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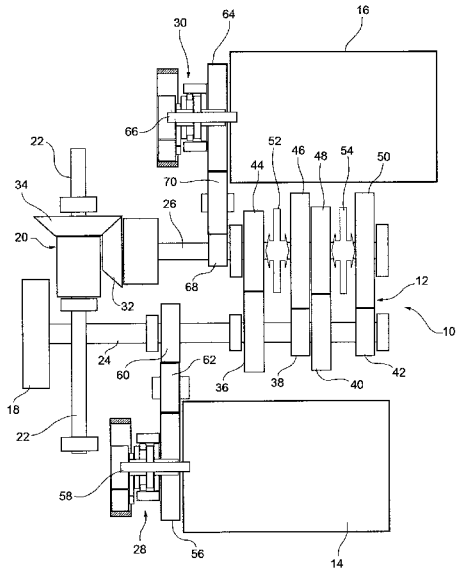

FIG. 1

(57) Abstract: The transmission (10) comprises a main gearbox (12), a first electric machine (14) and a second electric machine (16). The main gearbox (12) is a mechanical gearbox with a plurality of gears and comprises a primary shaft (24) adapted to be connected to a shaft of the internal combustion engine of the vehicle and a secondary shaft (26) adapted to be connected to the vehicle wheels. The transmission (10) further comprises a first coupling de- vice (74) interposed between the first electric machine (14) and the primary shaft (24) and a second coupling device (74) interposed between the second electric machine (16) and the secondary shaft (26). The first electric machine (14) is releasably connected, through the first coupling device (74), to the primary shaft (24) by means of a first connection gear set (56, 60, 62) including a first gearwheel (60) mounted on the primary shaft (24). The second electric machine (16) is releasably connected, through the second coupling device (74), to the secondary shaft (26) by means of a second connection gear set (64, 68, 70) including a second gearwheel (68) mounted on the secondary shaft (26). The transmission (10) further comprises a first secondary gearbox (28) with two or more gears interposed between the first electric machine (14) and the first gearwheel (60), and a second secondary gearbox (30) with two or more gears interposed between the second electric machine (16) and the second gearwheel (68).

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Hybrid transmission for a motor vehicle

The present invention relates to a hybrid transmission for a motor vehicle, comprising a main gearbox, which is made as a mechanical gearbox with a plurality of gears and is adapted to be connected to a shaft of the internal combustion engine of the vehicle, as well first and second electric machines connected to the main gearbox so as to assist the internal combustion engine of the vehicle in the generation of the driving torque to be transmitted to the vehicle wheels.

Hybrid transmissions for motor vehicles are known, both of the single-clutch type and of the double-clutch type, in which the electric machine is permanently connected or selectively connectable to a primary shaft or to a secondary shaft of the main gearbox so as to be able to transmit torque to that shaft or to receive torque from that shaft. The electric machine is thus able to perform not only the main functions of traction (generation of mechanical power for the vehicle wheels using the energy provided by the vehicle batteries) and of regeneration (generation of electric power for the vehicle batteries using the energy recovered from the kinetic energy of the vehicle or produced by the internal combustion engine when the vehicle is stationary), but also secondary functions such as for example the functions of alternator and of starting motor.

It is an object of the present invention to provide a hybrid transmission for a motor vehicle which is able to offer a wider range of available operating modes.

This and other objects are fully achieved according to the present invention by virtue of a hybrid transmission for a motor vehicle having the characteristics defined in the enclosed independent claim 1.

Preferred embodiments of the invention are the subject-matter of the dependent claims, the content of which is to be regarded as being an integral and integrating part of the following description.

In short, the invention is based on the idea of making both the input (primary shaft or

shafts) and the output (secondary shaft or shafts) of the main gearbox connectable each to a respective electric machine.

Preferably, the two electric machines are connectable the first one to the primary shaft of the main gearbox (or to one of the primary shafts, in case of a main gearbox with more than one primary shaft) via a gear set comprising a first gearwheel mounted on that primary shaft and via a first coupling device, and the second one to the secondary shaft of the main gearbox (or to one of the secondary shafts, in case of a main gearbox with more than one secondary shaft) via a gear set comprising a second gearwheel mounted on that secondary shaft and via a second coupling device. By suitably controlling the first and second coupling devices, the first and second electric machines can be connected to the input and to the output of the main gearbox, respectively.

According to a preferred embodiment of the invention, the transmission further comprises, for each electric machine, a respective secondary gearbox coupled to that machine so as to change the transmission ratio between this latter and the main gearbox.

Further characteristics and advantages of the present invention will appear from the following detailed description, given purely by way of non-limiting example with reference to the appended drawings, where:

Figure 1 is a schematic view of a hybrid transmission for a motor vehicle according to an embodiment of the present invention, in the neutral condition;

Figures 2 and 3 are a section view and a front view, respectively, which show in detail, on an enlarged scale, one of the two secondary gearboxes of the transmission of Figure 1;

Figure 4 is a schematic view of the transmission of Figure 1 in the condition of engagement of the first gear of the main gearbox;

Figure 5 is a schematic view of the transmission of Figure 1 in the condition of engagement of the second gear of the main gearbox;

Figure 6 is a schematic view of the transmission of Figure 1 in the condition of engagement of the third gear of the main gearbox;

Figure 7 is a schematic view of the transmission of Figure 1 in the condition of en-

gagement of the fourth gear of the main gearbox;

Figure 8 is a schematic view of the transmission of Figure 1 in the condition of traction in purely electric mode, in which the driving torque is generated only by the second electric machine (i.e. by the electric machine associated to the secondary shaft of the main gearbox) with the low gear of the respective secondary gearbox engaged;

Figure 9 is a schematic view of the transmission of Figure 1 in the condition of traction in purely electric mode, in which the driving torque is generated only by the second electric machine (i.e. by the electric machine associated to the secondary shaft of the main gearbox) with the high gear of the respective secondary gearbox engaged;

Figure 10 is a schematic view of the transmission of Figure 1 in the condition in which the first electric machine (i.e. the electric machine associated to the primary shaft of the main gearbox) is connected to the internal combustion engine of the vehicle with the low gear of the respective secondary gearbox engaged; and

Figure 11 is a schematic view of the transmission of Figure 1 in the condition in which the first electric machine is connected to the internal combustion engine of the vehicle with the high gear of the respective secondary gearbox engaged.

With reference first to Figure 1, a hybrid transmission for a motor vehicle according to an embodiment of the present invention is generally indicated 10 and basically comprises a main gearbox 12 associated to the internal combustion engine of the vehicle (not shown), a first electric machine 14 and a second electric machine 16. The main gearbox 12 is a mechanical gearbox with a plurality of gears (in the illustrated embodiment, the gearbox has four gears, but it might of course have a different number of gears, for example six gears) and is intended to be connected on the input side to the internal combustion engine of the vehicle through a friction clutch 18 and on the output side to vehicle wheels (not shown) through a differential gear 20 and through a pair of semi-axles 22. The friction clutch 18, as well as the differential gear 20, are of per-se-known type and do not play any role in the present invention, and therefore they will not be described in detail in the following description. The first electric machine 14 is releasably connected to the input (namely, to a primary shaft 24) of the main gearbox 12 and is therefore able to exchange (i.e. to transmit and to receive) torque with the internal combustion engine of the vehicle, according to a plurality of operating modes which will be illustrated in detail further on. The second elec-

tric machine 16 is releasably connected to the output (namely, to a secondary shaft 26) of the main gearbox 12 and is therefore able to exchange (i.e. to transmit and to receive) torque with the vehicle wheels, according to a plurality of operating modes which will be illustrated in detail further on. The transmission 10 further comprises a first secondary gearbox 28, which is interposed between the first electric machine 14 and the primary shaft 24 of the main gearbox 12 to change the transmission ratio with which the first electric machine 14 transmits the motion to the primary shaft 24 of the main gearbox 12 or receives the motion from that shaft, and a second secondary gearbox 30, which is interposed between the second electric machine 16 and the secondary shaft 26 of the main gearbox 12 to change the transmission ratio with which the second electric machine 16 transmits the motion to the secondary shaft 26 of the main gearbox 12 or receives the motion from that shaft.

In the embodiment shown in Figure 1, the transmission is of the single-clutch type and therefore the main gearbox 12 comprises a single primary shaft 24 which can be torsionally coupled to the shaft of the internal combustion engine of the vehicle by means of the friction clutch 18. However, the transmission might also be of the double-clutch type, in which case the main gearbox would comprise, in per-se-known manner, two primary shafts, each of which can be coupled to the shaft of the internal combustion engine of the vehicle by means of a respective friction clutch.

Moreover, in the embodiment shown in Figure 1, the main gearbox 12 is a gearbox with two axes and therefore comprises a single secondary shaft 26 arranged parallel to the primary shaft 24. However, the main gearbox 12 might also comprise more than one secondary shaft.

