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(54) **TRANSMISSION UNIT FOR VEHICLE EQUIPPED WITH PROPULSION PEDALS.**

(57) The invention is directed to a transmission unit (2) for a vehicle equipped with propulsion pedals, comprising: a central shaft (4); a transmission output shaft (8) coaxial with the central shaft (4); a planetary gear unit (12) carried by the central shaft (4) and configured for transmitting mechanical power from an input shaft of said planetary gear unit (12) to the transmission output shaft (8); an electric motor unit (14); a housing (18) carrying the central shaft (4), the transmission output shaft (8) and the planetary gear unit (12); the electric motor unit (14) is coaxial with the central shaft (4) and comprises an output shaft fixedly coupled to the input shaft of the planetary gear unit (12), and the central shaft (4) is coupled to said output shaft of the electric motor unit (14) and said input shaft of the planetary gear unit (12) by a freewheel.

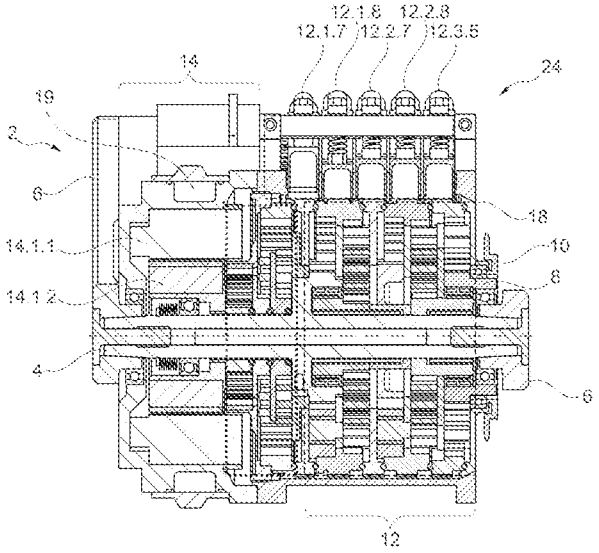

Fig. 2

Description

TRANSMISSION UNIT FOR VEHICLE EQUIPPED WITH PROPULSION PEDALS

Technical field

[0001] The invention is directed to the field of transmission for muscle driven vehicles equipped with propulsion pedals, like bicycles, in particular electrically assisted bicycles.

Background art

[0002] Prior art patent document published WO 2019/0158811 A1 discloses a drive assembly for bicycle, configured to be mounted on the bicycle frame and supporting the pedal arms. The drive assembly comprises a central input shaft supporting the pedal arms, a coaxial output shaft supporting a chain sprocket. The power transmission between the input shaft and the output shaft comprises a series of planetary gear units operatively connected to each other and whose ring gear, planetary gear carrier or sun gear can be selectively stopped by frictional braking units, so as to provide different transmission ratios. The use of frictional braking units is advantageous for smooth speed shifting, however lowers the mechanical efficiency of the transmission due to the frictional losses during shifting and the energy required for operating the shifting. The drive assembly also comprises an electric motor that is operatively permanently coupled to the input shaft, which is not favourable when using the drive assembly without power input of the electric motor. Also, the electric motor is positioned radially laterally relative to the central input and output shafts and operatively coupled to the power transmission via a reducing gearing. This increases the volume of the drive system and potentially raises the gravity centre of the bicycle.

[0003] Prior art patent document published US 2012/0071290 A1 discloses a drive assembly for bicycles, configured to be mounted on the bicycle frame and supporting pedal arms. The drive assembly comprises a central input shaft supporting the pedal arms, a coaxial output shaft supporting a chain sprocket. The power transmission between the input shaft and the output shaft comprises a series of planetary gear units operatively connected to each other. The central input shaft comprises ratchet pawls pivotally

mounted in recesses formed in the central input shaft. A tubular transmission shaft extends around the central input shaft and comprises pawl operation holes which allow, by rotation of the transmission shaft to selectively activate torque transmission to a specific sun gear while disactivate torque transmission to the other sun gears and thereby achieved different gear ratios. This construction has for advantage to be very compact; however, it has for disadvantage that gear shifting under load is difficult. Also, it does not provide any input from an auxiliary electric motor.

Summary of invention

Technical Problem

[0004] The invention has for technical problem to overcome at least one drawback of the above-mentioned prior art. More specifically, the invention has for technical problem to provide a transmission unit for a vehicle equipped with propulsion pedals, like a bicycle, that is compact, has a high number of gear ratios, has a large transmission range, couples to an electric motor and provides a smooth great shifting under load.

Technical solution

[0005] The invention is directed to transmission unit for a vehicle equipped with propulsion pedals, comprising: a central shaft with two opposite ends configured, each, for supporting a pedal crank; a transmission output shaft coaxial with the central shaft and configured for outputting mechanical power; a planetary gear unit carried by the central shaft and configured for transmitting mechanical power from an input shaft of said planetary gear unit to the transmission output shaft, according to several selectable transmission ratios; an electric motor unit operatively coupled to the planetary gear unit in order to transmit mechanical power to the transmission output shaft; a housing carrying the central shaft, the transmission output shaft and the planetary gear unit; wherein the electric motor unit is coaxial with the central shaft and comprises an output shaft fixedly coupled to the input shaft of the planetary gear unit, and the central shaft is coupled to said output shaft of the electric motor and said input shaft of the planetary gear unit by a freewheel.

[0006] According to a preferred embodiment, the electric motor unit comprises an electric motor coaxial with the central shaft, and a planetary gear reduction unit coaxial with the central shaft and coupled to said electric motor.

[0007] According to a preferred embodiment, the planetary gear reduction unit comprises: a first planetary gear set with a sun gear coupled to the electric motor, a fixed ring gear, and a planetary gear carrier; a second planetary gear set with a sun gear fixedly coupled to the planetary gear carrier of the first planetary gear set, a fixed ring gear, and a planetary gear carrier coupled to the output shaft of the electric motor unit.

[0008] According to a preferred embodiment, the planetary gear reduction unit further comprises: a third planetary gear set with a sun gear fixedly coupled to the planetary gear carrier of the second planetary gear set, a fixed ring gear, and a planetary gear carrier fixedly coupled to the output shaft of the electric motor unit.

[0009] According to a preferred embodiment, the electric motor unit is located on an end portion of the central shaft.

[0010] Advantageously, the transmission unit comprises an annular cavity surrounding the electric motor and configured for containing a liquid for cooling the electric motor. The cavity can be formed on a portion of the housing that receives a stator of the electric motor. The annular cavity is formed by metallic material that contacts directly the stator of the electric motor.

[0011] According to a preferred embodiment, the planetary gear unit comprises a double planetary gear set comprising a ring gear, a first sun gear, first planetary gears meshing with the first sun gear and with the ring gear, a second sun gear, second planetary gears meshing with the second sun gear and with the ring gear, a carrier of the first and second planetary gears, a carrier brake and a ring gear brake, the first sun gear being formed on the input shaft of the planetary gear unit and the second sun gear being formed on an output shaft of the double planetary gear set.

[0012] According to a preferred embodiment, the freewheel is a first freewheel, the input shaft of the planetary gear unit being coupled to the output shaft of the double planetary gear set by a second freewheel, in order to bypass said

double planetary gear set when the ring gear brake is released and the carrier brake is released.

[0013] Advantageously, the electric motor unit is coupled to the input shaft of the planetary gear unit by a freewheel so that rotation of the electric motor drives said input shaft, whereas said input shaft can be driven without driving said electric motor. That freewheel can be provided operatively between the electric motor and the input shaft of the planetary gear unit.

[0014] According to a preferred embodiment, the planetary gear unit further comprises an additional double planetary gear set comprising a ring gear, a first sun gear, first planetary gears meshing with the first sun gear and with the ring gear, a second sun gear, second planetary gears meshing with the second sun gear and with the ring gear, a carrier of the first and second planetary gears, a carrier brake and a ring gear brake, the first sun gear being formed on the output shaft of the double planetary gear set and the second sun gear being coupled to the transmission output shaft.

[0015] According to a preferred embodiment, the planetary gear unit comprises an output planetary gear set comprising an input shaft, a ring gear, a sun gear formed on the transmission output shaft, planetary gears meshing with the ring gear and the sun gear, a carrier of the planetary gears, fixedly coupled to the input shaft, a ring brake, the input shaft being coupled with the transmission output shaft by a freewheel, so as to by-pass the output planetary gear set when the ring brake is released.

[0016] According to a preferred embodiment, the input shaft of the output planetary gear set is the output shaft of the double planetary gear set or, if present, of the additional double planetary gear set.

[0017] According to a preferred embodiment, the double planetary gear set and, if present, the additional double planetary gear set provide(s), by selectively activating the carrier brake(s) and ring gear brake(s) of said double planetary gear set and, if present, said additional double planetary gear set, at least three transmission ratios comprising a maximum ratio and a minimum ratio, and the output planetary gear set provides, by selectively activating the ring brake of said output planetary gear set, two range transmission ratios with a difference between said range transmission ratios

that is greater than a difference between said at least three transmission ratios.

[0018] According to a preferred embodiment, the ring gear brake and the carrier brake or each of the ring gear brakes and carrier brakes is of the dog type.

[0019] According to a preferred embodiment, the ring gear brake or each of the ring gear brakes comprises stops distributed along a periphery of the corresponding ring gear and a movable dog configured for selectively engaging in one of the stops for blocking said corresponding ring gear.

[0020] According to a preferred embodiment, the movable dog or each of the movable dogs is pivotable and actuatable by a rotatable cam.

[0021] According to a preferred embodiment, the movable dog or each of the movable dogs comprises a cam follower and a finger with a tooth extending laterally and configured for engaging the corresponding recess.

