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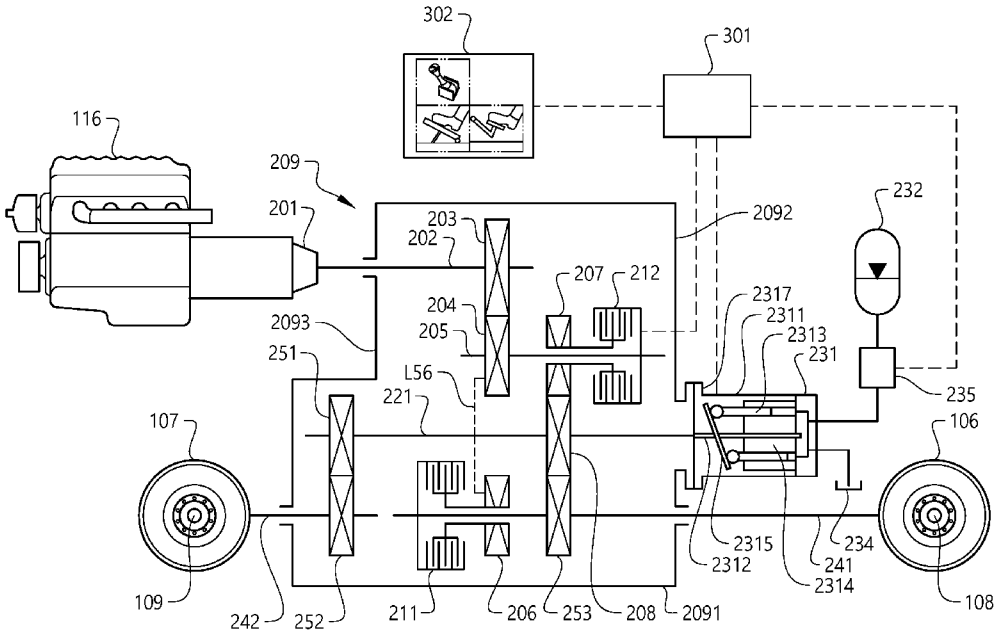

FIG. 2

(57) Abstract: The invention provides a working machine driveline arranged to transfer torque from an internal combustion engine (1 16) of the working machine to at least one front wheel axle (108) and at least one rear wheel axle (109) of the working machine, the driveline comprising an energy accumulation arrangement (231, 232, 233, 234, 235) with a kinetic energy conversion device (231), arranged to recuperatively brake the working machine, wherein the driveline comprises a transfer case (209) arranged to distribute the torque from the engine to the front and rear axles (108, 109), the transfer case comprising a housing (2091), the kinetic energy conversion device being mounted to the housing (2091) so as to be supported solely by the housing.

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A WORKING MACHINE DRIVELINE

TECHNICAL FIELD

The invention relates to a working machine driveline. The invention also relates to a method for controlling a working machine driveline, a computer program, a computer readable medium, a control unit, and a working machine.

The invention is applicable to working machines in the form of moving working machines within the fields of industrial construction machines or construction equipment, in particular wheel loaders. The invention may also be used in other working machines such as articulated haulers, wheeled excavators, and motor graders.

BACKGROUND

A working machine, such as a wheel loader, is usually provided with a bucket, container, gripper, or other type of implement for digging, carrying and/or transporting a load. For example, a wheel loader has a lift arm unit for raising and lowering the implement. Usually a hydraulic cylinder or a pair of hydraulic cylinders is arranged for raising the lift arm and a further hydraulic cylinder is arranged for tilting the implement relative to the lift arm.

In addition, the working machine is often articulated frame-steered and has a pair of hydraulic cylinders for turning or steering the working machine by pivoting a front unit and a rear unit of the working machine relative to each other. The hydraulic system generally further comprises at least one hydraulic pump, which is arranged to supply hydraulic power, i.e. hydraulic flow and/or hydraulic pressure, to the hydraulic cylinders.

A moving working machine usually operates in harsh environments with uneven supporting surfaces, in which the machine frequently performs maneuvers to change loads and driving directions, involving large accelerations and forces, and putting high demands on machine components.

In addition to robustness and durability, a modern working machine is also subjected to demands of fuel efficiency and reductions of environmental disturbances. In efforts to meet such demands, solutions involving energy recuperation have been considered.

Thereby, an energy recuperation arrangement is provided to brake the machine while storing energy which is used later for propulsion of the machine. An example is disclosed in US2015120114A1. However, modern working machines include a large amount of parts, e.g. for subsystems, so space is often limited. Thereby, the integration of an energy recuperation arrangement is often problematic.

SUMMARY

It is an object of the invention to provide an energy recuperation arrangement in a working machine, which is easy to implement.

This object is achieved by a working machine driveline according to claim 1. Thus, the invention provides a working machine driveline arranged to transfer torque from an internal combustion engine of the working machine to at least one front wheel axle and at least one rear wheel axle of the working machine, the driveline comprising an energy accumulation arrangement with a kinetic energy conversion device, arranged to recuperatively brake the working machine, wherein the driveline comprises a transfer case arranged to distribute the torque from the engine to the front and rear axles, the transfer case comprising a housing, the kinetic energy conversion device being mounted to the housing so as to be supported solely by the housing.

Thus, the invention relates to a working machine, also referred to as a moving working machine. By the driveline being arranged to transfer torque from the engine, the driveline is arranged to transfer power from the engine. The energy accumulation arrangement may be arranged to recuperatively brake the working machine, e.g. when changing the rotational direction of the wheel in relation to the engine.

The kinetic energy conversion device is preferably arranged to convert kinetic energy to energy in another form, such as pressure energy or electric energy. The kinetic energy conversion device is preferably also arranged to convert non-kinetic energy, such as pressure energy or electric energy, to kinetic energy. Thereby, the energy accumulation arrangement is preferably arranged to convert, by means of the kinetic energy conversion device, kinetic energy in the drivetrain to non-kinetic energy, and to store the non-kinetic energy. Also, the energy accumulation arrangement is preferably arranged to convert, by

means of the kinetic energy conversion device, the stored non-kinetic energy to kinetic energy in the drivetrain.

It should be noted that the energy accumulation arrangement may be hydraulic. Thereby, the kinetic energy conversion device could be a hydraulic machine, herein also referred to as a pump/motor. For example, the kinetic energy conversion device may be any suitable pump/motor, such as an inline axial piston pump, a radial piston pump, a gear pump, a rotary vane pump, or a screw pump. In some embodiments, the energy accumulation arrangement may be electric, wherein the kinetic energy conversion device is an electric machine electrically connected to an electric energy storage unit, wherein a rotatable part forms a rotor of the electric machine.

Normally, at least two wheels are mounted to each wheel axle. The working machine may be provided with one or more front wheel axles, and one or more rear wheel axles. It should also be mentioned that the driveline could be arranged to provide a propulsion torque flow to any suitable number of wheels, e.g. four or six.

The transfer case may be arranged to distribute the torque from the engine to the front and rear axles by any suitable means, e.g. by gears, hydraulics and/or one or more chain or belt drives. The distribution arrangement means that the transfer case is arranged to divide or split the torque from the engine into separate torques in the front and rear axles. These separate torques may be equal or unequal in size. The transfer case may be arranged to synchronize differences between the rotation of the front and rear wheels. The transfer case may contain one or more sets of low range gears. In some embodiments, the transfer case is provided without a transmission arranged to selectively provide a plurality of gear ratios between the engine and wheels of the working machine. Thereby, such a transmission may be provided separately in the driveline. In other embodiments, the transfer case may be integrated with, or include such a transmission.

It is understood that the kinetic energy conversion device is fixedly mounted to the transfer case housing. Preferably the kinetic energy conversion device is mounted externally on the transfer case housing. Mounting the kinetic energy conversion device so as to be supported solely by the transfer case housing provides for a simple and easily implementable adaption of the working machine to present a capacity for recuperative braking by means of the energy accumulation arrangement. The invention makes it

possible to make use of the transfer case for transferring torque to and from the energy accumulation arrangement. More specifically, by mounting the kinetic energy conversion device to the transfer case housing, an easy and close access may be provided to moving parts in the transfer case. Also, the invention provides for a space effective integration of the energy accumulation arrangement in the working machine. This is particularly beneficial, since in many modern working machines the availability of space is very limited. The kinetic energy conversion device may be mounted directly to the transfer case housing, or by means of an intermediate adaptor or flange. By the kinetic energy conversion device being supported solely by the transfer case housing, the transfer case provides the double function of transferring torque to and from the energy accumulation arrangement, and supporting the kinetic energy conversion device.

The kinetic energy conversion device may be mounted to the transfer case housing in any suitable manner, such as with threaded fasteners, for example bolts. Further examples include bayonet connectors, rivets, or pins.

Also, in a manufacturing process of the working machine, the transfer case and the kinetic energy conversion device may be provided in an assembled form before the transfer case is mounted to a frame of the working machine. Thereby, other parts of the energy accumulation arrangement, such as an energy storage unit, may be mounted in the working machine separately from the transfer case kinetic energy conversion device assembly.

By the invention, the energy accumulation arrangement may be easily integrated into working machine designs originally not adapted for such arrangements. For example, in embodiments of the invention, a shaft in the transfer case may simply be increased in length to extend through the transfer case housing, and to be fixed to a rotatable part of the kinetic energy conversion device which is mounted to the transfer case housing. In some embodiments, the extension of the shaft through the transfer case housing may be effected simply by removing a cover of an opening in the housing, originally designed for providing access for a bearing support of the shaft in the transfer case manufacturing. The invention may also advantageously be implemented for retrofitting working machines for energy accumulation for recuperative braking.

Preferably, where the kinetic energy conversion device comprises a casing and a rotatable part, the casing is mounted to the housing of the transfer case. Thereby, the casing may be fixedly mounted to the housing. Thus, embodiments of the invention may be easily implemented, e.g. by mounting the kinetic energy conversion device casing to the transfer case housing by a flange on the casing and a bolt connection through the flange.

Preferably, where the kinetic energy conversion device comprises a casing and a rotatable part, the rotatable part, e.g. a shaft thereof, is directly coupled to a shaft of the transfer case. The shaft of the transfer case may for example be a transfer case input shaft, an intermediate shaft in the transfer case, or an output shaft of the transfer case. Thereby, in addition to the kinetic energy conversion device being mounted to the transfer case housing, the rotatable part may be connected directly to a shaft in the transfer case, the shaft serving in the transfer of the torque from the engine to the front and rear axles. This provides for a manner of connecting the rotatable part to the shaft, which is simple to implement. In addition, said transfer case shaft may serve the multiple purposes of transferring torque from the engine to the front and rear axles, transferring torque from the front and rear axles or from the engine to the energy accumulation arrangement, and transferring torque from the energy accumulation arrangement to the front and rear axles or to the engine.

The direct connection of the transfer case shaft to the rotatable part of the kinetic energy conversion device may be effected in any suitable manner, e.g. by a connection with splines. It should be noted however, that within the scope of the invention it is possible that the rotatable part of the kinetic energy conversion device and the transfer case shaft are indirectly connected to each other, e.g. via a gear and/or a clutch.

Preferably, where the driveline is arranged to provide a propulsion torque flow in a direction from the engine to the wheel axles, the transfer case is arranged to provide, in the propulsion torque flow direction, a vertical drop. This is advantageous e.g. where a transfer case input shaft extends in a longitudinal direction of the working machine, i.e. in a direction which is substantially parallel to a direction of straight travel of the working machine. The vertical drop provides for the transfer case being arranged to direct the torque flow laterally from the transfer case input shaft to the transfer case output shafts, which may be connected to the front and rear axles. The vertical drop may provide vertical

external surfaces of the transfer case housing on which the kinetic energy conversion device of the energy accumulation arrangement is advantageously mounted. The vertical drop may be effected e.g. by at least one gear set, i.e. one or more gear wheel pairs, or at least one chain or belt drive, connecting parallel shafts. Thereby, the rotatable part of the kinetic energy conversion device, mounted externally to the transfer case housing, may be easily connected to one of the transfer case shafts extending through the housing. This shaft may be the transfer case input shaft, a transfer case output shaft, or an intermediate shaft of the transfer case. The rotatable part of the kinetic energy conversion device may simply be connected, e.g. directly, to an end of such a shaft.