The primary shaft 24 of the main gearbox 12 carries a plurality of driving gearwheels (four driving gearwheels, in the embodiment shown in Figure 1) each associated to a respective gear (or transmission ratio), whereas the secondary shaft 26 carries a corresponding plurality of driven gearwheels permanently meshing each with a respective driving gearwheel to provide a respective gear. The secondary shaft 26 also carries a final reduction pinion 32 intended to mesh with an input gearwheel 34 of the differential gear 20.

More specifically, in the embodiment shown in Figure 1 the primary shaft 24 carries, in the order from left to right with respect to a person looking at Figures 1 to 9, a driving gearwheel 36 associated to the fourth gear, a driving gearwheel 38 associated to the second gear, a driving gearwheel 40 associated to the third gear and a driving gearwheel 42 associated to the first gear. In the embodiment shown in Figure 1 the driving gearwheels 36, 38, 40 and 42 are made as fixed wheels and are therefore permanently connected for rotation with the primary shaft 24.

According to an embodiment, the secondary shaft 26 carries, in the order from left to right with respect to a person looking at Figure 1, a driven gearwheel 44 permanently meshing with the driving gearwheel 36 to form the gear set of fourth gear, a driven gearwheel 46 permanently meshing with the driving gearwheel 38 to form the gear set of second gear, a driven gearwheel 48 permanently meshing with the driving gearwheel 40 to form the gear set of third gear and a driven gearwheel 50 permanently meshing with the driving gearwheel 42 to form the gear set of first gear. Preferably, the driven gearwheels 44, 46, 48 and 50 are idly mounted on the secondary shaft 26 and are selectively connectable for rotation therewith by means of coupling devices of per-se-known type. More specifically, the secondary shaft 26 carries a first coupling device 52 arranged between the driven gearwheels 44 and 46 to selectively connect either of these wheels for rotation with the secondary shaft 26, and a second coupling device 54 interposed between the driven gearwheels 48 and 50 to selectively connect either of these wheels for rotation with the secondary shaft 26. The first coupling device 52 is shiftable between a first engagement position (left-hand position with respect to a person looking at Figure 1), in which it connects the driven gearwheel 44 for rotation with the secondary shaft 26, and a second engagement position (right-hand position with respect to a person looking at Figure 1), in which it connects the driven gearwheel 46 for rotation with the secondary shaft 26, passing through an intermediate neutral position, in which it does not connect for rotation with the secondary shaft 26 either the driven gearwheel 44 or the driven gearwheel 46. The second coupling device 54 is shiftable between a first engagement position (left-hand position with respect to a person looking at Figure 1), in which it connects the driven gearwheel 48 for rotation with the secondary shaft 26, and a second engagement position (right-hand position with respect to a person looking at Figure 1), in which it connects the driven gearwheel 50 for rotation

with the secondary shaft 26, passing through an intermediate neutral position, in which it does not connect for rotation with the secondary shaft 26 either the driven gearwheel 48 or the driven gearwheel 50.

Not only the number of shafts of the main gearbox 12, as already mentioned above, but also the number of gears and the arrangement of the gearwheels associated to the various gears may of course be different from those proposed herein.

As already stated above, the first electric machine 14 is releasably connected to the input of the main gearbox 12, while the second electric machine 16 is releasably connected to the output of the main gearbox 12.

According to an embodiment, the first electric machine 14 is releasably connected to the primary shaft 24 of the main gearbox 12 through a first connection gear set comprising a gearwheel 56 carried by an output shaft 58 of that machine (which output shaft 58 is advantageously oriented parallel to the shafts 24 and 26 of the main gearbox 12), a gearwheel 60 carried by the primary shaft 24 and an intermediate gearwheel 62 permanently meshing both with the gearwheel 56 and with the gearwheel 60. Likewise, the second electric machine 16 is releasably connected to the secondary shaft 26 of the main gearbox 12 through a second connection gear set comprising a gearwheel 64 carried by an output shaft 66 of that machine (which output shaft 66 is advantageously oriented parallel to the shafts 24 and 26 of the main gearbox 12), a gearwheel 68 carried by the secondary shaft 26 and an intermediate gearwheel 70 permanently meshing both with the gearwheel 64 and with the gearwheel 68. Further intermediate gearwheels, in addition to the gearwheel 62, might be interposed between the gearwheels 56 and 60 of the first connection gear set. Likewise, further intermediate gearwheels, in addition to the gearwheel 70, might be interposed between the gearwheels 64 and 68 of the second connection gear set.

In the embodiment shown in Figure 1, the gearwheel 60 of the first connection gear set is made as a fixed wheel, and is therefore drivingly connected for rotation with the primary shaft 24, whereas the gearwheel 56 of the first connection gear set is idly mounted on the output shaft 58 of the first electric machine 14 and is connectable for rotation therewith by

means of the first secondary gearbox 28. Likewise, the gearwheel 68 of the second connection gear set is made as a fixed wheel, and is therefore drivingly connected for rotation with the secondary shaft 26, whereas the gearwheel 64 of the second connection gear set is idly mounted on the output shaft 66 of the second electric machine 16 and is connectable for rotation therewith by means of the second secondary gearbox 30. Alternatively, should the first and second secondary gearboxes 28 and 30 not be provided for, the gearwheel 56 of the first connection gear set would be made as a fixed wheel, and therefore would be drivingly connected for rotation with the output shaft 58 of the first electric machine 14, whereas the gearwheel 60 of the first connection gear set would be idly mounted on the primary shaft 24 and would be connectable for rotation therewith by means of a respective coupling device. Likewise, the gearwheel 64 of the second connection gear set would be made as a fixed wheel, and therefore would be drivingly connected for rotation with the output shaft 66 of the second electric machine 16, whereas the gearwheel 68 of the second connection gear set would be idly mounted on the secondary shaft 26 and would be connectable for rotation therewith by means of a respective coupling device.

The first secondary gearbox 28 allows to vary the transmission ratio with which the first electric machine 14 transmits the motion to the primary shaft 24 of the main gearbox 12, or receives the motion from that shaft, and also to disconnect the first electric machine 14 from the primary shaft 24 of the main gearbox 12. Likewise, the second secondary gearbox 30 allows to vary the transmission ratio with which the second electric machine 16 transmits the motion to the secondary shaft 26 of the main gearbox 12, or receives the motion from that shaft, and also to disconnect the second electric machine 16 from the secondary shaft 26 of the main gearbox 12.

The structure and operation of the two secondary gearboxes 28 and 30 will be described now in detail, with reference in particular to Figures 2 and 3. In Figures 2 and 3 the reference numerals relating to the first secondary gearbox 28 are used, but the description provided here below is also applicable to the second secondary gearbox 30. In the embodiment shown in Figures 2 and 3, the first secondary gearbox 28 is a gearbox with two gears and comprises a reduction mechanism 72 interposed between the shaft 58 of the first electric machine 14 and the gearwheel 56 of the first connection gear set and a coupling device

74 adapted to connect the gearwheel 56 for rotation alternatively with the reduction mechanism 72 or with the output shaft 58. In this way, when the gearwheel 56 is connected for rotation with the reduction mechanism 72, the first electric machine 14 transmits the motion to the primary shaft 24 of the main gearbox 12 with a first gear (low gear) engaged, the torque passing through the output shaft 58, the reduction mechanism 72, the gearwheel 56, the intermediate gearwheel 62 and the gearwheel 60, or vice versa (depending on the first electric machine 14 operating as a motor or as a generator), whereas when the gearwheel 56 is connected for rotation directly with the output shaft 58, the first electric machine 14 transmits the motion to the primary shaft 24 of the main gearbox 12 with a second gear (high gear) engaged, the torque passing through the output shaft 58, the gearwheel 56, the intermediate gearwheel 62 and the gearwheel 60, or vice versa (depending on the first electric machine 14 operating as a motor or as a generator). More specifically, in the embodiment shown in Figures 10 and 11 the reduction mechanism 72 is a planetary reduction mechanism and comprises a sun gear 76, which is drivingly connected for rotation with an intermediate shaft 78 connected in turn for rotation, for example by means of a splined coupling 80, with the output shaft 58 of the first electric machine 14, a planet carrier 82 carrying a plurality of planet gears 84 (three planet gears, in the embodiment shown in the drawings), and a ring gear 86. Both the planet carrier 82 and the gearwheel 56 are idly mounted on the intermediate shaft 78. The coupling device 74 allows to connect alternatively the planet carrier 82 or the gearwheel 56 for rotation with the intermediate shaft 78, and hence with the output shaft 58 of the first electric machine 14. In the embodiment shown in Figures 2 and 3, the coupling device 74 is made as a sliding sleeve and is provided on the one hand with first engagement teeth 88 (made as inner teeth in the illustrated example) adapted to mesh alternatively with corresponding engagement teeth 90 of the planet carrier 82 or with corresponding engagement teeth 92 of the intermediate shaft 78 (both made as outer teeth in the illustrated example) and on the other hand with second engagement teeth 94 (made as inner teeth in the illustrated example) which permanently mesh with corresponding engagement teeth 96 (made as outer teeth in the illustrated example) of the gearwheel 56. The coupling device 74 is shiftable between a first engagement position (left-hand position with respect to a person looking at Figure 2), in which it connects the planet carrier 82 for rotation with the gearwheel 56, thus providing the low gear, a second engagement position (right-hand position with respect to a person looking at

Figure 2), in which it connects the intermediate shaft 78, and hence the output shaft 58, for rotation with the gearwheel 56, thus providing the high gear, and a neutral position, in which the gearwheel 56 is neither connected to the planet carrier 82 nor to the intermediate shaft 78.