[0022] According to a preferred embodiment, the finger or each finger is configured so that the corresponding tooth is movable along said finger against an elastic force. That movement is advantageously a translation movement, e.g a sliding movement.

[0023] According to a preferred embodiment, the movable dog or each of the movable dogs comprises a bore and the finger or each finger is slidingly received in said bore, said finger carrying the corresponding tooth and delimiting with said bore a chamber containing a medium providing the elastic force.

[0024] According to a preferred embodiment, the medium is a spring, a gas, or a liquid in communication with an auxiliary chamber delimited by an elastic element such as a spring-piston assembly.

[0025] Advantageously, the communication between the chamber and the auxiliary chamber comprises a check-valve with a flow restriction when the liquid medium flows from the chamber to the auxiliary chamber and without restriction in the opposite direction.

[0026] According to a preferred embodiment, the movable dog or each of the movable dogs comprises an engagement controller configured for allowing engagement of the movable dog with the stop or one of the stops only when the movable dog is at a distance from the stop.

[0027] According to a preferred embodiment, the engagement controller or each of the engagement controllers comprises a contact member configured for sliding along the periphery of the corresponding ring gear and carrier and pivotally mounted on the movable dog between an extended position preventing engagement and a retracted position allowing engagement, and a spring urging the contact member in the extended position. The contact member is positioned for contacting the periphery of the corresponding ring gear and carrier before, in the sense of rotation of said corresponding ring gear and carrier, a portion of the movable dog engaging with a stop, said portion being for instance the tooth of the finger of the movable dog.

[0028] Advantageously, the planetary gear unit and the electric motor unit are concentric with the central axis and supported by the central axis.

[0029] The invention is also directed to a vehicle equipped with propulsion pedals and comprising a transmission unit carrying said propulsion pedals and configured for driving at least one wheel of said vehicle upon activation of the pedal; wherein the transmission unit is accord to the invention.

[0030] The invention can also be directed to a brake assembly for one or more planetary gear sets, comprising: a body, a pivoting shaft, one or more dog elements pivotally mounted on said pivoting shaft, a cam shaft with one or more cams cooperating with the one or more dog elements, respectively, a shifting unit operatively coupled to the cam shaft for selectively pivoting the one or more dog elements.

[0031] Advantageously, each dog element comprises a finger with a tooth extending essentially transversally from the finger, for engaging with a stop at the periphery of a ring or carrier of the one or more planetary gear sets.

[0032] Advantageously, for each dog element, the finger is slidably mounted in a bore formed in a body of the dog element, the finger delimiting with the bore a chamber containing a medium providing an elastic force.

[0033] Advantageously, the medium is a spring, a gas, or a liquid communication with an auxiliary chamber delimited by an elastic element such as a spring-piston assembly.

[0034] Advantageously, the communication between the chamber and the auxiliary chamber comprises a check-valve with a flow restriction when the liquid

medium flows from the chamber to the auxiliary chamber and without restriction in the opposite direction.

Advantages of the invention

[0035] The invention is particularly interesting in that it provides a compact transmission unit including an electric motor. The latter is centred on the central shaft and thereby is optimally integrated to the transmission unit.

[0036] The planetary gear unit can provide a high number of transmission ratios with a large range while remaining compact. The construction of the double planetary gear set and any additional double planetary gear set is particularly interesting that respect. Also, the planetary gear unit provides a useful range splitter, participating in providing a large transmission range.

[0037] The planetary gear reduction unit of the electric motor unit provides a high transmission reduction ratio while remaining compact and fully integrated by being coaxial and lateral with the planetary gear unit.

[0038] Also, the different freewheels provides interesting functionalities to the transmission unit.

[0039] Further, the brake assembly of the dog type achieves a rapid gear shifting without losses inherent of frictional brake assemblies and very low activation forces compared to frictional brakes.

Brief description of the drawings

[0040] Figure 1 is schematic functional layout of a transmission unit according to the invention.

[0041] Figure 2 is a sectional view of the transmission unit schematically represented in figure 1.

[0042] Figure 3 is perspective representation of the brake assembly of the ring gears of the transmission unit of figure 2.

[0043] Figure 4 is another perspective representation of the brake assembly of figure 4.

[0044] Figure 5 is a sectional view of one of the ring gear brakes and carrier brakes of the brake assembly of figures 3 and 4.

[0045] Figure 6 is a perspective view of the brake assembly of figures 3 to 5, where one of the ring gear brakes and carrier brakes is represented in sectional view.

[0046] Figure 7 is a perspective view of one of the ring gear brakes and carrier brakes, with an optional engagement controller.

[0047] Figure 8 is a sectional view of the brake assembly equipped with the engagement controller and of a portion of one of the rings and planetary carriers, in a first engagement configuration.

[0048] Figure 9 corresponds to figure 8 in another engagement configuration.

[0049] Figure 10 corresponds to figure 8 in further other engagement configuration.

Description of an embodiment

[0050] In the following description, several freewheels are mentioned with reference to the drawings, for instance the freewheels 16, 17, 20 and 22, which are represented in figure 1 in a schematic way by a diode symbol as in electric wiring plans. This is for the sake of clarity and conciseness. It is to be understood that the direction represented by the arrow corresponds to direction in which the rotational movement is transmitted. The freewheel(s) can be formed by rachet pawls carried by a first rotating element and resiliently urged towards a notched surface of second directly neighbouring rotating element, so that in one rotating direction, the pawls engage with the notches and rotation of the first element is transmitted to the second element, whereas in the opposite rotating direction, the pawls slide on the notches and there is no rotation transmission. Other constructions can be considered.

[0051] Figures 1 and 2 illustrate a transmission unit according to the invention. Figure 1 is a schematic functional layout whereas figure 2 is a sectional view.

[0052] The transmission unit 2 comprises a central shaft 4 with two opposite ends configured, each, for supporting a pedal crank 6, a transmission output shaft 8 coaxial with the central shaft 4 and configured outputting mechanical power via a chain sprocket 10 attached to said transmission output shaft 8. The transmission unit 2 further comprises a planetary gear unit 12 carried by the central shaft 4 and configured for transmitting mechanical power from an input shaft 12.0 of said planetary gear unit 12 to the transmission output shaft 8, according to several selectable transmission ratios, and an electric motor unit 14 operatively coupled to the planetary gear unit 12 in order to

transmit mechanical power to the transmission output shaft 8. The transmission unit 2 further comprises a housing 18 carrying the central shaft 4, the transmission output shaft 8, the planetary gear unit 12 and the electric motor unit 14. As this is apparent, the planetary gear unit 12 comprises several planetary gear sets, for instance three planetary gear sets 12.1, 12.2 and 12.3, arranged operatively one after the other. Each of the planetary gear sets 12.1, 12.2 and 12.3 comprises one or several brakes of different components of said planetary gear sets, said brakes being carried by the housing 18. The planetary gear sets 12.1 and 12.2 advantageously have the same construction principle, whereas they can have different dimensions, i.e. different teeth modules and/or different numbers of teeth one each gear.

[0053] The electric motor unit 14 is coaxial with the central shaft and arranged laterally to the planetary gear unit 12. It comprises an output shaft 14.0 fixedly coupled to the input shaft 12.0 of the planetary gear unit 12. The central shaft 4 is coupled to the output shaft 14.0 of the electric motor unit 14 and the input shaft 12.0 of the planetary gear unit 12 by a freewheel 16. This arrangement provides a direct coupling between the electric motor unit 14 and the planetary gear unit 12 while the coupling of the central shaft 4 which is driven by the user allows the output shaft 14.0 of the electric motor unit 14 and the input shaft 12.0 of the planetary gear unit 12 to rotate at a higher rotational speed than the central shaft 4, by virtue of the freewheel 16.

[0054] The electric motor unit 14 comprises an electric motor 14.1 which comprises, essentially, a stator 14.1.1 and a rotor 14.1.2, the latter being carried by a shaft rotatably mounted on the central shaft 4. The electric motor unit 14 further comprises a planetary gear reduction unit 14.2 coaxial with the central shaft 4 and coupled to the electric motor 14.1. The planetary gear reduction unit 14.2 comprises a first planetary gear set 14.2.1 with a sun gear 14.2.1.1 coupled to the electric motor 14.1 via the shaft carrying the rotor 14.1.2, a fixed ring gear 14.2.1.3, and a planetary gear carrier 14.2.1.2; a second planetary gear set 14.2.2 with a sun gear 14.2.2.1 fixedly coupled to the planetary gear carrier 14.2.1.2 of the first planetary gear set 14.2.1, a fixed ring gear 14.2.2.3, and a planetary gear carrier 14.2.2.2, and

a third planetary gear set 14.2.3 with a sun gear 14.2.3.1 fixedly coupled to the planetary gear carrier 14.2.2.2 of the second planetary gear set 14.2.2, a fixed ring gear 14.2.3.3, and a planetary gear carrier 14.2.3.2 fixedly coupled to the output shaft 14.0 of the electric motor unit 14. Advantageously, the fixed ring gears 14.2.2.3 and 14.2.3.3 of the second and third planetary gear sets 14.2.2 and 14.2.3 are common, i.e. form a single ring gear, for constructional simplicity and manufacturing cost reduction.

[0055] As illustrated in figure 1, the electric motor unit 14 can comprise a freewheel such as the freewheel 17, such that rotation of the central shaft 4 can drive the transmission output shaft 8 without having to drive the electric motor 14.1, for instance its rotor 14.1.2 which shows inertia and generates a resisting cogging torque when not supplied with electrical energy. The freewheel 17 is for instance provided between the rotor 14.1.2 and the sun gear 14.2.1.1 of the first planetary gear set 14.2.1, being however understood that the freewheel could be provided at other places in the planetary gear reduction unit 14.2.