As suggested, the kinetic energy conversion device is preferably mounted on an external side of the transfer case housing. Preferably, the kinetic energy conversion device is mounted on a side of the transfer case which is opposite to a side of the transfer case which receives a transfer case input shaft, e.g. from the engine and/or a transmission of the driveline. Thereby, a particularly advantageous utilization of free space, provided by the vertical drop, may be embodied. It should be noted however that in some embodiments, the kinetic energy conversion device may be mounted on the side of the transfer case which receives the input shaft.

Where the driveline is arranged to provide a propulsion torque flow in a direction from the engine to the wheel axles, the kinetic energy conversion device comprises a rotatable part, and the driveline comprises a transmission arranged to selectively provide a plurality of gear ratios between the engine and the front and rear axles, the rotatable part may be downstream of the transmission, in the propulsion torque flow direction.

Thus, the transfer case, with the kinetic energy conversion device mounted to the transfer case housing, may be located downstream of the transmission. Thereby, an advantageous arrangement for installing the kinetic energy conversion device may be provided, since the engine and the transmission are located on the same side of the transfer case, whereby space may be readily available around the transfer case housing for the kinetic energy conversion device installation.

Also, the location of the kinetic energy conversion device downstream of the transmission may reduce loads to the transmission. Energy recuperation processes may put, in the context of tough operational conditions, very high demands on the driveline of the working

machine. Driveline components, such as the transmission may be subjected to risks of excessive wear, unless compensations are made with increased sizes of parts. Also, large amounts of energy may be lost in the form of heat. Locating the rotatable part of the kinetic energy conversion device of the energy accumulation arrangement downstream of the transmission, in the propulsion torque flow direction means that the transmission is not subjected to torques caused by any energy recuperation process of the energy accumulation arrangement. At energy storage, torques from the wheel pass to the energy accumulation arrangement without passing through the transmission. Similarly, at energy release, torques from the energy accumulation arrangement pass to the wheel without passing through the transmission. This substantially decreases risks of excessive wear in the transmission, and/or decreases the need to adjust sizes of transmission parts due to added loads from energy recuperation processes. Thereby, the cost of producing and maintaining the working machine decreases.

Also, locating the rotatable part of the kinetic energy conversion device downstream of the transmission provides for avoiding energy losses in the transmission during recuperation processes. Thereby, the efficiency of such processes increases.

The driveline may comprise a driving direction change arrangement for changing the rotational direction of the front and rear axles, and hence the working machine wheels, in relation to the engine. Thereby, the driving direction change arrangement may form a part of the transfer case. Thereby, the transfer case and the kinetic energy conversion device may form an integrated unit, including the driving direction change arrangement, which is particularly beneficial in the interest of optimizing space usage in the working machine. Also, such embodiments provide for the kinetic energy conversion device being close to the driving direction change arrangement which makes it easy to control the driveline when braking and accelerating using the energy accumulation arrangement. The reason is that the torques, thereby affecting the kinetic energy conversion device and the driving direction change arrangement, may not be dependent on other components in the driveline.

In advantageous embodiments, where the driveline is arranged to provide a propulsion torque flow in a direction from the engine to the wheel axles, and the kinetic energy conversion device comprises a rotatable part, the rotatable part is located downstream of the driving direction change arrangement in the propulsion torque flow direction. Locating

the rotatable part downstream of the driving direction change arrangement means that the driving direction change arrangement is not subjected to torques caused by energy recuperation processes of the energy accumulation arrangement. This substantially decreases the need to increase sizes of driving direction change arrangement parts due to added loads from energy recuperation processes. Also, such embodiments of the invention provides for avoiding energy losses in the driving direction change arrangement during recuperation processes. For example, where the driving direction change arrangement includes wet clutches, as exemplified below, the size of the clutches may be decreased without introducing risks of excessive wear or heat losses.

In some embodiments, the rotatable part is located upstream of the driving direction change arrangement in the propulsion torque flow direction. Thereby, the rotatable part of the energy accumulation arrangement is advantageously, as mentioned above, located downstream of the transmission. It should be noted that is some embodiments, the driving direction change arrangement may be provided in the transmission.

Preferably, the kinetic energy conversion device is a hydraulic machine. The hydraulic machine may be hydraulically connected to a hydraulic accumulator, which may also be referred to as a hydraulic energy storage unit. The hydraulic machine may be a variable displacement hydraulic machine. Thereby, a simple and robust energy accumulation arrangement may be provided. Where the hydraulic machine is mounted to the transfer case housing, so as to be supported solely by the housing, a particularly simple implementation of the invention may be provided. The hydraulic accumulator may also be mounted to the housing of the transfer case, so as to be supported solely by the housing. However, the hydraulic accumulator may alternatively be mounted elsewhere in the working machine.

A reservoir may be hydraulically connected to the hydraulic machine, a valve arrangement being provided for control of a movement of hydraulic fluid from the hydraulic accumulator to the reservoir via the hydraulic machine, and vice versa. Thereby, the energy accumulation arrangement may be embodied with an open circuit with suction from the reservoir to supply a low pressure side of the hydraulic machine. The valve arrangement secures control over an energy recuperation process. Where the hydraulic machine is a variable displacement hydraulic machine, the movement of hydraulic fluid from the hydraulic accumulator to the reservoir, and vice versa, may be controlled by displacement

adjustments of the hydraulic machine, as an alternative to, or in addition to, the valve arrangement. The valve arrangement may, as the hydraulic machine, be mounted to the housing of the transfer case, so as to be supported solely by the housing. However, the valve arrangement may alternatively be mounted elsewhere in the working machine.

In an advantageous embodiment, the valve arrangement is adapted to provide a four quadrant operation of the hydraulic machine. Thereby, the hydraulic machine may provide a positive torque as well as a negative torque, in two rotational directions. This enables quick response times and more accurate timing when switching between charging and discharging the energy accumulation arrangement, e.g. at working machine driving direction changes. In addition, hydraulic machines adapted to work in four quadrants are relatively complicated and costly, and a valve arrangement according to embodiments of the invention, adapted to provide a four quadrant operation, allows the use of simpler and less costly hydraulic machines.

In some embodiments, where said hydraulic accumulator is a first accumulator, a second accumulator is hydraulically connected to the hydraulic machine so as for hydraulic fluid to be moved from the first accumulator to the second accumulator, and vice versa, the second accumulator being arranged to accumulate the hydraulic fluid at a pressure which is lower than a pressure at which the first accumulator is arranged to accumulate the hydraulic fluid. Thus, the second accumulator may be a low pressure accumulator. Thereby, the energy accumulation arrangement may be embodied with a closed circuit, with the second accumulator to supply a low pressure side of the hydraulic machine. Hydraulic machines adapted to work in a open circuit may be relatively complicated and costly. The second accumulator, according to embodiments of the invention, may provide a pressure on the low pressure side of the hydraulic machine, allowing the use of a simpler and less costly hydraulic machine. The second accumulator may, as the hydraulic machine, be mounted to the housing of the transfer case, so as to be supported solely by the housing. However, the second accumulator may alternatively be mounted elsewhere in the working machine.

In some embodiments, the hydraulic machine is hydraulically connected to a hydraulic system for cooling, lubrication, and/or actuation of the driving direction change arrangement. This means that the hydraulic machine can then be used to assist a pump of said hydraulic system, or to handle such a functionality completely on its own. The

hydraulic system may include simple control valves, suitably including pressure reducing valves, for supplying the oil to flow consumers of the driving direction change arrangement. This may reduce costs and/or power losses of additional pumps.

As mentioned, the kinetic energy conversion device may, in some embodiments, be an electric machine electrically connected to an electric energy storage unit. Thereby, recuperation processes may be secured in an alternative manner. The electric energy storage unit may be of any suitable type, e.g. of a super capacitance type and/or one or more batteries. The electric machine, or motor/generator, may be provided with a gear arrangement for increasing the rotational speed in order to keep the electric machine relatively small. The electric energy storage unit may, as the electric machine, be mounted to the housing of the transfer case, so as to be supported solely by the housing. However, the electric energy storage unit may alternatively be mounted elsewhere in the working machine.

An aspect of the invention provides a method for controlling a working machine driveline arranged to provide a propulsion torque flow in a direction from an internal combustion engine of the vehicle to at least one front wheel axle and at least one rear wheel axle of the vehicle, the driveline comprising a transmission arranged to selectively provide a plurality of gear ratios between the engine and the front and rear axles, the method comprising

- controlling a driving direction change arrangement to provide a movement of the vehicle in a first direction by means of the propulsion torque flow,
- controlling, while the vehicle is moving in the first direction, an energy accumulation arrangement of the driveline to store, downstream of the transmission in the propulsion torque flow direction, energy from a vehicle braking torque directed in opposite to the propulsion torque flow direction,
- and, before the control of the energy accumulation arrangement to store the energy, controlling the driving direction change arrangement to disconnect the energy accumulation arrangement from the transmission.

Similarly to what has been mentioned above, storing energy from the working machine braking torque downstream of the transmission, means that the transmission is not subjected to the braking torque. This substantially decreases risks of excessive wear in the transmission, and/or decreases the need to adjust sizes of transmission parts due to

added loads from energy recuperation processes. Also, energy losses in the transmission are avoided.

By controlling, before the control of the energy accumulation arrangement to store the energy, the driving direction change arrangement to disconnect the energy accumulation arrangement from the transmission, the energy accumulation arrangement is not subjected to any torque to or from the engine via the transmission, whereby the control of the energy accumulation arrangement during a recuperation process becomes easier. Where the energy accumulation arrangement is controlled to store the energy downstream of the driving direction change arrangement, it is possible to keep the engine and the transmission at virtually the same speed when performing a driving direction change. This is an advantage since, in addition to reducing power losses, it increases the controllability of the energy accumulation process, since a control unit of the energy accumulation arrangement does not need to consider the upstream inertia of the engine and the transmission, which may change, e.g. due to a transmission gear shift.

Advantageously, the method comprises controlling the energy accumulation arrangement to release from downstream of the transmission the stored energy in the propulsion torque flow direction. Similar to the energy storage described above, this means that the transmission is not subjected to any torque caused by the energy release process.

Preferably, the method comprises, after initiation of the control of the energy accumulation arrangement to release the energy, controlling the driving direction change arrangement to connect the transmission to the wheel. Thereby, at least an initial part of the acceleration of the working machine after a driving direction change, may be powered by the energy accumulation arrangement only. In some embodiments, after the initial part of the acceleration of the working machine, the driving direction change arrangement is controlled to gradually connect the transmission to the front and rear axles. By the assistance in the acceleration of the energy accumulation arrangement energy release, parts in the driving direction change arrangement, e.g. one or more clutches thereof, may be less loaded, which means that such parts may be provided with reduced performance requirements. In some embodiments, the energy accumulation arrangement energy release, and a gradual connection of the transmission to the front and rear axles, may be provided throughout the entire working machine acceleration.

An aspect of the invention provides a method for controlling a working machine driveline arranged to provide a propulsion torque flow in a direction from an internal combustion engine of the working machine to at least one front wheel axle and at least one rear wheel axle of the working machine, the driveline comprising a transmission arranged to selectively provide a plurality of gear ratios between the engine and the front and rear axles, the method comprising

- controlling a driving direction change arrangement for providing a movement of the working machine in a first direction by means of the propulsion torque flow, the driving direction change arrangement comprising a hydraulically actuatable clutch,
- controlling, while the working machine is moving in the first direction, an energy accumulation arrangement of the driveline to store energy from a working machine braking torque directed in opposite to the propulsion torque flow direction, the energy accumulation arrangement comprising a hydraulic machine,
- and controlling a valve arrangement to control a movement of hydraulic fluid from the hydraulic machine to actuate the clutch.

Similarly to what has been discussed above, this means that the hydraulic machine can then be used to assist a pump of said hydraulic system, or to handle such a functionality completely on its own, which may reduce costs and/or power losses of additional pumps. The energy from the working machine braking torque may be stored downstream of the transmission, in the propulsion torque flow direction.

Preferably, the method comprises controlling the driving direction change arrangement to connect the energy accumulation arrangement to the transmission, and controlling the energy accumulation arrangement to release, from downstream of the transmission, the stored energy opposite to the propulsion torque flow direction. Thereby, the energy accumulation arrangement may advantageously be used as an engine start motor.

Aspects of the invention also provide a computer program according to claim 23, a computer readable medium according to claim 24, a control unit according to claim 25, or a working machine according to claim 26.

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Fig. 1 is a side view of a wheel loader.

Fig. 2 is a schematic view of a driveline of the wheel loader in fig. 1.