With reference now to Figures 4 to 11, where the gear sets associated to the first, second, third and fourth gears of the main gearbox 12 are indicated with the roman numerals I, II, III and IV, respectively, while the positions of the coupling devices 74 of the two secondary gearboxes 28 and 30 corresponding to the engagement of the low gear and to the engagement of the high gear are indicated L and H, respectively, some of the various operating conditions of the transmission 10 according to the proposed embodiment will be described. In each of the schemes shown in Figures 4 to 11, the torque path inside the transmission is indicated by an arrow.

Figures 4 to 7 refer to the condition where neither of the electric machines 14 and 16 is connected to the main gearbox 12, as both the coupling devices 74 of the two secondary gearboxes 28 and 30 are in the neutral position.

More specifically, Figure 4 shows the condition of engagement of the first gear, obtained by shifting the coupling device 54 into the second engagement position defined above, in which that device connects the driven gearwheel 50 for rotation with the secondary shaft 26. The transmission of the motion from the primary shaft 24 to the secondary shaft 26 of the main gearbox 12 takes place therefore through the gear set of first gear formed by the driving gearwheel 42 and by the driven gearwheel 50.

Figure 5 shows the condition of engagement of the second gear, obtained by shifting the coupling device 52 into the second engagement position defined above, in which that device connects the driven gearwheel 46 for rotation with the secondary shaft 26. The transmission of the motion from the primary shaft 24 to the secondary shaft 26 of the main gearbox 12 takes place therefore through the gear set of second gear formed by the driving gearwheel 38 and by the driven gearwheel 46.

Figure 6 shows the condition of engagement of the third gear, obtained by shifting the coupling device 54 into the first engagement position defined above, in which that device connects the driven gearwheel 48 for rotation with the secondary shaft 26. The transmission of the motion from the primary shaft 24 to the secondary shaft 26 of the main gearbox 12 takes place therefore through the gear set of third gear formed by the driving gearwheel 40 and by the driven gearwheel 48.

Figure 7 shows the condition of engagement of the fourth gear, obtained by shifting the coupling device 52 into the first engagement position defined above, in which that device connects the driven gearwheel 44 for rotation with the secondary shaft 26. The transmission of the motion from the primary shaft 24 to the secondary shaft 26 of the main gearbox 12 takes place therefore through the gear set of fourth gear formed by the driving gearwheel 36 and by the driven gearwheel 44.

In each of the four above-described operating conditions, the second electric machine 16 can be connected to the secondary shaft 26 of the main gearbox 12 by shifting the coupling device 74 of the second secondary gearbox 30 into the first or the second engagement position (low gear or high gear) and can therefore transmit torque to the vehicle wheels in parallel to the internal combustion engine. In this connection, it is to be noticed that having a secondary gearbox with two or more gears associated to the second electric machine allows this latter to operate in optimal number of revolutions per minute conditions (maximum efficiency) in a wider speed range of the motor vehicle than in the case where there is no secondary gearbox associated to the second electric machine.

Figures 8 and 9 refer to the purely electric operating condition of the transmission, in which the second electric machine 16 is connected to the secondary shaft 26 of the main gearbox 12 by virtue of the fact that the coupling device 74 of the second secondary gearbox 30 is in the first or second engagement position defined above, while the coupling devices 52 and 54 of the main gearbox 12 are each in the neutral position. In the condition illustrated in Figure 8 the second electric machine 16 transmits torque with the low gear engaged, whereas Figure 9 refers to the condition of engagement of the high gear of the second secondary gearbox 30.

Figures 10 and 11 finally refer to the condition in which the first electric machine 14 is connected to the primary shaft 24 of the main gearbox 12 and hence, through the friction clutch 18, to the internal combustion engine of the vehicle, to operate either as a starting motor to start the internal combustion engine or as a generator to generate current to charge the batteries on board of the vehicle. In that condition, the coupling device 74 of the first secondary gearbox 28 is in the first or second engagement position defined above, as shown in Figure 10 and in Figure 11, respectively, whereas the coupling devices 52 and 54 of the main gearbox 12 are each in the neutral position.

As is clear from the above description, the connection of the first electric machine 14 with the primary shaft 24 of the main gearbox 12 and the connection of the second electric machine 16 with the secondary shaft 26 of the main gearbox 12 are controllable through the coupling devices 74 of the two secondary gearboxes 28 and 30 associated to those electric machines. Should the secondary gearboxes associated to the two electric machines 14 and 16 not be provided for, the gearwheels 60 and 68 of the first and second connection gear sets might be idly mounted on the respective primary shaft 24 and secondary shaft 26 and be connectable for rotation each with the respective shaft by means of a respective coupling device, in which case the connection between the electric machines and the primary and secondary shafts of the main gearbox would be controllable through these two coupling devices.

The hybrid transmission according to the invention is therefore able to operate in the following operating modes:

- non-hybrid traction mode, in which the electric machines are neither connected to the input (primary shaft) nor to the output (secondary shaft) of the main gearbox and therefore the vehicle wheels receive the torque from the internal combustion engine only;
- hybrid traction mode, in which the second electric machine is connected to the output of the transmission (secondary shaft) and operates as a motor to generate torque for the vehicle wheels in parallel to the internal combustion engine;
- purely electric traction mode, in which the second electric machine is connected to the output of the transmission (secondary shaft) and operates as a motor to generate torque for the vehicle wheels in place of the internal combustion engine; this mode can be used

either when the vehicle is running in purely electric mode (in the forward or backward direction, this latter being obtained by inverting the direction of rotation of the electric machine) or during the gear shift phases of the main gearbox to compensate for or at least to reduce the interruption in the transmission of the torque (the so-called "torque hole") that occurs during shifting from one gear to another;

- starting mode, in which the first electric machine is connected to the input of the transmission (primary shaft) and operates as a starting motor to start the internal combustion engine of the vehicle;

- generation mode, in which the first electric machine is connected to the input of the transmission (primary shaft) and receive the motion from the internal combustion engine of the vehicle to operate as an electric power generator to charge the batteries on board of the vehicle; and

- kinetic energy recovery mode, in which the second electric machine is connected to the output of the transmission (secondary shaft) and receives the motion from the vehicle wheels to operate as an electric power generator to charge the batteries on board of the vehicle; in this operating mode the resisting torque from the second electric machine causes a braking effect on the vehicle wheels and can thus be used as a braking assisting means.

Naturally, the principle of the invention remaining unchanged, the embodiments and the constructional details may vary widely from those described and illustrated purely by way of non-limiting example, without thereby departing from the scope of the invention as defined in the attached claims.

CLAIMS

1. Hybrid transmission (10) for a motor vehicle, comprising a main gearbox (12), a first electric machine (14) and a second electric machine (16),
wherein the main gearbox (12) is a mechanical gearbox with a plurality of gears and comprises at least one primary shaft (24) adapted to be connected to a shaft of the internal combustion engine of the vehicle and at least one secondary shaft (26) adapted to be connected to the vehicle wheels,
wherein the transmission (10) further comprises a first coupling device (74) interposed between said first electric machine (14) and said at least one primary shaft (24) and a second coupling device (74) interposed between said second electric machine (16) and said at least one secondary shaft (26),
wherein said first electric machine (14) is releasably connected, through said first coupling device (74), to said at least one primary shaft (24), and
wherein said second electric machine (16) is releasably connected, through said second coupling device (74), to said at least one secondary shaft (26).

2. Transmission according to claim 1, further comprising a first connection gear set (56, 60, 62) for connection of said first electric machine (14) with said at least one primary shaft (24) and a second connection gear set (64, 68, 70) for connection of said second electric machine (16) with said at least one secondary shaft (26), wherein said first connection gear set (56, 60, 62) includes a first gearwheel (60) mounted on said at least one primary shaft (24), and wherein said second connection gear set (64, 68, 70) includes a second gearwheel (68) mounted on said at least one secondary shaft (26).

3. Transmission according to claim 2, further comprising a first secondary gearbox (28) with two or more gears interposed between said first electric machine (14) and said first gearwheel (60).

4. Transmission according to claim 3, wherein said first electric machine (14) comprises a first output shaft (58) on which a first output gearwheel (56) forming part of said first connection gear set (56, 60, 62) is idly mounted, and wherein said first secondary

gearbox (28) comprises a first reduction mechanism (72), which is interposed between said first output shaft (58) and said first output gearwheel (56), and a coupling device (74), which is shiftable at least into a first engagement position, in which it connects said first output shaft (58) for rotation with said first output gearwheel (56) through said first reduction mechanism (72) to provide a first gear, or low gear, of said first secondary gearbox (28), and into a second engagement position, in which it connects said first output gearwheel (56) for rotation directly with said first output shaft (58) to provide a second gear, or high gear, of said first secondary gearbox (28).