[0056] The above constructions of planetary gear reduction unit 14.2 achieves a high reduction ratio while taking about less than half of the useful length of the central shaft 4, and remaining compact radially, as this more apparent in figure 2.

[0057] The planetary gear unit 12 comprises a first planetary gear set 12.1 being for instance a double planetary gear set comprising a ring gear 12.1.6, a first sun gear 12.1.1, first planetary gears 12.1.3 meshing with the first sun gear 12.1.1 and with the ring gear 12.1.6, a second sun gear 12.1.5, second planetary gears 12.1.4 meshing with the second sun gear 12.1.5 and with the ring gear 12.1.6, a carrier 12.1.2 of the first and second planetary gears 12.1.3 and 12.1.4, a carrier brake 12.1.7 and a ring gear brake 12.1.8, the first sun gear 12.1.1 being formed on the input shaft 12.0 of the planetary gear unit 12 and the second sun gear 12.1.5 being formed on an output shaft 12.1.9 of the double planetary gear set 12.1.

[0058] As this is apparent, the input shaft 12.0 of the planetary gear unit 12 is coupled to the output shaft 12.1.9 of the double planetary gear set 12.1 by

a freewheel 20, in order to bypass the double planetary gear set 12.1 when both the ring gear brake 12.1.8 and the carrier brake 12.1.7 are released.

[0059] The planetary gear unit 12 can further comprise a second planetary gear set 12.2 being for instance an additional double planetary gear set comprising a ring gear 12.2.6, a first sun gear 12.2.1, first planetary gears 12.2.3 meshing with the first sun gear 12.2.1 and with the ring gear 12.2.6, a second sun gear 12.2.5, second planetary gears 12.2.4 meshing with the second sun gear 12.2.5 and with the ring gear 12.2.6, a carrier 12.2.2 of the first and second planetary gears 12.2.3 and 12.3.4, a carrier brake 12.2.7 and a ring gear brake 12.2.8, the first sun gear 12.2.1 being formed on the output shaft 12.1.9 of the double planetary gear set 12.1. The second sun gear 12.2.5 is rigidly carried by an output shaft 12.2.9 of the additional double planetary gear set 12.2.

[0060] In the above additional double planetary gear set 12.2, it is possible to provide a freewheel (not represented) between the first sun gear 12.2.1 and the second sun gear 12.5.1, similarly the freewheel 20 of the double planetary gear set 12.1. This provides at least one additional speed or gear ratio, for instance when each of the carrier brake 12.2.7 and the ring brake 12.2.8 are not activated.

[0061] The planetary gear unit 12 further comprises a third planetary gear set 12.3 being for instance an output planetary gear set comprising a ring gear 12.3.4, a sun gear 12.3.1 formed on the transmission output shaft 8, planetary gears 12.3.3 meshing with the ring gear 12.3.4 and the sun gear 12.3.1, a carrier 12.3.2 of the planetary gears 12.3.3, fixedly coupled to the output shaft 12.2.9 of the additional double planetary gear set 12.2, a ring brake 12.3.5, the output shaft 12.2.9 being coupled with the transmission output shaft 8 by a freewheel 22, so as to by-pass the output planetary gear set 12.3 when the ring brake 12.3.5 is released.

[0062] The above-described planetary gear unit 12 provides 10 different gear ratios that will be detailed here after in connection with the below table 1. In that table, the sign # corresponds to the different gear or speed number, whose transmission ratio progressively diminishes with the speed number. In other words, the speed number #1 is for starting the vehicle or bicycle at low speed whereas the speed number #10 is for driving or riding at maximum

speed. The symbol "x" means that the brake or freewheel is activated, being understood that for the brake the activation is active whereas for the freewheel it is passive, i.e. results of the activation and non-activation of the brakes.

[0063] [Table 1]

#	1st planetary gear set 12.1			2nd planetary gear set 12.2		3rd planetary gear set 12.3	
	Brake 12.1.7 of planetary gears carrier 12.1.2	Brake 12.1.8 of ring gear 12.1.6	Freewheel 20	Brake 12.2.7 of planetary gears carrier 12.2.2	Brake 12.2.8 of ring gear 12.2.6	Brake 12.3.5 of ring gear 12.3.4	Freewheel 22
1			x		x		x
2			x	x			x
3		x			x		x
4		x		x			x
5	x			x			x
6			x		x	x	
7			x	x		x	
8		x			x	x	
9		x		x		x	
10	x			x		x	

[0064] In the speed number #1, none of the brakes of the 1st planetary gear set 12.1 is activated, meaning that the freewheel 20 is active. The power is then transmitted directly, i.e. without any change of rotational speed, from the input shaft 12.0 of the transmission unit 12 to the output shaft 12.1.9 of the 1st planetary gear set 12.1. In the 2nd planetary gear set 12.2, the brake 12.2.8 of the ring gear 12.2.6 is activated, meaning that the power is transmitted through rotation of the planetary gears 12.2.3 and 12.2.4 and of their carrier 12.2.2, from the first sun gear 12.2.1 to the second sun gear 12.2.5 rigidly carried by the output shaft 12.2.9 of the 2nd planetary gear set 12.2. In the 3rd planetary gear set 12.3, the brake 12.3.5 of the ring gear

12.3.4 is deactivated, meaning that the power is transmitted through the freewheel 22 to the output shaft 8.

[0065] In the speed number #2, the configuration of the 2nd planetary gear set 12.2 is changed by deactivating the brake 12.2.8 of the ring gear 12.2.6 and activating the brake 12.2.7 of planetary gears carrier 12.2.2. The power is therefore transmitted from the first sun gear 12.2.1 to the second sun gear 12.2.5 via the planetary gears 12.2.3 and 12.2.4 free to rotate while their carrier 12.2.2 is blocked.

[0066] In the speed number #3, the 2nd planetary gear set 12.2 and 3rd planetary gear set 12.3 are as in the speed number #1, whereas in the 1st planetary gear set 12.1, the brake 12.1.8 of ring gear 12.1.6 is activated, meaning that the power is transmitted through rotation of the planetary gears 12.1.3 and 12.1.4 and of their carrier 12.1.2, from the first sun gear 12.1.1 to the second sun gear 12.1.5 rigidly carried by the output shaft 12.1.9 of the 1st planetary gear set 12.1.

[0067] In the speed number #4, compared with the speed number #3, the configuration of the 2nd planetary gear set 12.2 is changed by deactivating the brake 12.2.8 of the ring gear 12.2.6 and activating the brake 12.2.7 of planetary gears carrier 12.2.2, similarly to the speed number #2.

[0068] In the speed number #5, compared with the speed number #4, the configuration of the 1st planetary gear set 12.1 is changed by deactivating the brake 12.1.8 of the ring gear 12.1.6 and activating the brake 12.1.7 of planetary gears carrier 12.1.2, meaning that the power is transmitted from the first sun gear 12.1.1 to the second sun gear 12.1.5 via the planetary gears 12.1.3 and 12.1.4 free to rotate while their carrier 12.1.2 is blocked.

[0069] In the speed number #6, compared with the speed number #1, on the 3rd planetary gear set 12.3, the brake 12.3.5 of the ring gear 12.3.4 is activated, meaning that the power is transmitted through rotation of carrier 12.3.2 and the planetary gears 12.3.3 to the sun gear 12.3.1 rigidly carried by the transmission output shaft 8.

[0070] The speed number #7 is similar to the speed number #2 while the 3rd planetary gear set 12.3 is as in the speed number #6.

[0071] The speed number #8 is similar to the speed number #3 while the 3rd planetary gear set 12.3 is as in the speed numbers #6 and #7.

[0072] The speed number #9 is similar to the speed number #4 while the 3rd planetary gear set 12.3 is as in the speed numbers #6, #7 and #8.

[0073] The speed number #10 is similar to the speed number #5 while the 3rd planetary gear set 12.3 is as in the speed numbers #6, #7, #8 and #9.

[0074] In the case of the presence an additional freewheel (not represented) between the first sun gear 12.2.1 and the second sun gear 12.2.5, an additional speed is obtained where none of the ring and carrier brakes is activated, meaning that the freewheels 20 and 22 are activated and the additional one mentioned here above also, corresponding to the 1:1 transmission ratio between the central shaft 4 and the transmission output shaft 8. With reference to the above table 1, that additional speed could be named speed number #0.

[0075] As this more visible in figure 2, the brakes, i.e. the carrier brake 12.1.7 and ring brake 12.1.8 of the 1st planetary gear set 12.1, the carrier brake 12.2.7 and the ring brake 12.2.8 of the 2nd planetary gear set 12.2, and the ring brake 12.3.5 of the 3rd planetary gear set 12.3 are advantageously of the dog type, i.e. with a movable dog configured for selectively engaging with a stop formed on an external surface of the carrier or ring to be braked. That type of brake has the advantage to avoid frictional movements between the carrier or ring to be braked and the movable element of the brake interacting with said carrier or ring.

[0076] All brakes 12.1.7, 12.1.8, 12.2.7, 12.2.8 and 12.3.5 are for instance formed by a brake assembly 24 attached to the housing 18 of the transmission unit 2.

[0077] Still in figure 2, we can observe that the housing 18 houses the electric motor, for instance the stator 14.1.1 thereof and that a cavity 19 is formed with the housing around the stator 14.1.1, the cavity 19 being specifically designed for containing a liquid for cooling the stator. For instance, that cavity 19 forms a recess on the outer circular surface for the housing 18, that is closed in a liquid tight fashion by a ring placed around said housing and recess. It is understood that annular cavity 19 can be constructed differently while still achieving a useful cooling of the electric motor.

