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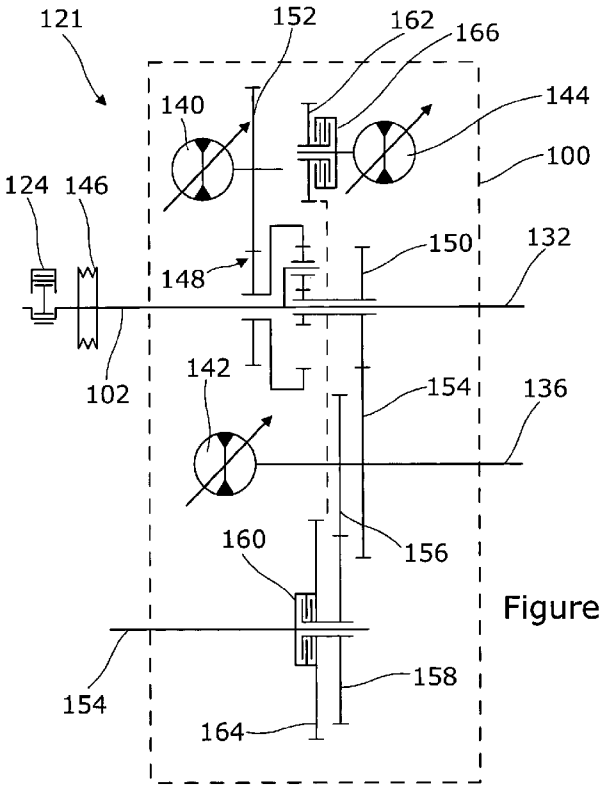

Figure 4

(57) Abstract: A continuously variable transmission for an agricultural vehicle, the transmission comprising a transmission casing and transmission components, the components including: an input shaft drivable by a prime mover, an output drive shaft for connection to driven wheels of the vehicle, a hydrostatic transmission branch having a hydraulic pump driveable by the input shaft, and first and hydraulic second motors hydraulically driveable by the pump, wherein the first hydraulic motor is positioned within a first quadrant of the transmission, the second hydraulic motor is positioned within a second quadrant of the transmission, the hydraulic pump is positioned within a third quadrant of the transmission,and the output drive shaft is at least partly positioned within a fourth quadrant of the transmission.

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AGRICULTURAL VEHICLE TRANSMISSION

The present invention relates to vehicle transmissions and in particular, but not exclusively, to a transmission adaptable for use with a variety of configurations of agricultural vehicles, such as tractors.

Transmissions form part of the driveline tractors. The purpose of the driveline is to transmit torque from the engine (most usually an internal combustion engine and/or or electric motor) to the wheels (or tracks as may be the case in larger tractors). In addition to the engine and transmission, the driveline may also include a flywheel; one or more clutches; a transfer box; and front, centre and rear differentials.

The configuration of the driveline depends on the specific type of tractor, for example whether the vehicle is rear wheel drive or four wheel drive, front wheel steered or centrally articulated, tracked or provided with conventional wheels and tyres. Each variation of driveline requires a different transmission layout.

Additionally, the transmission may be required to drive front and/or rear power take off (PTO) shafts to allow the tractor to operate ancillary equipment such as seed drills and bailers.

By way of an example, a rear wheel drive tractor with steered front wheels would not require a front differential or a front output shaft from the transmission, but would require a rear output shaft and a rear differential. In addition it may be provided with front and/or rear PTO shafts.

In contrast, a tracked tractor would not require an output shaft from the transmission to the front wheels, but would require a rear drive shaft and rear differential capable of splitting the torque between the left and right tracks in order to steer the tractor. Furthermore, the rear output shaft of a tracked tractor would be repositioned with respect to the tired tractor due to the smaller size of the wheels driving the track.

Historically, the provision of different transmissions for each configuration of vehicle has necessitated the design and development of a distinct transmission for each

particular application. This has led to the parallel development of transmissions for each of the following commonly provided configuration of tractor:

a) standard tractors with undriven and steered front wheels of smaller diameter and driven rear wheels of larger diameter;
b) four wheel drive standard tractors with steered and driven front wheels of smaller diameter and driven rear wheels of larger diameter; and
c) tracked tractors where only the rear track wheels, not the front idler wheels, are driven whereby the rear track wheels are at a lower level relative to the chassis.

It is therefore advantageous to provide a transmission that is adaptable to a number of different configurations of vehicle. However, such a solution can lead to a transmission which takes up a significant amount of space within the vehicle chassis. However the space available in modern agricultural vehicles is limited. This is especially the case where vehicle performance continues to improve (for example by improved cooling) while the outer dimensions of vehicles cannot be increased accordingly.

It is an objective of the present invention to at least mitigate one or more of the above problems.

According to an aspect of the invention there is provided a continuously variable transmission for an agricultural vehicle, the transmission comprising a transmission casing and transmission components,

the components including:

an input shaft drivable by a prime mover,

an output drive shaft for connection to driven wheels of the vehicle,

a hydrostatic transmission branch having a hydraulic pump driveable by the input shaft, and first and hydraulic second motors hydraulically driveable by the pump,

wherein

the first hydraulic motor is positioned within a first quadrant of the transmission,

the second hydraulic motor is positioned within a second quadrant of the transmission,

the hydraulic pump is positioned within a third quadrant of the transmission,

and the output drive shaft is at least partly positioned within a fourth quadrant of the transmission.

Advantageously, the provision of a transmission with four separate quadrants which each contain the one of the pump, motors output shafts provides for the most efficient use of space within the transmission. This has two benefits. Firstly, the size of the transmission is minimised, and secondly the maximum flexibility in terms of variability of the transmission to provide for different configurations of vehicle is achieved.

Preferably, the output shaft is a pinion shaft.

Alternatively, the output shaft is connected to a cardan shaft.

Preferably, the output shaft is carried by at least one bearing, the at least one bearing being supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the pump.

Preferably, the pinion shaft carries a pinion gear which sits at least partly inboard of the outer profile of the first motor, the second motor and the pump.

Advantageously, this allows the transmission to fit into a small a profile as possible. In prior art transmissions, the pinion is positioned outboard of the outer profile of the motor. Thus, the transmission of the present invention is reduced in length compared to known transmissions which delivers significant advantages in terms of packaging within the vehicle and cost of manufacture.

According to a second aspect of the invention there is provided a continuously variable transmission for an agricultural vehicle, the transmission comprising a transmission casing and transmission components,

the components including:

an input shaft drivable by a prime mover,

an output drive shaft for connection to driven wheels of the vehicle,

an electrical transmission branch having a generator driveable by the input shaft, and first and second electric motors powered by the generator,

wherein

the first electric motor is positioned within a first quadrant of the transmission,

the second electric motor is positioned within a second quadrant of the transmission,

the generator is positioned within a third quadrant of the transmission,

and the output drive shaft is at least partly positioned within a fourth quadrant of the transmission.

Preferably, the output shaft is a pinion shaft.

Alternatively, the output shaft is connected to a cardan shaft.

Preferably, the output shaft is carried by at least one bearing, the at least one bearing being supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the generator.

Preferably, the output shaft is carried by two bearings supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the generator.

Preferably, the pinion shaft carries a pinion gear which sits at least partly inboard of the outer profile of the first motor, the second motor and the generator.

Advantageously, this allows the transmission to fit into a small a profile as possible. In prior art transmissions, the pinion is positioned outboard of the outer profile of the motor. Thus, the transmission of the present invention is reduced in length compared to known transmissions which delivers significant advantages in terms of packaging within the vehicle and cost of manufacture.

Preferably, the transmission includes a mechanical transmission branch which transfers torque mechanically from the input shaft to the output shaft.

The invention will now be described, by way of example only, and with reference to the following drawings, in which:

Figure 1 is a schematic layout of a prior art drivetrain;

Figures 2A to 2D are schematic views of alternative prior art drivetrains;

Figure 2E is a schematic plan view of a prior art drivetrain;

Figure 3 is a representation of a standard tractor including a transmission according to the present invention;

Figure 4 is a schematic representation of the driveline of the tractor of Figure 3, including a first configuration of the transmission of the present invention;

Figure 5 is a plan view of the layout of first transmission configuration of Figure 4;

Figure 6 is an elevated rear view of the layout of the first transmission configuration of Figure 4;

Figure 7 is a rear view of the layout of the first transmission configuration of Figure 4;

Figure 8 is a schematic representation of an alternative tractor driveline including a second configuration of the transmission of the present invention;

Figure 9 is a plan view of the layout of the second transmission configuration of Figure 8;

Figure 10 is an elevated rear view of the layout of the second transmission configuration of Figure 8;

Figure 11 is a rear view of the layout of the second transmission configuration of Figure 8;

Figure 12 is a schematic representation of a third transmission configuration of the transmission of the present invention;

Figure 13 is a schematic representation of a fourth transmission configuration of the transmission of the present invention;

Figure 14 is a schematic representation of a fifth transmission configuration of the transmission of the present invention;

Figure 15 is a schematic representation of a sixth transmission configuration of the transmission of the present invention;

Figure 16 is a schematic representation of a seventh transmission configuration of the transmission of the present invention;

Figure 17 is a schematic rear view of the transmission of the present invention;

Figure 18 is a schematic front view of the transmission of the present invention; and

Figure 19 is a schematic side view of the transmission of the present invention.

Figure 20 is a top view of the transmission of the present invention.

Referring to Figure 1, a tractor 1 has an engine 2 providing drive to a transmission 3 which in turn has a rear PTO shaft 4 and a rear output shaft 5. The rear output shaft 5 drives a transfer box 6 and a rear axle 7 via a rear differential 11. The transfer box 6 has a front drive shaft 8 which drives a front axle 9. It can be seen that the transfer box 6 does not form part of the transmission 3 and serves to drop the front drive shaft 8 by a vertical distance A relative to the rear output shaft 5.

Figures 2A to 2D show alternative uses of the "bolt-on" transfer box 6 to alter the relative vertical displacements of the output shafts. Figure 2A replicates part of the

view of Figure 2 and once again shows the relative vertical distance A between front drive shaft 8 and the rear output shaft 5 for ease comparison with Figures 2B to 2D. Figure 2B shows the use of a second configuration of transfer box 6B which raises the height of the rear differential 11 by a distance B relative to the rear output shaft 5. Figure 2C shows use of a second transfer box 6' in front of the transmission 3 in order to raise the height of the front differential (not shown for clarity) by a distance C relative to the front drive shaft 8. Lastly, Figure 2D shows an arrangement similar to Figure 2B in which transfer box 6D raises the height of the rear differential 11 by a distance D relative to the rear output shaft 5.

Figure 2E shows the internal construction of the transmission 3 having a hydraulic pump 15 (in quadrant C), a hydraulic motor 17 (in quadrant A), and a second hydraulic motor 19 (in quadrant B) in order to provide the output shaft assembly 5 with continuously variable drive. Output shaft assembly 5 comprises a pinion shaft 5a carrying a pinion gear 5b. Pinion shaft 5a is connected to the housing structure (not shown) by bearings 5c.