5. Transmission according to claim 4, wherein said first gearwheel (60) is drivingly connected for rotation with said at least one primary shaft (24), wherein the coupling device (74) of said first secondary gearbox (28) is also shiftable into a neutral position, in which it disconnects said first output gearwheel (56) both from said first output shaft (58) and from said first reduction mechanism (72), and wherein said first coupling device (74) is formed by the coupling device of said first secondary gearbox (28).

6. Transmission according to any of claims 2 to 5, further comprising a second secondary gearbox (30) with two or more gears interposed between said second electric machine (16) and said second gearwheel (68).

7. Transmission according to claim 6, wherein said second electric machine (16) comprises a second output shaft (66) on which a second output gearwheel (64) forming part of said second connection gear set (64, 68, 70) is idly mounted, and wherein said second secondary gearbox (30) comprises a second reduction mechanism (72), which is interposed between said second output shaft (66) and said second output gearwheel (64), and a coupling device (74), which is shiftable at least into a first engagement position, in which it connects said second output shaft (66) for rotation with said second output gearwheel (64) through said second reduction mechanism (72) to provide a first gear, or low gear, of said second secondary gearbox (30), and into a second engagement position, in which it connects said second output gearwheel (64) for rotation directly with said second output shaft (66) to provide a second gear, or high gear, of said second secondary gearbox (30).

8. Transmission according to claim 7, wherein said second gearwheel (68) is drivingly connected for rotation with said at least one secondary shaft (26), wherein the coupling device (74) of said second secondary gearbox (30) is also shiftable into a neutral position, in which it disconnects said second output gearwheel (64) both from said second output shaft (66) and from said second reduction mechanism (72), and wherein said second coupling device (74) is formed by the coupling device of said second secondary gearbox (30).

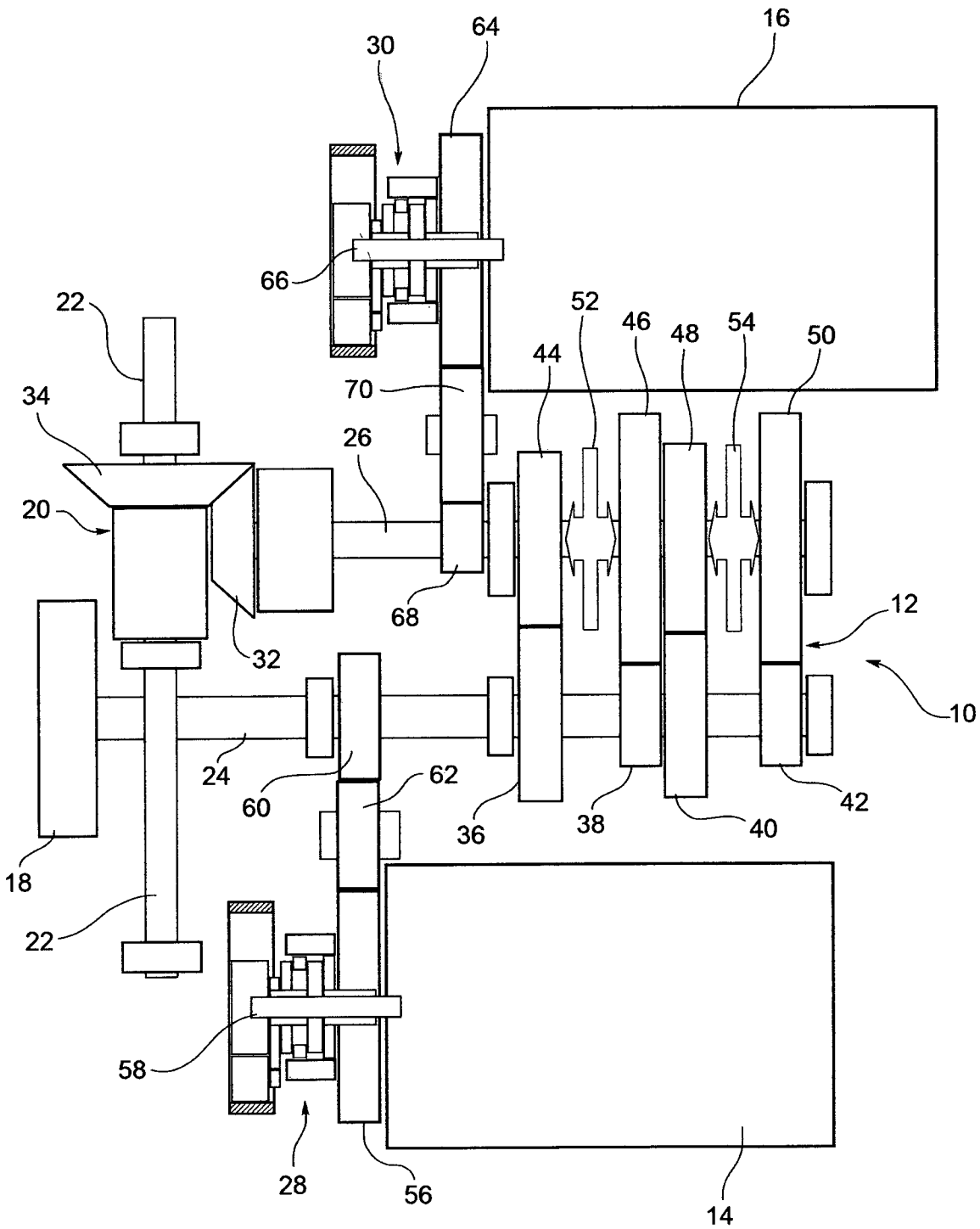
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FIG. 1