Fig. 3 is a block diagram depicting steps in a method for controlling the driveline in fig. 2.

Fig. 4 is a diagram showing the velocity of the wheel loader as a function of time.

Fig. 5 is a schematic view of a driveline according to an alternative embodiment of the invention.

Fig. 6 is a schematic view of a driveline according to a further embodiment of the invention.

Fig. 7 is a block diagram depicting steps in a method for controlling the driveline in fig. 6

Fig. 8 is a schematic view of a driveline according to another embodiment of the invention.

Fig. 9 is a schematic view of a driveline according to yet another embodiment of the invention.

Fig. 10 is a schematic view of a driveline according to a further embodiment of the invention.

Fig. 11 is a perspective view of parts of a driveline according to an additional embodiment of the invention.

Fig. 12 is a perspective view of an articulated hauler with a driveline according to an embodiment of the invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

Fig. 1 is an illustration of a working machine 1, more specifically a wheel loader. It should be noted that the invention is equally applicable to other types of working machines, such as articulated haulers.

The wheel loader comprises a body structure 101 with a front unit 102 and a rear unit 103. The front unit 102 and the rear unit 103 are mounted to each other via a pivotable coupling 104. The front unit 102 and the rear unit 103 present two front wheels 106 and two rear wheels 107, respectively. The front wheels 106 are mounted to a front wheel axle 108 and the rear wheels 107 are mounted to a rear wheel axle 109.

The pivotable coupling 104 is arranged to allow the front and rear units to pivot in relation to each other around a pivot axis 105, which is substantially vertical when the wheel loader 1 is supported on a horizontal surface. Two steering hydraulic cylinders 110 are arranged on opposite sides of the wheel loader 1 for turning the wheel loader by means of relative movement of the front unit 102 and the rear unit 103. In other words, the wheel loader 1 is articulated and frame steered by means of the steering hydraulic cylinders 110.

The rear unit 103 of the wheel loader 1 comprises an engine compartment 111 with a radiator system 112 and an internal combustion engine of a driveline described below. The rear unit 103 further comprises a driver compartment 113, herein also referred to as a cab.

The wheel loader 1 comprises an implement 14. The term “implement” is intended to comprise any kind of tool suitable for a wheel loader, such as a bucket, a fork, or a gripping tool. The implement 14 illustrated in fig. 1 is a bucket. The implement 14 is arranged on an elongated lift arm 6 for raising and lowering the implement 14, relative to the body structure 101.

The lift arm 6 is at a first end rotatably or pivotably connected to a frame 3 of the front unit 102, at a first pivot connection 7, at a lift arm mounting point presented by the frame 3. The implement 14 is mounted to the lift arm 6 at a second pivot connection 141, at a second end of the lift arm 6. The lift arm 6 is arranged to be pivoted around the first pivot connection 7 by means of an actuator in the form of a main hydraulic cylinder 8 being part of a hydraulic system of the wheel loader. Thereby the lift arm 6 is pivotable between an upper end position and a lower end position.

The wheel loader also comprises a tilting hydraulic cylinder 9 arranged to actuate a tilting movement of the implement 14 in relation to the lift arm 6. For this, the implement 14 is pivotally mounted to the lift arm 6 at the second pivot connection 141. The tilting hydraulic cylinder 9 extends from the lift arm 6 to a linkage mechanism 901, which is adapted to transfer movements from the tilting hydraulic cylinder 9 to the implement 14.

Reference is made is made to fig. 2, depicting the driveline of the working machine, arranged to provide a propulsion torque flow in a direction from the internal combustion engine 116 to the wheels 106, 107, via front and rear wheel drive shafts 241, 242. The driveline comprises a transmission 201 at the engine 116, arranged to selectively provide a plurality of gear ratios between the engine 116 and the wheels 106, 107.

The driveline comprises a transfer case 209, herein also referred to as a dropbox, arranged to provide, in the propulsion torque flow direction, a vertical drop from the transmission 201 to the front and rear wheel drive shafts 241, 242. The transfer case comprises a housing 2091.

The transfer case comprises a driving direction change arrangement 211, 212, for changing the rotational direction of the wheels 106, 107 in relation to the engine 116, comprising a hydraulically actuatable wet friction first clutch 211 for selectively connecting the wheels 106, 107 to the transmission 201. The driving direction change arrangement further comprises a hydraulically actuatable wet friction second clutch 212 for selectively connecting the wheels 106, 107 to the transmission 201.

A transfer case input shaft, in the form of a transmission output shaft 202, is connected to the second clutch 212 via a first and second gear wheel 203, 204 and a first intermediate

shaft in the form of a second clutch input shaft 205. The second gear wheel is engaged with a third gear wheel 206, as indicated by a broken line L56. Thereby, the transmission output shaft 201 is connected to the first clutch 211 via the first, second, and third gear wheel 203, 204, 206. The first clutch 211 is connected to the front wheel drive shaft 241, which may also be referred to as a first output shaft of the transfer case 209. The second clutch 212 is connected to an intermediate shaft 221 via a fourth and fifth gear wheel 207, 208. The intermediate shaft 221 is connected to the rear wheel drive shaft 242 via a sixth and seventh gear wheel 251, 252. The rear wheel drive shaft 242 may also be referred to as a second output shaft of the transfer case 209. The front wheel drive shaft 241 is connected to the intermediate shaft 221 via an eighth gear wheel 253 and the fifth gear wheel 208.

Thereby, any of the first and second clutches 211, 212 may drive all wheels 106, 107. One of the first and second clutches 211, 212 is arranged to drive the wheels 106, 107 in one direction, and the other of the first and second clutches 211, 212 is arranged to drive the wheels 106, 107 in the other direction. The wheel loader 1 comprises a control unit 301 arranged to control the first and second clutches 211, 212. Thus, the first and second clutches 211, 212 are used to change the driving direction of the wheel loader 1, as exemplified below. It is understood that the shaft and gear arrangement of the transfer case 209 may, in alternative embodiments be different from what is described with reference to fig. 2. For example, the transfer case 209 may comprise additional intermediate shafts, e.g. for a larger vertical drop provided by the transfer case.

The driveline further comprises an energy accumulation arrangement arranged to recuperatively brake the working machine, e.g. when decelerating the vehicle to perform a change of the rotational direction of the wheels 106, 107 in relation to the engine 116, as described below. The energy accumulation arrangement comprises a kinetic energy conversion device in the form of a hydraulic machine 231, hydraulically connected to a hydraulic accumulator 232.

The hydraulic machine 231 is mounted to the transfer case housing 2091 so as to be supported solely by the housing. For this, the hydraulic machine 231 comprises a casing 2311 which is mounted to the transfer case housing 2091. The casing 2311 is provided with a flange 2317 which is bolted to the housing 2091. As suggested above, the casing 2311 could be mounted to the housing 2091 in any suitable manner, such as with some

other type of threaded fasteners, or with bayonet connectors, rivets, or pins. The hydraulic machine 231 is mounted on a side 2092 of the transfer case 209 which is opposite to a side 2093 of the transfer case which receives the transfer case input shaft 202. The side 2092 may be a vertical side, or a substantially vertical side of the transfer case housing 2091 to make use of the available, and typically unused space.

The intermediate shaft 221 is arranged to drive the hydraulic machine 231. The intermediate shaft 221 may be arranged to drive the hydraulic machine directly or via a gearing and/or a clutch. In this example, the intermediate shaft 221 is directly connected to a central shaft 2312 of the hydraulic machine 231. Thereby, the intermediate shaft extends through the housing 2091, and is connected to the central shaft 2312 with splines.

A valve arrangement 235 is provided for control of a movement of hydraulic fluid from the accumulator 232 to the hydraulic machine 231, and vice versa. The control unit 301 is arranged to control the valve arrangement 235.

The hydraulic machine 231 is, in this example, an axial piston pump forming a variable displacement hydraulic machine 231. The hydraulic machine 231 may be rotated in two different directions, whereby the hydraulic machine may work as either a hydraulic pump or a hydraulic motor.

The hydraulic machine comprises the casing 2311 and a rotatable part. The rotatable part comprises the central shaft 2312 connected to the intermediate shaft 211, a plurality of pistons 2313 in cylinders of a cylinder carrier 2314, and a swashplate 2315 to which ends of the pistons 2313 are connected. As is known per se, the angle of the swashplate 2315 may be changed, and as the pistons 2313 rotate, the angle of the plate 2315 causes the pistons 2313 to move in and out of their cylinders. A rotary valve alternately connects each cylinder to a conduit to the hydraulic accumulator 232 and a conduit to a reservoir 234. The control unit 301 is arranged to change to angle of the swashplate 2315 so as to change the displacement of the hydraulic machine 231.

It should be noted that in alternative embodiments, the rotatable part 2312, 2313, 2314, 2315 could be a part of any suitable hydraulic machine such as a bent axis piston pump, a radial piston pump, a gear pump, a rotary vane pump or a screw pump.

As understood from the description above the rotatable part 2312, 2313, 2314, 2315 of the hydraulic machine 231 is downstream of the transmission 201, and the first and second clutches 211, 212, in the propulsion torque flow direction. The first and second clutches 211, 212 form parts of the transfer case.

The control unit 301 is arranged to receive signals from control devices 302 adapted to be manipulated by a driver of the wheel loader. The control devices include a brake pedal, an accelerator pedal, and a transmission control device. The control unit 301 is further arranged to determine the speed of the wheel loader 1, e.g. by use of a suitable sensor at one of the drive shafts 241, 242, and/or by use of the Global Positioning System (GPS). The control unit may further be arranged to receive signals from one or more pressure sensors (not shown) in the accumulator 232 and/or the hydraulic machine 231. In addition or alternatively, the control unit may be arranged to receive signals from a displacement sensor (not shown) in the hydraulic machine.

Reference is made to fig. 3 depicting steps in a method for controlling the driveline in fig. 2. The method comprises controlling S1 the first and second clutches 211, 212 for providing a movement of the wheel loader in a first direction, in this example the forward direction, by means of the propulsion torque flow from the engine 116 to the wheels 106, 107. Thereby, the first clutch 211 is engaged and the second clutch 212 is not engaged. Further, the angle of the swashplate 2315 is controlled so as for the hydraulic machine to provide zero displacement.

Based on signals from the driver control devices 302, the control unit 301 controls the driveline for a change of the driving direction of the wheel loader 1 to be executed, whereby the wheel loader 1 changes from moving in the forward direction to moving in the rearward direction. It is understood that corresponding steps are carried out in a method where the wheel loader 1 changes from moving in the rearward direction to moving in the forward direction.

Reference is made also to fig. 4. The control includes controlling S2 the swashplate 2315 of the hydraulic machine so as to provide a pump displacement, and disengaging S2 the first clutch 211, at a time t1. Thereby, the energy accumulation arrangement 231, 232, 234 is disconnected from the transmission 201. In addition, the intermediate shaft 221,

driven by the wheels 106, 107 via the front and rear wheel drive shafts 241, 242, drives the rotatable part of the hydraulic machine 231 so that the energy accumulation arrangement 231, 232, 234 stores energy S3 by pumping hydraulic oil to the accumulator 232. Thereby, a working machine braking torque is provided, directed in opposite to the propulsion torque flow direction, whereby the wheel loader is decelerated. The deceleration may include the use of one or more brakes in the driveline or at the wheels, in addition to the energy storage of the energy accumulation arrangement 231, 232, 234.

During the deceleration, the wheel loader speed is monitored S4. When the speed is zero, at a time t2, the second clutch 212 is engaged S5. Thereby the wheels 106, 107 are driven by the engine 116 in the opposite direction, so as to accelerate the wheel loader in the rearward direction. Also, the rotatable part 2312, 2313, 2314, 2315 of the hydraulic machine 231 changes its rotation direction. Thereby, the energy accumulation arrangement 231, 232, 234 is allowed to release S6 the stored energy in the propulsion torque flow direction to the wheels 106, 107.

In alternative embodiments, the second clutch 212 is engaged after an initiation of the energy release of the energy accumulation arrangement 231, 232, 234.

Fig. 5 is a schematic view of a driveline according to an alternative embodiment of the invention. The driveline in fig. 5 is similar to the driveline in fig. 2, with the following exception:

The rotatable part 2312, 2313, 2314, 2315 of the hydraulic machine 231 is connected, directly or via a gearing and/or a clutch, to the second clutch input shaft 205. Thereby, the rotatable part 2312, 2313, 2314, 2315 of the hydraulic machine 231 is downstream of the transmission 201 and upstream of the first and second clutches 211, 212 in the propulsion torque flow direction.