It will be appreciated that the output drive shaft assembly 5 of the prior art transmission 3 lies across quadrants A and D.

Figure 3 shows an agricultural vehicle, in the form of a tractor 110, having front wheels 112, rear wheels 114, an engine cover 116 and operator cab 118. The tractor 110 has a chassis 120 (not shown in Figure 3 for clarity) and provides support for the tractor and a driveline 121 which provides propulsive drive. In some tractors the driveline may form part of the chassis, for example where the outer casing of a transmission and a rear transaxle is structurally integral to the chassis.

Figure 4 shows the driveline 121 having a prime mover in the form of an internal combustion engine 124 and a first configuration of transmission 100 (indicated schematically in Figure 4 by dotted line 100). The transmission 100 has an inner transmission casing 199 (not shown in Figure 4) which is mounted inside an outer structural housing (not shown) which forms part of the chassis. Accordingly, the transmission 100, specifically the casing 199, supports or houses all of the

components required to provide a full range of gear ratios to the driven wheels and to any power take off shafts.

It will be appreciated that whilst the example of prime mover given is that of an internal combustion engine, it is conceivable within the scope of the invention that the prime mover could be an electric motor or other form of propulsive engine.

The configuration of the tractor 110 shown in Figures 3 to 7 is a four wheel drive tractor with steered front wheels. Alternatively, the tractor may be rear wheel drive only in which case the driveline 121 and the transmission 100 would not require a front axle drive shaft.

The engine 124 provides drive to the transmission 100 via a flywheel 146. The transmission 100 drives the front and rear axle drive shafts 134,136 to provide propulsive drive to the wheels 112, 114. In addition to providing propulsive drive, the transmission 100 also provides drive to a rear power take-off drive shaft 132.

The engine 124 is connected to an input shaft 102 of the transmission 100 via the flywheel 146. The input shaft 102 is connected at its inboard end to a planetary gear assembly indicated generally 148. The purpose of the planetary gear assembly 148 is to split the torque provided by the input shaft 102 between a mechanical branch indicated generally at 150 and a hydrostatic branch indicated generally at 152. On the opposite side of the planetary gear assembly to the input shaft 102 is a rear power take off shaft 132.

The hydrostatic branch 152 drives a hydraulic pump 140. The mechanical branch 150 is connected to a front axle drive shaft 134 and a rear axle drive shaft 136 as follows. Torque is transmitted from the mechanical branch 150 of the planetary gear assembly 148 to the rear axle drive shaft 136 via a rear axle gear 154. Mounted on the same shaft as the rear axle drive gear 154 is an intermediary gear 156 which in turn drives a front axle drive gear 158 which selectively drives the front axle drive shaft 134. A clutch 160 is provided to selectively engage and disengage the front axle drive shaft 134 from the rear axle drive shaft 136 or to control the ratio of torque distribution

between the two axles. This allows grip to be optimised dependant on the ground conditions.

In addition to the mechanical drive path described above, the hydraulic pump 140 is hydraulically connected (not shown in Figure 4 for clarity) to a first hydraulic motor 142 which is driveably connected to the rear axle drive shaft 136 in order to provide hydraulic drive to the rear wheels. The hydraulic pump 140 is also connected to a second hydraulic motor 144 in order to provide hydraulic drive to the front axle drive shaft 134 as follows. The motor 144 is driveably connected to the front axle drive shaft 134 via first and second hydraulic motor gears 162, 164. A clutch 166 allows the second hydraulic motor 144 to be selectively engaged and disengaged from the front axle drive shaft 134. This allows hydraulic drive to be provided to the front axle drive shaft 134 by the second hydraulic motor 144 in addition to, or alternatively to, the drive delivered to the front axle drive shaft 134 from the rear axle drive shaft 136 via the intermediary and front axle drive gears 156, 158, depending on the extent of engagement of the clutch 160.

The rear axle drive shaft 136 provides drive to the rear wheels 114. Similarly, the front axle drive shaft 134 provides drive to the front wheels 112.

By way of further explanation, various drive configurations are possible depending on the operating positions of clutches 160 and 166:

With the clutch 160 disengaged, and the clutch 166 engaged, motor 142 drives the rear axle drive shaft 136 and thereby rear axle 114, and motor 144 drives the front axle drive shaft 134 and thereby front axle 112.

With the clutch 160 disengaged, and the clutch 166 disengaged, motor 142 drives the rear axle drive shaft 136 and thereby rear axle 114. The front axle drive shaft 134 and thereby front axle 112 is not driven.

With the clutch 160 engaged, and the clutch 166 disengaged, motor 142 drives the rear axle drive shaft 136 and thereby rear axle 114. The motor 142 also drives the front axle drive shaft 134 and thereby front axle 112.

With the clutch 160 engaged, and the clutch 166 engaged, motor 142 and motor 144 both drive the rear axle drive shaft 136 and thereby rear axle 114. The motors 142, 144 also drive the front axle drive shaft 134 and thereby front axle 112.

With the clutch 160 variably controlled, and the clutch 166 engaged, torque supplied by motor 142 to the front axle drive shaft 134 and thereby front axle 112 can be adapted.

Referring now to Figures 5, 6 and 7, the input shaft 102, rear power take-off drive shaft 132, front axle drive shaft 134 and a rear axle drive shaft 136 are visible at the exterior of the an inner transmission casing 199. The transmission 100 has a blanking cap 138 which covers an aperture in the inner transmission casing 199 for an additional drive shaft not used in this first configuration of transmission. In addition, the hydraulic pump 140, first hydraulic motor 142 and second hydraulic motor 144 are shown mounted to the inner transmission casing 199.

In use, the operator is able to vary the division of torque provided by the transmission 100 either mechanically or hydraulically by varying the amount of hydraulic assistance provided by the first and second hydraulic motors.

The transmission of the present invention is also suitable for a tracked tractor as will now be described in further detail.

Figure 8 shows the driveline 221 for a tracked tractor having an engine 224 which drives a second configuration of transmission 200 which in turn provides drive to a rear axle drive shaft 236. The rear axle drive shaft 236 provides drive to the rear drive wheels (not shown) which in turn drive the track (not shown). As a result there is no requirement for a front axle drive shaft since no drive is transmitted to the front.

The engine 224 provides drive to the transmission 200 via a flywheel 246. In addition to providing propulsive drive to the rear axle drive shaft 236, the transmission 200 also provides drive to a rear power take-off drive shaft 232. The engine 224 is connected to the input shaft 202 of transmission 200 via the flywheel 246. The input

shaft 202 is connected at its inboard end to a planetary gear assembly indicated generally 248. The purpose of the planetary gear assembly 248 is to split the torque provided by the input shaft 202 between a mechanical branch indicated generally at 250 and a hydrostatic branch indicated generally at 252. On the opposite side of the planetary gear assembly 248 to the input shaft 202 is the rear PTO drive shaft 232.

The hydrostatic branch 252 drives first and second hydraulic motors 242, 244 via hydraulic pump 240 while the mechanical branch 250 provides drive to the rear axle drive shafts 236 as follows. Torque is transmitted from the mechanical branch 250 of the planetary gear assembly 248 to the rear axle drive shaft 236 via initial gear 254. Mounted on the same shaft as the initial gear 254 is an intermediary gear 256 which in turn drives a rear axle drive gear 258. The rear axle drive gear 258 is mounted on and thereby drives the rear axle drive shaft 236. A steering differential (not shown) is provided to split the torque delivered by the rear axle drive shaft 236 between the left and right rear drive wheels in order to steer the tractor 210.

In addition to the mechanical drive path described above, the hydraulic pump 240 is hydraulically connected to the first hydraulic motor 242 which is driveably connected to the rear axle drive shaft 236 via the intermediary gear 256 and rear axle drive gear 258 in order to provide supplementary hydraulic drive to the rear drive wheels 212. The hydraulic pump 240 is also connected to the second hydraulic motor 244 which is driveably connected to the rear axle drive shaft 236 via second hydraulic motor gear 264. A clutch 266 allows the second hydraulic motor 244 to be selectively engaged and disengaged from the rear axle drive shaft 236. This allows hydraulic drive to be provided to the rear axle drive shaft 236 by the second hydraulic motor 244 in addition to, or alternatively to, the drive delivered by the first hydraulic motor 242 and the mechanical branch 250 of the planetary gear assembly 248.

Referring now to Figures 9, 10 and 11 the input shaft 202, rear power take-off drive shaft 232, and rear axle drive shaft 236 are visible at the exterior of the inner transmission casing 299. It will be noted that the transmission 200 does not have the blanking cap 138 of the transmission 100. Instead the transmission 200 uses the aperture covered by the blanking cap 138 in transmission 100 to provide access for the rear axle drive shaft 236. Also the transmission 200 has no front axle drive shaft as

the tracked tractor 210 requires no drive to the front wheels. Furthermore, the transmission 200 is not provided with clutch 166 of transmission 100 as there is no need for torque distribution.

In addition, the hydraulic pump 240, and the first and second hydraulic motors 242, 244 are shown mounted to the inner transmission casing 299.

It will be appreciated that the transmission of the present invention can be configured to provide a configuration of transmission 100 for tractor 110 or transmission 200 for tractor 210. In each configuration, the inner transmission casing (199, 299) and many of the internal components remain the same. This provides significant advantages, for example a reduction in the complexity of production of the transmissions across a range of tractors typically offered by agricultural manufacturers.

The transmission unit 26 can provide further configurations of transmission to suit a large range of applications. Further alternative transmission configurations of transmission will now be described with reference to Figures 12 to 19. Each transmission is similar in construction and operation to transmissions 100, 200 described above and all provide at least two continuously variable output drive shafts. The modes of operation of each of the transmissions of Figures 12 to 19 will only be described in detail where they differ significantly from transmissions 100, 200 described above.

Referring initially to Figure 12, a configuration of transmission 400 has an input shaft 402 which drives a planetary gear system 448 with a mechanical branch 450 and a hydraulic branch 452. The hydraulic branch 450 drives a hydraulic pump 440 which provides hydraulic power to a hydraulic motor 442. The input shaft 402 passes through the planetary gear system 448 and exits the transmission at the rear as a rear PTO drive shaft 432. The rear PTO drive shaft 432 is co-axial with, and positioned diametrically within, a rear axle drive shaft 436. A front axle drive shaft 434 is driven by the hydraulic motor 442 and the mechanical branch 450 via gears 474, 476. The hydraulic motor 442 is also able to power the rear axle drive shaft 436 via gears 474, 476.

Figure 13 shows a further configuration of transmission 500. The transmission 500 has an input shaft 502, front axle drive shaft 534, rear axle drive shaft 536, gears 574, 576, hydraulic pump 540 and hydraulic motor 542 in common with transmission 400. Compared to the transmission 400, no PTO shaft is provided as the hollow shaft extending to the rear of the planetary gear system 548 is connected to the rear axle drive shaft 536. This arrangement may be suitable for a truck not requiring a rear PTO. As trucks require a transmission with a lower output speed, the planetary gear system 548' may be adapted so that the rear axle drive shaft 536 is drivingly connected to a component of the planetary gear system 548' which rotates with lower speed.