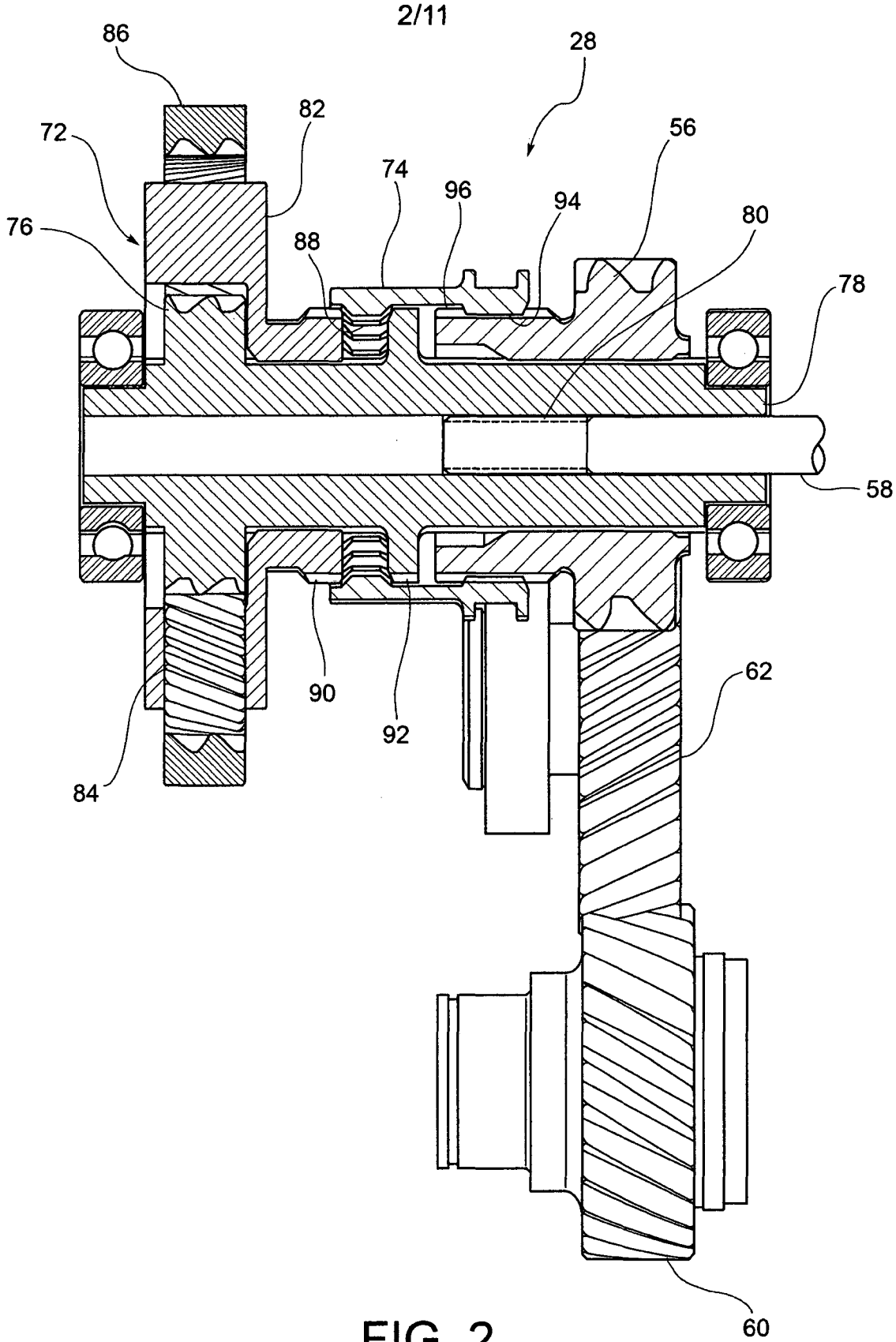

FIG. 2

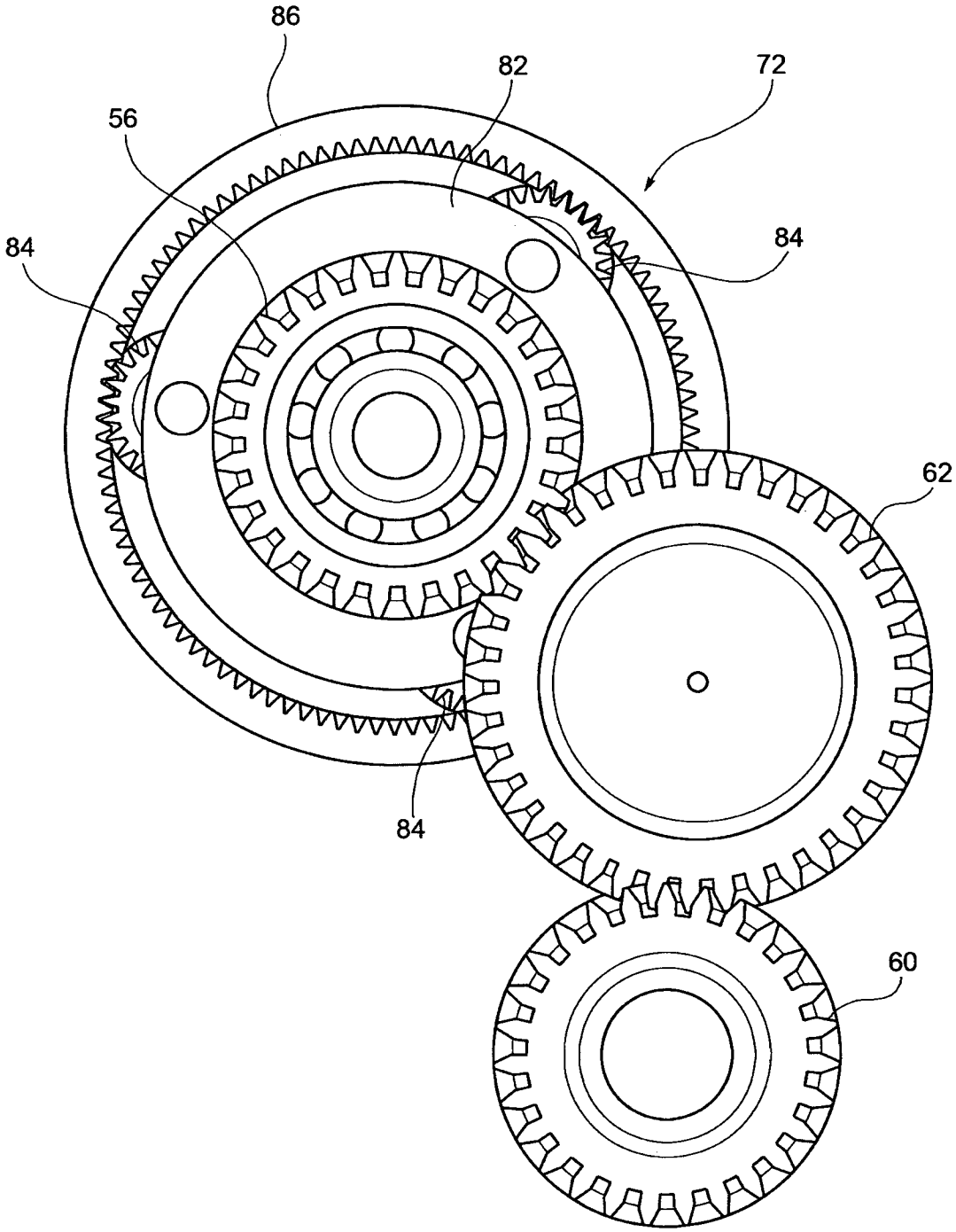

FIG. 3

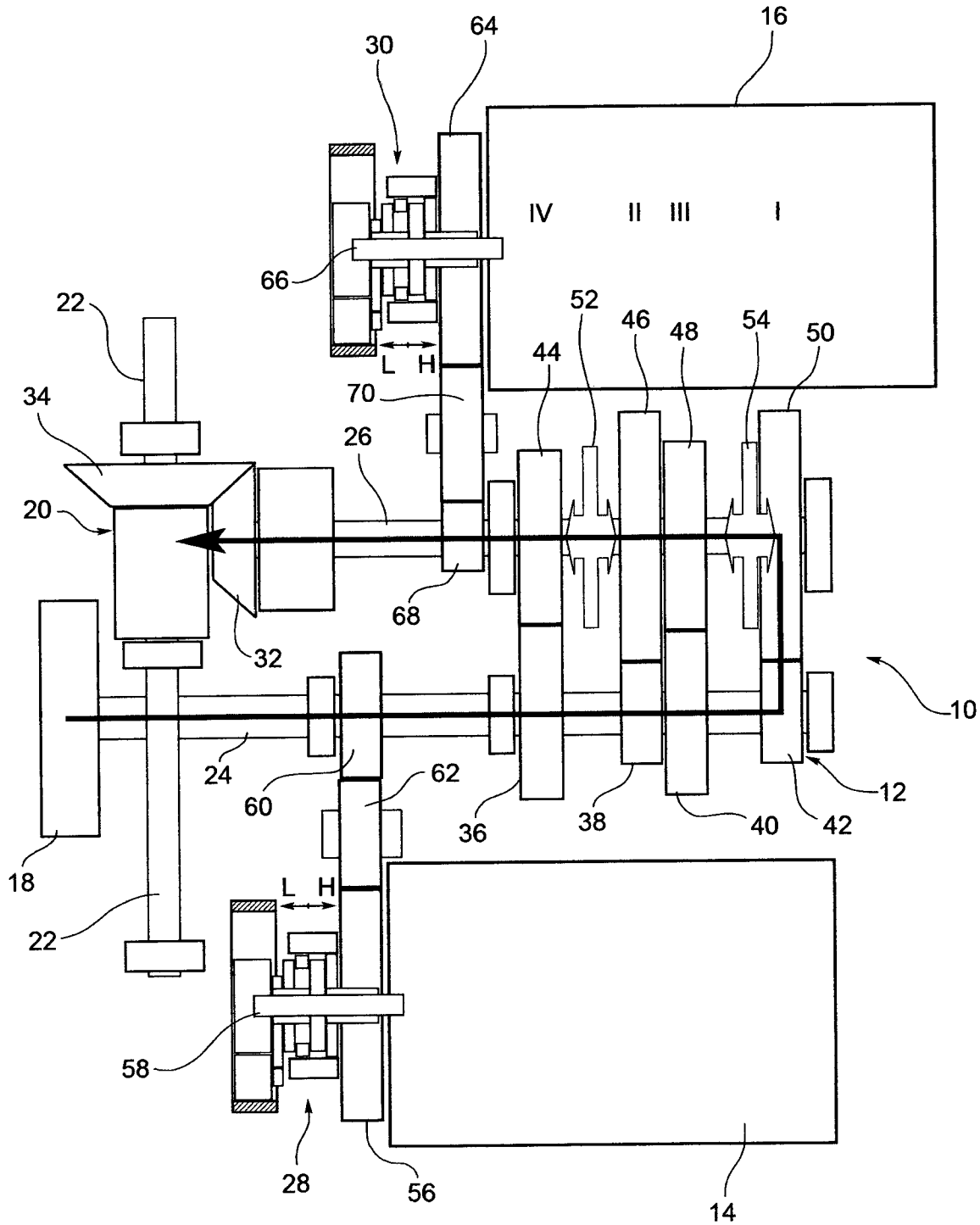
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FIG. 4