In the embodiment in fig. 5, during a change of the driving direction of the wheel loader 1, the rotatable part 2312, 2313, 2314, 2315 of the hydraulic machine 231 does not change its rotation direction. For a driving direction change, the transmission 201 is controlled so as to enter a neutral position, in which it cannot transfer any torque. Further, for driving direction change from a forward movement to a rearward movement, the first clutch 211 remains engaged until the wheel loader speed is zero. In addition, the second clutch input

shaft 205, driven by the wheels 106, 107 via the front and rear wheel drive shafts 241, 242 and the first clutch 211, drives the rotatable part of the hydraulic machine 231 so that the energy accumulation arrangement 231, 232, 234 stores energy by pumping hydraulic oil to the accumulator 232.

When the wheel loader speed is zero, the first clutch 211 is disengaged and the second clutch 212 is engaged. Thereafter, the swashplate 2315 angle is changed so that the energy accumulation arrangement 231, 232, 234 is allowed to release S6 the stored energy in the propulsion torque flow direction to the wheels 106, 107, via the second clutch 212.

It should be noted that energy may be stored by the energy accumulation arrangement 231, 232, 234 for longer periods of time than what has been suggested in the example above. The energy stored in the energy accumulation arrangement may be kept until some operational situation in which it is useful for increasing the propulsion power of the wheel loader. The energy accumulation arrangement may also be used as an engine start motor. Thereby, the energy may be transported from the energy accumulation arrangement, via one of the first and second clutches, and the transmission, to the engine.

Reference is made to fig. 6 showing a driveline according to a further embodiment of the invention. The driveline in fig. 6 is similar to the driveline in fig. 2, with the following exceptions:

Said hydraulic accumulator is a first accumulator 232, and a reservoir in the form of a second accumulator 233 is hydraulically connected to the hydraulic machine 231 so as for hydraulic fluid to be moved from the first accumulator 232 to the second accumulator 233, and vice versa. The second accumulator 233 is arranged to accumulate the hydraulic fluid at a pressure which is lower than a pressure at which the first accumulator 232 is arranged to accumulate the hydraulic fluid.

A valve arrangement 235 is provided for control of a movement of hydraulic fluid from the first accumulator 232 to the second accumulator 233 via the hydraulic machine 231, and vice versa. The control unit 301 is arranged to control the valve arrangement 235. The

valve arrangement 235 is adapted to provide a four quadrant operation of the hydraulic machine 231.

Reference is made to fig. 7, depicting steps in a method of controlling the driveline in fig. 6. Similarly to the method described with reference to fig. 3, the first and second clutches 211, 212 are controlled S1 for providing a movement of the wheel loader in the forward direction. Thereby, the first clutch 211 is engaged and the second clutch 212 is not engaged. Further, the angle of the valve arrangement 235 is controlled so as for no hydraulic fluid to be moved from the first accumulator 232 to the second accumulator 233, and vice versa.

For changing the driving direction of the wheel loader 1, the first clutch 211 is disengaged S2, and the valve arrangement 235 is controlled S2 so as for hydraulic fluid to be moved from the second accumulator 233 to the first accumulator 232. Thereby, the energy accumulation arrangement 231, 232, 233, 235 is disconnected from the transmission 201, and the intermediate shaft 221 drives the rotatable part of the hydraulic machine 231 so that the energy accumulation arrangement 231, 232, 233, 235 stores energy S3 by pumping hydraulic oil to the first accumulator 232. Thereby, a working machine braking torque is provided, whereby the wheel loader is decelerated.

When the wheel loader speed is zero, the second clutch 212 is engaged S5 for the wheels 106, 107 to be driven by the engine 116 to accelerate the wheel loader in the rearward direction. Also, the valve arrangement 235 is controlled S5 so as for hydraulic fluid to be moved from the first accumulator 232 to the second accumulator 233, whereby the energy accumulation arrangement 231, 232, 233, 235 is allowed to release S6 the stored energy in the propulsion torque flow direction to the wheels 106, 107.

Reference is made to fig. 8 showing a driveline according to another embodiment of the invention. The driveline in fig. 8 is similar to the driveline in fig. 2, with the following exception:

The hydraulic machine 231 is hydraulically connected to a hydraulic system 214 for actuation of the first and second clutches 211, 212. Thereby, a valve arrangement 235 is provided and controllable by the control unit 301, to selectively direct hydraulic fluid from the hydraulic machine 231 to the accumulator 232, or to a valve assembly of the hydraulic

system 214. Thereby, a movement of hydraulic fluid from the hydraulic machine 231 to actuate the clutch 211, 212 may be provided. It should be noted that the hydraulic system 214 may alternatively, or in addition, be arranged for other functions. For example, the hydraulic system 214 may be arranged to provide lubrication and/or cooling of the transfer case 209 and/or the transmission 201. The hydraulic system may alternatively, or in addition, be arranged for further hydraulic functions in the driveline or other systems in the working machine.

Fig. 9 shows a driveline according to yet another embodiment of the invention. The driveline comprises a transfer case 209, arranged to distribute the torque from the engine to front and rear axles 108, 109 of a working machine provided with the driveline. The transfer case comprises a housing 2091. In this simple embodiment the transfer case 209 is arranged to transfer the torque only by means of a gear set between a transfer case input shaft 202 and front and rear wheel drive shafts 241, 242. The driveline also comprises an energy accumulation arrangement 231, 232, arranged to recuperatively brake the working machine when changing the rotational direction of the wheels 106, 107 in relation to the engine 116. The energy accumulation arrangement comprises a kinetic energy conversion device 231 and an energy accumulator 232. The kinetic energy conversion device 231 is mounted to the housing 2091 so as to be supported solely by the housing. A rotatable part 2312 of the kinetic energy conversion device 231 is directly coupled to the transfer case input shaft 202.

Fig. 10 shows a further embodiment of the invention, in which the driveline of a working machine comprises a transfer case 209, which is integrated with a transmission 201, in turn connected to an internal combustion engine 116. The transfer case 209, comprising a housing 2091, is arranged to transfer torque from the engine 116 and the transmission 201 to front and rear wheel drive shafts 241, 242. The driveline comprises an energy accumulation arrangement 231, 232, arranged to recuperatively brake the working machine when changing the rotational direction of the wheels 106, 107 in relation to the engine 116. The energy accumulation arrangement comprises a kinetic energy conversion device, e.g. a hydraulic machine, 231 and an energy accumulator 232. The kinetic energy conversion device 231 is mounted to the housing 2091 so as to be supported solely by the housing. A rotatable part 2312 of the kinetic energy conversion device 231 is directly coupled to a transfer case shaft.

Fig. 11 shows parts of a driveline of a working machine, according to an additional embodiment of the invention. The driveline comprises a transfer case 209 which is mounted to a transmission 201, shown partly. The transfer case 209 comprises a housing 2091. A kinetic energy conversion device, in the form of a hydraulic machine 231, of an energy accumulation arrangement is mounted to the housing 2091 via a flange 2318. Thereby, the hydraulic machine 231 is supported solely by the housing 2091.

Fig. 12 illustrates an implementation of an embodiment of the invention in a working machine in the form of an articulated hauler 1, described in US20100292049, incorporated herein by reference. A driveline comprises a transfer case 209 arranged to distribute the torque from an internal combustion engine 116 and a transmission 201 to front and rear wheel drive shafts 241, 242, in turn arranged to drive a front axle 108 and two rear axles 109, respectively. The transfer case 209 comprises a housing 2091. The driveline also comprises an energy accumulation arrangement 231, 232, arranged to recuperatively brake the articulated hauler 1 when changing the rotational direction of the wheels in relation to the engine 116. The energy accumulation arrangement comprises a kinetic energy conversion device in the form of a hydraulic machine 231 and an energy accumulator 232. The hydraulic motor 231 is mounted to the housing 2091 so as to be supported solely by the housing.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims. For example, the energy accumulation arrangement may comprise an electric machine electrically connected to an electric energy storage unit, wherein the rotatable part is a rotor of the electric machine.

CLAIMS

1. A working machine driveline arranged to transfer torque from an internal combustion engine (116) of the working machine to at least one front wheel axle (108) and at least one rear wheel axle (109) of the working machine, the driveline comprising an energy accumulation arrangement (231, 232, 233, 234, 235) with a kinetic energy conversion device (231), arranged to recuperatively brake the working machine, characterized in that the driveline comprises a transfer case (209) arranged to distribute the torque from the engine to the front and rear axles (108, 109), the transfer case comprising a housing (2091), the kinetic energy conversion device (231) being mounted to the housing (2091) so as to be supported solely by the housing.

2. A driveline according to claim 1, characterized in that the kinetic energy conversion device (231) comprises a casing (2311) and a rotatable part (2312, 2313, 2314, 2315), the casing being mounted to the housing (2091) of the transfer case (209).

3. A driveline according to any one of the preceding claims, characterized in that the kinetic energy conversion device (231) comprises a casing (2311) and a rotatable part (2312, 2313, 2314, 2315), the rotatable part being directly coupled to a shaft (202, 205, 221) of the transfer case.

4. A driveline according to any one of the preceding claims, characterized in that the driveline is arranged to provide a propulsion torque flow in a direction from the engine (116) to the wheel axles (108, 109), and the transfer case (209) is arranged to provide, in the propulsion torque flow direction, a vertical drop.

5. A driveline according to any one of the preceding claims, characterized in that the kinetic energy conversion device (231) is mounted on a side (2092) of the transfer case (209) which is opposite to a side (2093) of the transfer case which receives a transfer case input shaft (202).

6. A driveline according to any one of the preceding claims, characterized in that the driveline is arranged to provide a propulsion torque flow in a direction from the engine (116) to the wheel axles (108, 109), the kinetic energy conversion device

comprising a rotatable part (2312, 2313, 2314, 2315), the driveline comprising a transmission (201) arranged to selectively provide a plurality of gear ratios between the engine (116) and the wheel axles (108, 109), wherein the rotatable part (2312, 2313, 2314, 2315) is downstream of the transmission (201) in the propulsion torque flow direction.

7. A driveline according to any one of the preceding claims, characterized in that the driveline comprises a driving direction change arrangement (211, 212) for changing the rotational direction of the front and rear axles (108, 109) in relation to the engine (116).

8. A driveline according to claim 7, characterized in that the driving direction change arrangement (211, 212) forms a part of the transfer case (209).

9. A driveline according to any one of claims 7-8, characterized in that the driveline is arranged to provide a propulsion torque flow in a direction from the engine (116) to the wheel axles (108, 109), the kinetic energy conversion device comprising a rotatable part (2312, 2313, 2314, 2315), and the rotatable part (2312, 2313, 2314, 2315) is located downstream of the driving direction change arrangement (211, 212) in the propulsion torque flow direction.

10. A driveline according to any one of claims 7-8, characterized in that the driveline is arranged to provide a propulsion torque flow in a direction from the engine (116) to the wheel axles (108, 109), the kinetic energy conversion device comprising a rotatable part (2312, 2313, 2314, 2315), and the rotatable part (2312, 2313, 2314, 2315) is located upstream of the driving direction change arrangement (211, 212) in the propulsion torque flow direction.

11. A driveline according to any one of the preceding claims, characterized in that the kinetic energy conversion device is a hydraulic machine (231) hydraulically connected to a hydraulic accumulator (232).

12. A driveline according to claim 11, characterized in that the hydraulic machine (231) is a variable displacement hydraulic machine (231).

13. A driveline according to any one of claims 11-12, characterized in that a reservoir (233, 234) is hydraulically connected to the hydraulic machine (231), a valve arrangement (235) being provided for control of a movement of hydraulic fluid from the hydraulic accumulator (232) to the reservoir (233, 234) via the hydraulic machine, and vice versa.

14. A driveline according to claim 13, characterized in that the valve arrangement (235) is adapted to provide a four quadrant operation of the hydraulic machine.

15. A driveline according to any one of claims 11-14, characterized in that said hydraulic accumulator is a first accumulator (232), and a second accumulator (233) is hydraulically connected to the hydraulic machine (231) so as for hydraulic fluid to be moved from the first accumulator (232) to the second accumulator (233), and vice versa, the second accumulator (233) being arranged to accumulate the hydraulic fluid at a pressure which is lower than a pressure at which the first accumulator (232) is arranged to accumulate the hydraulic fluid.

