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Hamrin et al.

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(54) **SHIFT ON THE FLY TRANSMISSION**

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(51) **Int. Cl.**
F16H 37/02 (2006.01)
F16H 3/00 (2006.01)

(52) **U.S. Cl.**
CPC ***F16H 37/021*** (2013.01); ***F16H 3/001*** (2013.01); *F16H 2200/0034* (2013.01)

(58) **Field of Classification Search**
CPC F16H 37/021; F16H 3/001
(Continued)

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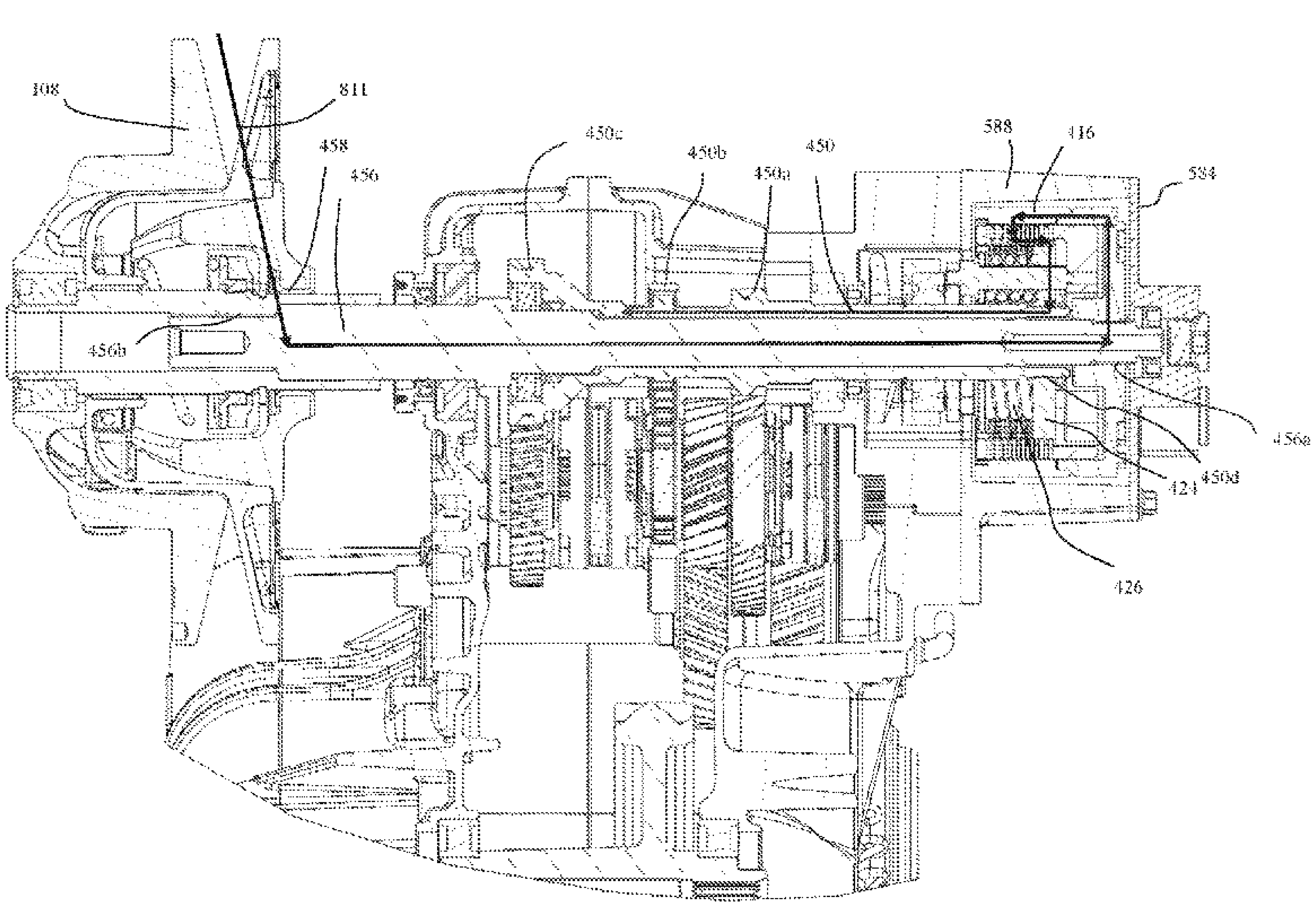
(57) **ABSTRACT**

A shift on the fly transmission is provided. The shift on the fly transmission includes a continuously variable transmission portion, a discrete transmission portion, at least one input shaft and a disconnect clutch. The continuously variable transmission portion is operationally coupled to receive torque from an engine. The discrete transmission portion includes a gear assembly. The at least one input shaft is operationally coupled to an output of the continuously variable transmission portion. The disconnect clutch operationally couples the at least one input shaft to the discrete transmission portion. The disconnect clutch is further configured to selectively decouple torque from the at least one input shaft to the discrete transmission portion during a range ratio shift of the discrete transmission portion.

17 Claims, 18 Drawing Sheets



(58) **Field of Classification Search**
USPC 74/721
See application file for complete search history.

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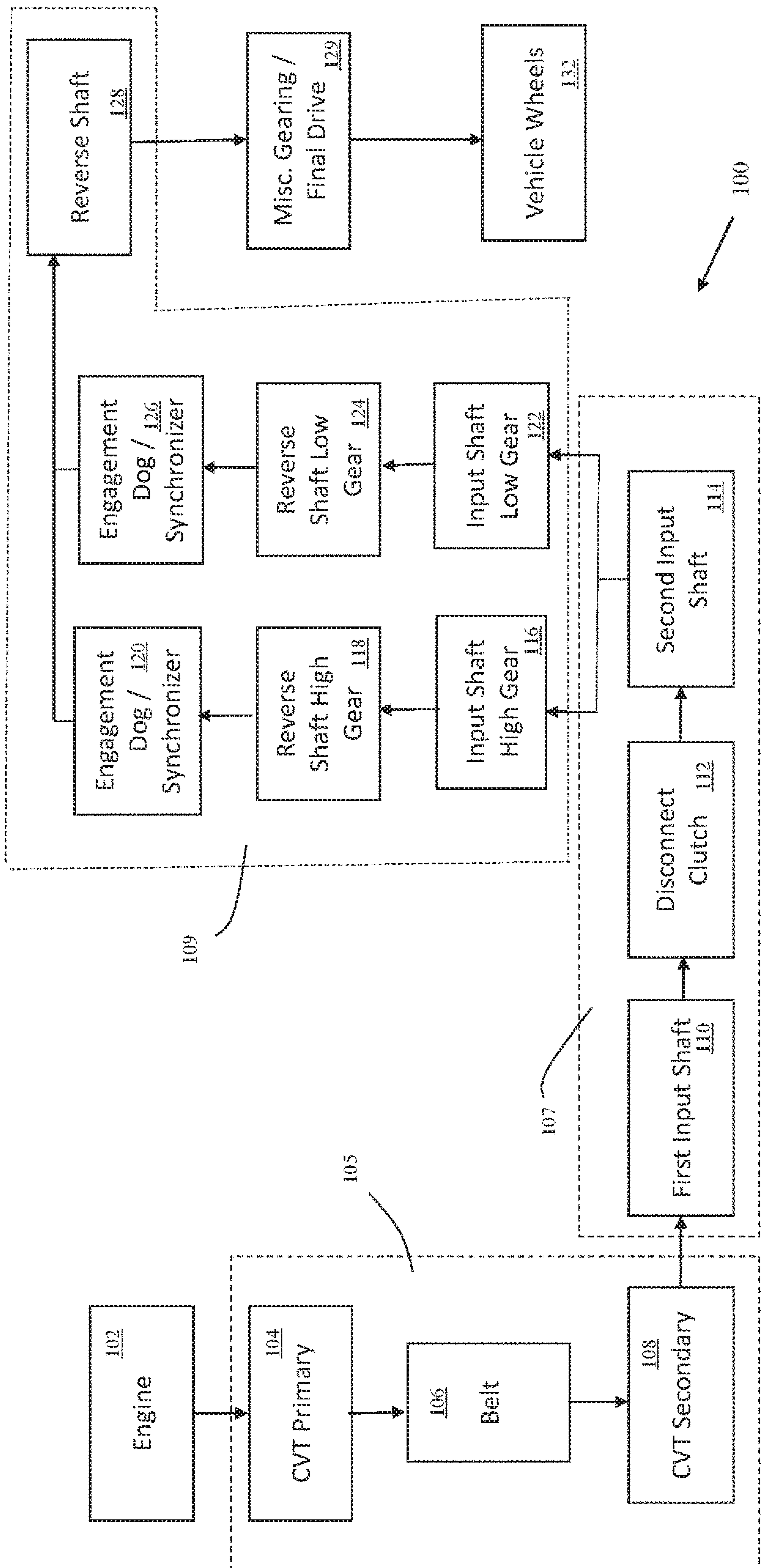

Reverse Shaft 128
Misc. Gearing / Final Drive 129
Vehicle Wheels 132
100
Engagement Dog / 126 Synchronizer
Reverse Shaft Low Gear 124
Input Shaft Low Gear 122
Engagement Dog / 120 Synchronizer
Reverse Shaft High Gear 118
Input Shaft High Gear 116
Second Input Shaft 114
Disconnect Clutch 112
First Input Shaft 110
109
107
105
Engine 102
CVT Primary 104
106 Belt
108 CVT Secondary