[0078] Figures 3 to 6 are different views of the brake assembly 24 of figure 2.

[0079] Figure 3 shows in perspective the brake assembly 24 cooperating with the ring-shaped planetary gears carriers and the rings of the planetary gear sets 12.1, 12.2 and 12.3 of the transmission unit 2. As this is apparent, the brake assembly 24 comprises a series of, for instance five, pivoting dog elements cooperating with the stops formed at the outer periphery of the corresponding ring-shaped planetary gears carriers and rings.

[0080] Figure 4 is a perspective view of the brake assembly 24 alone, seen from an opposite point of view as in figure 2.

[0081] The brake assembly 24 comprises a body 26 and a pivot axis 28 mounted on the body 26 and supporting the dog elements 30.1, 30.2, 30.3, 30.4 and 30.5. The dog elements 30.1, 30.2, 30.3, 30.4 and 30.5 are moved by virtue of the cam shaft 32 that is rotated by the shift unit 34 comprising an electric motor and gearing coupling the electric motor with the cam shaft 32. The latter comprises a series of, for instance five, cams each interacting with one of the dog elements 30.1, 30.2, 30.3, 30.4 and 30.5 so as to pivot them in a selective manner.

[0082] Figure 5 is section view of the one of the dog elements 30.1, 30.2, 30.3, 30.4 and 30.5, being understood that they are all identical or at least similar in their principle.

[0083] Each dog elements 30.1, 30.2, 30.3, 30.4 and 30.5 comprises a body 36 with a central hole 36.1 for receiving the pivoting axis 28 (figure 4), a cam follower 36.2, a first bore 36.3 slidably receiving a finger 38 with a tooth 38.1 extending laterally and configured for engaging one stop on the corresponding ring-shaped planetary gears carrier or ring, a second bore 36.4 slidably receiving a piston and spring assembly 42, and a fluid passage 36.5 interconnecting the first bore 36.3 with the second bore 36.4.

[0084] As this is apparent, the body 36 is provided with a retaining means 40 preventing the finger 38 from separating of the body 36 while allowing said finger 38 to be slidable in the first bore 36.3. The retaining means 40 is for instance a protrusion rigidly attached to or formed with the body 36, and showing an oblong hole into which a screw slidingly engages and rigidly engages with the finger 38. As this is apparent the cylindrical portion of the finger 38 that engages in the first bore 36.3 is provided with a gasket so as to delimit in said first bore 36.3 a first chamber that communicates via the

passage 36.5 with a second chamber delimited in the second bore 36.4 by the piston of the piston-spring assembly 42 mounted on the body 36. In the configuration as illustrated in figure 5, the second chamber shows a minimum volume, being for instance null, whereas the first chamber shows a maximum volume. The first chamber, the passage 36.5 and the second chamber are filled by a fluid, preferably a fluid that is incompressible, i.e. a liquid like oil. At rest, the finger 38 is urged in the illustrated extended position by the spring pushing the piston of the spring-piston assembly 42 towards the bottom of the second bore 36.4, thereby pushing, via the passage 36.5, the fluid towards the first chamber.

[0085] During operation of the transmission unit 2, when the brake assembly 24 is operated to as to rotate the cam shaft 32 (figure 4) and thereby pivot one of the dog elements 30.1, 30.2, 30.3, 30.4 and 30.5 via the cam follower 36.2 so that its tooth 38.1 engages with one of the stops formed at the outer periphery of the corresponding ring-shaped planetary gears carrier or ring. The engagement of the tooth with one of the recesses occurs while the corresponding ring-shaped planetary gears carrier or ring is rotating, meaning that said carrier or ring is abruptly decelerated while important forces are generated between the tooth and the stop. These forces can be lowered by the sliding movement of the finger 38 relative to the body 36. Upon engagement of the tooth with the stop, an important force is transmitted from the rotating carrier or ring to the finger 38 causing movement thereof towards the bottom of the first chamber in the first bore 36.3 and movement of the fluid towards the second chamber in the second bore 36.4 via the passage 36.5, against the resilient force of the spring that progressively increases while the fluid fills the second chamber and moves the piston away from the bottom of the second chamber. This movement dampens the braking action of the dog element engaging with one of the recesses.

[0086] The passage 36.5 can comprise a check-valve with a flow restriction, configured so as to create a flow restriction when the fluid flows from the first chamber in the first body 36.3 towards the second chamber in the second body 36.4 while allowing the fluid to flow without such restriction in the reverse direction.

[0087] Figure 6 is another perspective view of the brake assembly 24, illustrating the potentially complex profiles of the cams on the cam shaft 32, as well as the presence of springs 44 urging each dog element 30.1, 30.2, 30.3, 30.4 and 30.5 towards engagement of their tooth with the corresponding the ring-shaped carriers or rings.

[0088] Figure 7 is a perspective view of one of the ring and carrier brakes, for instance the dog element 30.1, 30.2, 30.3, 30.4 and 30.5, provided with an optional engagement controller 46. The latter is provided at the distal end of the body 36, for instance on the finger 38. It is configured for allowing engagement of the finger with the stop on the ring-shaped carriers or rings only when the tooth of the finger is at a distance from the stop, so as to avoid a later engagement that can damage the contact surfaces on the finger and the stop.

[0089] As this is apparent, the engagement controller 46 comprises a clevis 46.1 fixedly mounted or attached to the body 36 of the dog element 30.1, 30.2, 30.3, 30.4 and 30.5, a contact member 46.2 pivotally mounted on the clevis 46.1, a spring exerting a resilient force on the contact member 46.2 to as to urge it to the extended position illustrated in figure 7, an a stop pin 46.4 mounted on the contact member 46.2, parallel to its pivoting axis and configured for abutting against the clevis 46.1 when the contact member 46.2 is in the extended position.

[0090] Figures 8 to 10 are sectional views of the brake assembly 24 equipped with the engagement controller 46 and of a portion of one of the ring-shaped carriers or rings 12.1.7, 12.1.8, 12.2.7, 12.2.8 and 12.3.5, in three different engagement configurations.

[0091] In figure 8, the tooth 38.1 of the finger 38 is in position relative to the ring-shaped carrier or ring 12.1.7, 12.1.8, 12.2.7, 12.2.8 or 12.3.5 where it can engage with the stop, however at a late stage where the tooth will engage only partially with the stop, leading to damages of the respective contact surface. The partial engagement is essentially due to the fact the pivoting movement of the dog element 30.1, 30.2, 30.3, 30.4 or 30.5, although rapid, occurs while the ring-shaped carrier or ring 12.1.7, 12.1.8, 12.2.7, 12.2.8 or 12.3.5 is still rotating.

[0092] In the configuration of figure 8, the engagement controller 46 prevents engagement of the dog element 30.1, 30.2, 30.3, 30.4 or 30.5 despite the rotation of the cam shaft 32 presenting a recess of the cam profile to the cam follower 36.2. The contact member 46.2 slides along the outer periphery of the stop of the ring-shaped carrier or ring 12.1.7, 12.1.8, 12.2.7, 12.2.8 or 12.3.5, while remaining in the extended position by virtue of the force of the spring 46.4.

[0093] In the configuration of figure 9, the engagement controller 46 prevents full engagement of the dog element 30.1, 30.2, 30.3, 30.4 or 30.5 despite the rotation of the cam shaft 32 presenting a recess of the cam profile to the cam follower 36.2. The contact member 46.2 slides along the outer periphery of the ring-shaped carrier or ring 12.1.7, 12.1.8, 12.2.7, 12.2.8 or 12.3.5, before the spot thereof, while remaining in the extended position by virtue of the force of the spring 46.4.

[0094] In the configuration of figure 10, corresponding to a further step of the configuration of 9, the contact member 46.2 further to being contacted by the stop has pivoted to a retracted position allowing the dog element to further 30.1, 30.2, 30.3, 30.4 or 30.5 in the engagement direction until the tooth 38.1 fully engages with the stop.

[0095] The above-described brake assembly is particularly advantageous by its robustness and efficiency. By being mounted on the outside of the housing, its maintenance is greatly facilitated. More importantly, the mechanical engagement between the dog elements and the ring-shaped carriers and rings occurs at about the maximum radial distance of the central shaft, meaning that the forces generated by these engagements are minimum for a given torque. It also provides an efficient shifting of the transmission unit in that the transmission energy losses substantially reduced compared with friction brakes while still providing smooth operation thanks to the engagement controller 46.

[0096] The above-described brake assembly can of course be applied to other configurations of transmission unit as to the one detailed here above in relation with figures 1 and 2. It is indeed applicable to any planetary gear set, in particular when several planetary gear sets are mounted side by side as in the planetary gear unit detailed in figures 1 and 2.

Claims

1. Transmission unit (2) for a vehicle equipped with propulsion pedals, comprising:

a central shaft (4) with two opposite ends configured, each, for supporting a pedal crank (6);

a transmission output shaft (8) coaxial with the central shaft (4) and configured for outputting mechanical power;

a planetary gear unit (12) carried by the central shaft (4) and configured for transmitting mechanical power from an input shaft (12.0) of said planetary gear unit (12) to the transmission output shaft (8), according to several selectable transmission ratios;

an electric motor unit (14) operatively coupled to the planetary gear unit (12) in order to transmit mechanical power to the transmission output shaft (8);

a housing (18) carrying the central shaft (4), the transmission output shaft (8) and the planetary gear unit (12);

characterized in that

the electric motor unit (14) is coaxial with the central shaft (4) and comprises an output shaft (14.0) fixedly coupled to the input shaft (12.0) of the planetary gear unit (12), and

the central shaft (4) is coupled to said output shaft (14.0) of the electric motor unit (14) and said input shaft (12.0) of the planetary gear unit (12) by a freewheel (16).