16. A driveline according to any one of claims 11-15, characterized in that the hydraulic machine is hydraulically connected to a hydraulic system (214) for cooling, lubrication, and/or actuation of the driving direction change arrangement (211, 212).

17. A driveline according to any one of the preceding claims, characterized in that the kinetic energy conversion device (231) is an electric machine electrically connected to an electric energy storage unit.

18. A method for controlling a working machine driveline arranged to provide a propulsion torque flow in a direction from an internal combustion engine (116) of the working machine to at least one front wheel axle (108) and at least one rear wheel axle (109) of the working machine, the driveline comprising a transmission (201) arranged to selectively provide a plurality of gear ratios between the engine (116) and the front and rear axles (108, 109), characterized by

- controlling a driving direction change arrangement (211, 212) for providing a movement of the working machine in a first direction by means of the propulsion torque flow,

- controlling, while the working machine is moving in the first direction, an energy accumulation arrangement (231, 232, 233, 234, 235) of the driveline to store, downstream of the transmission (201) in the propulsion torque flow direction, energy from a working machine braking torque directed in opposite to the propulsion torque flow direction,
- and, before the control of the energy accumulation arrangement (231, 232, 233, 234, 235) to store the energy, controlling the driving direction change arrangement (211, 212) to disconnect the energy accumulation arrangement (231, 232, 233, 234, 235) from the transmission.

19. A method according to claim 18, characterized by controlling the energy accumulation arrangement (231, 232, 233, 234, 235) to release from downstream of the transmission (201), the stored energy in the propulsion torque flow direction.

20. A method according to claim 19, characterized by, after initiation of the control of the energy accumulation arrangement (231, 232, 233, 234, 235) to release the energy, controlling the driving direction change arrangement (211, 212) to connect the transmission (201) to the front and rear axles (108, 109).

21. A method for controlling a working machine driveline arranged to provide a propulsion torque flow in a direction from an internal combustion engine (116) of the working machine to at least one front wheel axle (108) and at least one rear wheel axle (109) of the working machine, the driveline comprising a transmission (201) arranged to selectively provide a plurality of gear ratios between the engine (116) and the front and rear axles (108, 109), characterized by
- controlling a driving direction change arrangement (211, 212) to provide a movement of the working machine in a first direction by means of the propulsion torque flow, the driving direction change arrangement (211, 212) comprising a hydraulically actuatable clutch (211, 212),
- controlling, while the working machine is moving in the first direction, an energy accumulation arrangement (231, 232, 233, 234, 235) of the driveline to store energy from a working machine braking torque directed in opposite to the propulsion torque flow direction, the energy accumulation arrangement comprising a hydraulic machine (231),

- and controlling a valve arrangement (235) to control a movement of hydraulic fluid from the hydraulic machine (231) to actuate the clutch (211, 212).

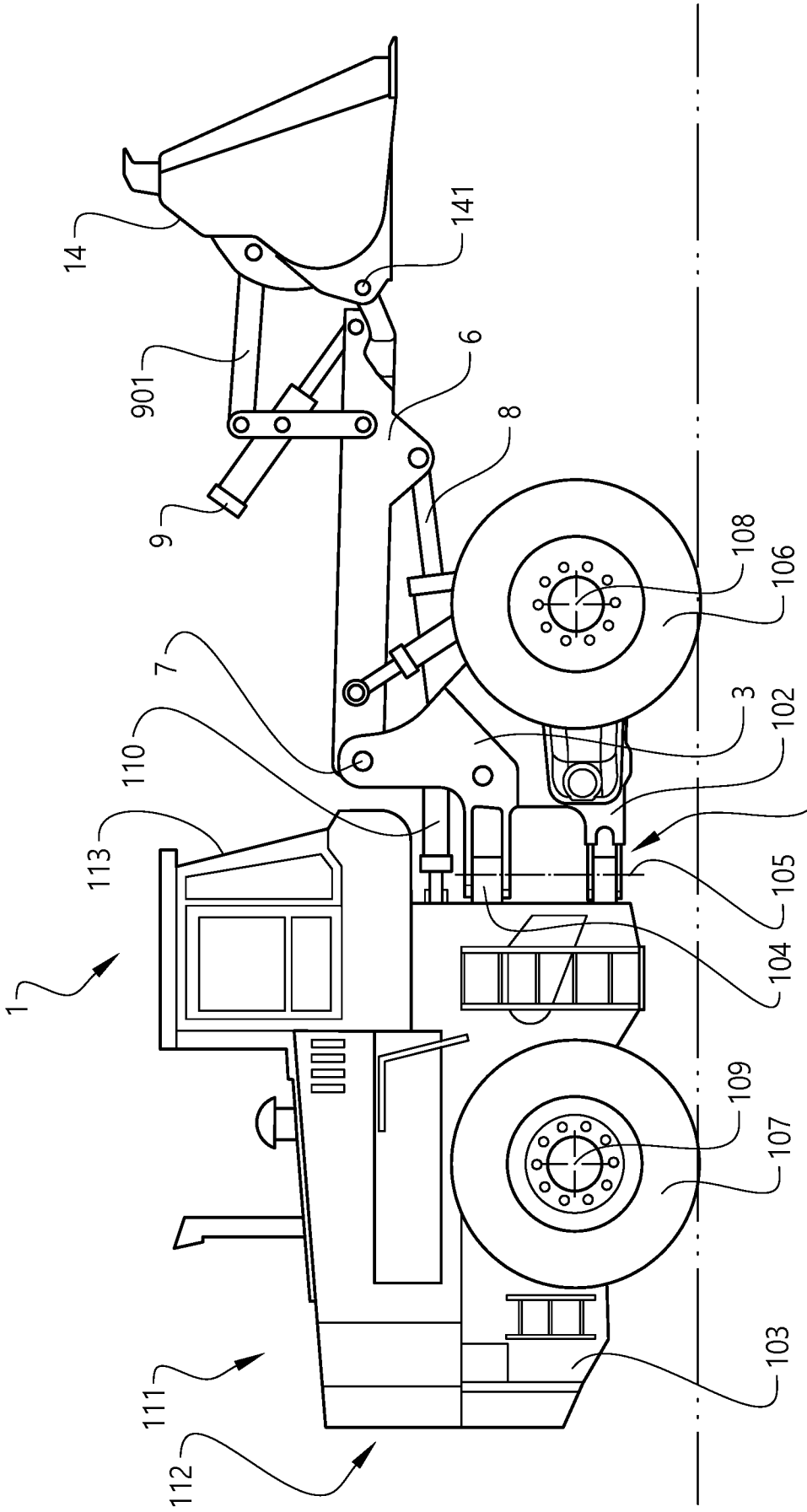
22. A method according to any one of claims 18-21, characterized by controlling the driving direction change arrangement (211, 212) to connect the energy accumulation arrangement (231, 232, 233, 234, 235) to the transmission (201), and controlling the energy accumulation arrangement (231, 232, 233, 234, 235) to release, from downstream of the transmission (201), the stored energy opposite to the propulsion torque flow direction.

23. A computer program comprising program code means for performing the steps of any of claims 18-22 when said program is run on a computer.

24. A computer readable medium, carrying a computer program comprising program code means for performing the steps of any of claims 18-22 when said program product is run on a computer.

25. A control unit configured to perform the steps of the method according to any of claims 18-22.

26. A working machine comprising a driveline according to any one of claims 1-17 or a control unit according to claim 25.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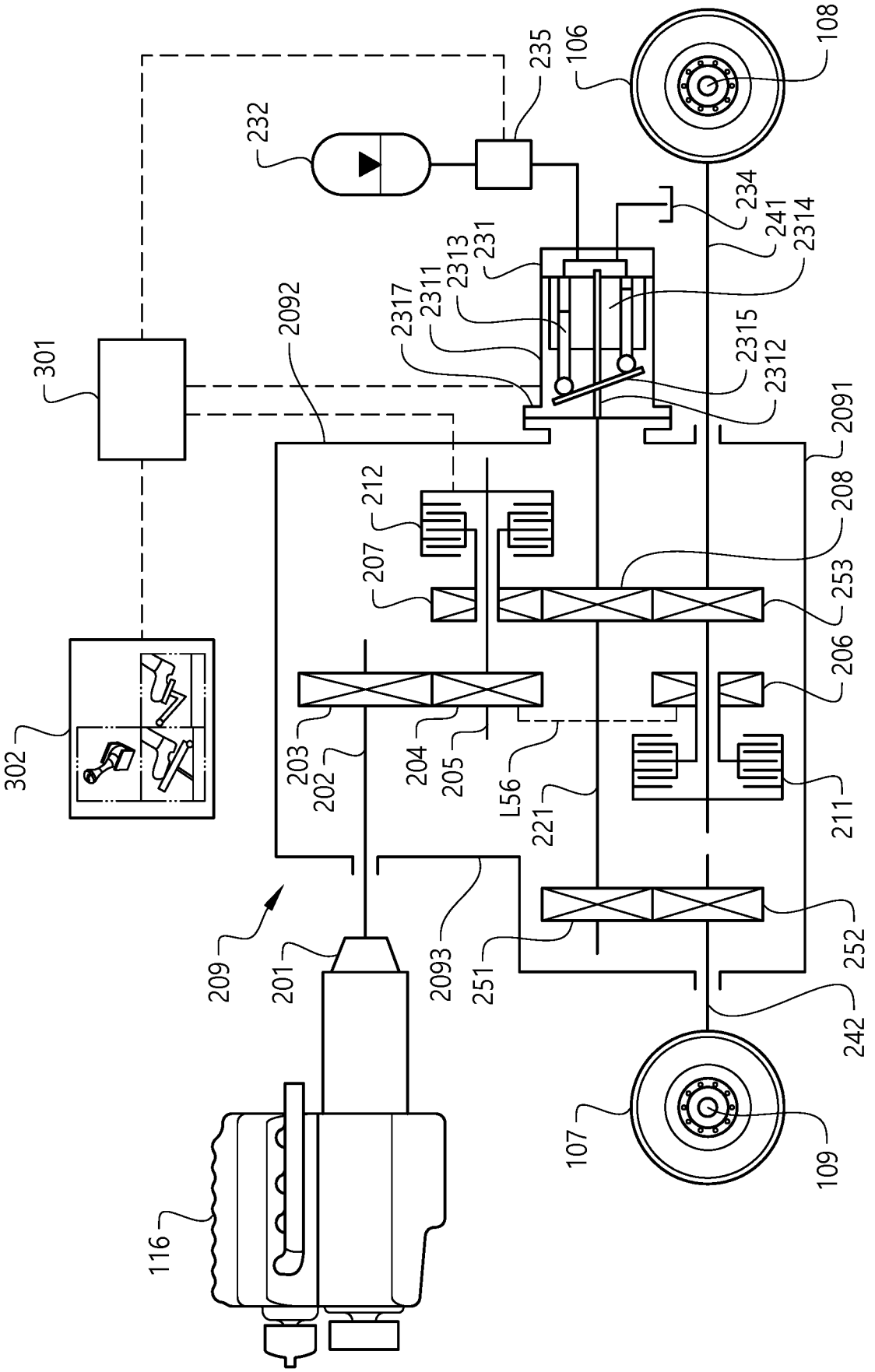
112

FIG. 1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108
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241
2314
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2313
2311
2317
2092
301
2315
2312
2091
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253
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201
2093
251
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107
109
116