FIG. 1

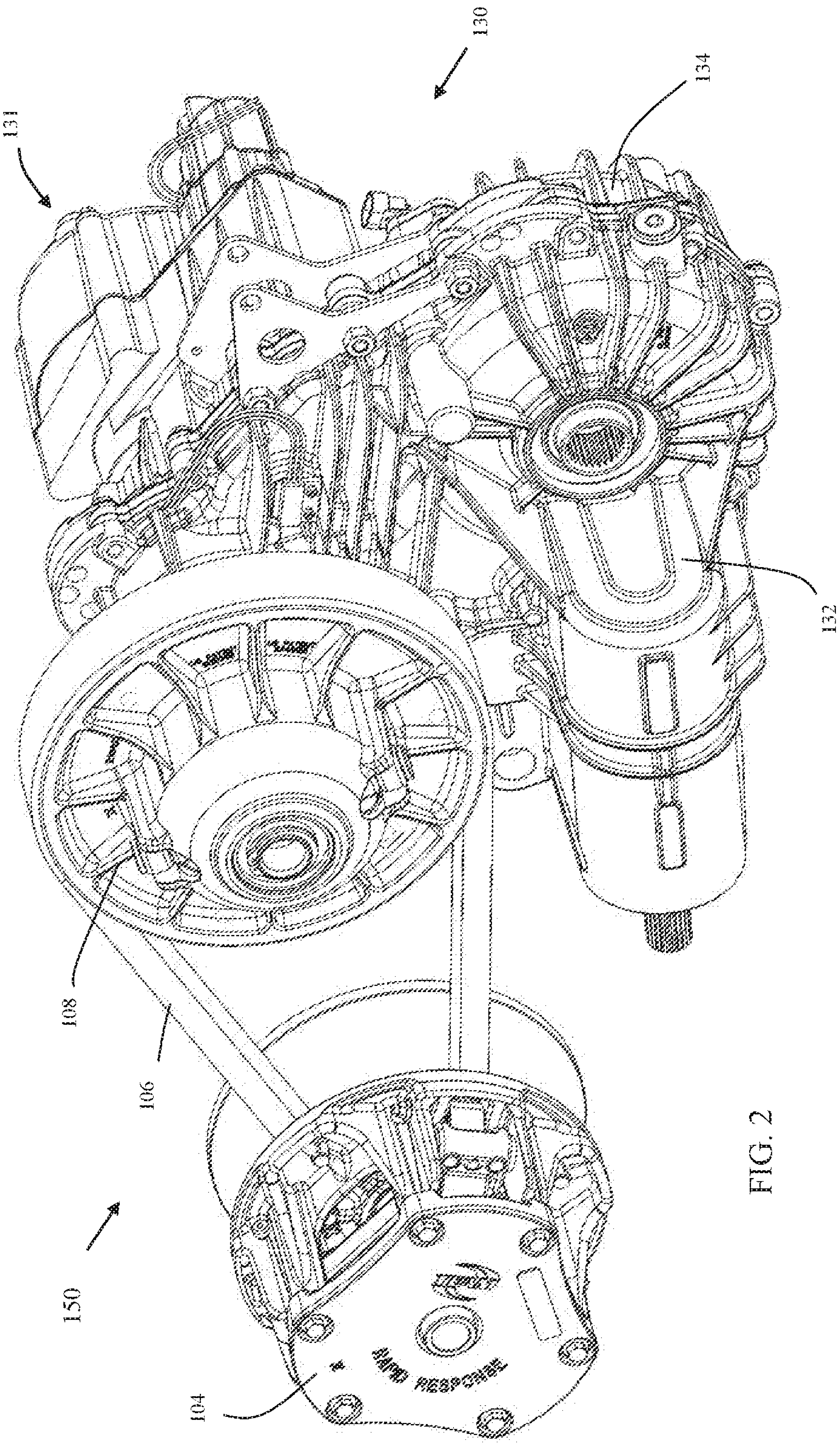

FIG. 2

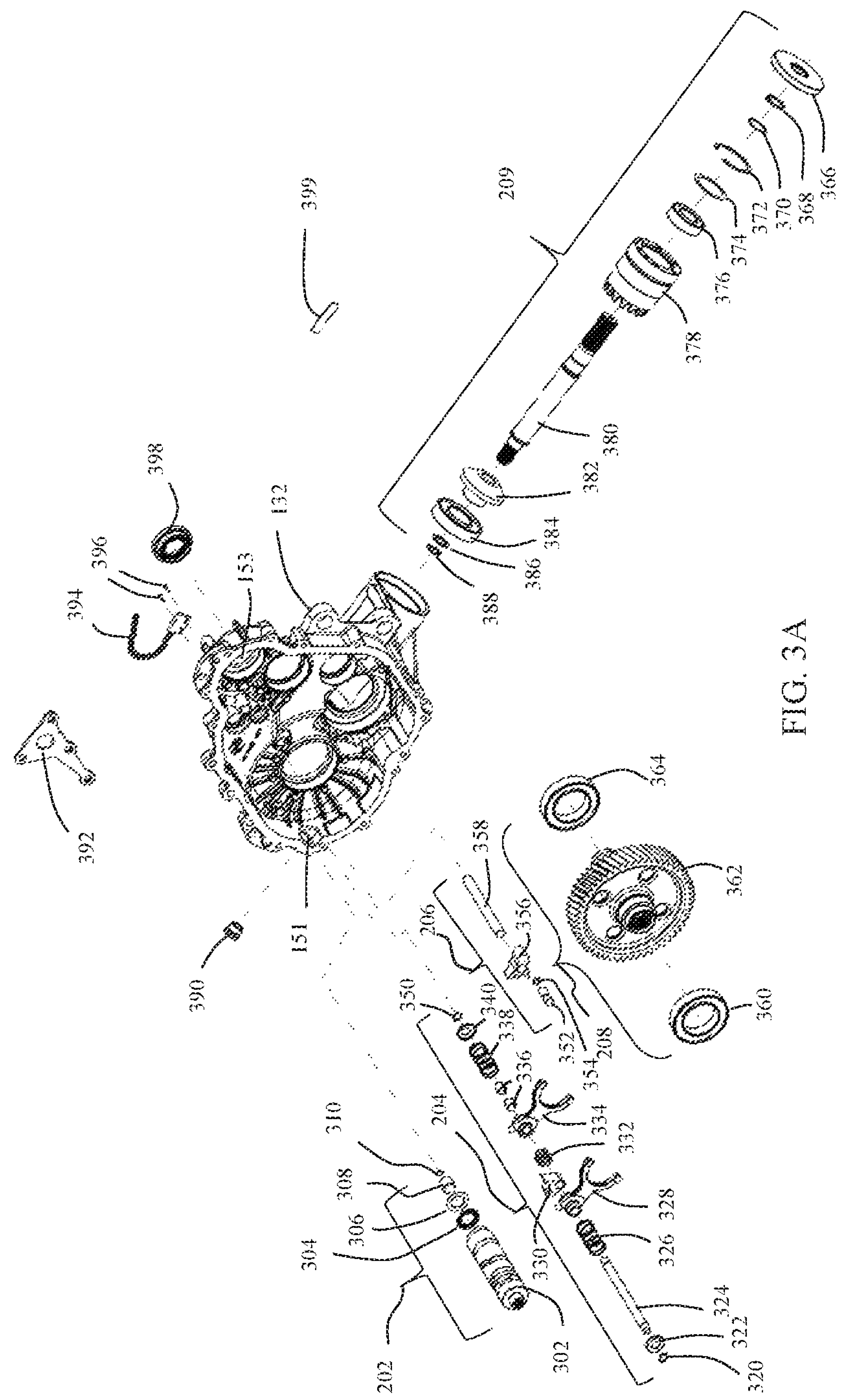
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FIG. 3A

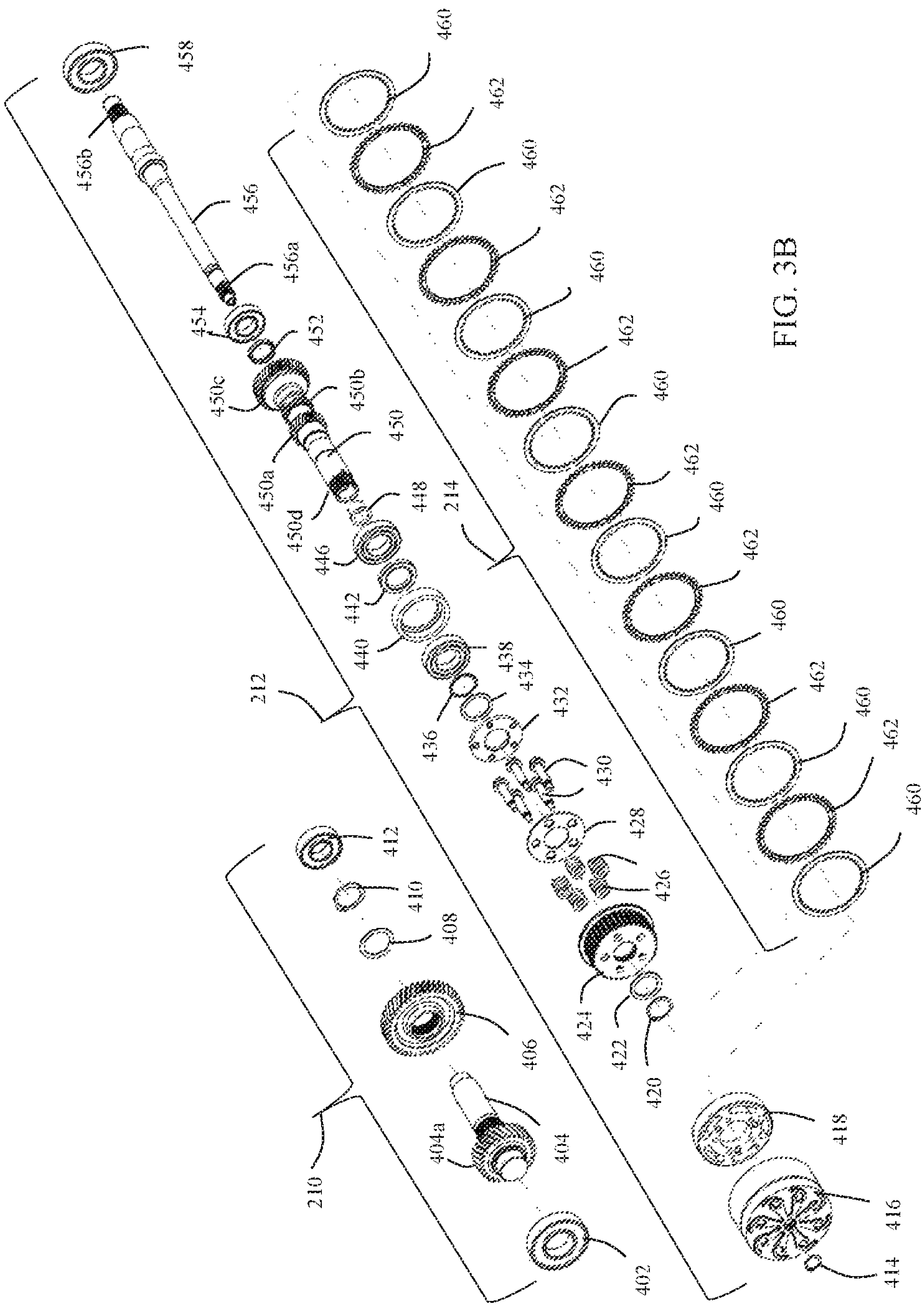
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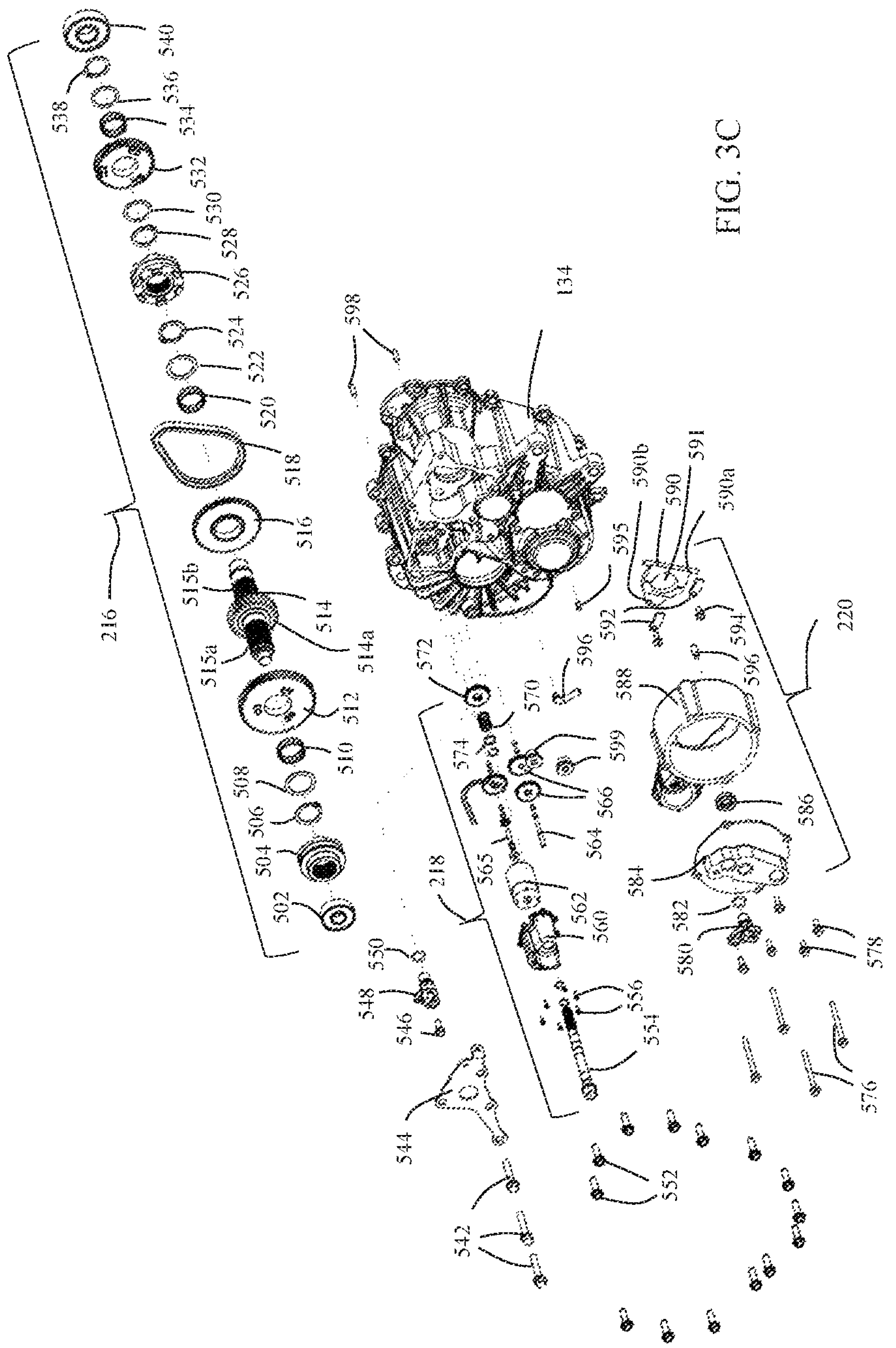
FIG. 3B



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565
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566
574
572
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FIG. 3C