2. Transmission unit (2) according to claim 1, wherein the electric motor unit (14) comprises an electric motor (14.1) coaxial with the central shaft (4), and a planetary gear reduction unit (14.2) coaxial with the central shaft (4) and coupled to said electric motor (14.1).

3. Transmission unit (2) according to claim 2, wherein the planetary gear reduction unit (14.2) comprises:

a first planetary gear set (14.2.1) with a sun gear (14.2.1.1) coupled to the electric motor (14.1), a fixed ring gear (14.2.1.3), and a planetary gear carrier (14.2.1.2);

a second planetary gear set (14.2.2) with a sun gear (14.2.2.1) fixedly coupled to the planetary gear carrier (14.2.1.2) of the first planetary gear set (14.2.1), a

fixed ring gear (14.2.2.3), and a planetary gear carrier (14.2.2.2) coupled to the output shaft (14.0) of the electric motor unit (14).

4. Transmission unit (2) according to claim 3, wherein the planetary gear reduction unit (14.2) further comprises:

a third planetary gear set (14.2.3) with a sun gear (14.2.3.1) fixedly coupled to the planetary gear carrier (14.2.2.2) of the second planetary gear set (14.2.2), a fixed ring gear (14.2.3.3), and a planetary gear carrier (14.2.3.2) fixedly coupled to the output shaft (14.0) of the electric motor unit (14).

5. Transmission unit (2) according to any one of claims 1 to 4, wherein the electric motor unit (14) is located on an end portion of the central shaft (4).

6. Transmission unit (2) according to any one of claims 1 to 5, wherein the planetary gear unit (12) comprises a double planetary gear set (12.1) comprising a ring gear (12.1.6), a first sun gear (12.1.1), first planetary gears (12.1.3) meshing with the first sun gear (12.1.1) and with the ring gear (12.1.6), a second sun gear (12.1.5), second planetary gears (12.1.4) meshing with the second sun gear (12.1.5) and with the ring gear (12.1.6), a carrier (12.1.2) of the first and second planetary gears (12.1.3, 12.14), a carrier brake (12.1.7) and a ring gear brake (12.1.8), the first sun gear (12.1.1) being formed on the input shaft (12.0) of the planetary gear unit (12) and the second sun gear (12.1.5) being formed on an output shaft (12.1.9) of the double planetary gear set (12.1).

7. Transmission unit (2) according to claim 6, wherein the freewheel (16) is a first freewheel, the input shaft (12.0) of the planetary gear unit (12) being coupled to the output shaft (12.1.9) of the double planetary gear set (12.1) by a second freewheel (20), in order to bypass said double planetary gear set (12.1) when the ring gear brake (12.1.8) is released and the carrier brake (12.1.7) is released.

8. Transmission unit (2) according to one of claims 6 and 7, wherein the planetary gear unit (12) further comprises an additional double planetary gear set (12.2) comprising a ring gear (12.2.6), a first sun gear (12.2.1), first planetary gears (12.2.3) meshing with the first sun gear (12.2.1) and with the ring gear (12.2.6), a second sun gear (12.2.5), second planetary gears (12.2.4) meshing with the second sun gear (12.2.5) and with the ring gear (12.2.6), a carrier (12.2.2)

of the first and second planetary gears (12.2.3, 12.2.4), a carrier brake (12.2.7) and a ring gear brake (12.2.8), the first sun gear (12.2.1) being formed on the output shaft (12.1.9) of the double planetary gear set (12.1) and the second sun gear (12.2.5) being coupled to the transmission output shaft (8).

9. Transmission unit (2) according to any one of claims 1 to 8, wherein the planetary gear unit (12) comprises an output planetary gear set (12.3) comprising an input shaft, a ring gear (12.3.4), a sun gear (12.3.1) formed on the transmission output shaft (8), planetary gears (12.3.3) meshing with the ring gear (12.3.4) and the sun gear (12.3.1), a carrier (12.3.2) of the planetary gears (12.3.3), fixedly coupled to the input shaft, a ring brake (12.3.5), the input shaft being coupled with the transmission output shaft (8) by a freewheel (22), so as to by-pass the output planetary gear set (12.3) when the ring brake (12.3.5) is released.

10. Transmission unit (2) according to one of claims 6 to 8, and according to claim 9, wherein the input shaft of the output planetary gear set (12.3) is the output shaft (12.1.9, 12.2.9) of the double planetary gear set (12.1) or, if present, of the supplementary double planetary gear set (12.2).

11. Transmission unit (2) according to claim 10, wherein the double planetary gear set (12.1) and, if present, the additional double planetary gear set (12.2) provide(s), by selectively activating the carrier brake(s) (12.1.7, 12.2.7) and ring gear brake(s) (12.1.8, 12.2.8) of said double planetary gear set (12.1) and, if present, said additional double planetary gear set (12.2), at least three transmission ratios comprising a maximum ratio and a minimum ratio, and the output planetary gear set (12.3) provides, by selectively activating the ring brake (12.3.5) of said output planetary gear set (12.3), two range transmission ratios with a difference between said range transmission ratios that is greater than a difference between said at least three transmission ratios.

12. Transmission unit (2) according to one of claims 6 to 11, wherein the ring gear brake and carrier brake or each of the ring gear brakes (12.1.8, 12.2.8, 12.3.5) and carrier brakes (12.1.7, 12.2.7) is of the dog type.

13. Transmission unit (2) according to claim 12, wherein the ring gear brake and the carrier brake or each of the ring gear brakes and carrier brakes comprises

stops distributed along a periphery of the corresponding ring gear and carrier and a movable dog (30.1, 30.2, 30.3, 30.4, 30.5) configured for selectively engaging in one of the stops for blocking said corresponding ring gear or carrier.

14. Transmission unit (2) according to claim 13, wherein the movable dog or each of the movable dogs (30.1, 30.2, 30.3, 30.4, 30.5) is pivotable and actuatable by a rotatable cam.

15. Transmission unit (2) according to claim 14, wherein the movable dog or each of the movable dogs (30.1, 30.2, 30.3, 30.4, 30.5) comprises a cam follower (36.2) and a finger (38) with a tooth extending laterally and configured for engaging the corresponding stop.

16. Transmission unit (2) according to claim 15, wherein the finger or each finger (38) is configured so that the corresponding tooth is movable along said finger against an elastic force.

17. Transmission unit (2) according to claim 16, wherein the movable dog or each of the movable dogs (30.1, 30.2, 30.3, 30.4, 30.5) comprises a bore (36.3) and the finger or each finger (38) is slidingly received in said bore, said finger carrying the corresponding tooth and delimiting with said bore (36.3) a chamber containing a medium providing the elastic force.

18. Transmission unit (2) according to claim 17, wherein the medium is a spring, a gas, or a liquid communication with an auxiliary chamber (36.4) delimited by an elastic element such as a spring-piston assembly (42).

19. Transmission unit (2) according to one of claims 13 to 18, wherein the movable dog (30.1, 30.2, 30.3, 30.4, 30.5) or each of the movable dogs (30.1, 30.2, 30.3, 30.4, 30.5) comprises an engagement controller (46) configured for allowing engagement of the movable dog with the stop or one of the stops only when the movable dog is at a distance from the stop.

20. Transmission unit (2) according to claim 19, wherein the engagement controller (46) or each of the engagement controllers (46) comprises a contact member (46.2) configured for sliding along the periphery of the corresponding ring gear or carrier and pivotally mounted on the movable dog (30.1, 30.2, 30.3, 30.4,

30.5) between an extended position preventing engagement and a retracted position allowing engagement, and a spring (46.4) urging the contact member (46.2) in the extended position.

21. Vehicle equipped with propulsion pedals and comprising a transmission unit carrying said propulsion pedals and configured for driving at least one wheel of said vehicle upon activation of the pedal; characterized in that the transmission unit is accord to any one of claims 1 to 20.

REVENDICATIONS

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1. Groupe de transmission (2) pour véhicule équipé de pédales de propulsion, comprenant :

un arbre central (4) avec deux extrémités opposées configurées, chacune, pour supporter une manivelle de pédale (6) ;

un arbre de sortie de transmission (8) coaxial à l'arbre central (4) et configuré pour délivrer une puissance mécanique ;

une unité de train planétaire (12) portée par l'arbre central (4) et configurée pour transmettre la puissance mécanique d'un arbre d'entrée (12.0) de ladite unité de train planétaire (12) à l'arbre de sortie de transmission (8), selon plusieurs rapports de transmission sélectionnables ;

une unité de moteur électrique (14) fonctionnellement couplée à l'unité de train planétaire (12) afin de transmettre une puissance mécanique à l'arbre de sortie de transmission (8) ;

un carter (18) portant l'arbre central (4), l'arbre de sortie de transmission (8) et l'unité de train planétaire (12) ;

caractérisé en ce que

l'unité de moteur électrique (14) est coaxiale avec l'arbre central (4) et comprend un arbre de sortie (14.0) couplé de manière fixe à l'arbre d'entrée (12.0) de l'unité de train planétaire (12), et

l'arbre central (4) est couplé audit arbre de sortie (14.0) de l'unité de moteur électrique (14) et audit arbre d'entrée (12.0) de l'unité de train planétaire (12) par une roue libre (16).

2. Groupe de transmission (2) selon la revendication 1, dans lequel l'unité de moteur électrique (14) comprend un moteur électrique (14.1) coaxial à l'arbre central (4), et un réducteur planétaire (14.2) coaxial à l'arbre central (4) et couplé audit moteur électrique (14.1).