FIG. 2

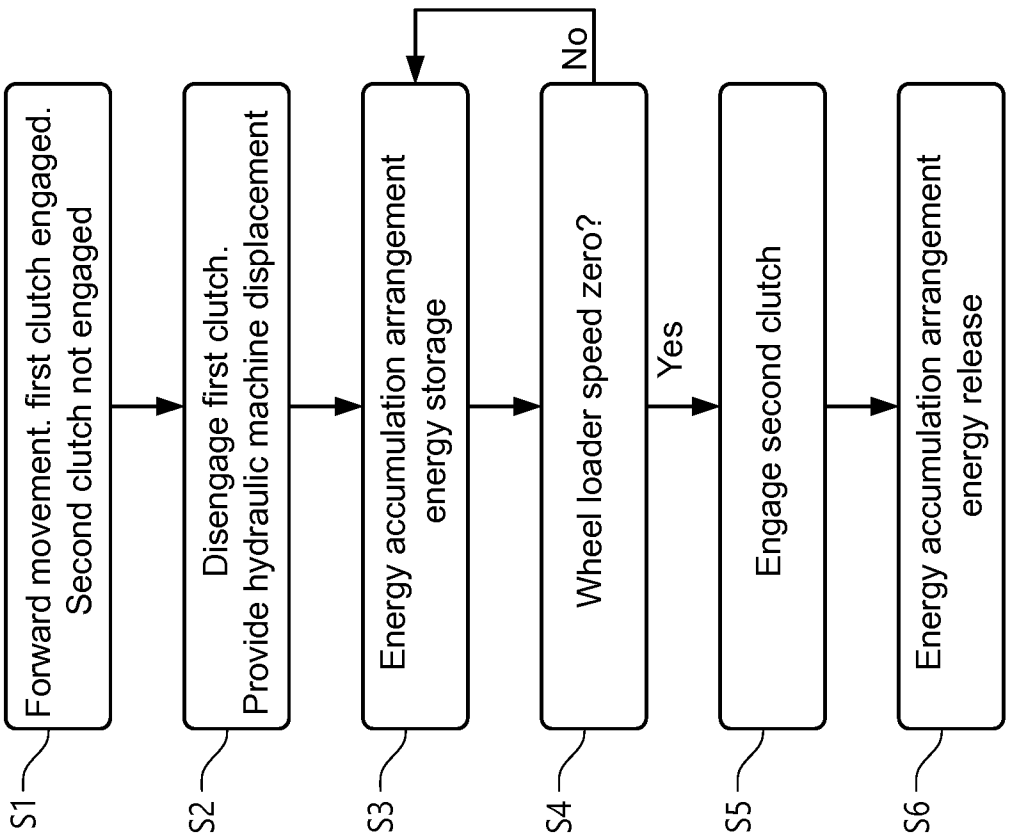

Forward movement. first clutch engaged. Second clutch not engaged
Disengage first clutch. Provide hydraulic machine displacement
Energy accumulation arrangement energy storage
Wheel loader speed zero?
No
Yes
Engage second clutch
Energy accumulation arrangement energy release
S1
S2
S3
S4
S5
S6

FIG. 3

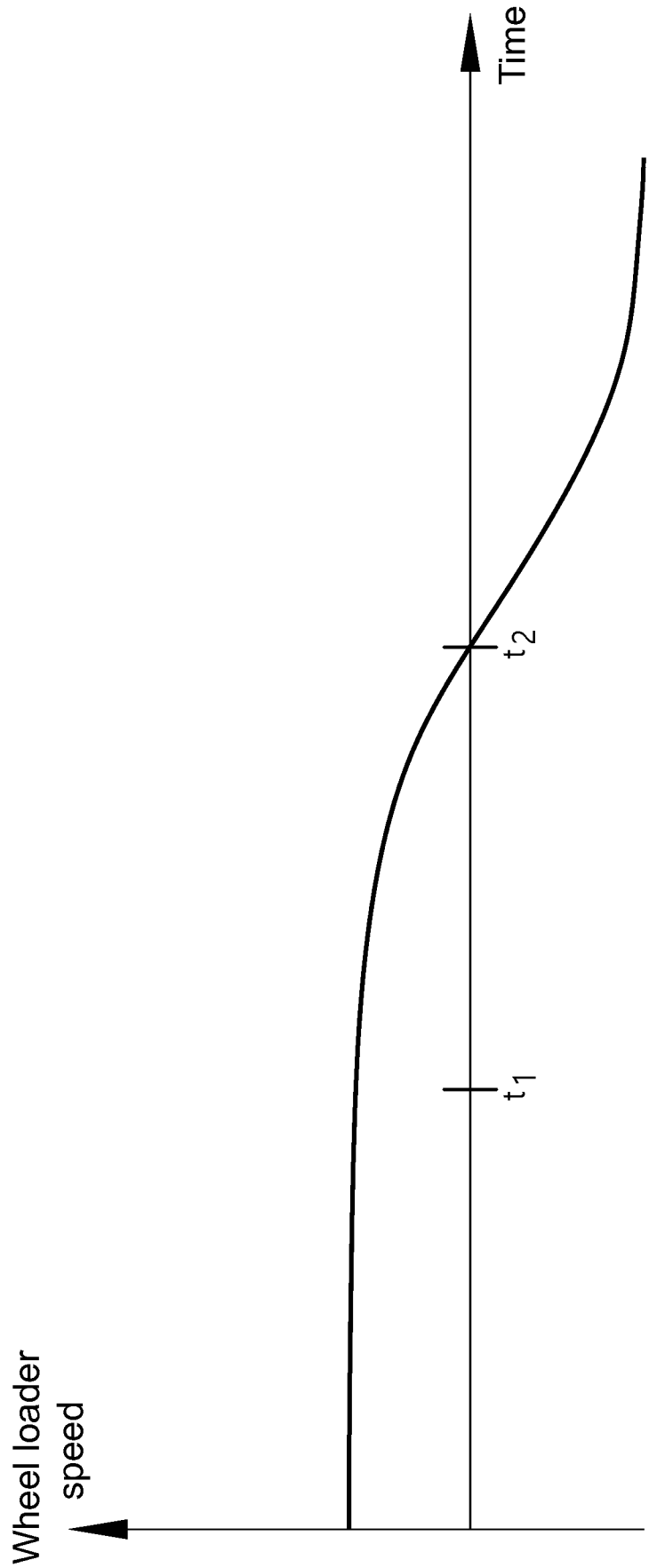


FIG. 4

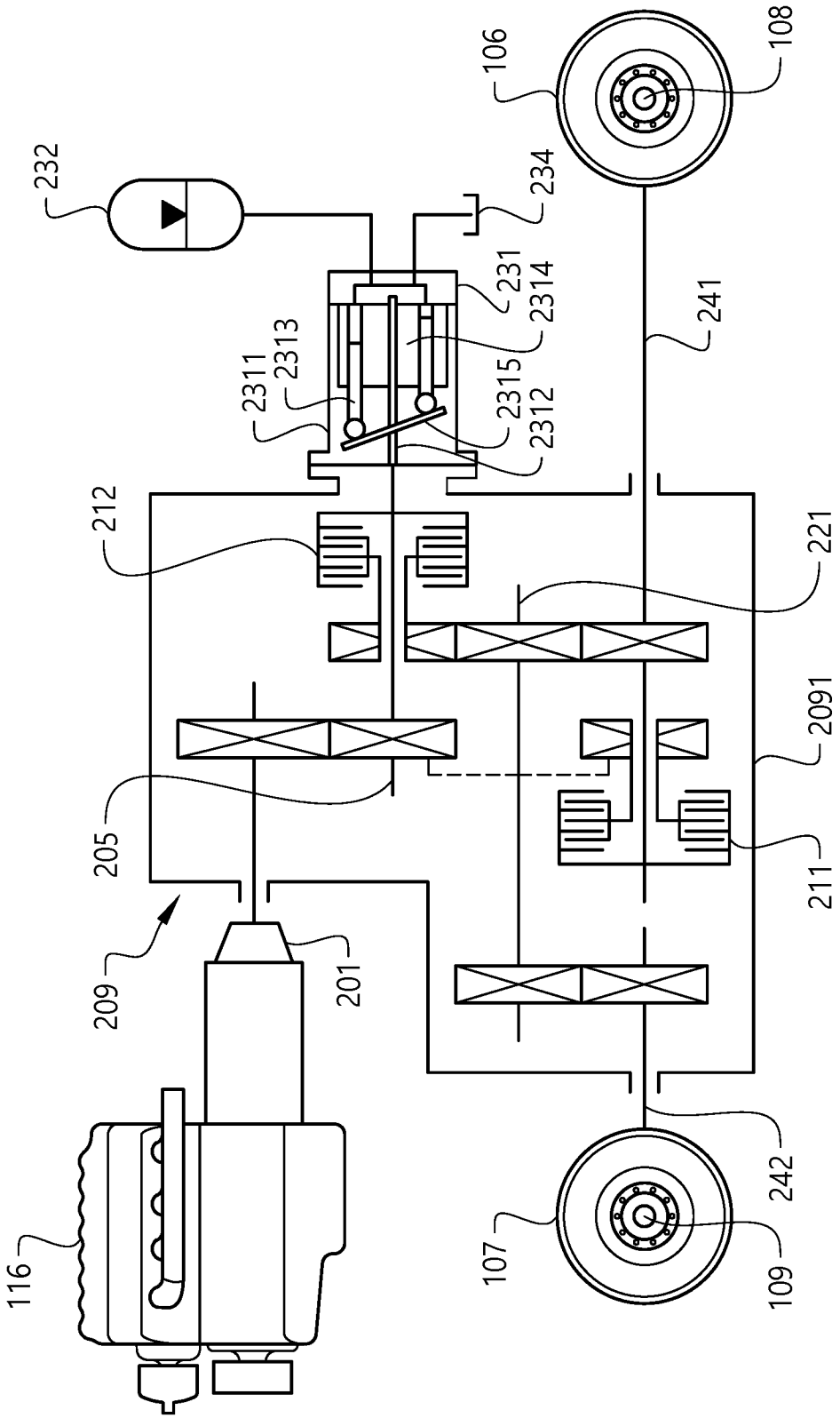
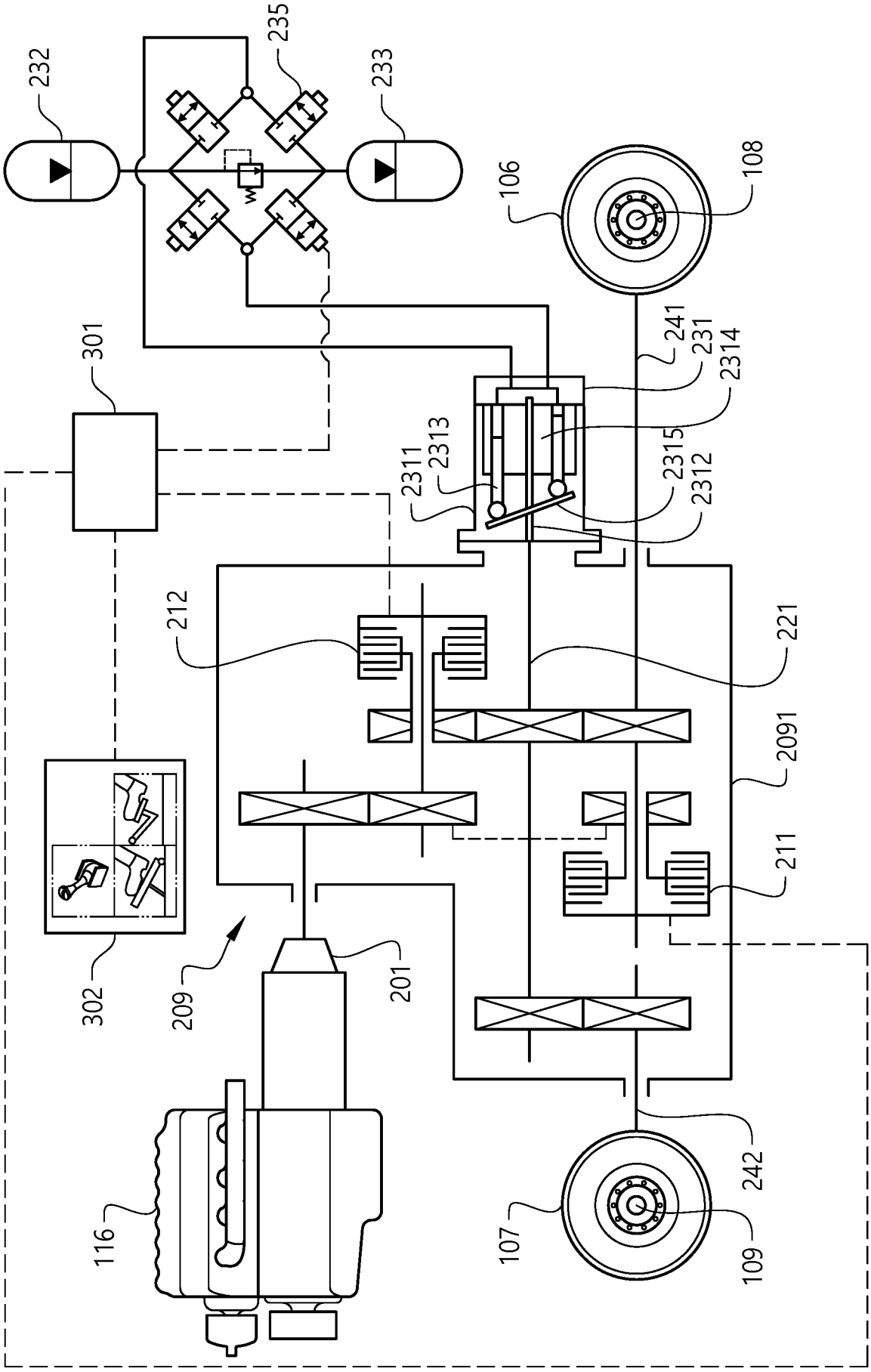