The transmission 600 of Figure 14 differs from transmission 400 (with identical components being numbered 200 higher in Figure 14 than in Figure 12) in that it has a second hydraulic motor 644 which acts in cooperation with the first hydraulic motor 642 to drive the front axle drive shaft 634 and rear axle drive shaft 636. The second motor 644 could also be provided in the embodiments shown in Figure 6 and 7.

Referring now to Figure 15, the transmission 700 has an input shaft 702 driving a planetary gear system 748 with a mechanical branch 750 and a hydraulic branch 752. The hydraulic branch 752 drives a hydraulic pump 740 which provides hydraulic power to first and second hydraulic motors 742, 744. The input shaft 702 passes through the planetary gear system 748 and exits the transmission at the rear as a rear PTO drive shaft 732. The rear PTO drive shaft 432 is co-axial with, and positioned diametrically within, a first rear drive shaft 736. A second rear drive shaft 790 is driven by the first hydraulic motor 742 and the mechanical branch 750 via gears 774, 776. The first hydraulic motor 742 is also able to power the first rear drive shaft 736 via gears 774, 776. A front axle drive shaft 734 is driven by the first hydraulic motor 742 and mechanical branch 750 of the planetary gear system 748 via gears 792, 794 and clutch 796. Attached to the other end of the front axle drive shaft 734 is a third rear drive shaft 798. The front axle drive shaft 734 and third rear drive shaft 798 are selectively driven by the second hydraulic motor 744 via clutch and gears 795, 797. In such a manner the clutch 766 can be engaged to enable the second hydraulic motor 744 to drive the first and second rear drive shafts 736, 790 via the gears 795, 797, 794, 792, 776 and 774. The clutch 796 can be engaged to mechanical drive and hydraulic

drive to the front axle drive shaft 734 and third rear drive shaft 798. As the clutch 796 is summing up the torque delivered by motors 742 and 744 via circumferential toothed portions, the front axle drive shaft 734 can extend through clutch 796 to provide third rear drive shaft 798. The configuration of transmission 700 may be used to drive a vehicle with more than two driven axles as follows.

In a vehicle with three axles, the front axle of the vehicle may be connected to front axle drive shaft 734, a mid vehicle axle may be connected to third rear drive shaft 798 while the rear vehicle axle may be connected to second rear drive shaft 790. In addition, rear PTO drive shaft 432 may drive a PTO.
In a vehicle with four axles, the front (first) axle of the vehicle may be connected to front axle drive shaft 734, a mid (second) vehicle axle may be connected to third rear drive shaft 798 while the first rear (third) vehicle axle may be connected to first rear drive shaft 736. In addition, the second rear (fourth) vehicle axle may be connected to first rear drive shaft 736. The rear PTO drive shaft 432 would not be used in this case.

The transmission 800 of Figure 16 differs from transmission 700 (with identical components being numbered 100 higher in Figure 16 than in Figure 15) in that second hydraulic motor 844 is positioned in line with the front axle drive shaft 834 in order to selectively (via clutches 866 and 896) drive the front axle drive shaft 834 and rear drive shafts 836, 890. The second hydraulic motor 844 is shown in an alternative location 844" by dashed lines in Figure 16 in which embodiment the front axle drive shaft 834 is removed in order to provide access for the motor 844" and a third rear drive shaft 898 is provided instead.

In Figure 17, the rear wall of the transmission unit 26 is depicted showing the shaft positions of configurations of transmission 100, 200, 400, 500, 600, 700 and 800. Figures 18 and 19 show the shaft positions in front wall and side walls, respectively.

The input shaft 102, 202, 402, 502, 602, 702, 802 enters the transmission unit 26 through aperture A1. The rear PTO drive shaft 132, 232, 432, 632, 732, 832 is positioned coaxially within the rear axle drive shaft 436, 536, 636, 736, 836 at position A exiting the transmission unit through aperture A3. Alternatively (or additionally in the case of transmissions 700, 800) the rear axle drive shaft 136, 790,

890 is provided at an intermediate position B exiting the transmission unit through aperture A4. In transmissions 400, 500 and 600 the front axle drive shaft 434, 534, 634 exits the front of the transmission casing at position B through aperture A6. Alternatively (or additionally in the case of transmissions 700, 800) the rear axle drive shaft 236, 798, 898 is provided at a low position C exiting the transmission unit through aperture A5. Alternatively (or additionally in the case of transmissions 700) the front axle drive shaft 134, 734, 834 exits the front of the transmission casing at position C through aperture A2.

Referring to Figure 20, transmission 100 is shown with the first hydraulic motor 142, second hydraulic motor 144, pump 140, and output gear drive shaft 136 each in separate quadrants A, B, C, D respectively. The output gear drive shaft 136 carries a pinion gear 139 which is arranged inboard (in direction of arrow E) of the outer profile of the first hydraulic motor 142 (indicated by dashed line F). The output gear drive shaft 136 is attached to the structural housing by bearings 137.

Alternatively, the pinion gear 139 could be replaced by any other means to connect the output gear drive shaft 136 to the driveline of a vehicle axle, e.g. a flange part which could to be connected to a cardan shaft.

The transmission of the present invention therefore achieves considerable space saving over the prior art transmissions as the transmission maximises the space available by positioning the pump, motors and output shaft within distinct quadrants.

In the shown embodiment, the quadrants A and B are provided on one side of the symmetric axis of the transmission (which is aligned with the longitudinally symmetric axis of the vehicle) and quadrants D and C are provided on the opposite side of said symmetric axis. In consequence, output gear drive shaft 136 is provided with an offset with respect to the symmetric axis.

As a result, the parts of the rear axle driveline, especially the rear axle pinion gear 138 or any other means to connect the output gear drive shaft 136 to the driveline of a vehicle axle can extend partly into the transmission unit enabling a reduced length of the overall drive line.

The embodiments of transmission described above all have a mechanical branch and a hydrostatic branch defined by a pump (driven by the input shaft) and two motors which are driven by the pump.

The mechanical branch may be omitted when a pure hydrostatic transmission is used according the present invention.

In an alternative embodiment the hydrostatic branch is replaced by an electrical branch in which the hydraulic pump is replaced by an electrical generator (driven by the input shaft) and the hydraulic motors are replaced by electric motors.

In the specific embodiments the transmission unit 26 is surrounded by an additional structural housing integral with the chassis of the tractor. This is especially advantageous for assembly and maintenance reasons.

Alternatively, and without departing from the scope of the invention, the transmission unit 26 could incorporate the structural housing in place of the inner transmission casing 199. In this case, all the components included in each configuration of the transmission unit 26 described above would be directly assembled to the structural housing.

Furthermore, the embodiments described above are based on an orientation of the transmission which is common in agricultural vehicles such as tractors, that is to say that the engine is at the front and the transmission is positioned rearwards of the engine relative to the driving direction. This results in the front axle being situated in front of the transmission while the rear axle is behind the transmission. However it is conceivable that the orientation of the transmission or the engine could be altered, e.g. for bucket loaders having a rear engine, would result in a different orientation of the vehicle front and rear axle(s) in relation to the transmission. So the reference of to front or rear axle must be more seen with reference to the transmission than strictly to the vehicle.

It is also conceivable within the scope of the invention that the transmission is provided only with a hydrostatic branch or electrical branch and no mechanical branch.

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CLAIMS

1. A continuously variable transmission for an agricultural vehicle, the transmission comprising a transmission casing and transmission components,

the components including:

an input shaft drivable by a prime mover,

an output drive shaft for connection to driven wheels of the vehicle,

a hydrostatic transmission branch having a hydraulic pump driveable by the input shaft, and first and hydraulic second motors hydraulically driveable by the pump,

wherein

the first hydraulic motor is positioned within a first quadrant of the transmission,

the second hydraulic motor is positioned within a second quadrant of the transmission,

the hydraulic pump is positioned within a third quadrant of the transmission,

and the output drive shaft is at least partly positioned within a fourth quadrant of the transmission.

2. The transmission of claim 1 wherein the output shaft is a pinion shaft.

3. The transmission of claim 1 wherein the output shaft is connected to a cardan shaft.

4. The transmission of claim 2 or 3 wherein the output shaft is carried by at least one bearing, the at least one bearing being supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the pump.

5. The transmission of claim 4 wherein the output shaft is carried by two bearings supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the pump.

6. The transmission of claim 2, or claims 4 or 5 when dependent on claim 2, wherein the pinion shaft carries a pinion gear which sits at least partly inboard of the outer profile of the first motor, the second motor and the pump.

7. The transmission of any of claims 1 to 6 including a mechanical transmission branch is provided which transfers torque mechanically from the input shaft to the output shaft.

8. A continuously variable transmission for an agricultural vehicle, the transmission comprising a transmission casing and transmission components,

the components including:

an input shaft drivable by a prime mover,

an output drive shaft for connection to driven wheels of the vehicle,

an electrical transmission branch having a generator driveable by the input shaft, and first and second electric motors powered by the generator,

wherein

the first electric motor is positioned within a first quadrant of the transmission,

the second electric motor is positioned within a second quadrant of the transmission,

the generator is positioned within a third quadrant of the transmission,

and the output drive shaft is at least partly positioned within a fourth quadrant of the transmission.

9. The transmission of claim 8 wherein the output shaft is a pinion shaft.

10. The transmission of claim 8 wherein the output shaft is connected to a cardan shaft.

11. The transmission of claim 9 or 10 wherein the output shaft is carried by at least one bearing, the at least one bearing being supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the generator.

12. The transmission of claim 11 wherein the output shaft is carried by two bearings supported by the casing and positioned inboard of the outer profile of the first motor, the second motor and the pump.

13. The transmission of claim 9, or claims 11 or 12 when dependent on claim 9, wherein the pinion shaft carries a pinion gear which sits at least partly inboard of the outer profile of the first motor, the second motor and the pump.

14. The transmission of any of claims 8 to 13 including a mechanical transmission branch is provided which transfers torque mechanically from the input shaft to the output shaft.