3. Groupe de transmission (2) selon la revendication 2, dans lequel le réducteur planétaire (14.2) comprend :

un premier train planétaire (14.2.1) avec une roue dentée solaire (14.2.1.1) couplée au moteur électrique (14.1), une couronne dentée fixe (14.2.1.3) et un porte-satellites (14.2.1.2) ;

un deuxième train planétaire (14.2.2) avec une roue dentée solaire (14.2.2.1) couplée de manière fixe au porte-satellites (14.2.1.2) du premier train planétaire (14.2.1), une couronne dentée fixe (14.2.1.1). 2.3), et un porte-satellites (14.2.2.2) couplé à l'arbre de sortie (14.0) de l'unité de moteur électrique (14).

4. Groupe de transmission (2) selon la revendication 3, dans lequel le réducteur planétaire (14.2) comprend en outre :

un troisième train planétaire (14.2.3) avec une roue dentée solaire (14.2.3.1) couplée de manière fixe au porte-satellites (14.2.2.2) du deuxième train planétaire (14.2.2), une couronne

dentée fixe (14.2. 3.3), et un porte-satellites (14.2.3.2) couplé de manière fixe à l'arbre de sortie (14.0) de l'unité de moteur électrique (14).

5. Groupe de transmission (2) selon l'une quelconque des revendications 1 à 4, dans lequel l'unité de moteur électrique (14) est située sur une partie d'extrémité de l'arbre central (4).

6. Groupe de transmission (2) selon l'une quelconque des revendications 1 à 5, dans lequel l'unité de train planétaire (12) comprend un train planétaire double (12.1) comprenant une couronne dentée (12.1.6), une première roue dentée solaire (12.1 .1), des premiers satellites (12.1.3) engrenant avec la première roue solaire (12.1.1) et avec la couronne dentée (12.1.6), une deuxième route dentée solaire (12.1.5), des deuxièmes satellites (12.1. 4) engrenant avec la deuxième roue dentée solaire (12.1.5) et avec la couronne dentée (12.1.6), un porte-satellites (12.1.2) des premiers et deuxième satellites (12.1.3, 12.14), un frein de porte-satellites (12.1.7) et un frein de couronne (12.1.8), la première roue dentée solaire (12.1.1) étant formée sur l'arbre d'entrée (12.0) de l'unité de train planétaire (12) et la deuxième roue dentée solaire (12.1.5) étant formée sur un arbre de sortie (12.1.9) du train planétaire double (12.1).

7. Groupe de transmission (2) selon la revendication 6, dans lequel la roue libre (16) est une première roue libre, l'arbre d'entrée (12.0) de l'unité de train planétaire (12) étant couplé à l'arbre de sortie (12.1.9) du train planétaire double (12.1) par une deuxième roue libre (20), afin de contourner ledit train planétaire double (12.1) lorsque le frein couronne (12.1.8) est relâché et le frein de porte-satellite (12.1.7) est relâché.

8. Groupe de transmission (2) selon l'une des revendications 6 et 7, dans lequel l'unité de train planétaire (12) comprend, en outre, un train planétaire double supplémentaire (12.2) comprenant une couronne dentée (12.2.6), une première roue dentée solaire (12.2.1), des premiers satellites (12.2.3) engrenant avec la première roue solaire (12.2.1) et avec la couronne dentée (12.2.6), une deuxième roue dentée solaire (12.2.5), des deuxièmes satellites (12.2 .4) engrenant avec la deuxième roue dentée solaire (12.2.5) et avec la couronne (12.2.6), un porte-satellites (12.2.2) des premiers et deuxièmes satellites (12.2.3, 12.2.4), un frein de porte-satellites (12.2.7) et un frein de couronne (12.2.8), la première roue dentée solaire (12.2.1) étant formée sur l'arbre de sortie (12.1.9) du train planétaire double (12.1) et la deuxième roue dentée solaire (12.2.5) étant couplée à l'arbre de sortie de transmission (8).

9. Groupe de transmission (2) selon l'une quelconque des revendications 1 à 8, dans lequel l'unité de train planétaire (12) comprend un train planétaire de sortie (12.3) comprenant un arbre d'entrée, une couronne dentée (12.3.4), un roue dentée solaire (12.3.1) formée sur l'arbre de sortie de transmission (8), des satellites (12.3.3) engrenant avec la couronne dentée

(12.3.4) et la roue dentée solaire (12.3.1), un porte-satellites (12.3.2) des satellites (12.3.3), couplé fixement à l'arbre d'entrée, un frein de couronne (12.3.5), l'arbre d'entrée étant couplé à l'arbre de sortie de transmission (8) par une roue libre (22), de manière à contourner le train planétaire de sortie (12.3) lorsque le frein de couronne (12.3.5) est relâché.

10. Groupe de transmission (2) selon l'une des revendications 6 à 8, et selon la revendication 9, dans lequel l'arbre d'entrée du train planétaire de sortie (12.3) est l'arbre de sortie (12.1.9, 12.2.9) du train planétaire double (12.1) ou, s'il est présent, du train planétaire double supplémentaire (12.2).

11. Groupe de transmission (2) selon la revendication 10, dans lequel le train planétaire double (12.1) et, s'il est présent, le train planétaire double supplémentaire (12.2) assure(nt), en activant sélectivement le ou les freins de porte-satellites (12.1.7, 12.2.7) et le ou les freins de couronne (12.1.8, 12.2.8) dudit train planétaire double (12.1) et, s'il est présent, dudit train planétaire double supplémentaire (12.2), au moins trois rapports de transmission comprenant un rapport maximal et un rapport minimal, et le train planétaire de sortie (12.3) fournit, en activant sélectivement la couronne de frein (12.3.5) dudit train planétaire de sortie (12.3), deux rapports de transmission de gamme avec un différence entre lesdits rapports de transmission de gamme qui est supérieure à une différence entre lesdits au moins trois rapports de transmission.

12. Groupe de transmission (2) selon l'une des revendications 6 à 11, dans lequel le frein de couronne et le frein de porte-satellites ou chacun des freins de couronne (12.1.8, 12.2.8, 12.3.5) et des freins de porte-satellites (12.1. 7, 12.2.7) est du type à crabot.

13. Groupe de transmission (2) selon la revendication 12, dans lequel le frein de couronne et le frein de porte-satellites ou chacun des freins de couronne et de porte-satellites comporte des butées réparties le long d'une périphérie de la couronne correspondante et du porte-satellite correspondant et un crabot mobile (30.1, 30.2, 30.3, 30.4, 30.5) configuré pour s'engager sélectivement avec l'une des butées de ladite couronne correspondante ou du porte-satellites correspondante.

14. Groupe de transmission (2) selon la revendication 13, dans lequel le crabot mobile ou chacun des crabots mobiles (30.1, 30.2, 30.3, 30.4, 30.5) est pivotant et actionnable par une came rotative.

15. Groupe de transmission (2) selon la revendication 14, dans lequel le crabot mobile ou chacun des crabots mobiles (30.1, 30.2, 30.3, 30.4, 30.5) comprend un suiveur de came (36.2) et un doigt (38) avec une dent prolongeant latéralement et configuré pour s’engager avec la butée correspondante.

16. Groupe de transmission (2) selon la revendication 15, dans lequel le doigt ou chaque doigt (38) est configuré pour que la dent correspondante soit mobile le long dudit doigt à l'encontre d'une force élastique.

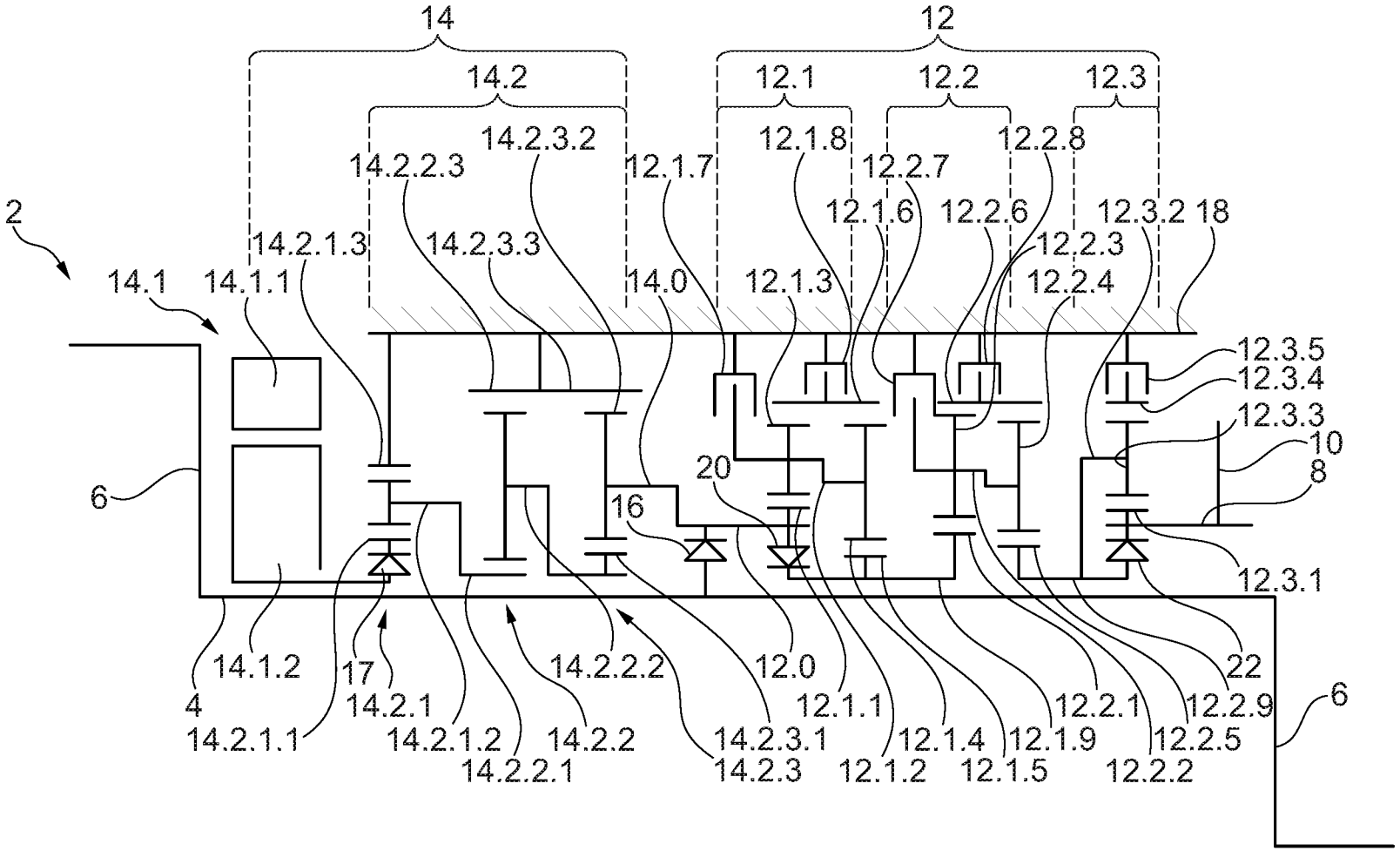
17. Groupe de transmission (2) selon la revendication 16, dans lequel le crabot mobile ou chacun des crabots mobiles (30.1, 30.2, 30.3, 30.4, 30.5) comprend un alésage (36.3) et le doigt ou chaque doigt (38) est coulissant dans ledit alésage, ledit doigt portant la dent correspondante et délimitant avec ledit alésage (36.3) une chambre contenant un milieu fournissant la force élastique.