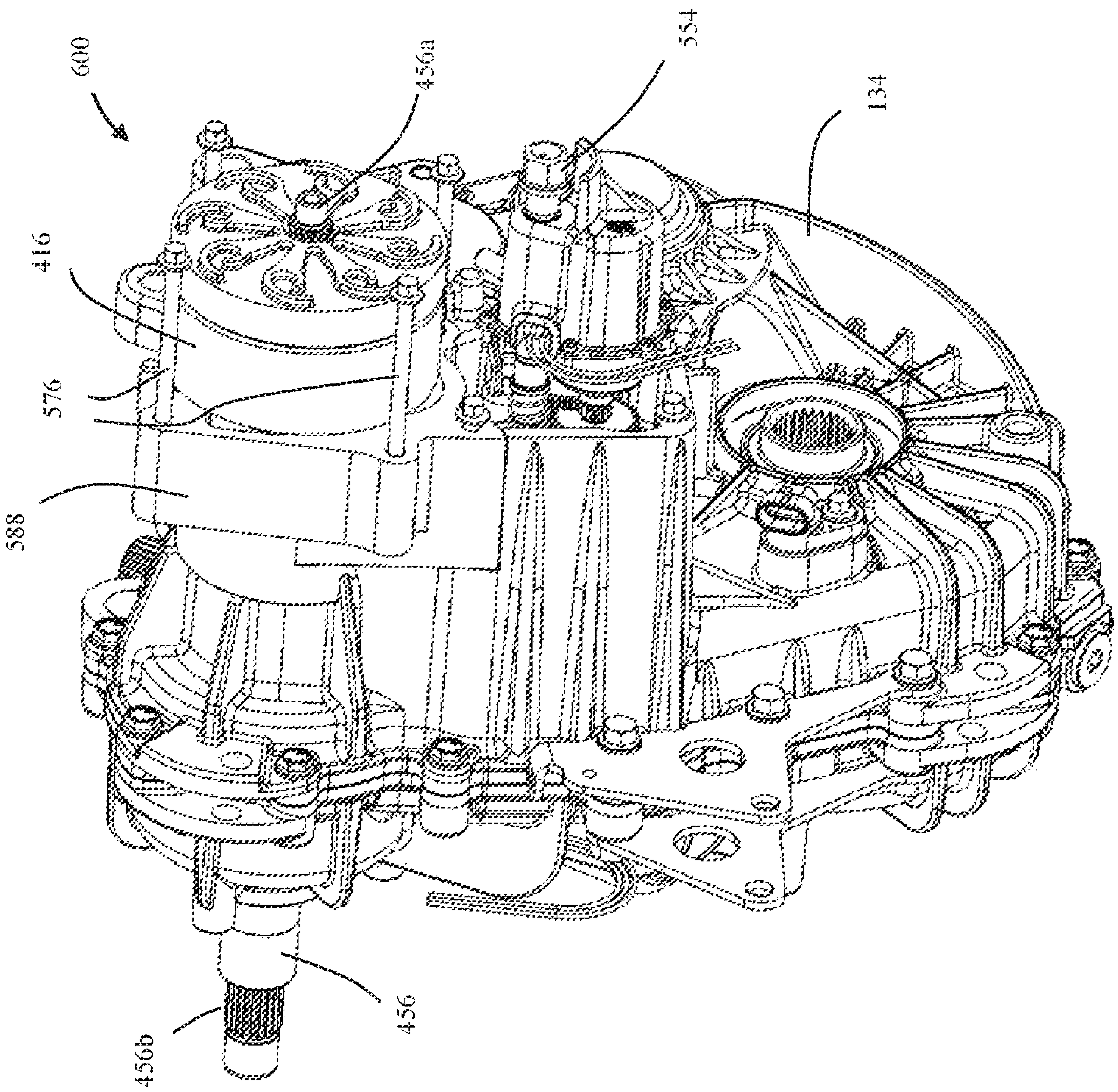

FIG. 4

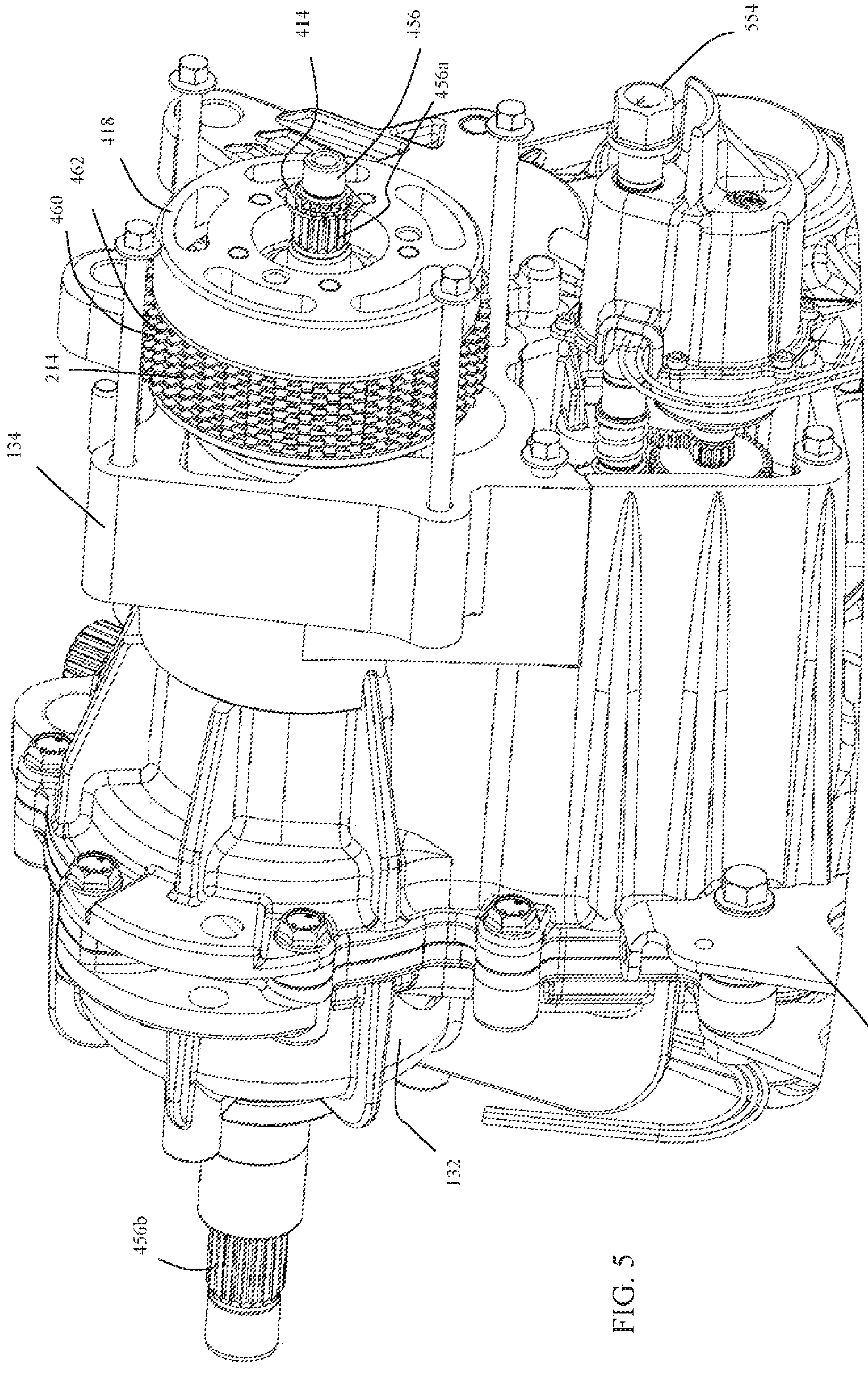

FIG. 5

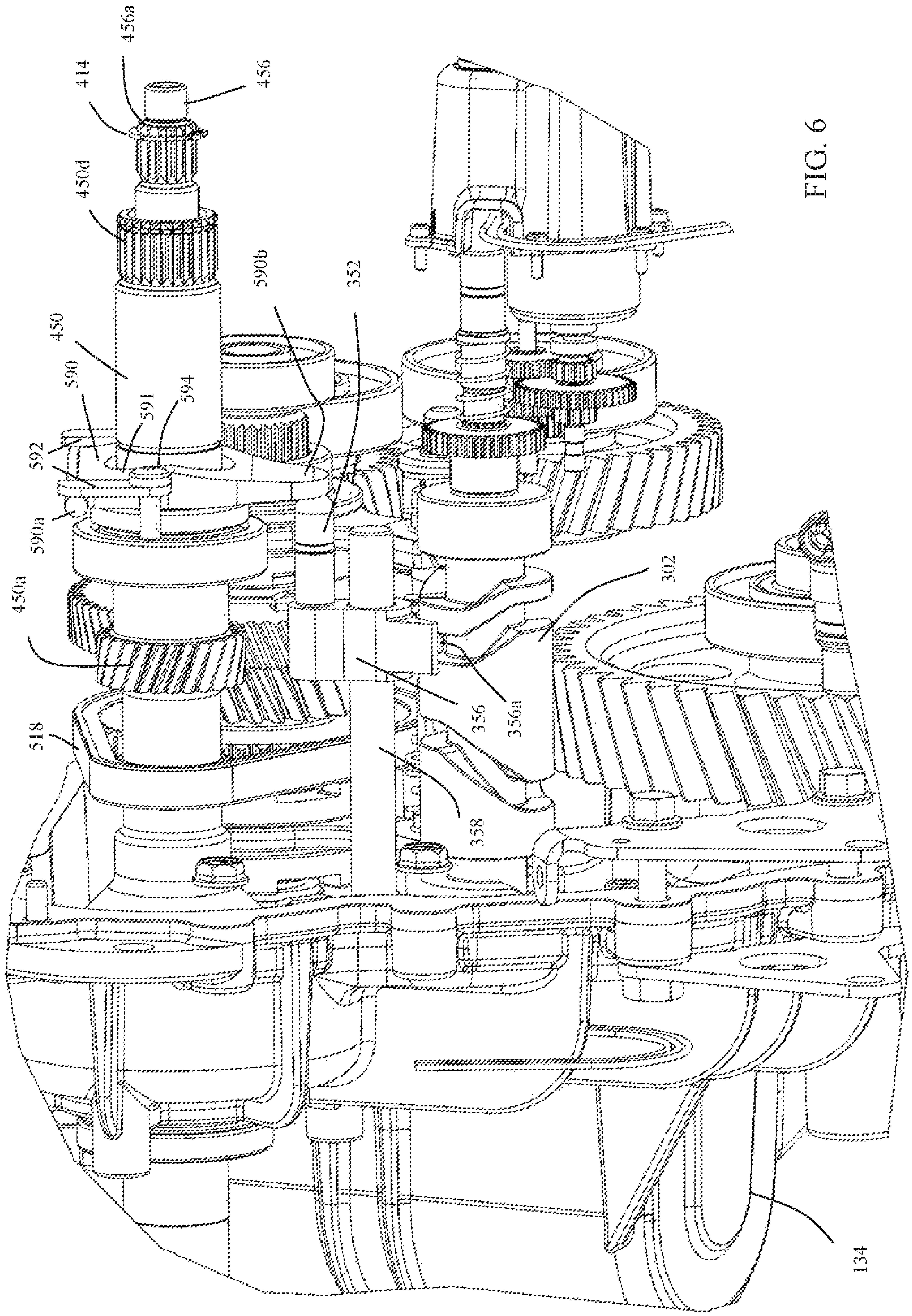
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FIG. 6

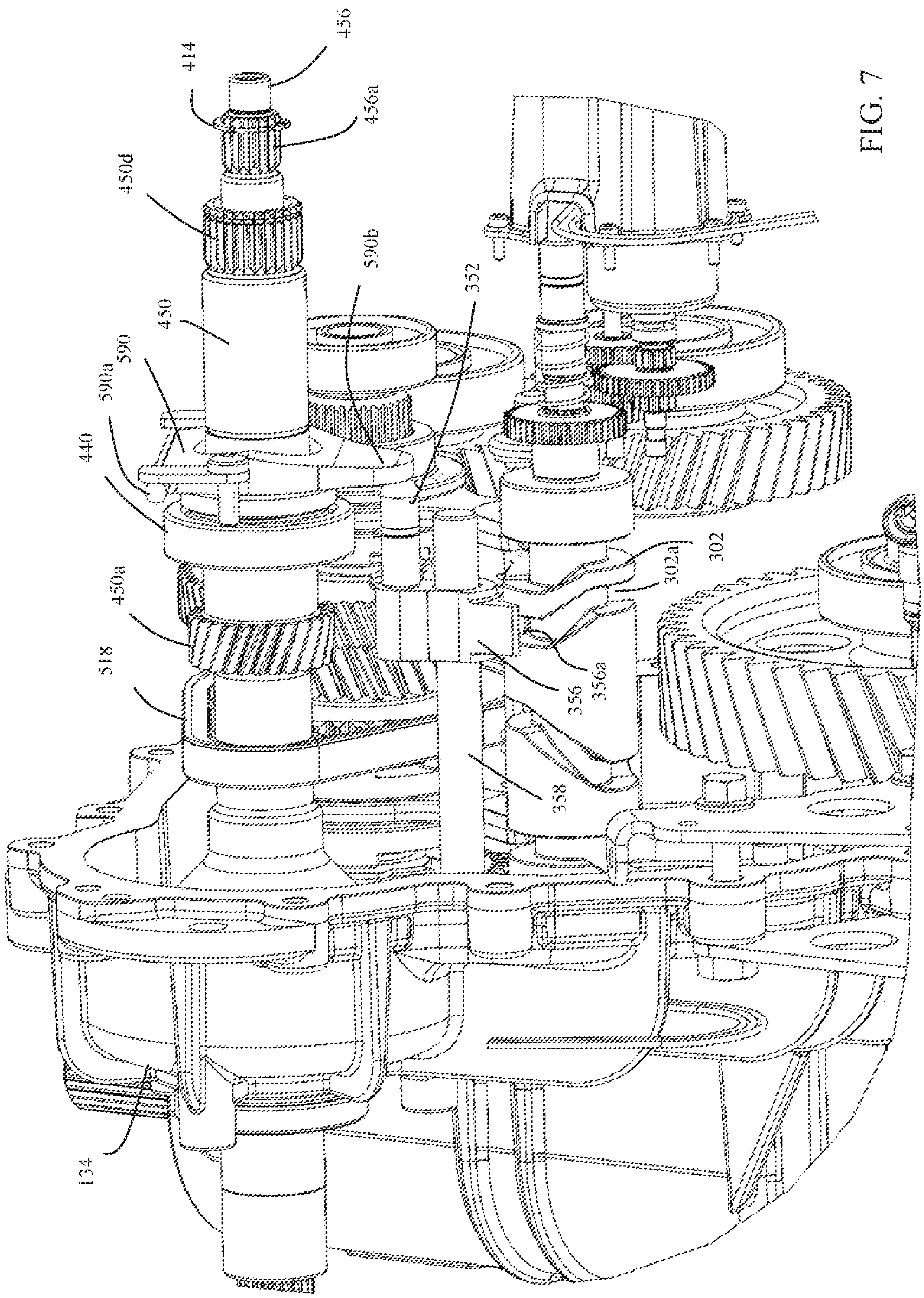
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FIG. 7

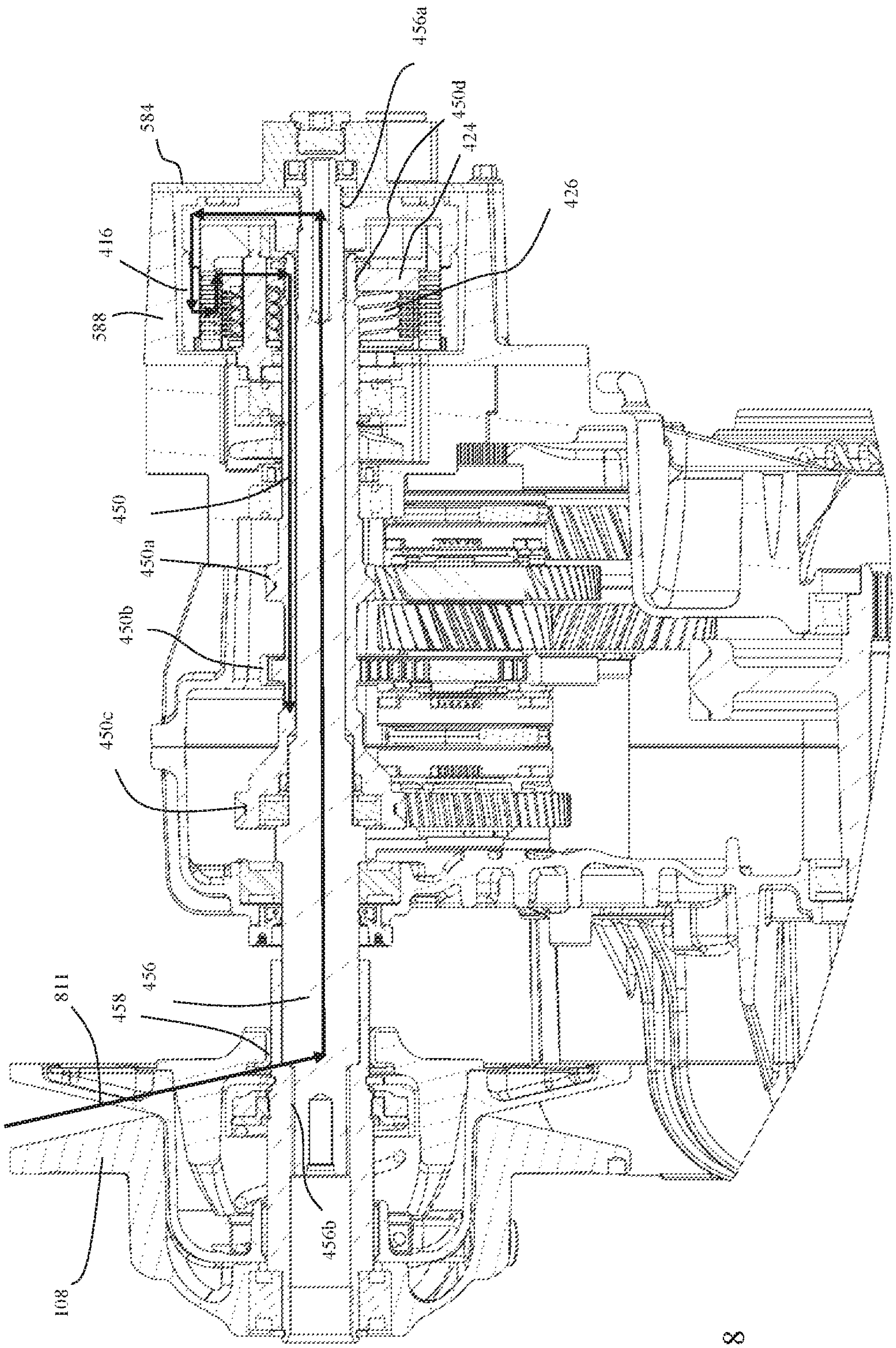
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FIG. 8