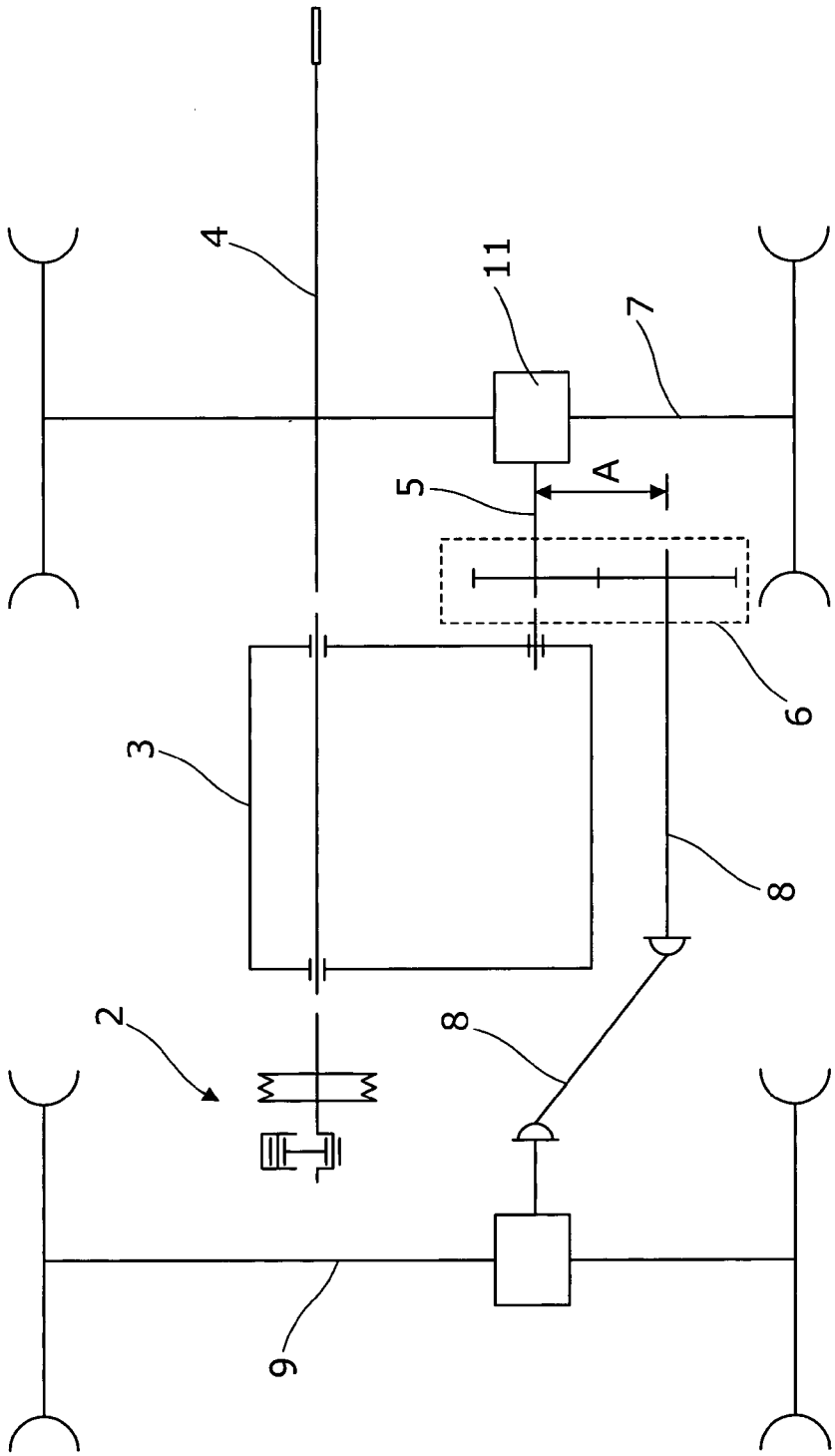

Figure 1
(Prior Art)

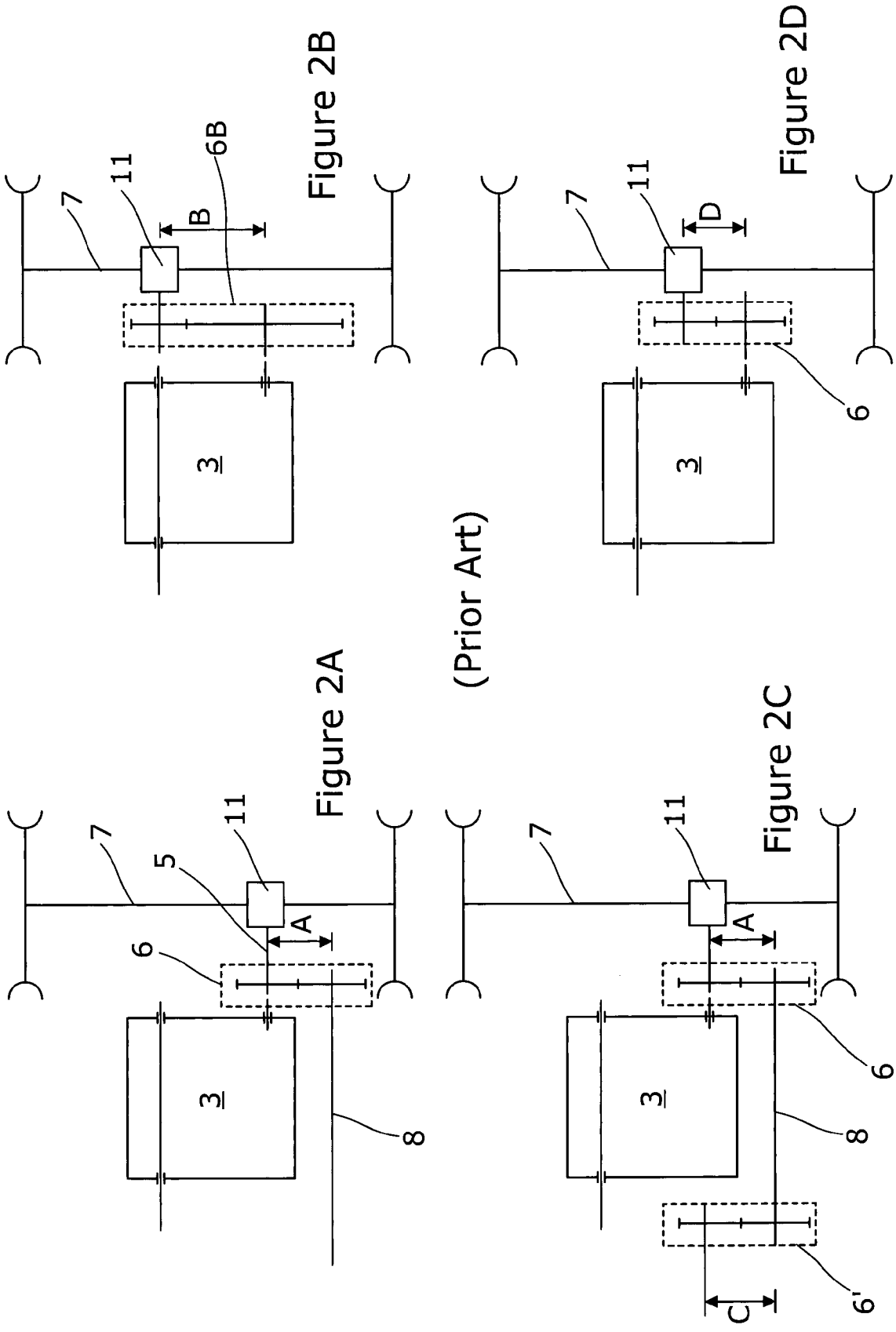
Figure 2A
Figure 2B
Figure 2C
Figure 2D
(Prior Art)
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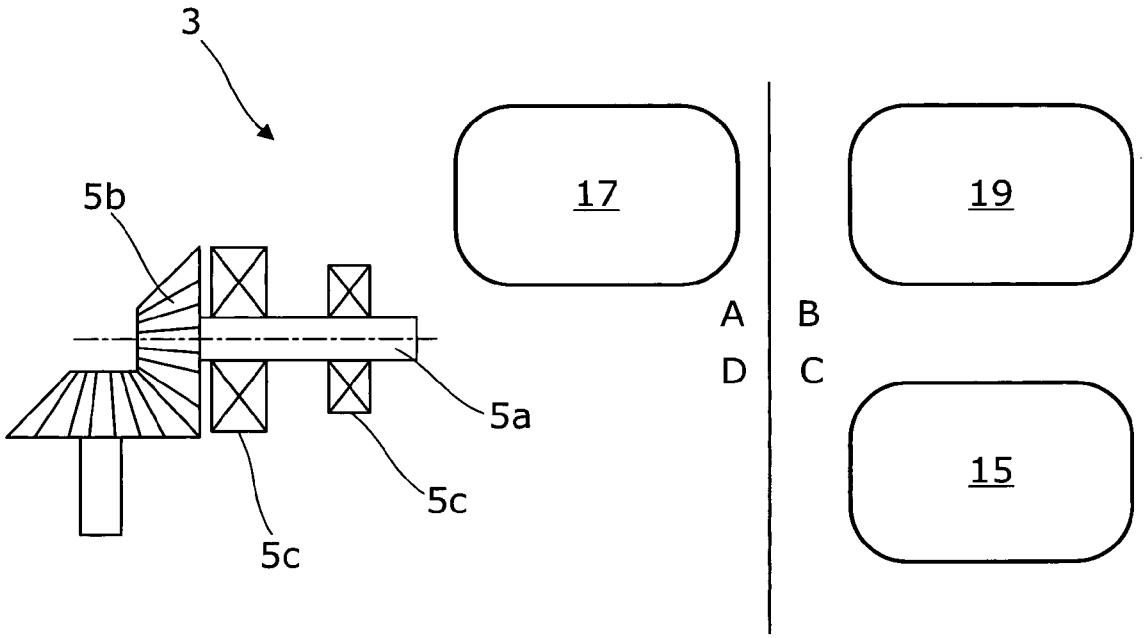