18. Groupe de transmission (2) selon la revendication 17, dans lequel le milieu est un ressort, un gaz ou un liquide en communication avec une chambre auxiliaire (36.4) délimitée par un élément élastique tel qu'un ensemble ressort-piston (42).

19. Groupe de transmission (2) selon l'une des revendications 13 à 18, dans lequel le crabot mobile (30.1, 30.2, 30.3, 30.4, 30.5) ou chacun des crabots mobiles (30.1, 30.2, 30.3, 30.4, 30.5) comprend un contrôleur d'engagement (46) configuré pour permettre l'engagement du crabot mobile avec la butée ou l'une des butées uniquement lorsque le crabot mobile est à distance de la butée.

20. Groupe de transmission (2) selon la revendication 19, dans lequel le contrôleur d'engagement (46) ou chacun des contrôleurs d'engagement (46) comprend un organe de contact (46.2) configuré pour coulisser le long de la périphérie de la couronne ou du porte-satellites correspondant et monté de manière pivotante sur le crabot mobile (30.1, 30.2, 30.3, 30.4, 30.5) entre une position sortie empêchant l'engagement et une position rentrée permettant l'engagement, et un ressort (46.4) sollicitant l'organe de contact (46.2) en position sortie.

21. Véhicule équipé de pédales de propulsion et comprenant un groupe de transmission portant lesdites pédales de propulsion et configuré pour entraîner au moins une roue dudit véhicule lors de l'activation des pédales ; caractérisé en ce que le groupe de transmission est conforme à l'une quelconque des revendications 1 à 20.


14
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12.1
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12.1.8
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12.2.8
2
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12.2.6
12.3.2
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14.2.3.3
12.2.3
14.1
14.1.1
14.0
12.1.3
12.2.4
12.3.5
12.3.4
12.3.3
10
20
8
6
16
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12.0
22
4
14.2.1
12.1.1
12.2.1
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12.1.2
12.1.5
12.2.2