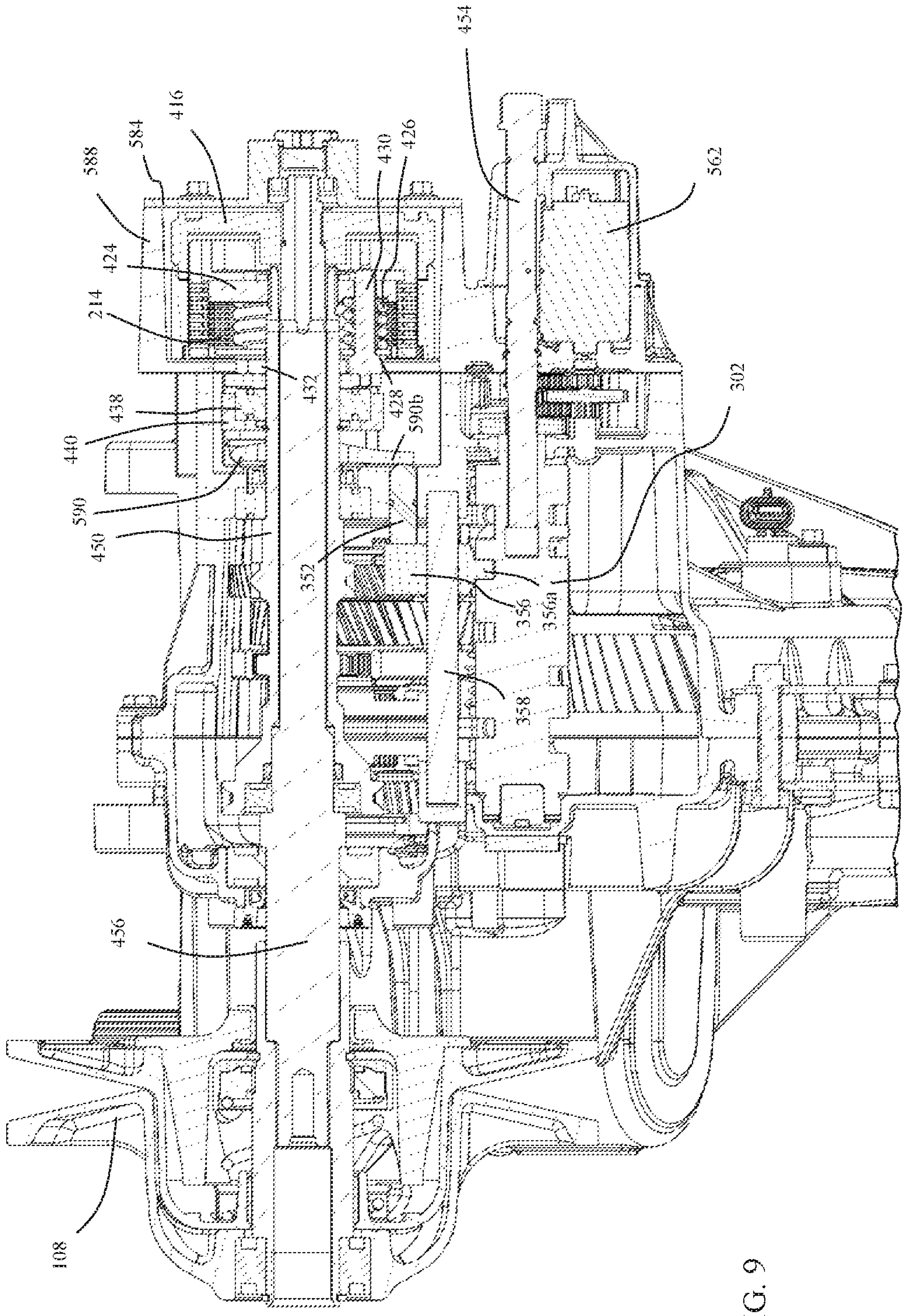
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FIG. 9

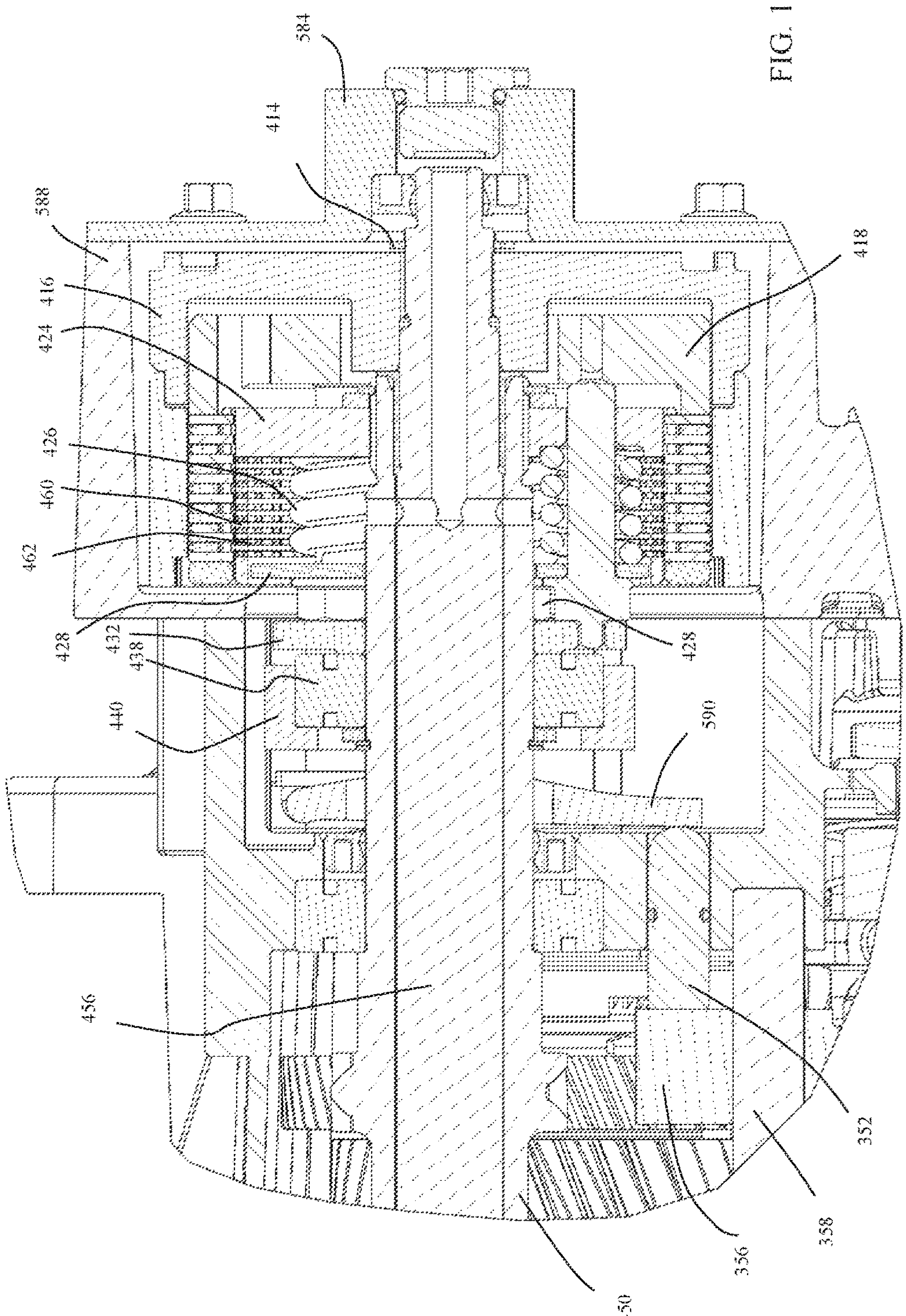
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FIG. 10