Figure 2E

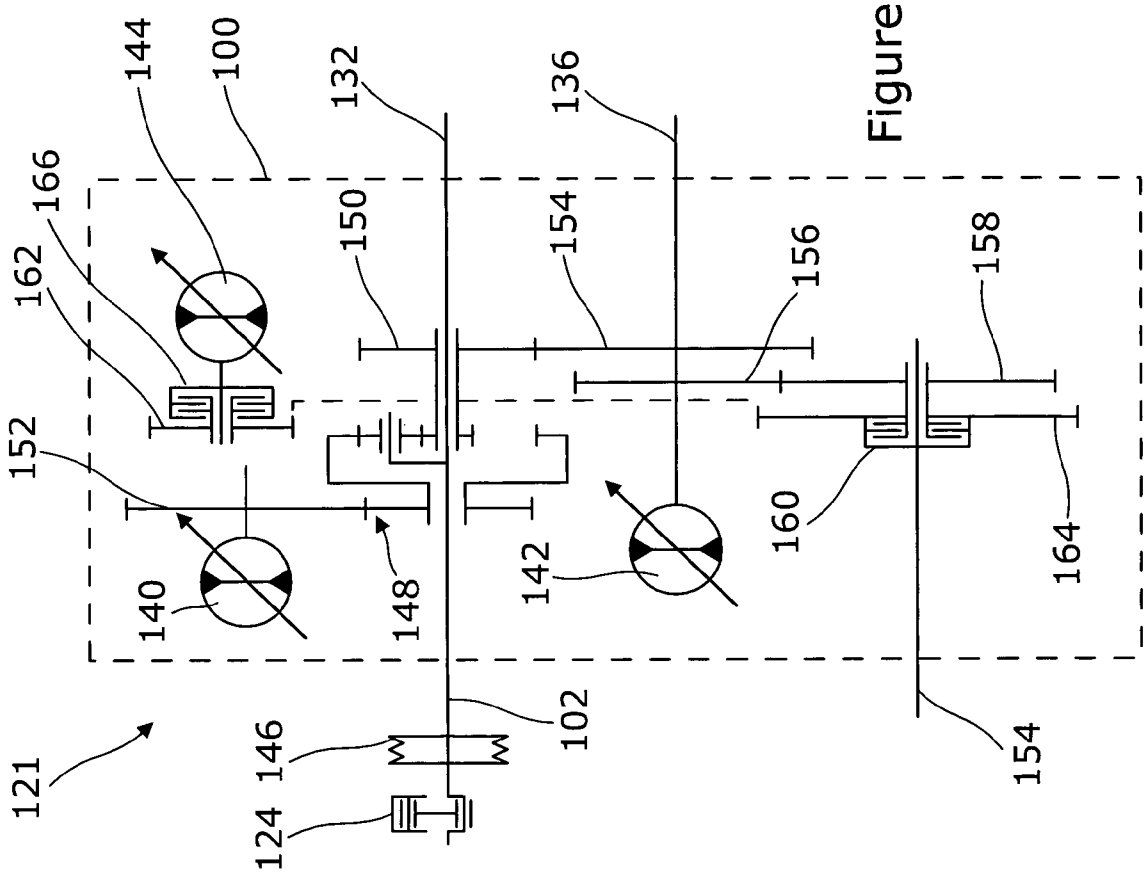


Figure 4

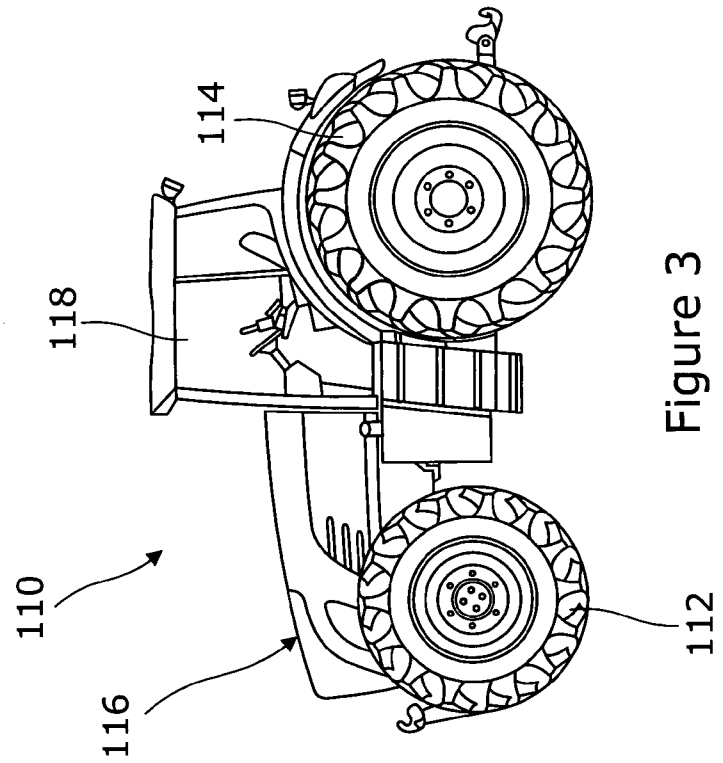


Figure 3

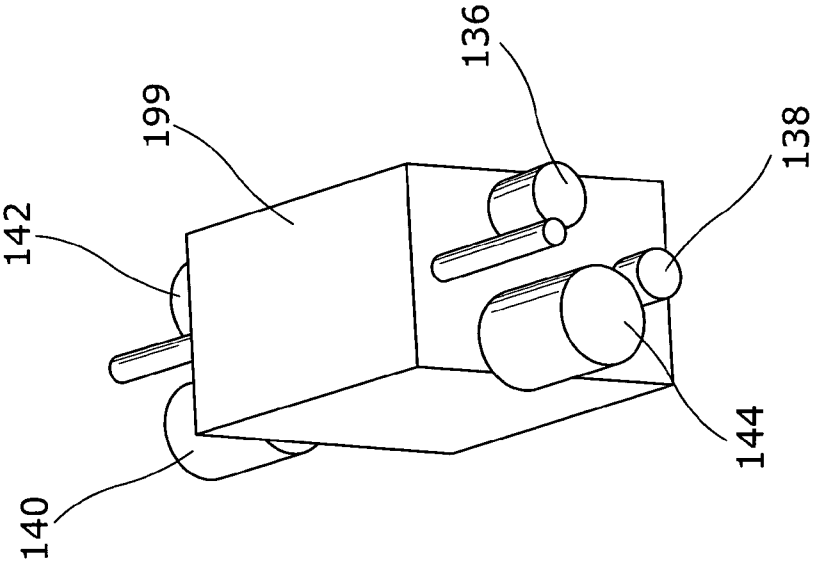


Figure 6

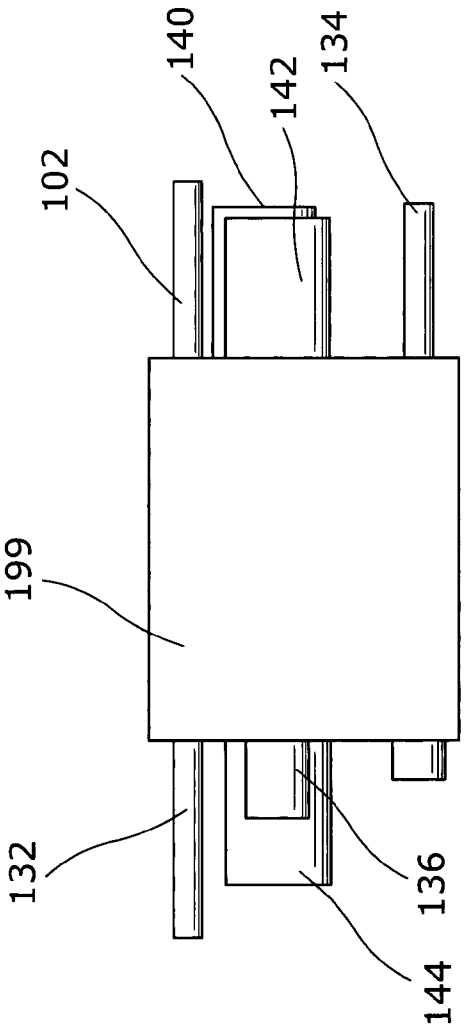
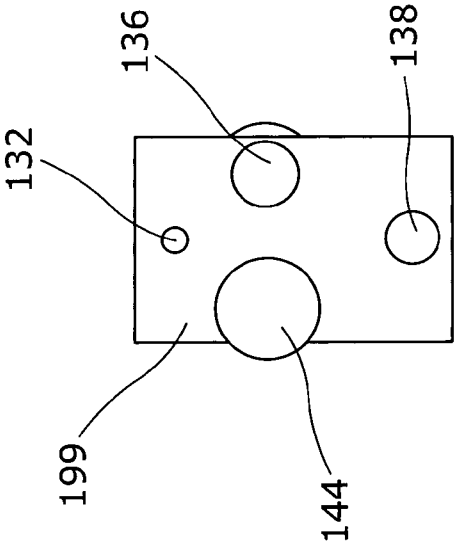


Figure 5



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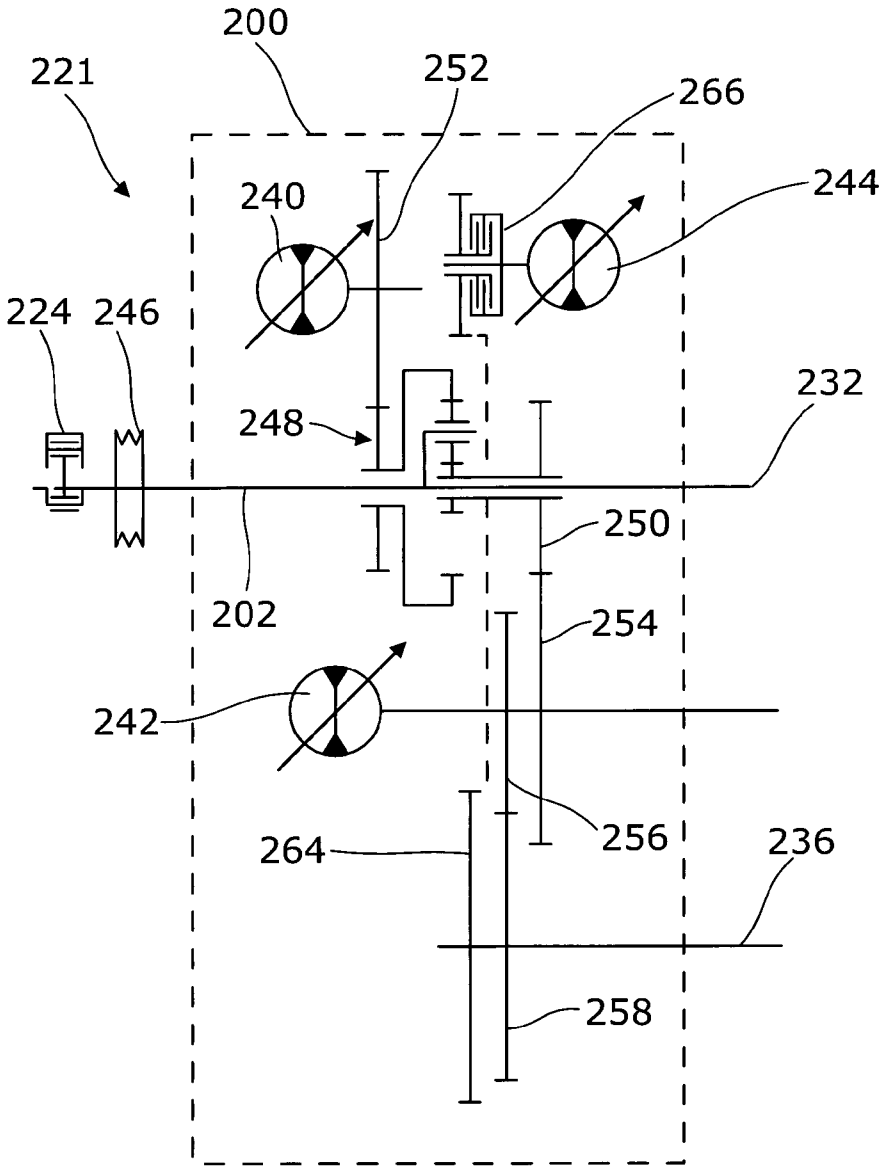
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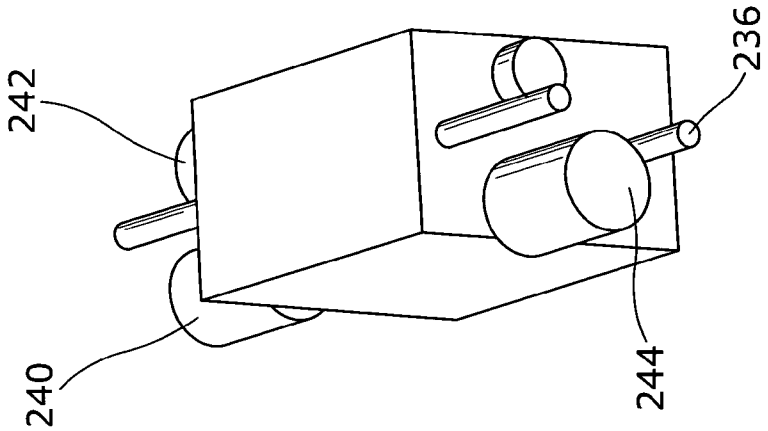
Figure 8