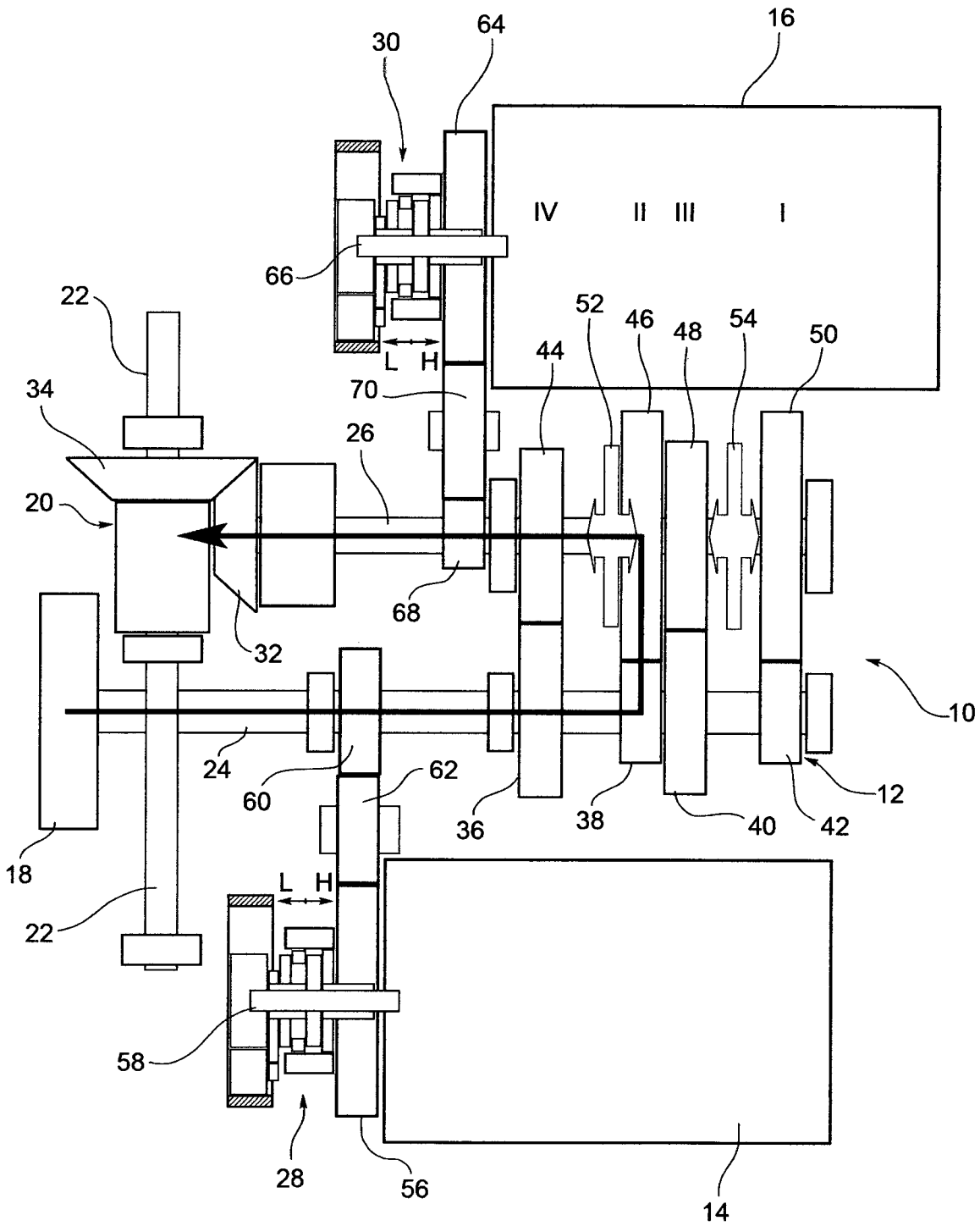
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FIG. 5

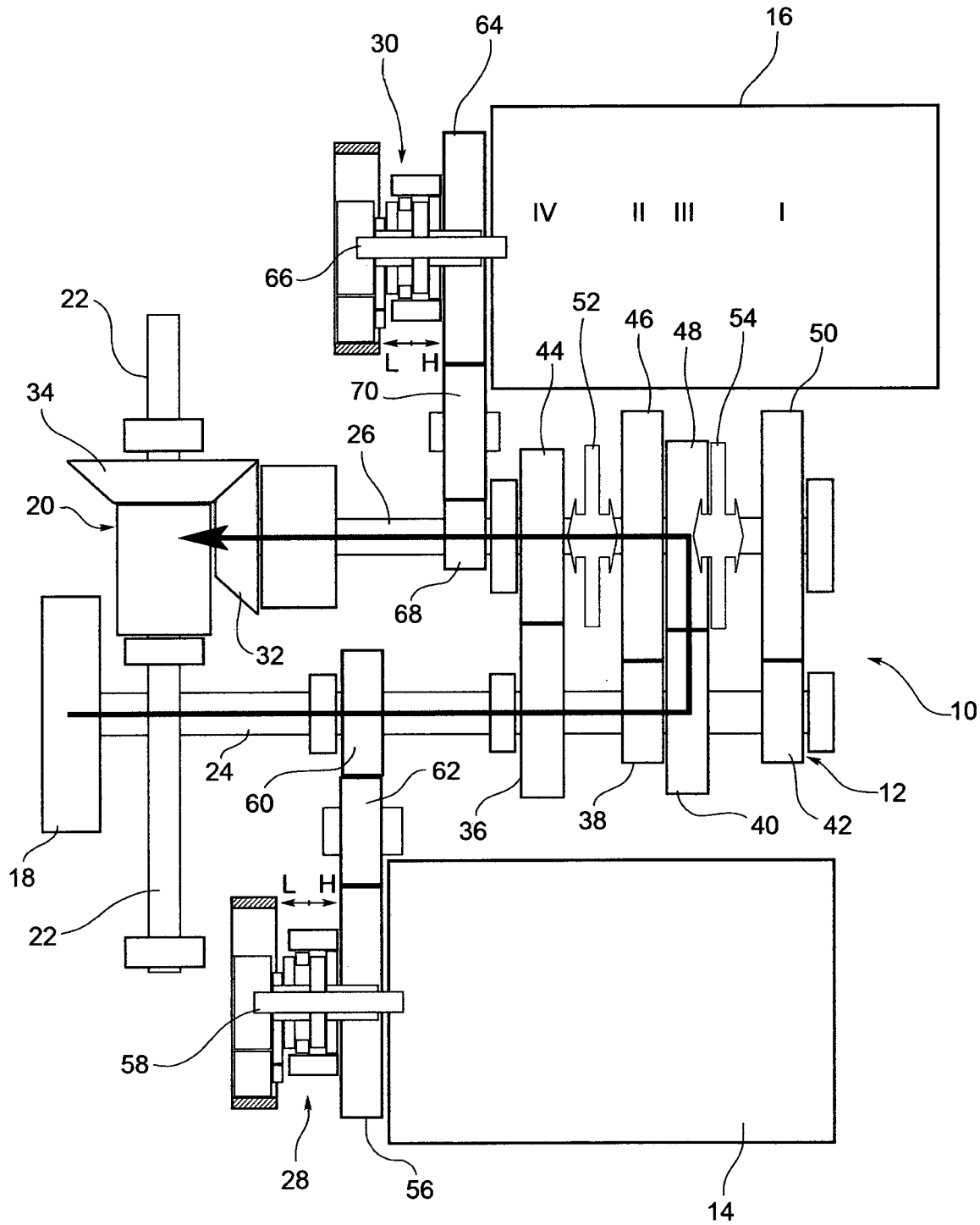
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FIG. 6