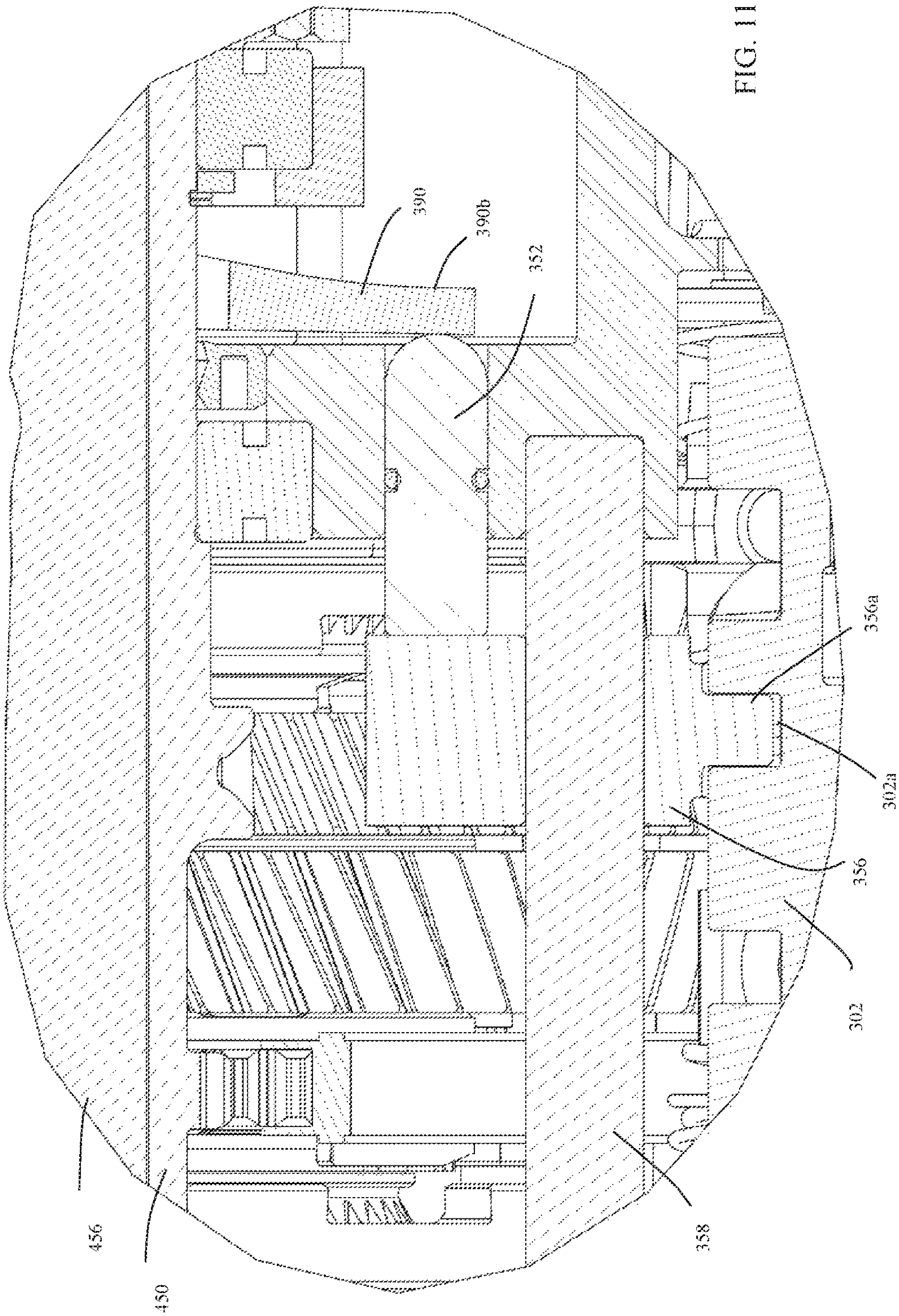

FIG. 11

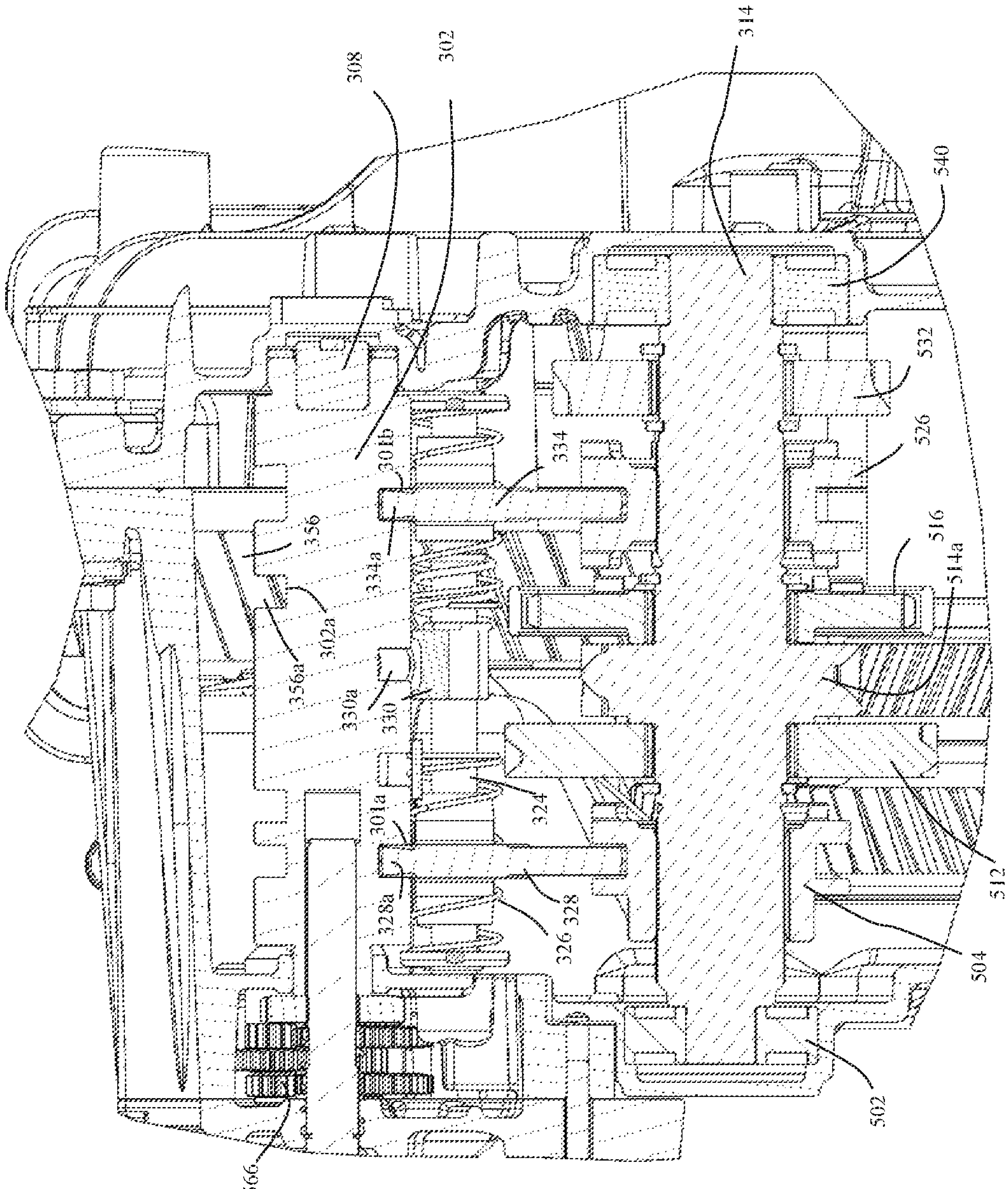
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FIG. 12

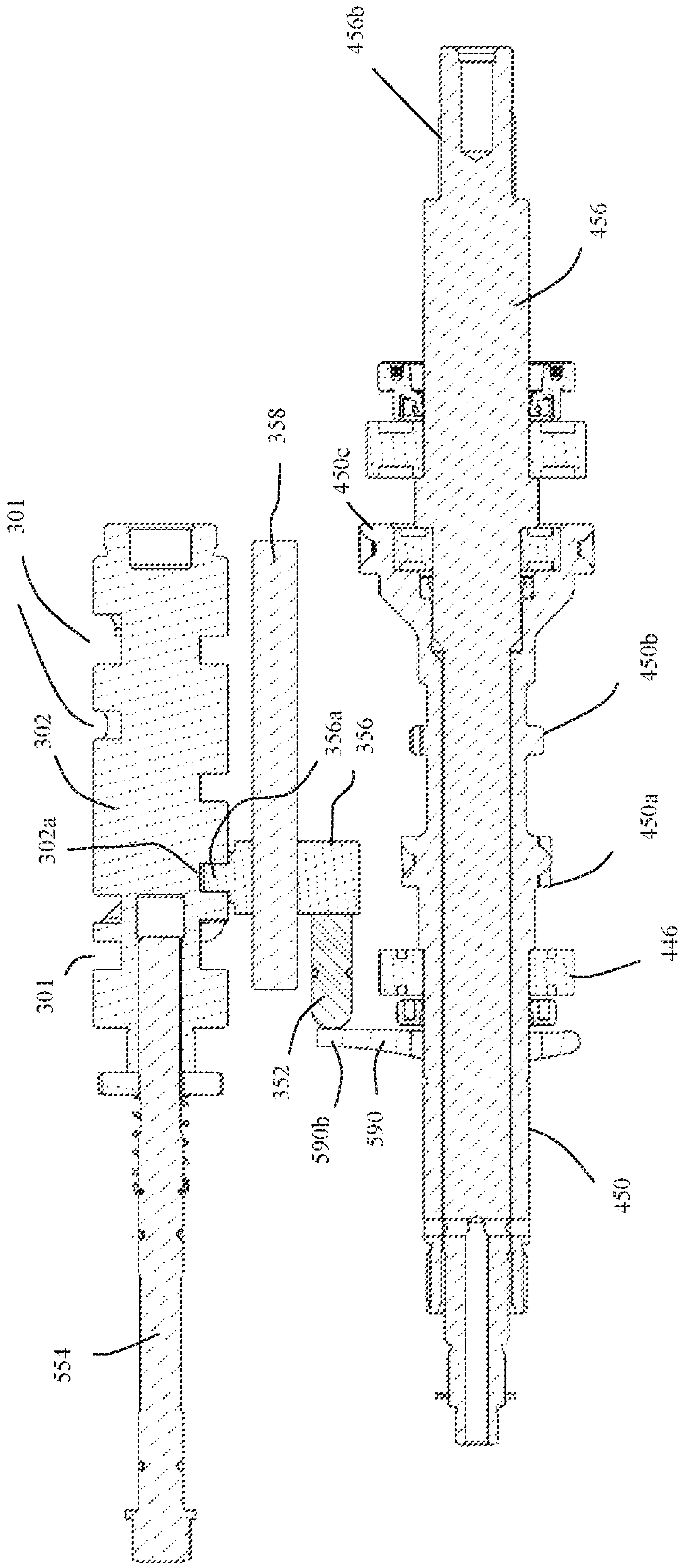
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FIG. 13

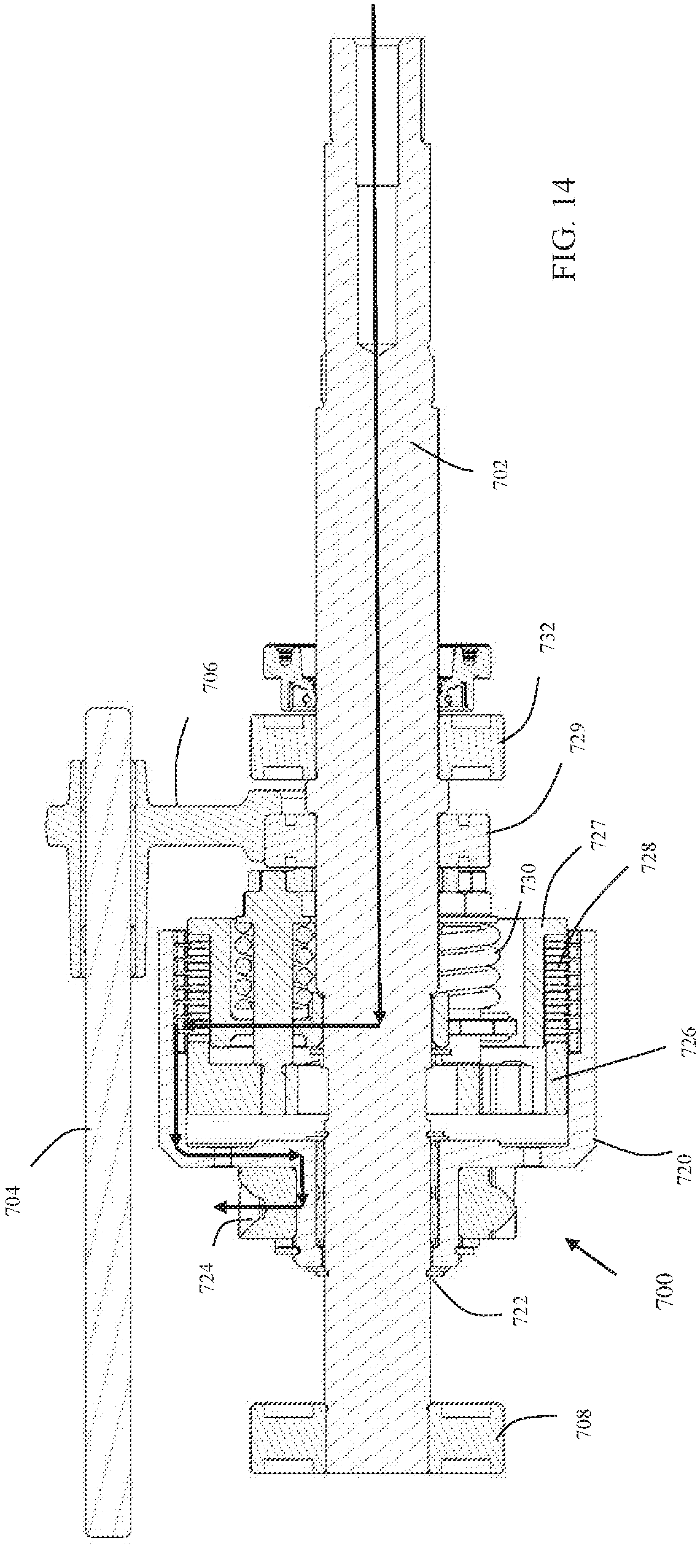

FIG. 14

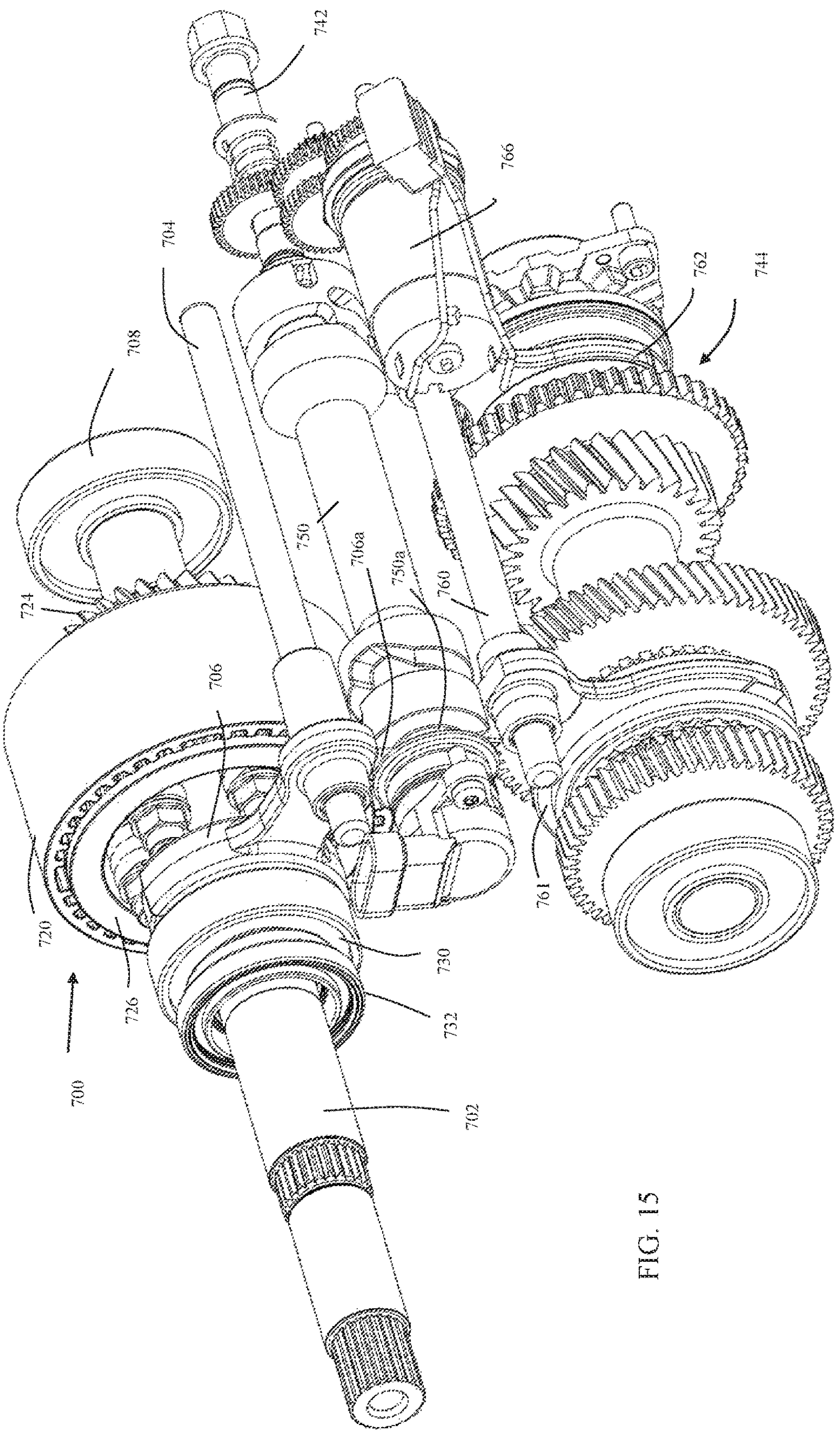
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FIG. 15