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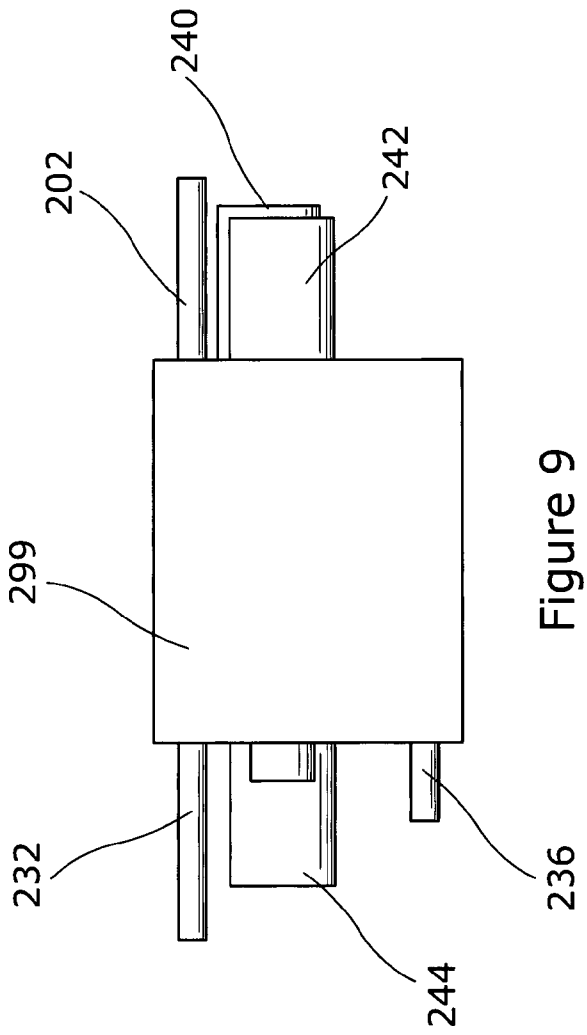
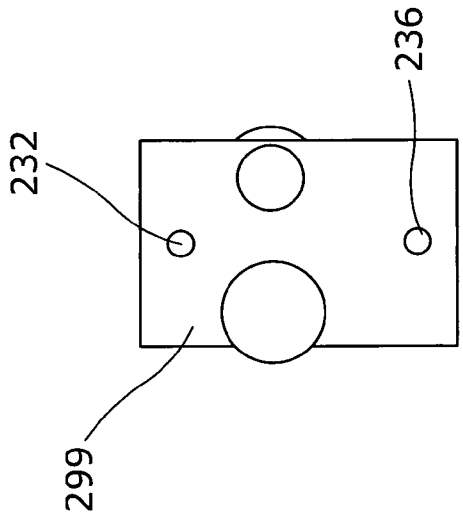


Figure 9



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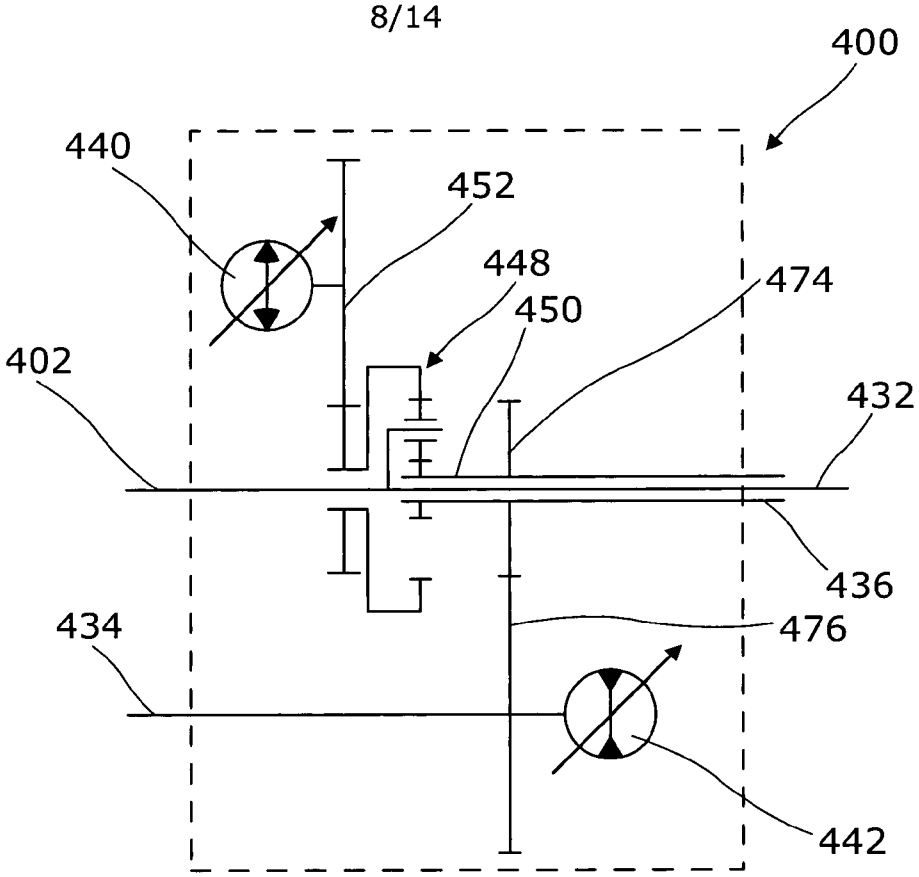

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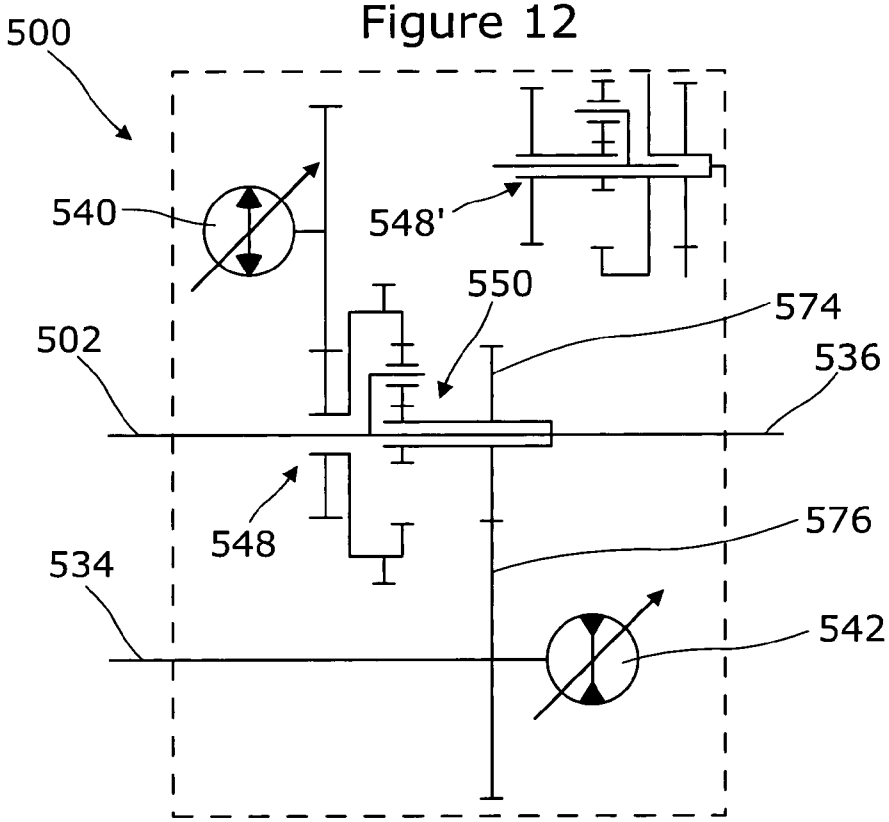
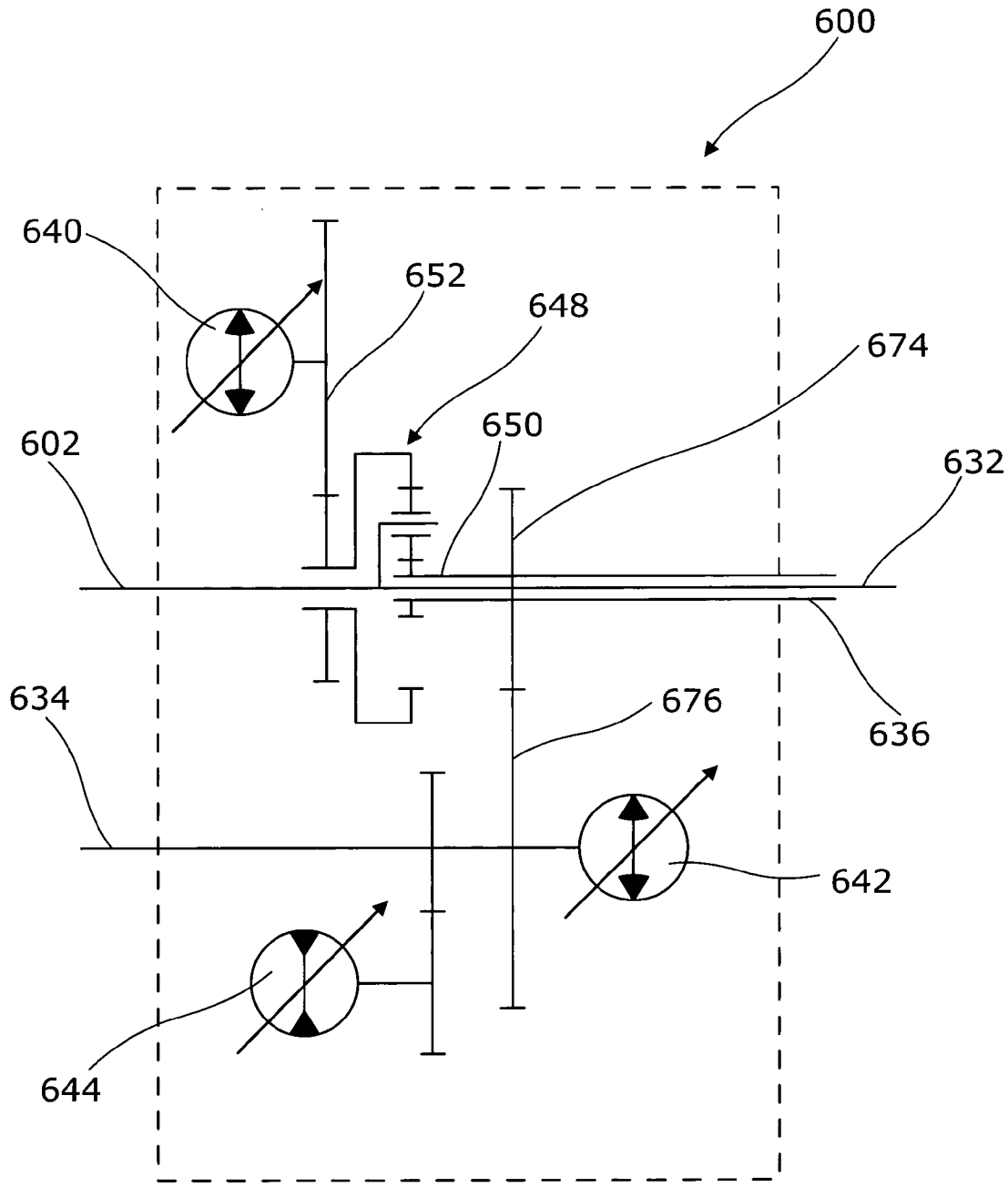