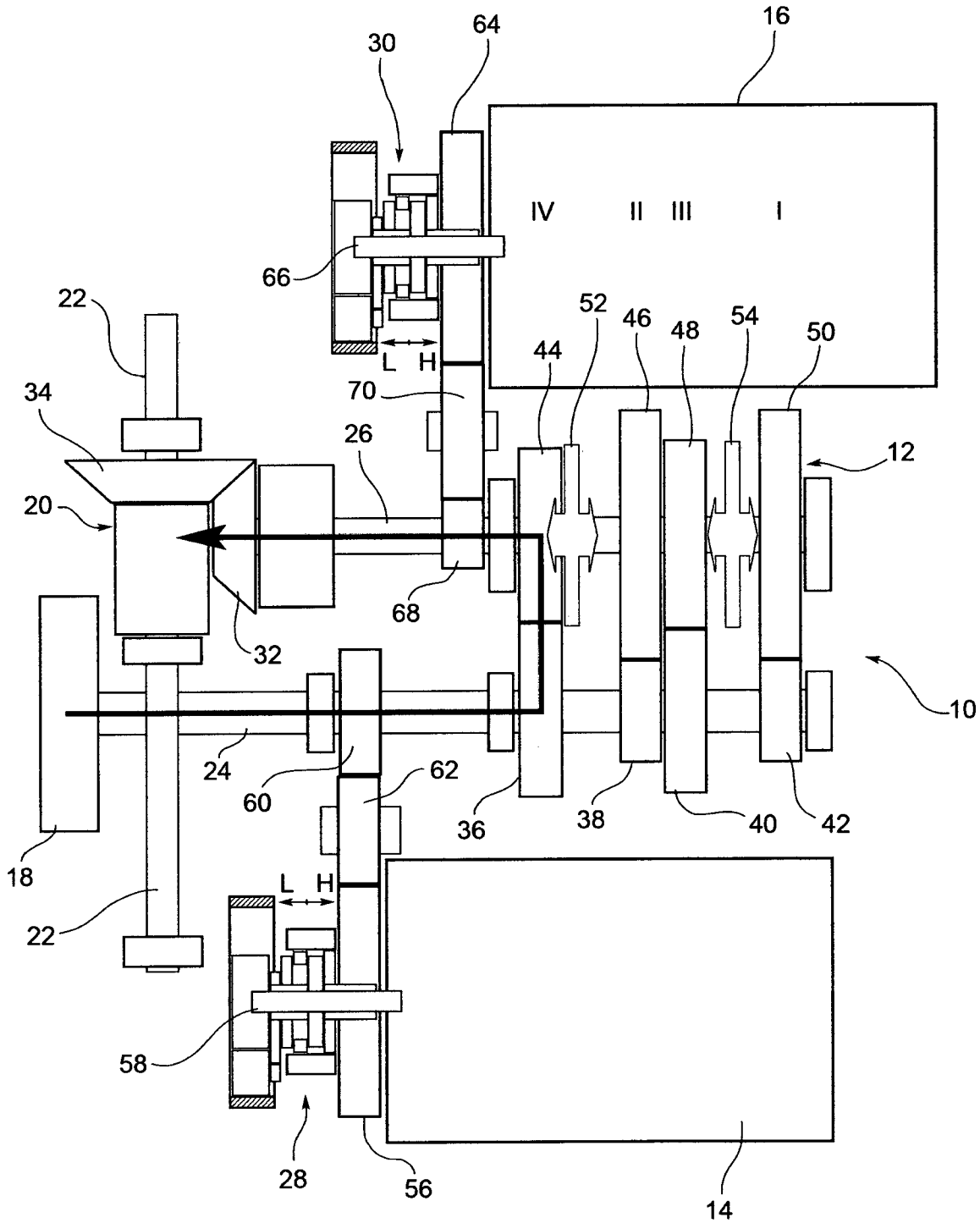
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FIG. 7

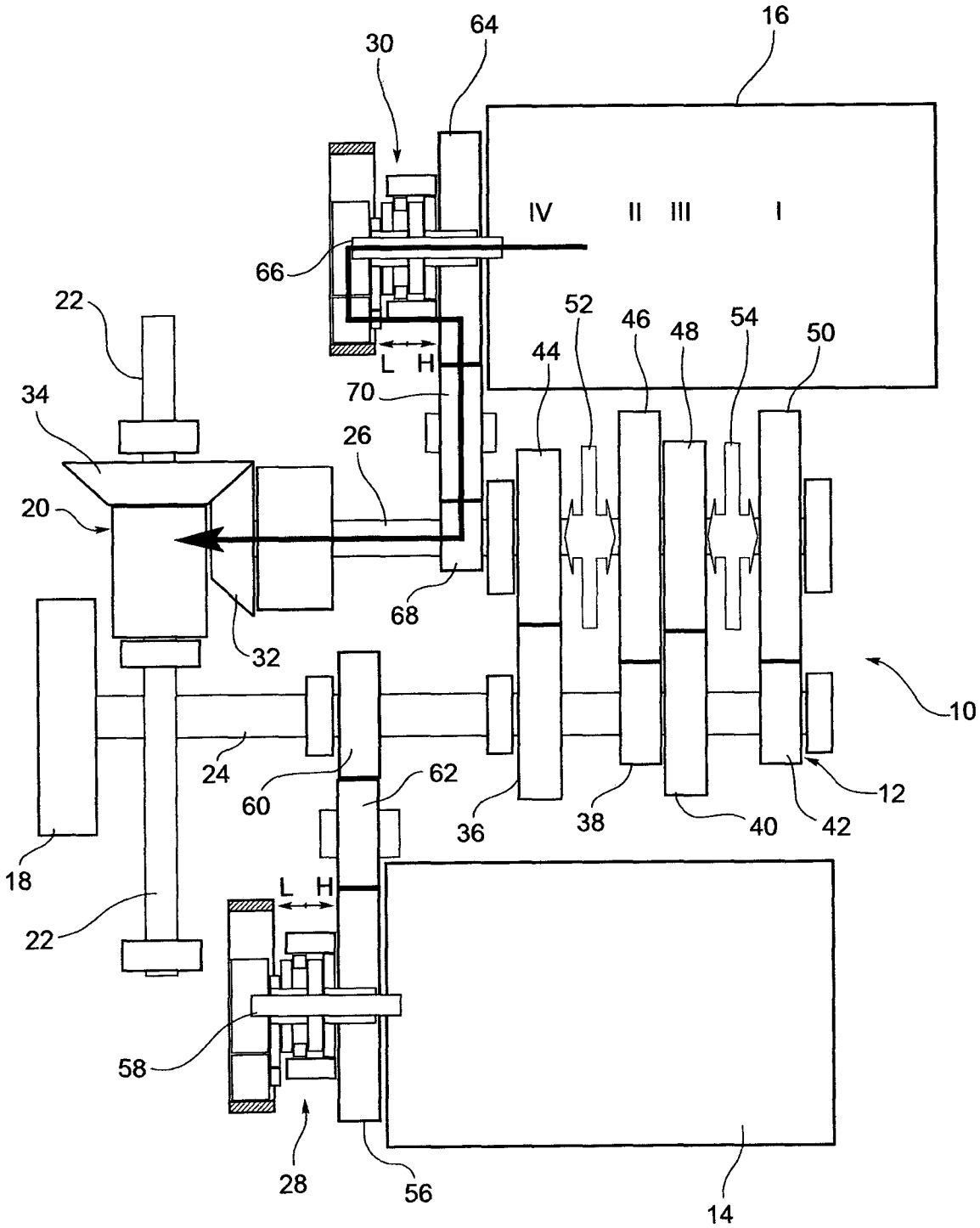
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FIG. 8

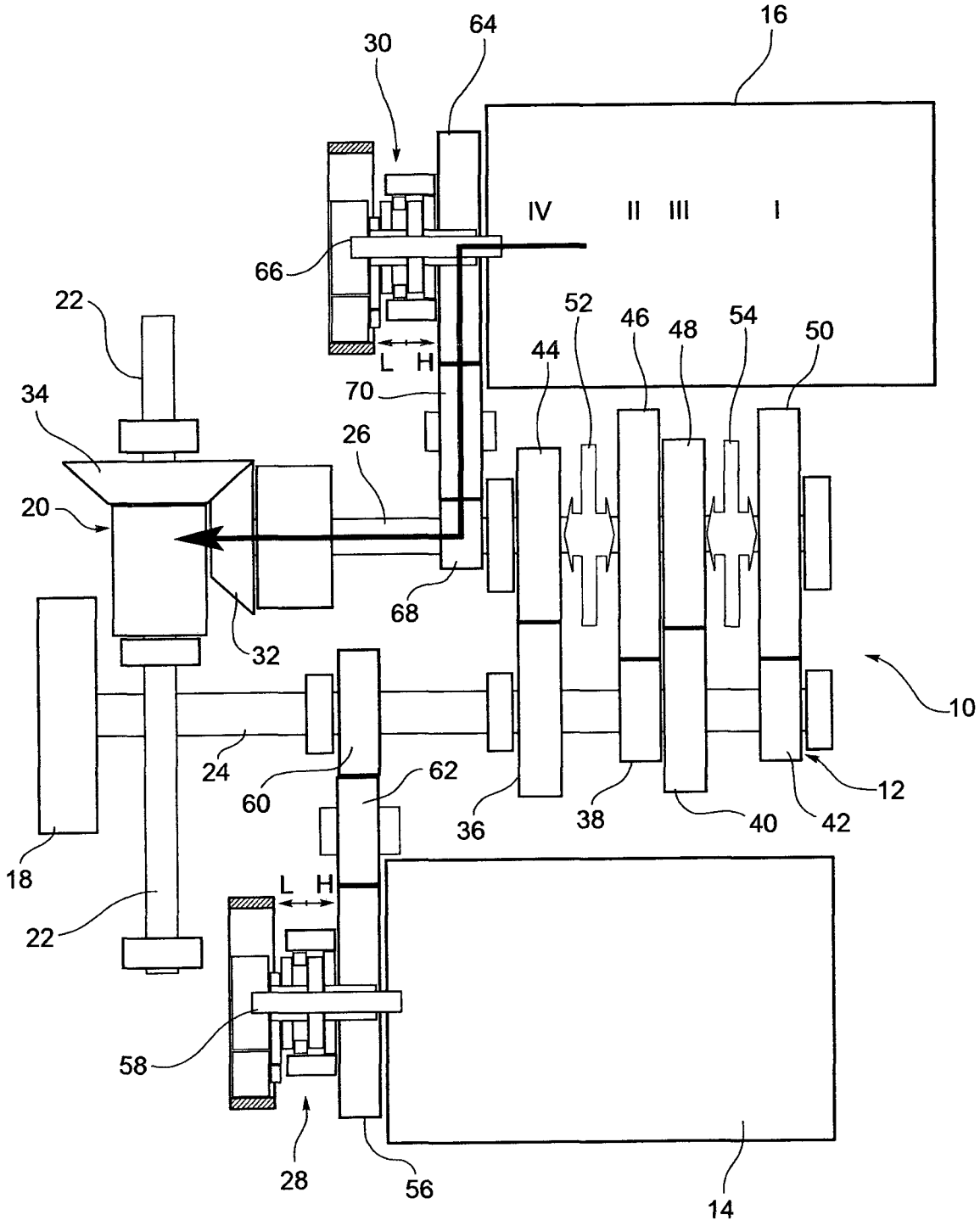
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FIG. 9