232
106
108
234
231
2314
241
2311
2313
2315
2312
212
221
2091
205
211
209
201
116
107
242
109

FIG. 5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106
108
301
241
231
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221
2091
211
302
209
201
116
242
107
109

FIG. 6

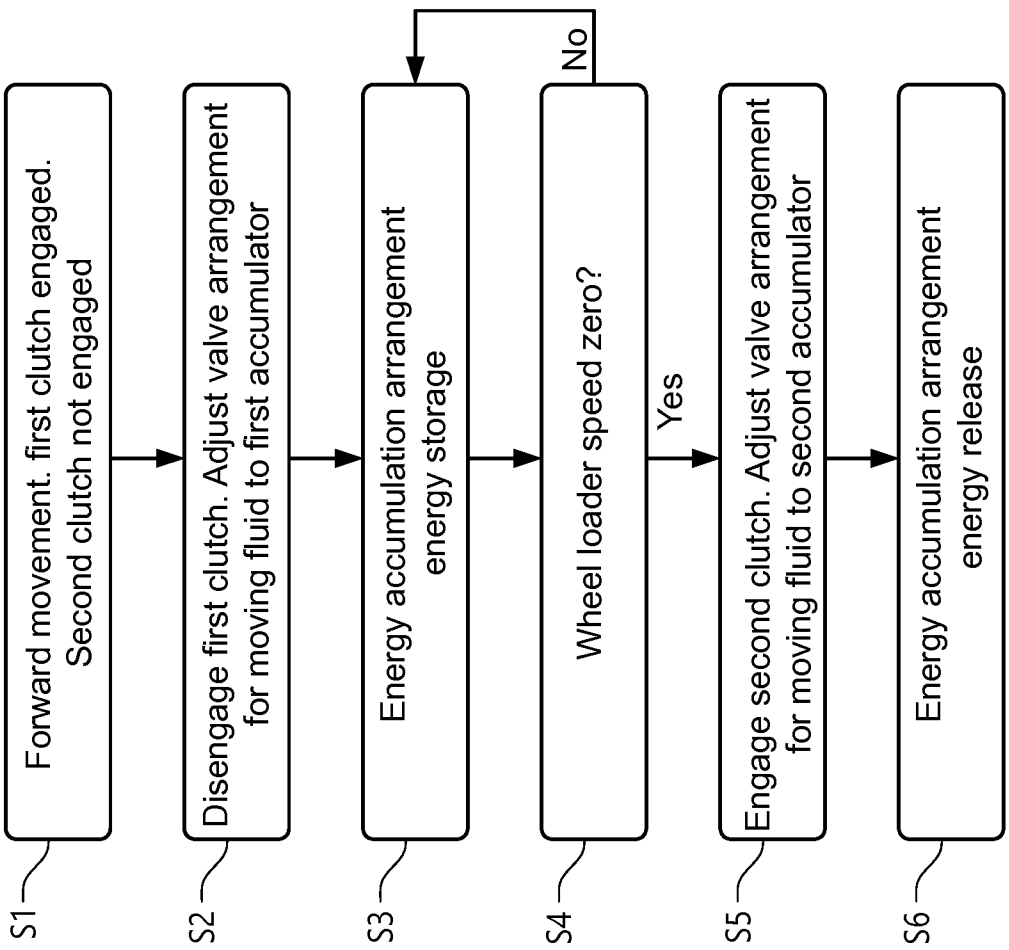
Forward movement. first clutch engaged. Second clutch not engaged
Disengage first clutch. Adjust valve arrangement for moving fluid to first accumulator
Energy accumulation arrangement energy storage
Wheel loader speed zero?
No
Yes
Engage second clutch. Adjust valve arrangement for moving fluid to second accumulator
Energy accumulation arrangement energy release
S1
S2
S3
S4
S5
S6

FIG. 7

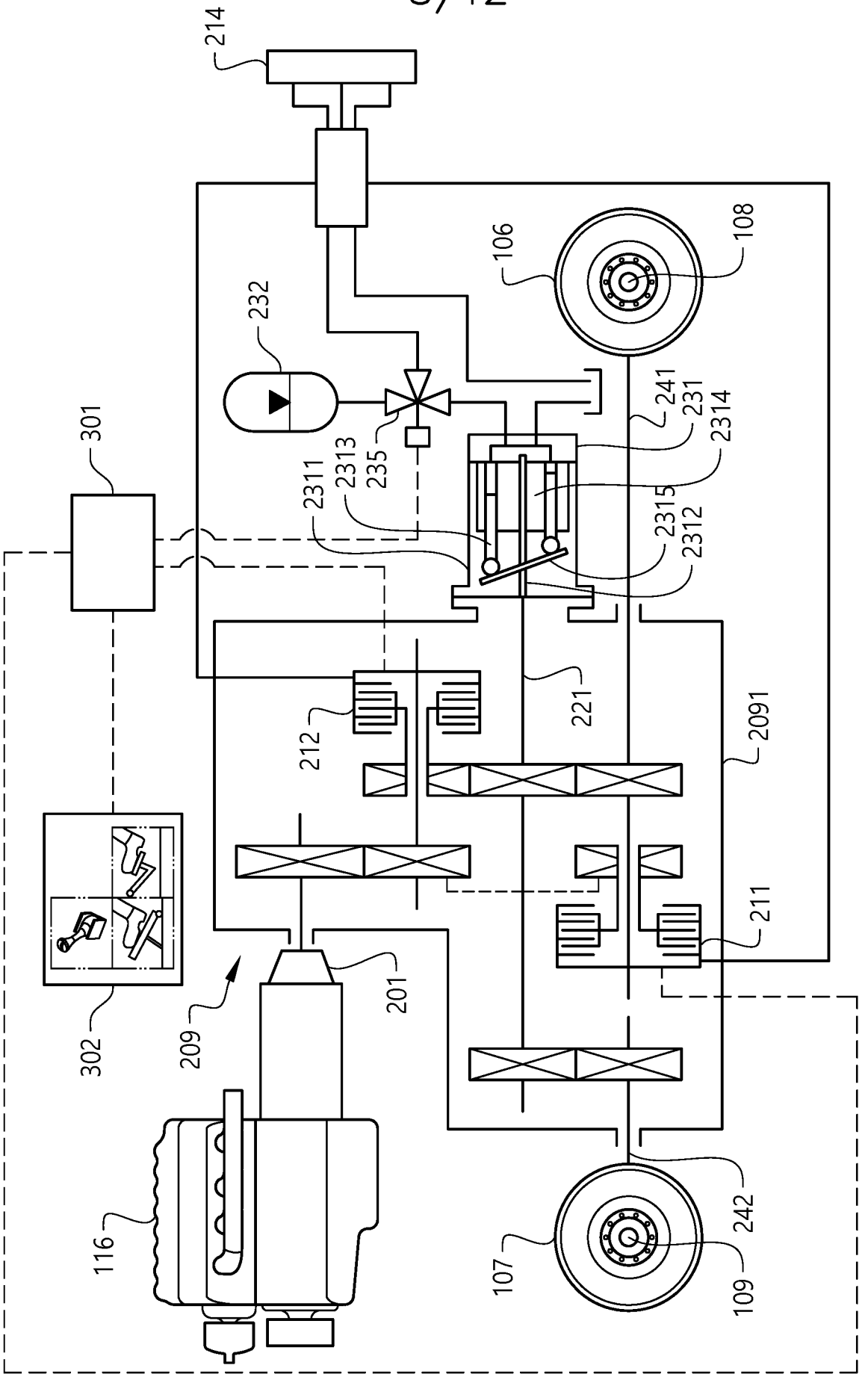
214
106
108
232
241
231
2314
301
2313
235
2311
2315
2312
221
2091
212
211
201
209
302
116
107
242
109