Figure 13



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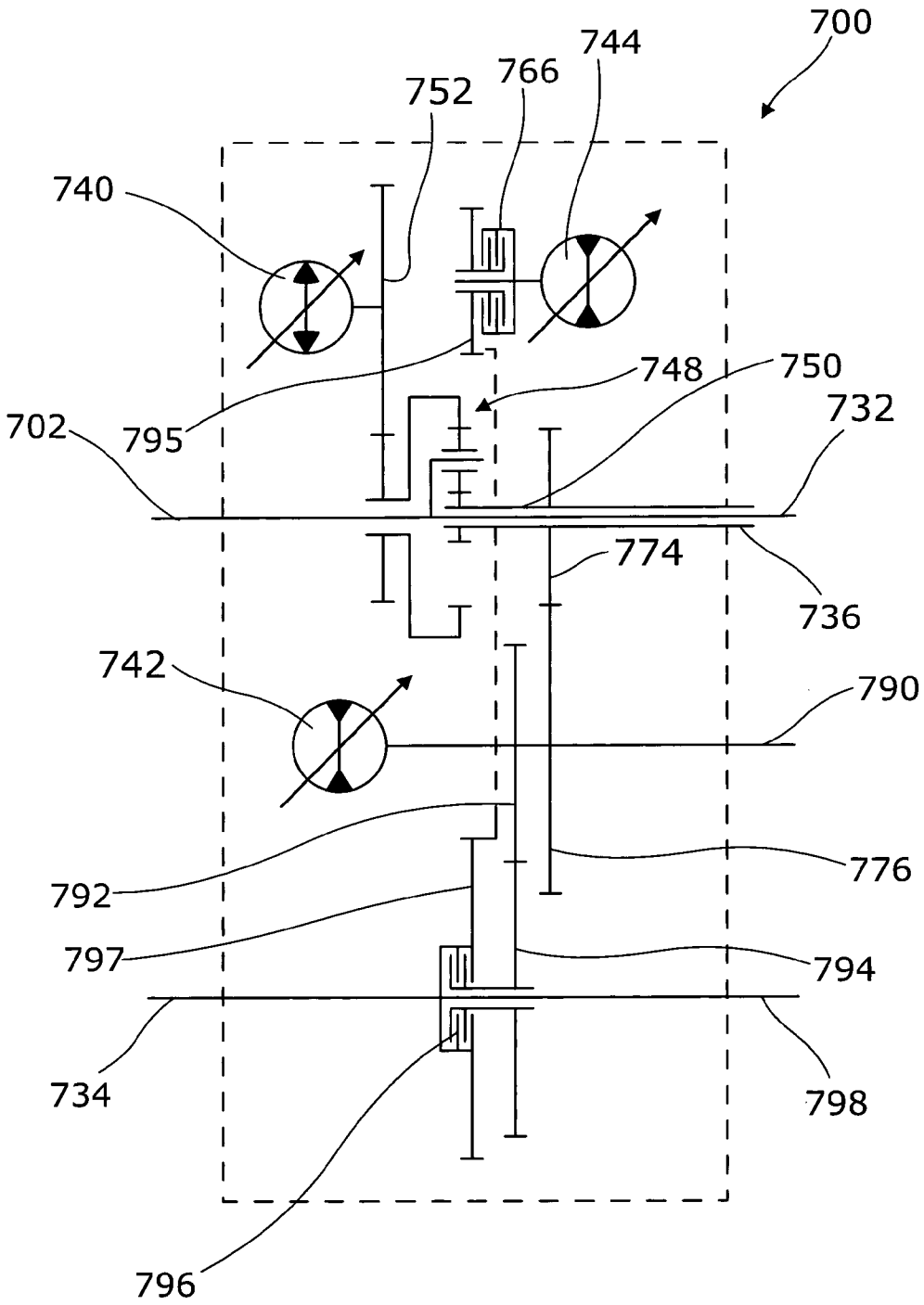
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Figure 15

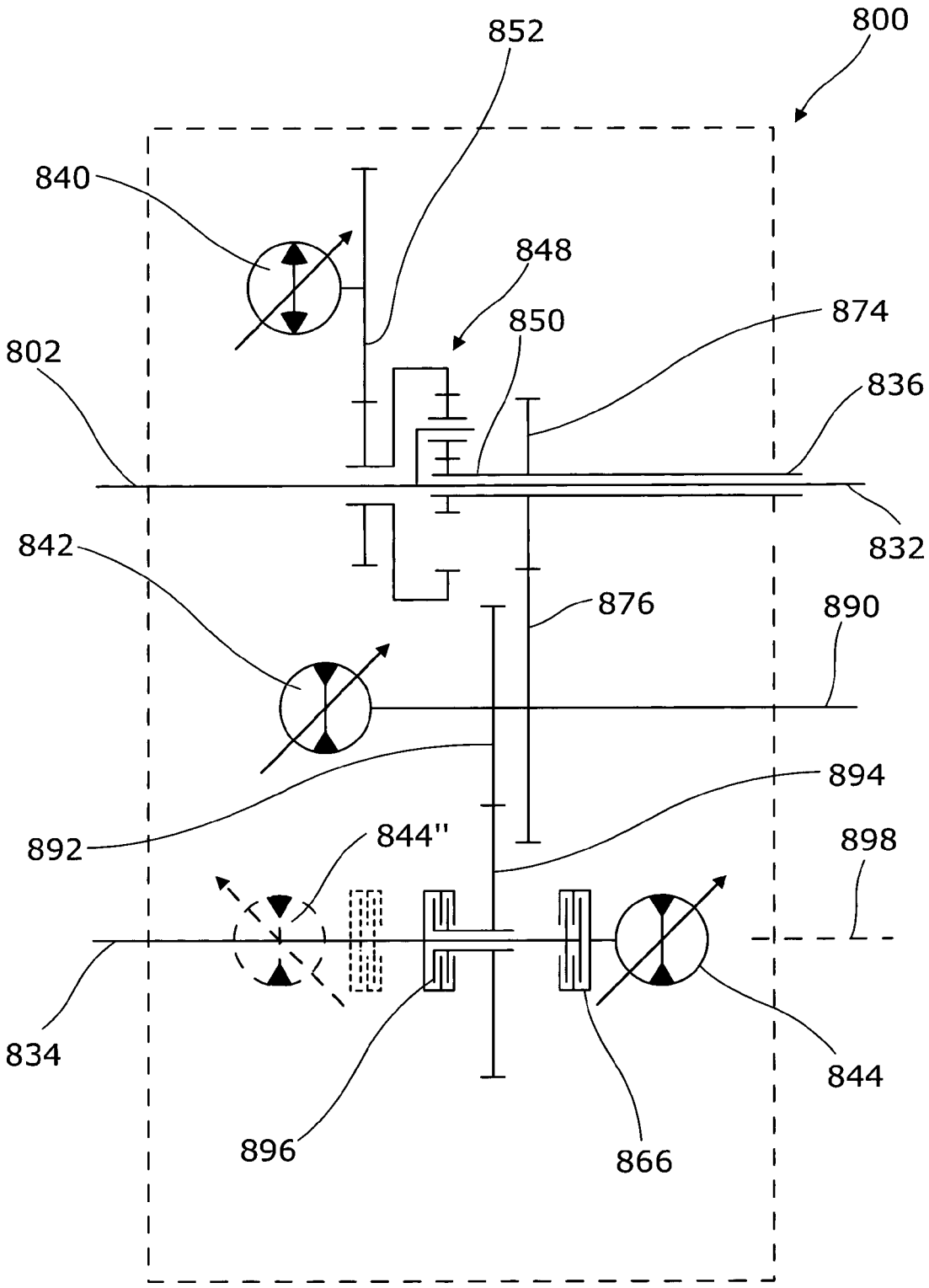
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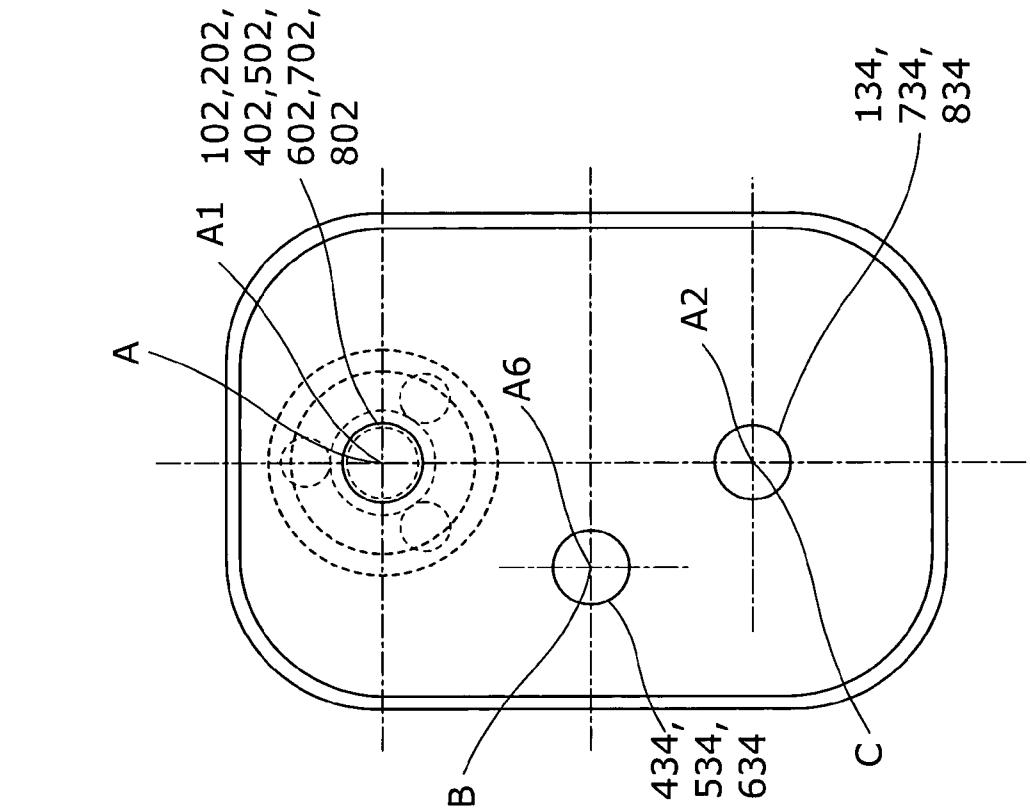
Figure 16