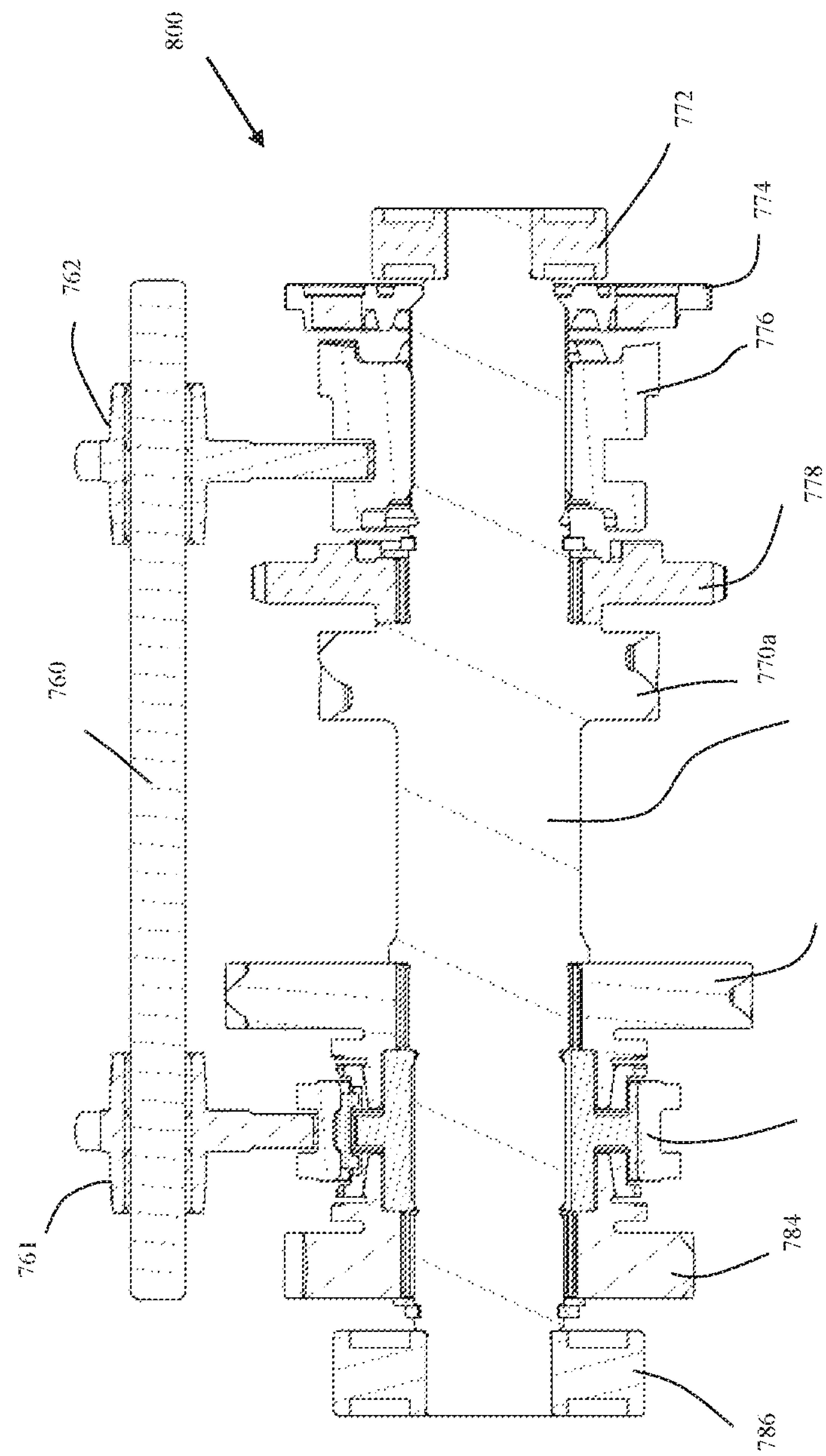

FIG. 16

SHIFT ON THE FLY TRANSMISSION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Ser. No. 62/255,965, same title herewith, filed on Nov. 16, 2015, which is incorporated in its entirety herein by reference.

BACKGROUND

Vehicles such as, but not limited to, recreational vehicles including all-terrain vehicles (ATVs) and utility task vehicles (UTVs) implement belt operated continuously variable transmission (CVT) or dual clutch transmissions. Vehicles that implement CVT typically require the vehicle to stop before shifting between low range and high gear range. However, it is not uncommon for operators to not come to a complete stop when shifting between low and high gear ranges. Some newer systems allow for shifting from low to high at higher speeds however noise, vibration and harness (NVH) factors and durability are very poor.

In a typical CVT system, to make a shift from low to high, the throttle is let off and a shift handle is moved from low to high. When this occurs a shift dog is disengaged from low into a short neutral band and then is slide into high. Because of a gear ratio difference between low and high, the high gear shift dog is going at a reverse shaft revolutions per minute (RPM) while the high gear is going at a different RPM. The RPM difference is dictated by the ratio difference between high and low and the input shaft RPM. An associated second clutch is also going at low gear RPM upon disengagement of low. Because of this RPM difference, there is a loud audible "clunk" that occurs between shift dogs when high is engaged. Once the shift happens, the secondary clutch, which was connected to the vehicle ground speed at a low transmission ratio, is now connected to ground in high transmission ratio. The energy required to change the clutch RPM results in the undesirable clunk when making this shift.

For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for and effective and efficient shift on the fly transmission.

SUMMARY OF INVENTION

The above-mentioned problems of current systems are addressed by embodiments of the present invention and will be understood by reading and studying the following specification. The following summary is made by way of example and not by way of limitation. It is merely provided to aid the reader in understanding some of the aspects of the invention.

In one embodiment, a shift on the fly transmission is provided. The shift on the fly transmission includes a continuously variable transmission portion, a discrete transmission portion, at least one input shaft and a disconnect clutch. The continuously variable transmission portion is operationally coupled to receive torque from an engine. The discrete transmission portion includes a gear assembly. The at least one input shaft is operationally coupled to an output of the continuously variable transmission portion. The disconnect clutch operationally couples the at least one input shaft to the discrete transmission portion. The disconnect clutch is further configured to selectively decouple torque

from the at least one input shaft to the discrete transmission portion during a range ratio shift of the discrete transmission portion.

Further in an embodiment, the at least one input shaft further includes a first input shaft and a second input shaft. The first input shaft is operationally coupled to an output of the continuously variable transmission portion. The second input shaft is operationally coupled to the discrete transmission portion and the disconnect clutch operationally couples the at least one input shaft to the second input shaft.

Further in an embodiment, the first input shaft is an inner input shaft and the second input shaft is an outer input shaft. The inner input shaft is received within the outer input shaft.

Further in an embodiment, the disconnect clutch includes a clutch pack.

Further in an embodiment, the shift on the fly transmission further includes a shift drum and disengagement fork. The shift drum has a disconnect track. The disengagement fork is operationally engaged with the disconnect track of the shift drum. The disengagement fork is further configured to activate the disconnect clutch.

Further in an embodiment, the disengagement fork is pivotally coupled to the at least one input shaft.

Further in an embodiment the continuously variable transmission portion includes a drive clutch, a driven clutch and belt. The drive clutch is operationally coupled to receive the torque from the engine in the form of a rotational input. The at least one input shaft is operationally coupled to the driven clutch. The belt is engaged between the drive clutch and the driven clutch to rotationally couple the drive clutch to the driven clutch.

Further in an embodiment the gear assembly of the discrete transmission portion further includes an input shaft high gear assembly and an input shaft low gear assembly.

Further in an embodiment the input shaft high gear assembly includes an input shaft high gear, a reverse shaft high gear and an engagement dog. The input shaft low gear assembly includes an input shaft low gear, a reverse shaft low gear and an engagement dog. Further the gear assembly includes a reverse shaft that is operationally coupled between the gear assembly and the final drive.

In another embodiment a shift on the fly transmission is provided. The shift on the fly transmission includes a drive clutch, a driven clutch, a belt, an inner input shaft, a discrete transmission portion, an outer input shaft and a disconnect clutch. The drive clutch is operationally coupled to receive torque from an engine in the form of a rotational input. The belt is engaged between the drive clutch and the driven clutch to rotationally couple the drive clutch to the driven clutch. The inner input shaft is operationally coupled to the driven clutch. The discrete transmission portion has a gear assembly. The outer input shaft is operationally coupled to the discrete transmission. The disconnect clutch operationally couples the inner input shaft to the outer input shaft. The disconnect clutch is configured to selectively decouple torque from the inner input shaft to the outer input shaft during a range ratio shift of the discrete transmission portion.

Further in an embodiment, the discrete transmission portion further includes a shift drum, a disconnect shift collar and a disengagement fork. The shift drum has a disconnect track. The disconnect shift collar is operationally engaged in the disconnect track of the shift drum. A push rod is operationally coupled to the disconnect shift collar. The disengagement fork is operationally engaged with the push rod. The disengagement fork is further configured and arranged to activate the disconnect clutch.

Further in an embodiment, the disconnect clutch further includes an inner ring clutch basket, an outer clutch basket and a clutch pack. The inner ring clutch basket is operationally coupled to the outer input shaft. The outer clutch basket is operationally coupled to the inner input shaft. The clutch pack includes a plurality sandwiched clutch plates and friction plates. The clutch plates are engaged with the inner ring basket and the friction plates are engaged with the outer clutch basket. Wherein activation of the disconnect clutch reduces friction between the sandwiched clutch plates and friction plates.

Further in an embodiment, the shift on the fly transmission includes at least one pressure plate that is configured and arranged to operationally engage the clutch pack and a plurality of compression springs. The compression springs are operationally engaged with the at least one pressure plate to compress the sandwiched clutch plates and friction plates of the clutch pack. The disengagement fork is configured to selectively compress the plurality of springs to disengage the disconnect clutch.

In another embodiment, a vehicle having a shift on the fly transmission system is provided. The vehicle includes an engine to provide torque, a continuously variable transmission portion, a discrete transmission portion. At least one input shaft, a disconnect clutch, a final drive and at least one vehicle wheel. The continuously variable transmission portion is operationally coupled to the engine to receive the torque. The discrete transmission portion has a gear assembly. The at least one input shaft is operationally coupled to the continuously variable transmission portion. The disconnect clutch operationally couples the at least one input shaft to the discrete transmission portion. The disconnect clutch is further configured and arranged to selectively decouple torque from the at least one input shaft to the discrete transmission portion. The final drive assembly is operationally coupled to an output of the discrete transmission and the at least one vehicle wheel operationally coupled to the final drive assembly.

Further in an embodiment, the at least one input shaft further includes a first input shaft, a second input shaft and a disconnect clutch. The first input shaft is operationally coupled to an output of the continuously variable transmission portion. The second input shaft is operationally coupled to the discrete transmission portion and the disconnect clutch is operationally coupling the at least one input shaft to the second input shaft.

Further in an embodiment, the first input shaft is an inner input shaft and the second input shaft is an outer input shaft. The inner input shaft is received within the outer input shaft.

Further in an embodiment, the vehicle further includes a shift drum, a disconnect shift collar, a push rod and a disengagement fork. The shift drum has a disconnect track. The disconnect shift collar is operationally engaged in the disconnect track of the shift drum. The push rod is operationally coupled to the disconnect shift collar and the disengagement fork is operationally engaged with the push rod. The disengagement fork is further configured and arranged to activate the disconnect clutch.

Further in an embodiment, the continuously variable transmission includes a drive clutch, a driven clutch and a belt. The drive clutch is operationally coupled to receive the torque of the engine in the form of a rotational input. The at least one input shaft is operationally coupled to the driven clutch. The belt is engaged between the drive clutch and the driven clutch to rotationally couple the drive clutch to the driven clutch.

Further in an embodiment, the gear assembly includes an input shaft high gear assembly and an input shaft low gear assembly.

Further in an embodiment, the input shaft high gear assembly includes an input shaft high gear, a reverse shaft high gear and a high engagement dog/synchronizer. The input shaft low gear assembly includes an input shaft low gear, reverse shaft low gear and a low engagement dog/synchronizer. The gear assembly further includes a reverse shaft that is operationally coupled between the gear assembly and the final drive.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more easily understood and further advantages and uses thereof will be more readily apparent, when considered in view of the detailed description and the following figures in which:

FIG. **1** is a block diagram of a vehicle of one embodiment of the present invention;

FIG. **2** is a side perspective view of an assembled CVT of an embodiment of the present invention;

FIGS. **3**A through **3**C are exploded views of a discrete transmission portion of the CVT of FIG. **2**;

FIG. **4** is a partial side perspective view of the discrete transmission portion of the CVT of FIG. **2** illustrating shift on the fly features in an embodiment;

FIG. **5** is a partial side perspective view of the discrete transmission portion of the CVT of FIG. **2** illustrating shift on the fly features of an embodiment;

FIG. **6** is a partial side perspective view of discrete transmission portion of the CVT of FIG. **2** illustrating shift on the fly features of an embodiment;

FIG. **7** is a partial side perspective view of the discrete transmission portion of FIG. **6** viewed at a slightly different angle;

FIG. **8** is a partial cross-sectional first side view of the discrete transmission portion of the CVT of FIG. **2** showing the driven clutch operationally coupled to the inner input shaft in an embodiment;

FIG. **9** is a partial cross-sectional second side view of the discrete transmission portion of the CVT of FIG. **2** showing the driven clutch operationally coupled to the inner input shaft of an embodiment;

FIG. **10** is a partial cross-sectional top view of a portion of the disconnect clutch of the embodiment of FIG. **2**;

FIG. **11** is a partial cross-sectional close up view of a portion of an activation assembly for the disconnect clutch of the embodiment of FIG. **2**;

FIG. **12** is a partial cross-sectional close up view of a portion of the discrete transmission portion of the CVT of FIG. **2** highlighting the shift drum of an embodiment;

FIG. **13** is a cross-sectional view of the partial components of the shift on the fly system of the embodiment of FIG. **2**;

FIG. **14** is a cross-sectional view of a portion of a shift on fly system implementing a single input shaft of one embodiment of the present invention;

FIG. **15** is a side perspective view of the shift on the fly system of the embodiment of FIG. **14**; and

FIG. **16** is a cross-sectional side view of a portion of the shift on the fly system of the embodiment of FIG. **14**.