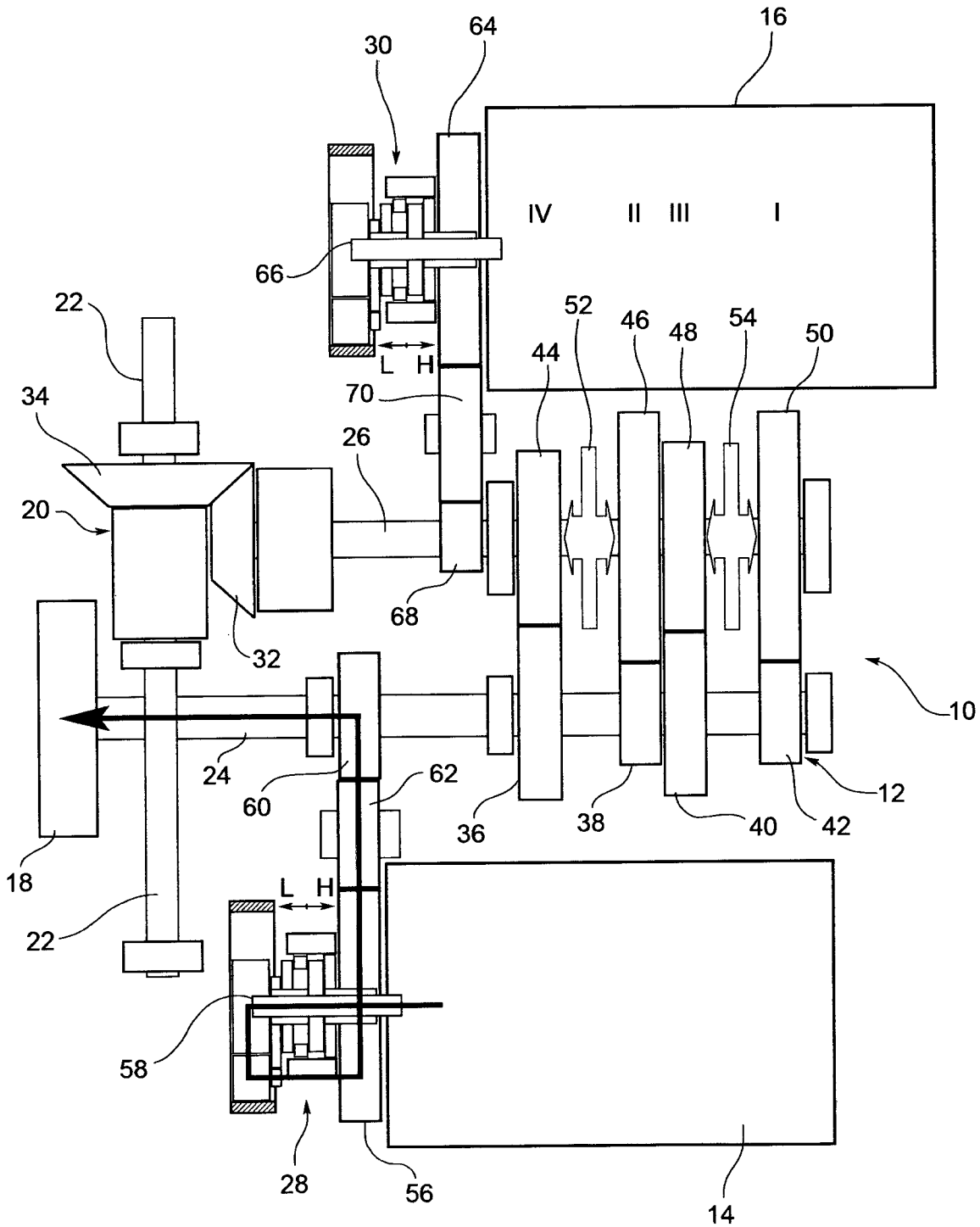
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FIG. 10

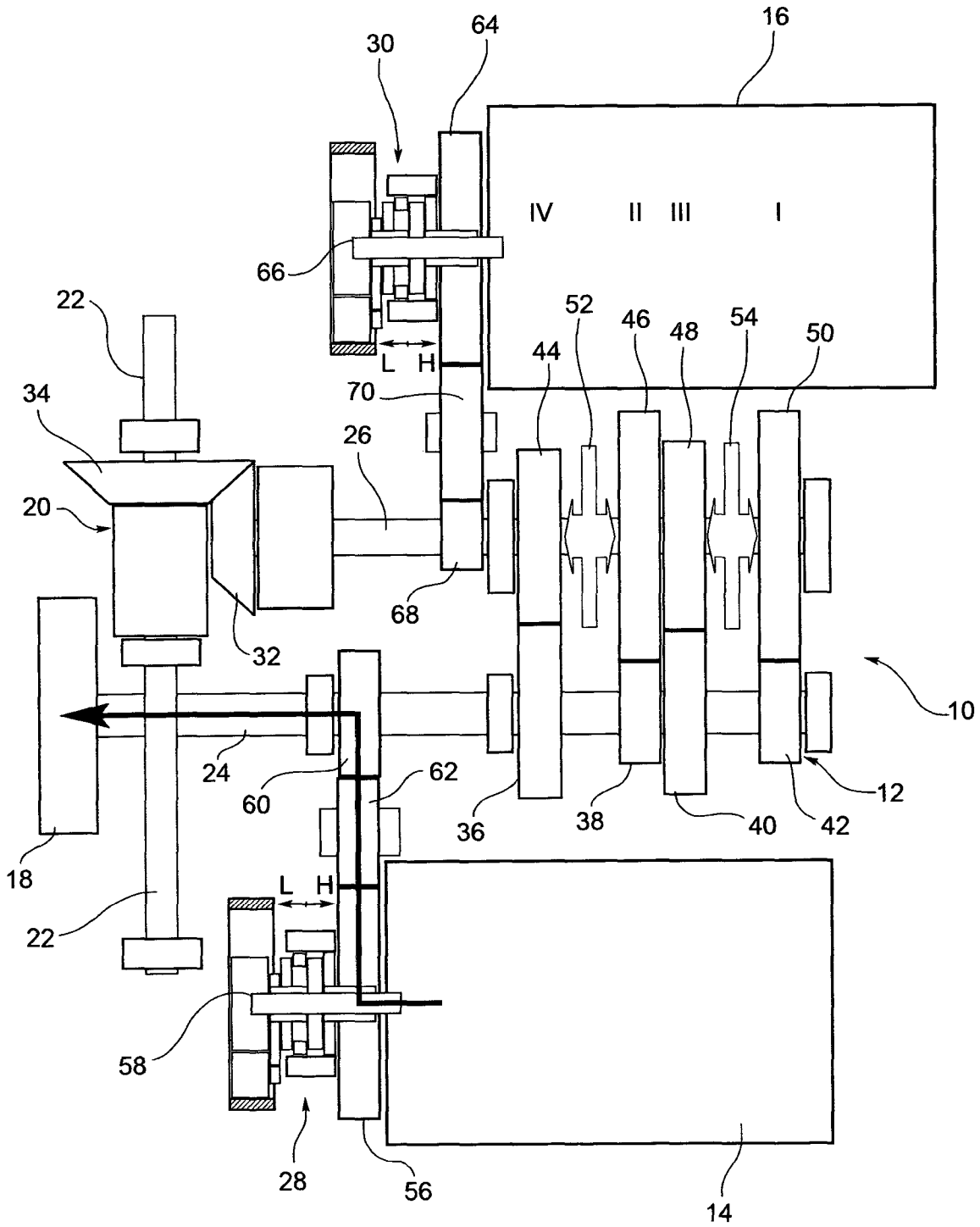
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FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/055216

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60K6/442 B60K6/387
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	US 2002/024306 A1 (IMAI NOBUYUKI [JP] ET AL) 28 February 2002 (2002-02-28) the whole document	1-3
Y	FR 2 951 995 A1 (RENAULT SA [FR]) 6 May 2011 (2011-05-06) the whole document	1,2
Y	EP 1 122 109 A2 (HITACHI LTD [JP]) 8 August 2001 (2001-08-08) the whole document	1,2

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

☒ See patent family annex.

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"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

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"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
25 October 2013	05/11/2013

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	Vogt-Schilb, Gérard

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2013/055216

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