2016
US 2007-0187908 A1	16/08/2007	AU 2005-286854 A1 AU 2006-236496 A1 CN 101056732 A CN 101056732 B CN 101203344 A CN 101203344 B EP 1714722 A2 EP 1714722 A3 EP 1791669 A2 EP 1791669 B1 EP 1998917 A2 EP 1998918 A2 EP 1999155 A2 EP 1999155 B1 EP 2015883 A2 EP 2537612 A2 EP 2537612 A3 EP 2537612 B1 JP 2008-513230 A JP 2008-538326 A JP 2009-532212 A JP 2009-532214 A JP 2009-532215 A JP 2009-535226 A US 2006-0061048 A1 US 2007-0132196 A1 US 2007-0158086 A1 US 2007-0170664 A1 US 2007-0170665 A1 US 7537421 B2	30/03/2006 26/10/2006 17/10/2007 21/03/2012 18/06/2008 17/08/2011 25/10/2006 17/01/2007 06/06/2007 11/01/2017 10/12/2008 10/12/2008 10/12/2008 12/08/2015 21/01/2009 26/12/2012 03/04/2013 12/11/2014 01/05/2008 23/10/2008 10/09/2009 10/09/2009 10/09/2009 01/10/2009 23/03/2006 14/06/2007 12/07/2007 26/07/2007 26/07/2007 26/05/2009

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/018041Patent document
cited in search reportPublication
datePatent family
member(s)Publication
date

US 7547165 B2	16/06/2009
US 7588398 B2	15/09/2009
US 7588399 B2	15/09/2009
US 7645101 B2	12/01/2010
US 7690658 B2	06/04/2010
WO 2006-034287 A2	30/03/2006
WO 2006-034287 A3	26/04/2007
WO 2006-113630 A2	26/10/2006
WO 2006-113630 A3	13/12/2007
WO 2007-115060 A2	11/10/2007
WO 2007-115060 A3	16/10/2008
WO 2007-115143 A2	11/10/2007
WO 2007-115143 A3	23/10/2008
WO 2007-115157 A2	11/10/2007
WO 2007-115157 A3	30/10/2008
WO 2007-127892 A2	08/11/2007
WO 2007-127892 A3	20/11/2008