In accordance with common practice, the various described features are not drawn to scale but are drawn to emphasize specific features relevant to the present invention. Reference characters denote like elements throughout Figures and text.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the inventions may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the spirit and scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the claims and equivalents thereof.

Embodiments of the present invention provide a vehicle that allows an operator to shift from a high gear to a low gear or from a low gear to a high gear without having to stop. Embodiments take some of the functions of a manual transmission (i.e. smooth shifting between gears) and combines them with the benefits of a belt driven continuously variable transmission (CVT). This results in a transmission system with responsive ratio optimization as well as fast and smooth acceleration across a wide speed range allowing the engine to stay at a maximum horse power during acceleration without shifting between gears (benefits of the CVT) while having features of shifting between a low range and a high range. This system is very beneficial in situations where a low gear is needed to climb a hill, get out of hole, start pulling something, etc. but then once over the hill, out of the hole or after the initial start of pulling, smoothly shifting from low gear to high gear without slowing down all while maintaining CVT functions. Moreover, the transmission system also allows driving in high gear range at a relatively high speed and shifting down into low gear range to go up a steep hill without coming to a stop or near stop to shift into low gear. In an example embodiment, a vehicle with a continuously variable transmission CVT implements a disconnect clutch as described below in detail to allow an operator to shift from a high gear to a low gear or from a low gear to a high gear without having to stop.

Referring to FIG. **1**, a block diagram of vehicle **100** of an embodiment is shown. The vehicle block diagram **100** of FIG. **1** illustrates how torque generated by the engine **102** is provided to the miscellaneous gearing/final drive train **129** and the vehicle wheels **132**. Embodiments of the present invention implement a CVT that includes a continuously variable transmission portion **105**, a shift on the fly system **107** and a discrete transmission portion **109** to deliver the engine torque. The continuously variable transmission portion **105** includes a CVT primary drive clutch **104** that is rotationally coupled to a CVT secondary driven clutch **108** via belt **106** such as, but not limited to, a rubber belt. As known, the drive clutch **104** and the driven clutch **108** vary a rotational output of the driven clutch **108** based at least in part on the rotational speed of the drive clutch **104** and the torque transmitted by the driven clutch **108**. The drive clutch **104** in an embodiment is operationally coupled to a crankshaft of the engine **102**.

The shift on the fly system **107**, includes a first input shaft **110**, a disconnect clutch **112** and a second input shaft **114**. The rotational output of the driven clutch **108** is operationally coupled to the first input shaft **110**. The first input shaft **110** in turn is operationally coupled to the disconnect clutch **112**. The disconnect clutch **112** is further operationally coupled to the second input shaft **114**. In embodiments, as further discussed below in detail, the disconnect clutch **112** is activated to disconnect torque between the first input shaft **110** and the second input shaft **114** during a range ratio shift of the discrete transmission portion **109**. In the embodiment of FIG. **1**, the second input shaft **114** is operationally coupled to an input shaft high gear assembly and an input shaft low gear assembly. The input shaft high gear assembly includes an input shaft high gear **116**, a reverse shaft high gear **118** and a high engagement dog/synchronizer **120**. The input shaft low gear assembly includes an input shaft low gear **122**, a reverse shaft low gear **124** and a low engagement dog/synchronizer **126**. An output of the input shaft high gear assembly and the input shaft low gear assembly is provided to a reverse shaft **128**, through miscellaneous gearing and the final drive **129** to the vehicle wheels **132**. In one embodiment, in going from low gear range to high gear range, engine power is first reduced. The disconnect clutch **112** is then activated to disengage torque from the continuously variable transmission portion **105** of the CVT system **100** to the discrete transmission portion **109** of the CVT system **100**. Low gear is first disengaged and then high gear is engaged. The disconnect clutch **112** is unactuated and then the engine power is restored. Moreover, in one embodiment, a high gear to low gear change includes reducing engine power. The disconnect clutch is then activated. High gear is then disengaged and then low gear is engaged. The disconnect clutch is then unactuated and the engine power is restored.

Referring to FIG. **2** an assembled CVT **150** of an embodiment is illustrated. The CVT **150** includes the drive clutch **104** which would be operationally coupled to an engine. The CVT **150** is illustrated as having a driven clutch **108** that is in rotational communication with the drive clutch **104** via belt **106**. The drive clutch **104** and the driven clutch **108** make up the continuously variable portion of the transmission. In the example embodiment of FIG. **2**, the CVT **150** includes a discrete transmission portion **130** with two gear ratios (high and low). Hence this portion of the transmission has discrete gear ratios. The discrete transmission portion **130** may be, but is not limited to, a transaxle, a transfer case or range box. FIG. **2** also illustrates a first transmission housing cover **132** coupled to a second transmission housing cover **134**. The CVT **150** further includes a shift on the fly system. The location of the shift on the fly system is generally designated as **131** in FIG. **2**.

Components that make up the discrete transmission portion **130** (including the shift on the fly system) are illustrated in the exploded views of FIGS. **3**A, **3**B and **3**C. Referring to FIG. **3**A, the first transmission housing cover **132**, a shift drum assembly **202**, a shift fork assembly **204**, a shift collar assembly **206**, a first output assembly **208** and a second output assembly **209** are illustrated. The shift drum assembly **202** includes a shift drum **302**, a bearing **304**, a washer **306**, a magnet holder insert **308** and a magnet **310**. The shift fork assembly **204** includes a shift shaft rail **324** upon which is mounted a retaining ring **320**, a washer **322**, a compression spring **326**, a first shift fork **328**, a shift collar **330**, a compression spring **332**, a second shift fork **334**, a pair of plain bearings **336**, a compression spring **338**, a washer **340** and a retaining ring **350**. The shift collar assembly **206** includes a shift rail **358** upon which is slidably mounted a disconnect shift collar **356** and an O-ring **354**. A push rod **352** extends from the disconnect shift collar **356** and engages a portion of the shift on the fly features described in detail below. The first output assembly **208** includes an output gear shaft **362** upon which is mounted on opposite sides of a shaft portion of the output gear shaft **362** a pair of ball bearings **360** and **364**. The second output assembly **209** includes a front output shaft **380** upon which is mounted on one side a snorkel gear **382**, a bearing **384**, a washer **386** and a retaining ring **388**. Mounted on another side of the front output shaft **380** is a snorkel tube **378**, a bearing **376**, a shim **374**, a retaining ring **372**, a shim **370**, a retaining ring **368** and a seal **366**. FIG. **3**A further illustrates a plug **390** adapted to selectively fill an opening **151** in the first transmission housing cover **132**, a rear mounted bracket **392** adapted to be attached to the first transmission housing cover **132**, a sensor **394** adapted to be coupled to the first transmission housing cover **132** via fasteners **396**, a label **399** and a seal **398** adapted to be received in an opening **153** in the first transmission housing cover **132** that is used to receive input shaft **456** further described in FIG. **3**.

Referring to FIG. **3**B, an idler shaft assembly **210**, a shift on the fly clutch assembly **212** and a clutch friction plate assembly or clutch pack **214** of the shift on the fly system is illustrated. The idler shaft assembly **210** includes an idler shaft **404** with a stationary idler gear **404***a* upon which a bearing **402** is mounted. Also mounted on the idler shaft **404** is a second idler gear **406**, a washer **408**, a snap ring **410** and another bearing **412**. The shift on the fly clutch assembly **212** includes an inner input shaft **456** (first input shaft) and an outer input shaft **450** (second input shaft). A portion of the inner input shaft **456** is received within the outer input shaft **450** as discussed and shown in detail below. The inner input shaft **456** includes first outer splines **456***a* proximate a first end of the inner input shaft **456** and second outer splines **456***b* proximate a second end of the inner input shaft **456**. Mounted proximate the second end of the inner input shaft **456** is a bearing **458**. Receive on the inner input shaft **456** is bearing **454** and seal **452**. In addition, a flanged bushing **448** is received on a first end of the outer input shaft **450**. The outer input shaft **450** includes a first gear **450***a*, a second gear **450***b* and third gear **450***c*. A first end of the output shaft **450** includes splines **450***d*. Mounted on the outer input shaft **450** is bearing **446**, seal **442**, thrust plate **440**, thrust bearing **438**, retaining ring **436**, shim **434**, pressure plate **432**, thrust bolts **430**, pressure plate **428**, compression springs **426**, an inner clutch basket **424**, a shim **422** and a retaining ring **420**. Further included in the shift on the fly clutch assembly **212** is a clutch pressure plate **418**, and outer clutch basket **416**, a retaining ring **414** and the clutch pack **214** that includes a plurality of clutch plates **460** and friction plates **462** that are described further in detail below.

FIG. **3**C illustrates a shift assembly **216**, an actuator assembly **218**, a clutch cover assembly **220** and the second transmission housing cover **134**. The shaft assembly **216** includes a reverse shaft **514**. The reverse shaft **514** includes a central gear **514***a* and first and second outer spline shaft portions **515***a* and **515***b*. Mounted on the first spine shaft portion **515***a* is a low gear **512**, a bearing **510**, a washer **508**, a snap ring **506**, a low engagement dog **504** and a bearing **502**. Mounted on the second spline shaft portion **515***b* is a sprocket **516** which is engaged with a chain **518**, a bearing **520**, a washer **522**, a snap ring **524**, an high/reverse engagement dog **526**, a retaining ring **528**, a washer **530**, a high gear **532**, a bearing **534**, a washer **536**, a retaining ring **538** and a bearing **540**. The actuator assembly **218** includes a disconnect shaft **554**, a motor cover **560**, a motor **562** to change gearing, fasteners **556** to couple the motor cover **560** to the second transmission housing cover **134**, a pinion shaft **565**, a gear cluster **566**, an idler shaft **564**, washer **574** compression spring **570** and gear **572**. The clutch cover assembly **220** includes a clutch cover **584** and a gear sector cover **588**. A speed sensor **580** and O-ring **582** are coupled to the clutch cover **584** via fasteners **578**. The gear section cover **588** is coupled to the second transmission housing cover **134** via bolts **576**. Also illustrated is seal **586**, tube vent **596** and disengagement fork **590** that is held in place via retainers **592** and fasteners **594**. The disengagement fork **590** includes a disconnect pivot rod **590***a* proximate a first end, an activation portion **590***b* proximate a second end and a central passage **591** to receive the outer input shaft **450** discussed further below. Further illustrated in FIG. **3**C is plugs **599**, pin **595**, tube vent **596** and dowel pins **598** used to align the second transmission housing cover **134** with the first transmission housing cover **132**. Further, fasteners **552** are used to couple the second transmission housing cover **134** to the first transmission housing cover **132**. Bracket **544** is also coupled to the second transmission housing cover **134** via fasteners **542**. The discrete transmission portion **130** further includes a speed sensor **548** which along with an O-ring seal **550** is fastened to the second transmission housing with fastener **546** and is positioned to measure speed of the vehicle.

Referring to FIG. **4**, a partial side perspective view of the discrete transmission portion **130** illustrates some of the shift on the fly features. In particular, FIG. **4** illustrates the outer clutch basket **416**, the gear section cover **588**, bolts **576** and the ends of the inner input shaft **456**. FIG. **5** further illustrates the shift on the fly features without the outer clutch basket **416**. FIG. **5** illustrates the clutch pressure plate **418** and the friction plates **462** and clutch plates **460** of the clutch pack **214**. It also illustrates the retaining ring **414** engaged with the inner input shaft **456**. In the embodiment, the retaining ring **414** is received in a retaining groove in the first outer splines **456***a* of the inner input shaft **456**.

FIG. **6** further illustrates a portion of the inner input shaft **456** received within the outer input shaft **450**. Also illustrated is splines **450***d* of the outer input shaft **450**. Further illustrated is disengagement fork **590**. As illustrated, the disengagement fork **590** is received around the outer input shaft **450** and held in place with the retainers **592** abutting the pivot rod **590***a* of the disengagement fork **590**. The activation portion **590***b* of the disengagement fork **590** engages the push rod **352** that is coupled to the disconnect shift collar **356** that is in turn coupled to the shift rail **358**. The disconnect shift collar **356** includes a track follower tab **356***a* that is received in a disconnect track **302***a* of the shift drum **302**. Hence, movement of the shift drum **302** will cause the track follower tab **356***a* of the disconnect shift collar **356** to follow the disconnect track **302***a* which in turn will pivot the disengagement fork **590** as further discussed below. FIG. **7** further illustrates the portion off the shift on the fly features of FIG. **6** and at slightly different angle.

Referring to FIG. **8**, a partial cross-sectional side view of the discrete transmission portion **130** with the driven clutch **108** operationally coupled to the inner input shaft **456** of an embodiment is illustrated. In particular, FIG. **8** illustrates a torque path **811** through the shift on the fly system. In particular, FIG. **8** illustrates how torque from the driven clutch **108** is transferred to the outer input shaft **450** of the shift on the fly system. As illustrated in FIG. **8**, driven clutch **108** is coupled to the inner input shaft **456** with a spline interface connection using splines **456***b* of the inner input shaft **456**. The torque is transferred to the outer clutch basket **416** with a spine interface connection using splines **456***a* of the inner input shaft **456**. Torque is then transferred to the clutch pack **214**. In particular, friction plates **462** of the clutch pack **214** engage an inner wall of the outer clutch basket **416**. The sandwiched clutch plates **460** of the clutch pack **214** further engage the inner clutch basket **424** to transfer the torque to the inner clutch basket **424**. The inner clutch basket **424** is connected to the outer input shaft **456** with a spline interface connection using the outer splines **450***d* of the outer input shaft **450**. The torque is then provided to input shaft low gear **450***a*, input shaft reverse sprocket **450***b* and input shaft high gear **450***c* of the outer input shaft **450**. Depending on the configuration of the shift assembly **216** as controlled by the shift drum assembly **202**, the respective input shaft low gear **450***a*, input shaft reverse sprocket **450***b* and input shaft high gear **450***c* provides torque to the select gear configuration of the discrete transmission portion **130**.