FIG. 8

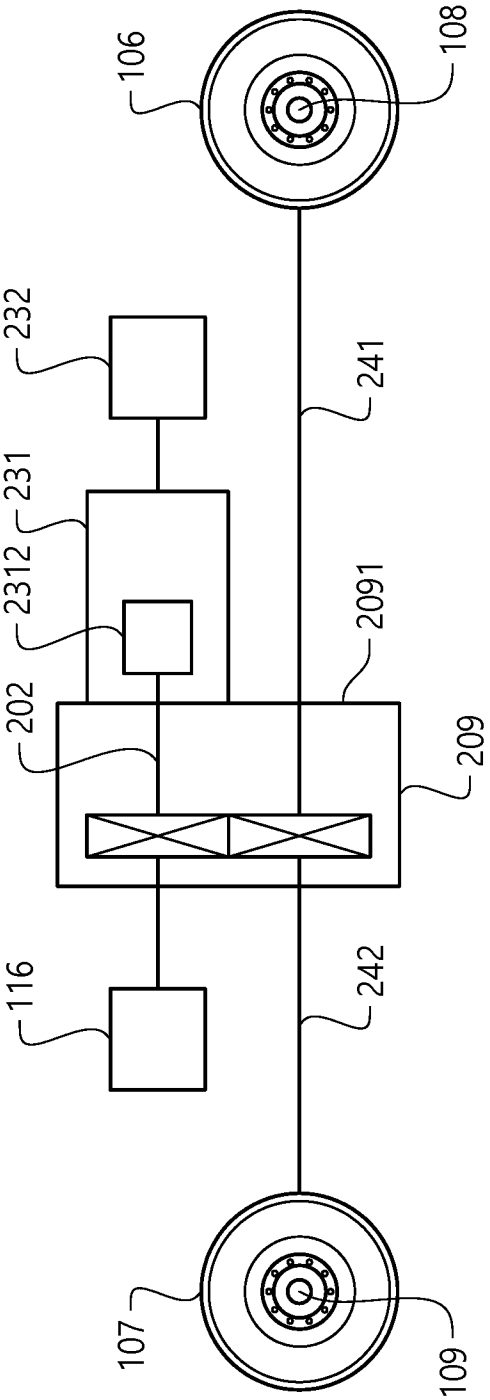

FIG. 9

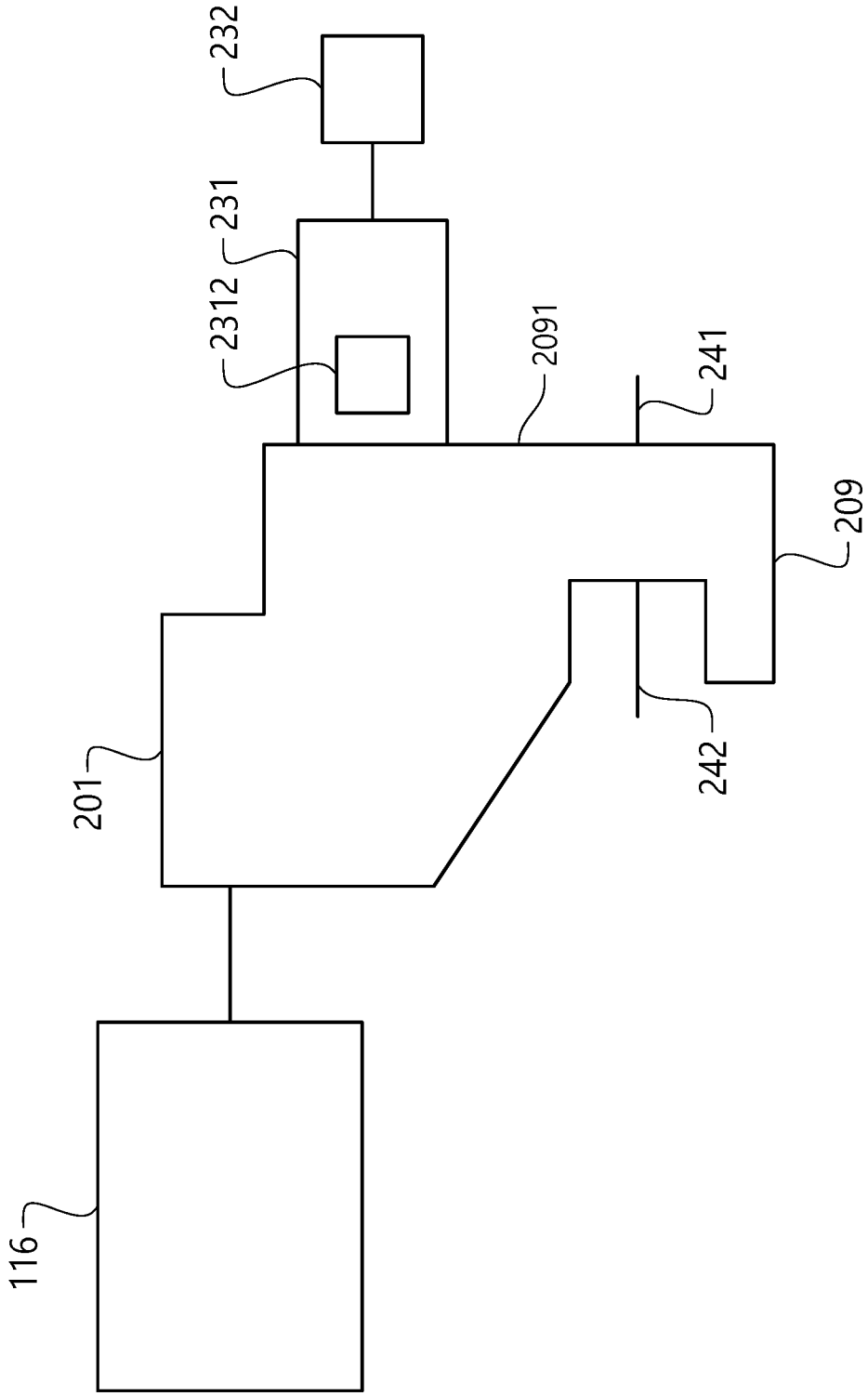

FIG. 10

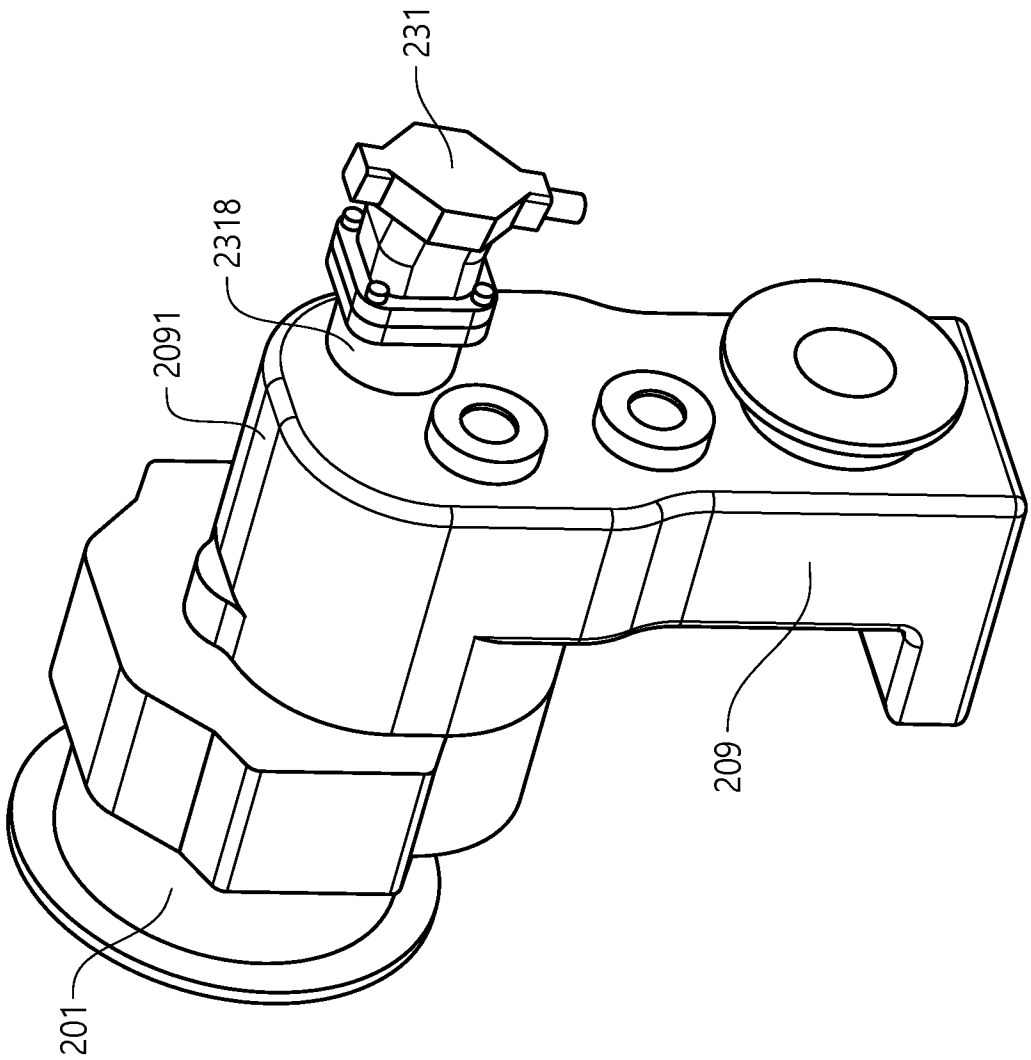

FIG. 11

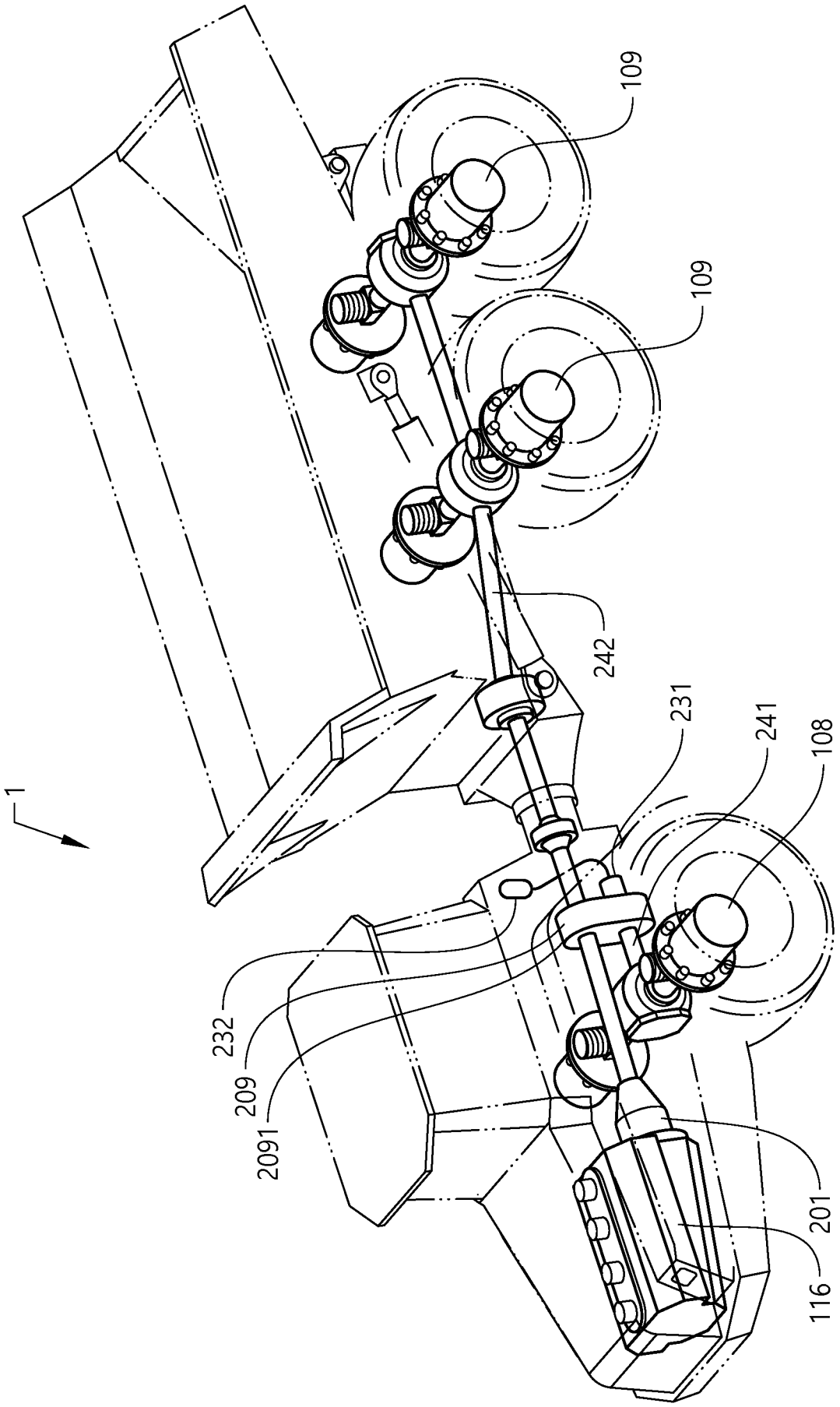

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/060808

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02F9/08 B60K6/12 B60K6/365 B60K6/52 E02F9/20
E02F9/22
ADD.
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)
E02F B60K

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/267233 A1 (WENTHEN DAVID [US]) 22 November 2007 (2007-11-22) figure 1 to 7 paragraph [0002] paragraph [0025] -----	1,4-6, 17,26
X	US 2016/221448 A1 (PRITCHARD LARRY A [US]) 4 August 2016 (2016-08-04) figure 1 to 3 paragraph [0021] paragraph [0002] paragraph [0014] -----	1,4-6,26
X	GB 2 415 670 A (FORD GLOBAL TECH LLC [US]) 4 January 2006 (2006-01-04) page 8, line 18 - line 26 figure 1 page 9, line 22 - line 35 ----- -/--	1-6,26

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 January 2018	23/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bultot, Coralie

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/060808

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/170573 A1 (DRAPER DON R [US] ET AL) 8 July 2010 (2010-07-08) figure 1 to 3 paragraph [0013] paragraph [0016] -----	1,4,6,26
A	WO 2016/159846 A1 (VOLVO CONSTR EQUIP AB [SE]) 6 October 2016 (2016-10-06) abstract; figures 1-4 -----	1

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/060808

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-6, 17, 26

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 17, 26

The driveline wherein the kinetic energy conversion device comprises a casing /or the transfer case is arranged to provide a vertical drop and/or the kinetic energy conversion device is mounted on a side of the transfer case /or the rotatable part of the kinetic energy conversion device is downstream of the transmission of the driveline;
and
The driveline wherein the regenerative stored energy is electric.

1.1. claims: 1-6, 26

The driveline wherein the kinetic energy conversion device comprises a casing /or the transfer case is arranged to provide a vertical drop and/or the kinetic energy conversion device is mounted on a side of the transfer case /or the rotatable part of the kinetic energy conversion device is downstream of the transmission of the driveline.

1.2. claim: 17

The driveline wherein the regenerative stored energy is electric.

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2. claims: 7-10

The driveline wherein the driving direction change arrangement forms part of the transfer case.

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3. claims: 11-16, 21-26

A method for controlling a working machine driveline further comprises the step of controlling a valve arrangement to control a movement of hydraulic fluid from the hydraulic machine - for recovery of braking energy - to actuate the clutch of the driving direction change arrangement; and its corresponding device in form of a driveline wherein the kinetic energy conversion device in the form of a hydraulic machine is connected to a hydraulic system for cooling, lubrication and/or actuation of the driving direction arrangement.

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4. claims: 18-20, 23-25

A method for controlling a working machine driveline further comprises the step of controlling, before the control of the energy accumulation arrangement to store the energy, the

driving direction change arrangement to disconnect the energy accumulation arrangement from the transmission

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/060808

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007267233 A1	22-11-2007	NONE	
US 2016221448 A1	04-08-2016	DE 102016201586 A1	04-08-2016
		US 2016221448 A1	04-08-2016
GB 2415670 A	04-01-2006	DE 102005027941 A1	09-02-2006
		GB 2415670 A	04-01-2006
		US 2006004507 A1	05-01-2006
US 2010170573 A1	08-07-2010	US 2010170573 A1	08-07-2010
		WO 2010080808 A1	15-07-2010
WO 2016159846 A1	06-10-2016	NONE	