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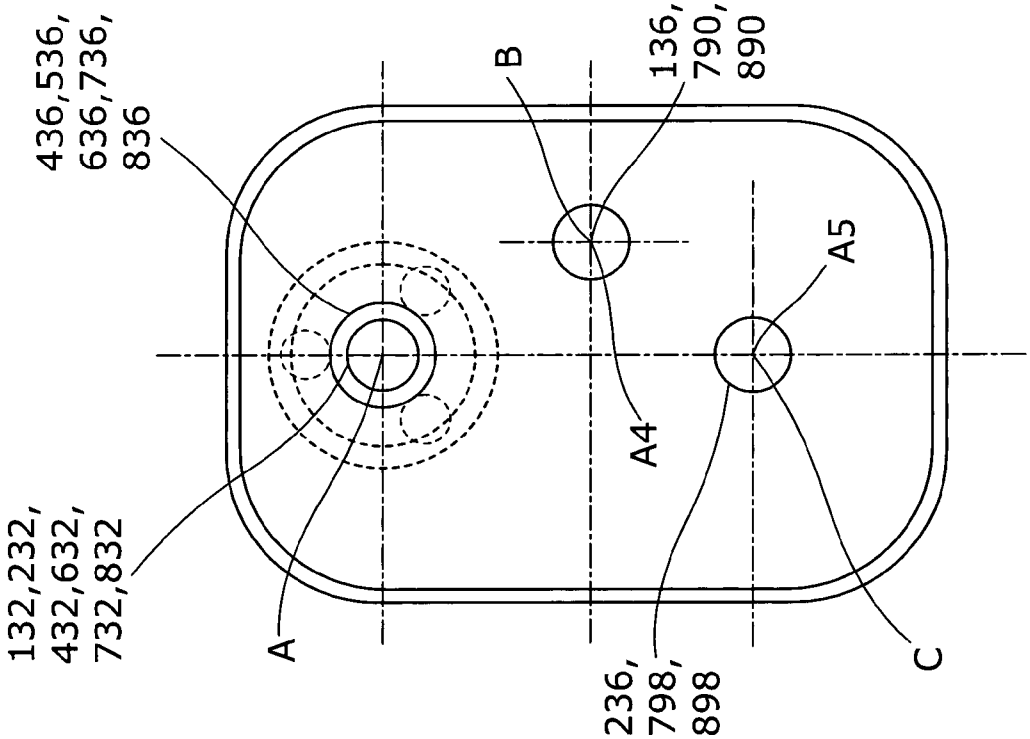

Figure 17

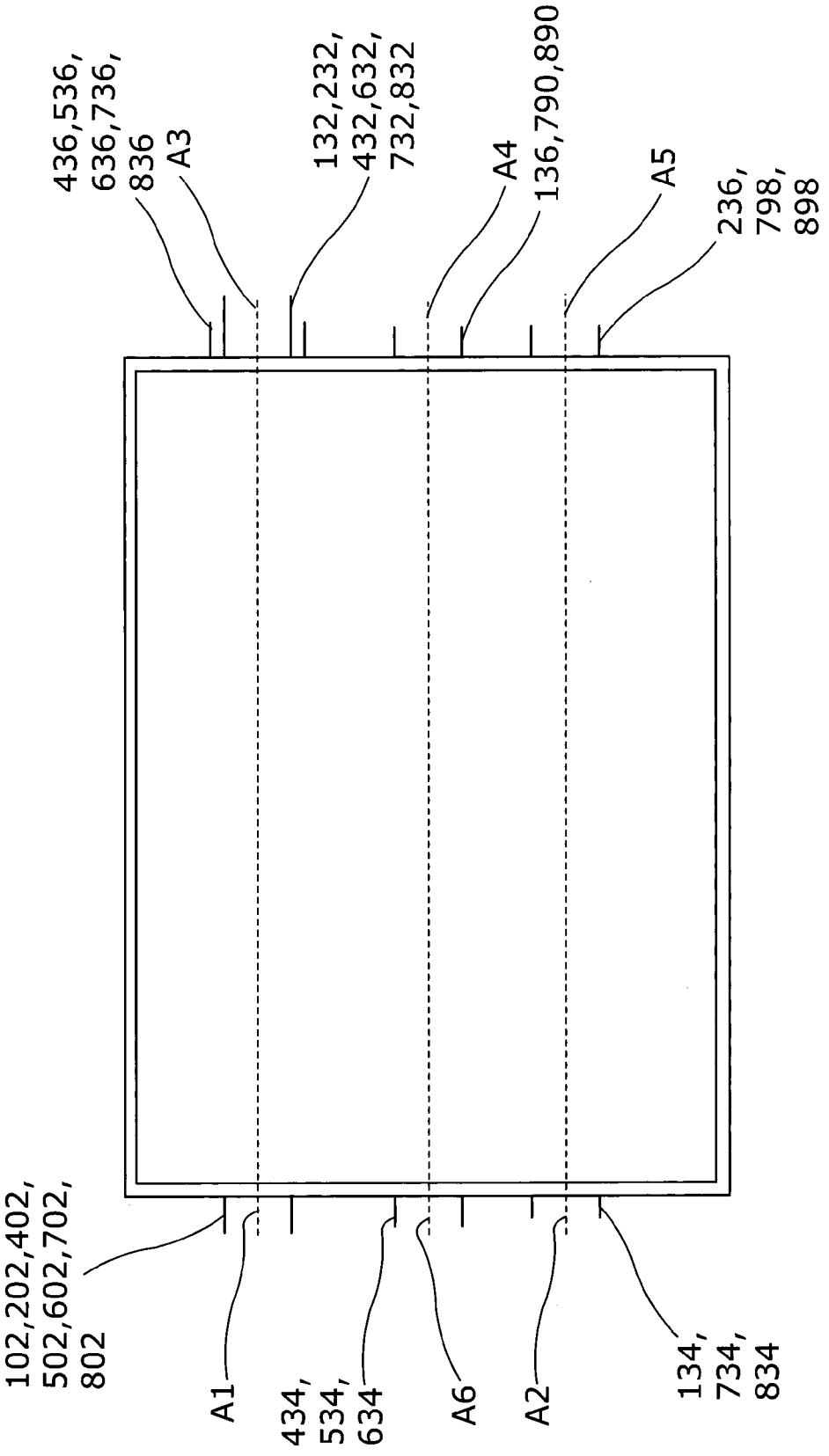
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Figure 19

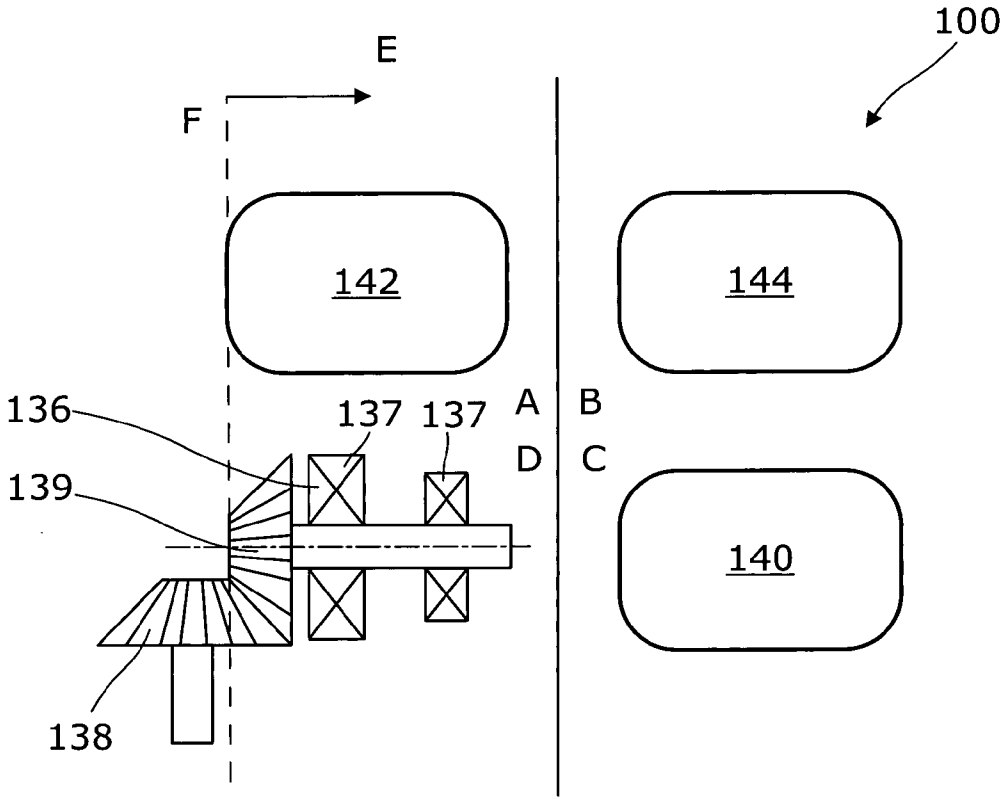

Figure 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/077908

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60K17/10 F16H47/04
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)
B60K F16H

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	DE 10 65 734 B (HEINRICH EBERT) 17 September 1959 (1959-09-17) figure 5	1-14
X	EP 0 826 907 A2 (CLARK HURTH COMPONENTS SPA [IT] DANA ITALIA SPA [IT]) 4 March 1998 (1998-03-04) abstract; figure	1-14
A	US 2010/048338 A1 (SI BAOJUN [US]) 25 February 2010 (2010-02-25) figures 1-5	8-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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"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
27 February 2014	12/03/2014

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	Meritano, Luciano

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/077908

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP 0826907 A2	04-03-1998	AT 241101 T	15-06-2003
		DE 69722104 D1	26-06-2003
		DE 69722104 T2	11-12-2003
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US 2010048338 A1	25-02-2010	NONE	