FIG. **9** provides a cross-sectional top view of the driven clutch and shift on the fly system. FIG. **9** further illustrates the track follower tab **356***a* of the disconnect shift collar **356** in a disconnect track of the shift drum **302**. Also illustrated is the push rod **352** coupled to the disconnect shift collar **356**. The push rod **352** in turn engages the activation portion **590***b* of the disengagement fork **590**. When the disengagement fork **590** is pivoted, a force is asserted on the thrust plate **440** and thrust bearing **438** which counters the force of the compression springs **426**. The compression springs provide the clutch pack pressure. When the compression springs **426** are compressed, the clutch pack pressure is released therein reducing pressure between the sandwiched clutch plates **460** and friction plates **462**. This action disconnects torque from the inner input shaft **456** to the outer input shaft **450**. FIG. **10** is a partial close up view of a portion of the shift on the fly system further illustrating the disengagement fork **590**, the thrust plate **440**, trust bearing **438**, pressure plate **432** and pressure plate **428**. FIG. **11** further provides a close up view of the track follower tab **356***a* of the disconnect shift collar **356** in a disconnect track **302***a* of the shift drum **302**. Also illustrated is the push rod **352** coupled to the disconnect shift collar **356**. The push rod **352** in turn engages the activation portion **590***b* of the disengagement fork **590**.

FIG. **12** illustrates another portion of the discrete transmission portion **109**. FIG. **12** illustrates the shift drum **302** having the track follower tab **356***a* of the disconnect shift collar **356** in the disconnect track **302***a* as discussed above. FIG. **12** also illustrates the shift drum have a plurality of shift tracks **301** that are configured to receive a shift tab **328***a* of shift fork **328**, shift tab **330***a* of shift collar **330** and shift tab **334***a* of shift fork **334**. Shift fork **328** is engaged with low engagement shift dog **504** and shift fork **334** is engaged with high/reverse engagement shift dog **526** which are both respectfully slidably engaged to the reverse shaft **314**. Hence movement by the shift drum **302**, controls the shifting of the gearing of the discrete transmission portion **109** as well the disconnect clutch **112**. In embodiments, the disconnect track **302***a* and the shift tracks **301** (including shift tracks **301***a* and **301***b*) are designed to that the disconnect clutch **112** is activated during a range ratio shift as discussed further below.

FIG. **13** is a cross-sectional view of the partial components of the shift on the fly system of an embodiment. In particular, FIG. **13** illustrates the shift drum **302** and the disconnect shaft **554** that allows for the manual movement of the shift drum **302** in the event of a power failure. The shift drum **302** is illustrated as having shift tracks **301** has discussed above are used to switch gearing of the discrete transmission portion **109**. The shift drum **302** is further illustrated as having the disconnect track **302***a* in which the track follower tab **356***a* of the disconnect shift collar **356** is received. The disconnect shift collar **356** is mounted on the disconnect shift rail **358**. The push rod **352** extends from the disconnect shift collar **356** and engages the activation portion **590***b* of the pivotally coupled disengagement fork **590** that is mounted on the outer input shaft **450**. As discussed above, the pivoting of the disengagement fork **590** reduces friction between friction plates **462** and the clutch plates **460** of the clutch pack **214** therein disconnection torque between the inner input shaft **456** and the outer input shaft **450**.

A low to high gear change overview of an embodiment in light of the embodiments illustrated in FIGS. **1-13** is herein provided. The CVT **150** initially in low range includes the shift drum **302** being rotated to a position such that a respective shift drum track **301***a* engages the low engagement dog **504** with the low gear **512**, while the high/reverse engagement shift dog **526** is disengaged with both the reverse shaft sprocket **516** and the reverse shaft high gear **532** and positions the disconnect shift collar **356** to a position that does not provide an axial force on the push rod **352** and therefor dictates that the disconnect clutch **112** is not activated and thus able to transmit torque. In initiating the low to high shift, the shift drum **302** begins to rotate from a "low" position to the "high" position. The disconnect track **302***a* of the shift drum **302** causes axial movement of the disconnect shift collar **356** which through push rod **352**, disengagement fork **590**, axial thrust collar **440**, thrust bearing **438**, axial thrust plate **432**, axial thrust bolts **430** and pressure plate **428** causes the disconnect clutch **112** to activate to disconnect the transfer of torque. Respective shift track **301***a* causes axial movement of the low shift fork **328** which causes movement of the low engagement dog **504** resulting in the disengagement of the low engagement dog **504** from the reverse shaft low gear **512**. In alternative embodiments synchronizers are used instead of the engagement dogs.

Shift drum track **301***b* further causes axial movement of the high/reverse shift fork **334** which causes axial movement of the high/reverse engagement dog **526** resulting in the engagement of the high/reverse engagement dog **526** to reverse shaft high gear **532**. In addition, the disconnect track **302***a* of the shift drum **302** causes axial movement of the disconnect shift collar **356** which causes the disconnect clutch **112** to un-activate to reengage the torque due the axial force of the clutch engagement springs **426**. During the engagement of the disconnect clutch **112**, the rotational speed of the input shaft **456** and the driven clutch **108** is synchronized with the rest of the transmission **150**. As this engagement is accomplished with the friction style clutch in embodiments, rather than a dog style engagement clutch, the energy required for speed synchronization is spread out in time compared to that of a dog clutch engagement therein resulting in the minimizing of "clunk."

FIG. **14** illustrates an alternative shift on the fly system **700**. In this embodiment, only one input shaft **702** with one gear **724** is used. A shaft containing multiple gear and shifting is further positioned downstream in the transmission system of this embodiment. In this embodiment, the shifting is done with a disconnect shift fork **706** actuated by the shift drum (not shown) acting directly on the thrust bearing **729**. This embodiment includes a disengagement shift rail **704** upon which a disconnect shift fork **706** is mounted. The disconnect shift fork **706** is further engaged with the thrust bearing **729**. Similar to the embodiment discussed above, the shift on the fly assembly includes an inner ring clutch basket **727**, compression springs **730**, an outer clutch basket **720** and a clutch pack **728**. The clutch pack includes a plurality of sandwiched friction plates and clutch plates. The friction plates are coupled to the outer clutch basket **720** and the clutch plates are coupled to the inner ring clutch basket **727**. Movement of the thrust bearing **729** into the clutch basket **720** reduces friction between the friction plates and clutch plates therein ceasing torque from the inner ring clutch basket **727** to be transferred to the outer clutch basket **720**. As illustrated, the outer clutch basket **720** is directly coupled to the gear **724**. FIG. **14** further illustrates how input torque flows through to the only gear **724**. As illustrated, torque enters the shaft **702** as the result of the shaft being coupled to a drive clutch or the like. The torque is passed through the inner ring clutch basket **727**, through the clutch pack **728** to the outer clutch basket **720**. Since, the outer clutch basket **720** is directly coupled to the only gear **724**, the torque is passed to the only gear **724**. FIG. **14** further illustrates bearings **708** and **732** mounted on the shaft **702** and clutch pressure plate **726** and retaining clip **722**.

FIG. **15** illustrates a side perspective view of the shift on the fly embodiment of FIG. **14**. As illustrated, the disconnect shift fork **706** has a disconnect tab **706*a*** that is received directly in a disconnect track **750*a*** of a shift drum **750**. The shift drum is rotated by an electric motor **766** to change the gearing of the transmission. This embodiment also includes a manual override **742** if power is lost and the gearing needs to be changed. As further illustrated in FIG. **15**, shift forks **761** and **762** are operationally coupled in shift tracks of the shift drum **750**. As in the above embodiment, movement of the shift forks moves respective shift dogs to change gearing **744**. FIG. **16** illustrates the shift shaft rail **760** upon which the shift forks **761** and **762** are mounted. FIG. **16** also illustrates a reverse shaft **770**. In one embodiment, the reverse shaft include a central gear **770*a***. Mounted on the reverse shaft **770** is a bearing **772**, park plate **774**, high engagement dog **776**, sprocket **778**, low gear **780**, low engagement dog **782**, high gear **784** and bearing **786**.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement, which is calculated to achieve the same purpose, may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.

The invention claimed is:

1. A shift on the fly transmission comprising:
- a continuously variable transmission portion operationally coupled to receive torque from an engine;
- a discrete transmission portion having a gear assembly;
- at least one input shaft operationally coupled to an output of the continuously variable transmission portion;
- a disconnect clutch operationally coupling the at least one input shaft to the discrete transmission portion, the disconnect clutch configured to selectively decouple torque from the at least one input shaft to the discrete transmission portion during a range ratio shift of the discrete transmission portion;
- a shift drum having a disconnect track; and
- a disengagement fork operationally engaged with the disconnect track of the shift drum, the disengagement fork further configured to activate the disconnect clutch.

2. The shift on the fly transmission of claim **1**, wherein the at least one input shaft further comprises:
- a first input shaft operationally coupled to an output of the continuously variable transmission portion;
- a second input shaft operationally coupled to the discrete transmission portion; and
- the disconnect clutch operationally coupling the at least one input shaft to the second input shaft.

3. The shift on the fly transmission of claim **2**, wherein the first input shaft is an inner input shaft and the second input shaft is an outer input shaft, the inner input shaft received within the outer input shaft.

4. The shift on the fly transmission of claim **1**, wherein the disconnect clutch includes a clutch pack.

5. The shift on the fly transmission of claim **1**, further comprising:
- the disengagement fork pivotally coupled to the at least one input shaft.

6. The shift on the fly transmission of claim **1**, wherein the continuously variable transmission portion further comprises:
- a drive clutch operationally coupled to receive the torque from the engine in the form of a rotational input;
- a driven clutch, the at least one input shaft operationally coupled to the driven clutch; and
- a belt engaged between the drive clutch and the driven clutch to rotationally couple the drive clutch to the driven clutch.

7. The shift on the fly transmission of claim **1**, wherein the gear assembly of the discrete transmission portion further comprises:
- an input shaft high gear assembly; and
- an input shaft low gear assembly.

8. The shift on the fly transmission of claim **7**, further comprising:
- the input shaft high gear assembly including,
  - an input shaft high gear,
  - a reverse shaft high gear, and
  - an engagement dog; and
- the input shaft low gear assembly including:
  - an input shaft low gear,
  - reverse shaft low gear, and
  - engagement dog; and:
- a reverse shaft operationally coupled between the gear assembly and the final drive.

9. A shift on the fly transmission comprising:
- a drive clutch operationally coupled to receive torque from an engine in the form of a rotational input;
- a driven clutch;
- a belt engaged between the drive clutch and the driven clutch to rotationally couple the drive clutch to the driven clutch;
- an inner input shaft operationally coupled to the driven clutch;
- a discrete transmission portion having a gear assembly;
- an outer input shaft operationally coupled to the discrete transmission;
- a disconnect clutch operationally coupling the inner input shaft to the outer input shaft, the disconnect clutch configured to selectively decouple torque from the inner input shaft to the outer input shaft during a range ratio shift of the discrete transmission portion; and
- the discrete transmission portion including,
  - a shift drum having a disconnect track,
  - a disconnect shift collar operationally engaged in the disconnect track of the shift drum,
  - a push rod operationally coupled to the disconnect shift collar, and
  - a disengagement fork operationally engaged with the push rod, the disengagement fork further configured and arranged to activate the disconnect clutch.

10. The shift on the fly transmission of claim **9**, wherein the disconnect clutch further comprises:

an inner ring clutch basket operationally coupled to the outer input shaft;

an outer clutch basket operationally coupled to the inner input shaft; and

a clutch pack including a plurality sandwiched clutch plates and friction plates, the clutch plates engaged with the inner ring basket and the friction plates engaged with the outer clutch basket, wherein activation of the disconnect clutch reduces friction between the sandwiched clutch plates and friction plates.

11. The shift on the fly transmission of claim **10**, further comprising:

at least one pressure plate configured and arranged to operationally engage the clutch pack; and

a plurality of compression springs operationally engaged with the at least one pressure plate to compress the sandwiched clutch plates and friction plates of the clutch pack, the disengagement fork configured to selectively compress the plurality of springs to disengage the disconnect clutch.

12. A vehicle having a shift on the fly transmission system, the vehicle comprising:

an engine to provide torque;

a continuously variable transmission portion operationally coupled to the engine to receive the torque;

a discrete transmission portion having a gear assembly;

at least one input shaft operationally coupled to the continuously variable transmission portion;

a disconnect clutch operationally coupling the at least one input shaft to the discrete transmission portion, the disconnect clutch further configured and arranged to selectively decouple torque from the at least one input shaft to the discrete transmission portion;

a final drive assembly operationally coupled to an output of the discrete transmission;

at least one vehicle wheel operationally coupled to the final drive assembly;

a shift drum having a disconnect track;

a disconnect shift collar operationally engaged in the disconnect track of the shift drum;

a push rod operationally coupled to the disconnect shift collar; and

a disengagement fork operationally engaged with the push rod, the disengagement fork further configured and arranged to activate the disconnect clutch.

13. The vehicle of claim **12**, wherein the at least one input shaft further comprises:

a first input shaft operationally coupled to an output of the continuously variable transmission portion;

a second input shaft operationally coupled to the discrete transmission portion; and

the disconnect clutch operationally coupling the at least one input shaft to the second input shaft.

14. The vehicle of claim **12**, wherein the first input shaft is an inner input shaft and the second input shaft is an outer input shaft, the inner input shaft received within the outer input shaft.

15. The vehicle of claim **12**, wherein the continuously variable transmission further comprises:

a drive clutch operationally coupled to receive the torque of the engine in the form of a rotational input;

a driven clutch, the at least one input shaft operationally coupled to the driven clutch; and

a belt engaged between the drive clutch and the driven clutch to rotationally couple the drive clutch to the driven clutch.

16. The vehicle of claim **12**, wherein the gear assembly further comprises:

an input shaft high gear assembly; and

an input shaft low gear assembly.

17. The vehicle of claim **12**, further comprising:

the input shaft high gear assembly including,

an input shaft high gear,

a reverse shaft high gear, and

at least one of a high engagement dog and a high synchronizer;

the input shaft low gear assembly including:

an input shaft low gear,

reverse shaft low gear, and

at least one of a low engagement dog and a low synchronizer; and

a reverse shaft operationally coupled between the gear assembly and the final drive.

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