Fig. 1

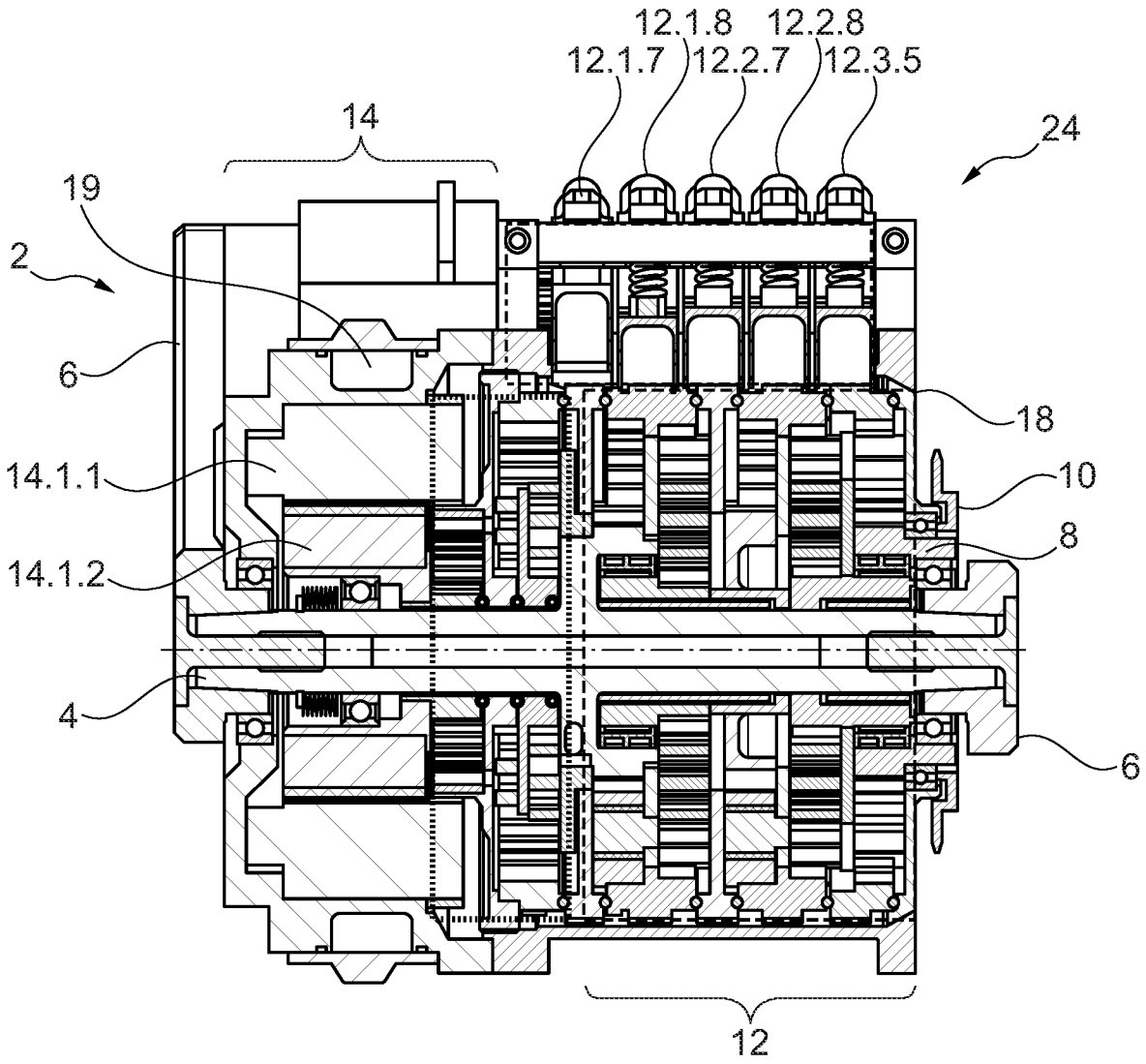

Fig. 2

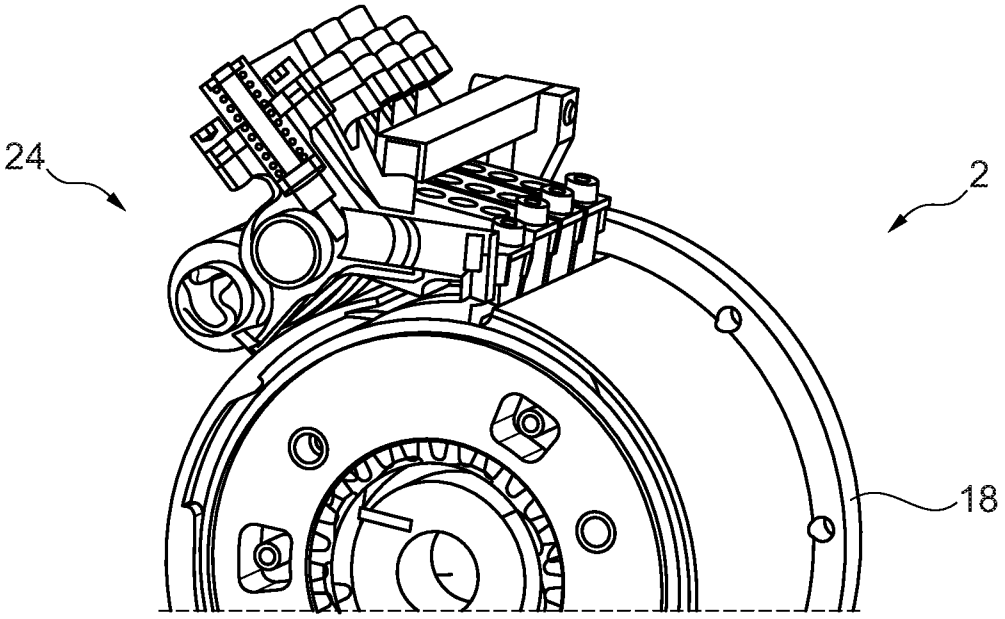

Fig. 3

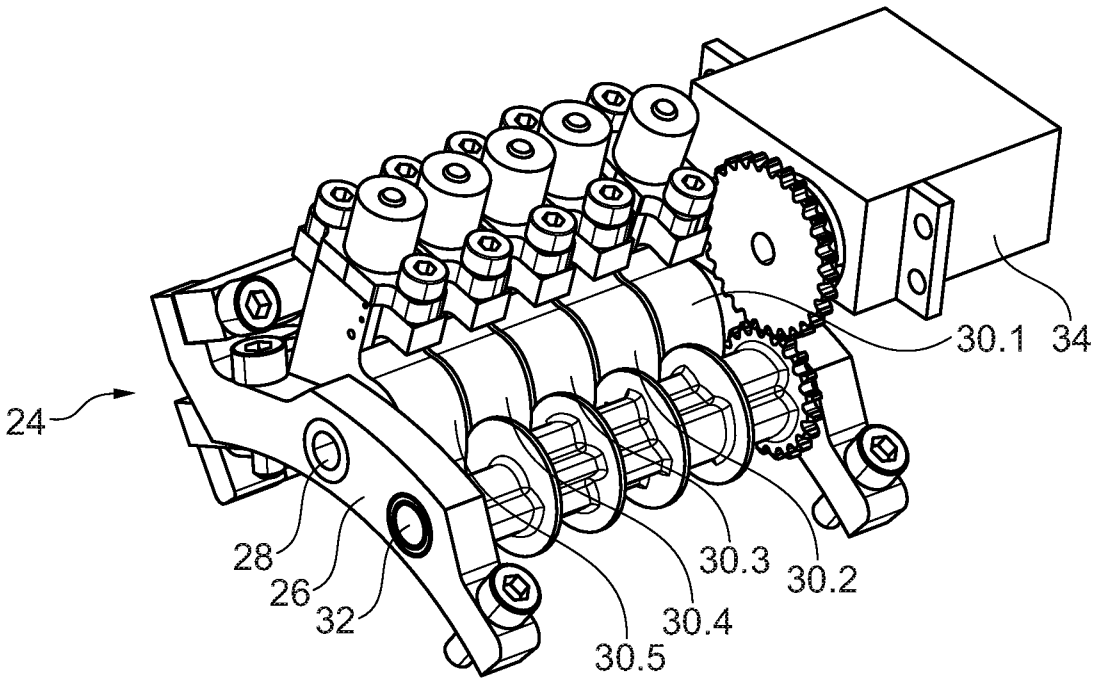

Fig. 4

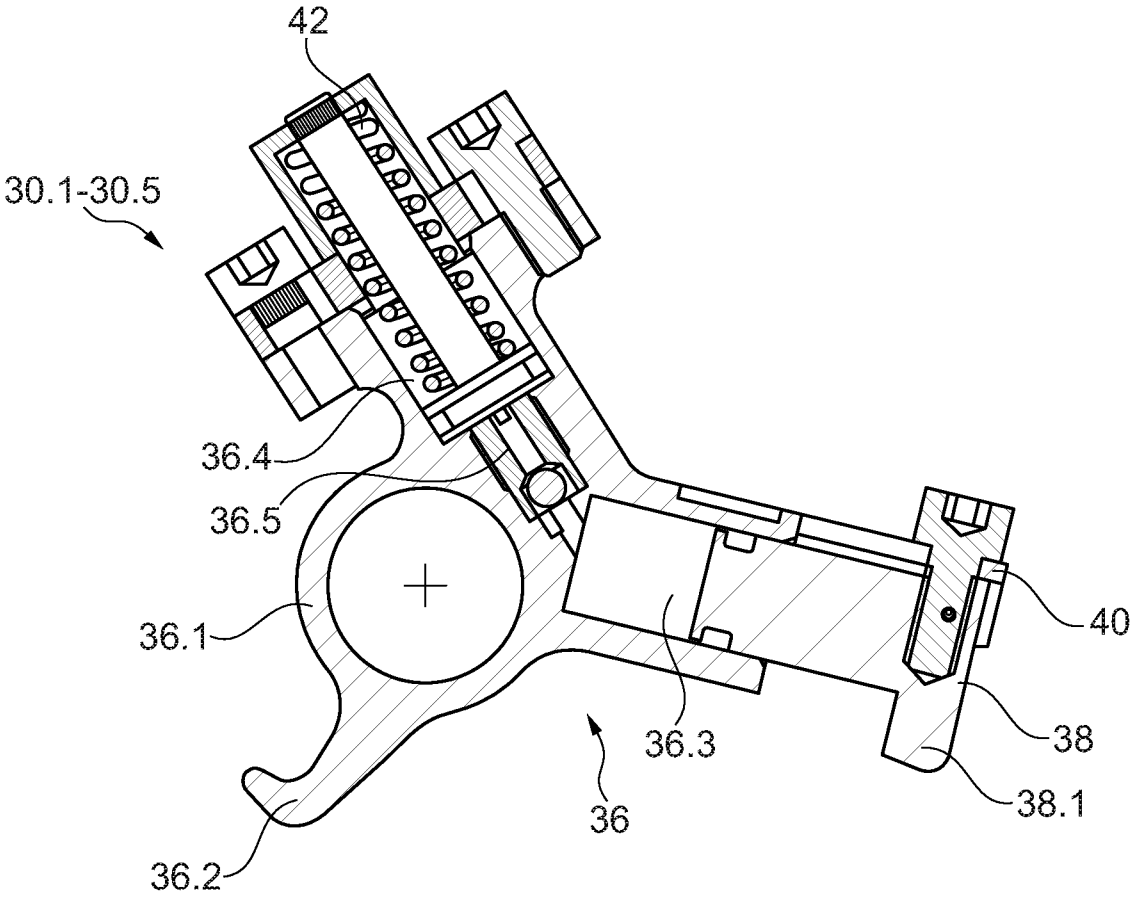

Fig. 5

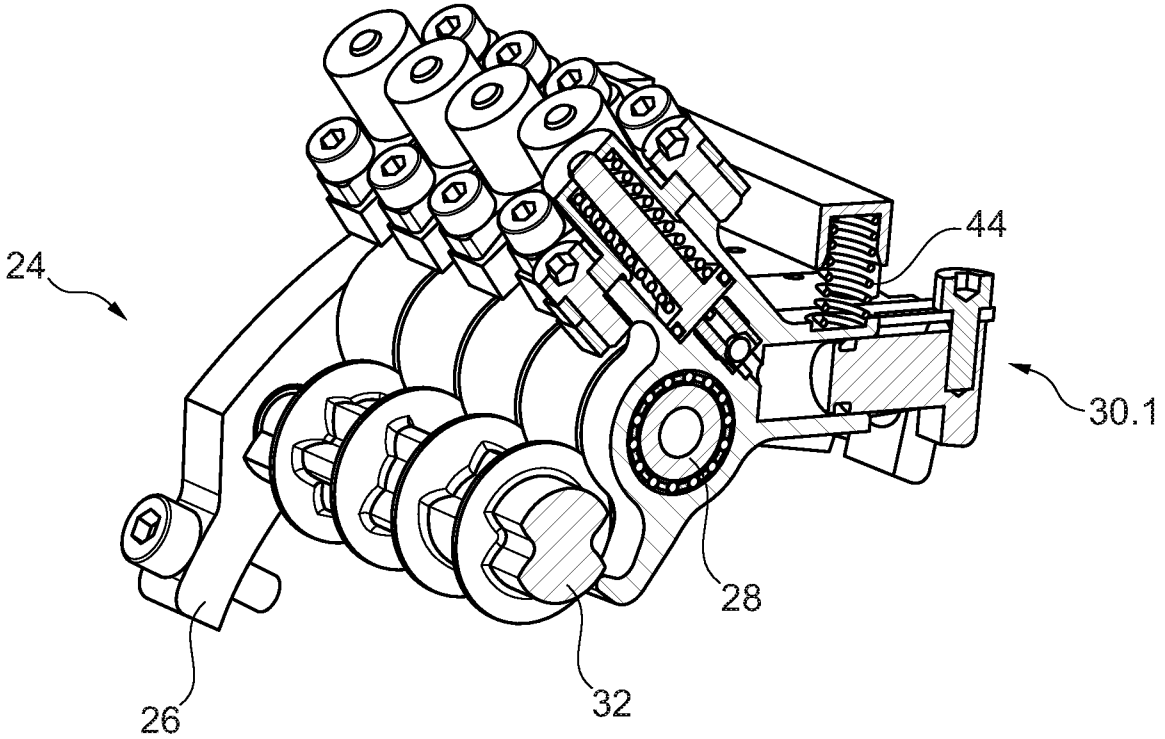

Fig. 6

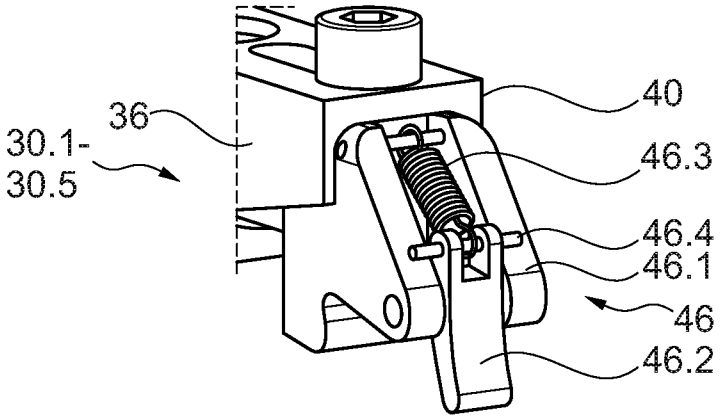

Fig. 7

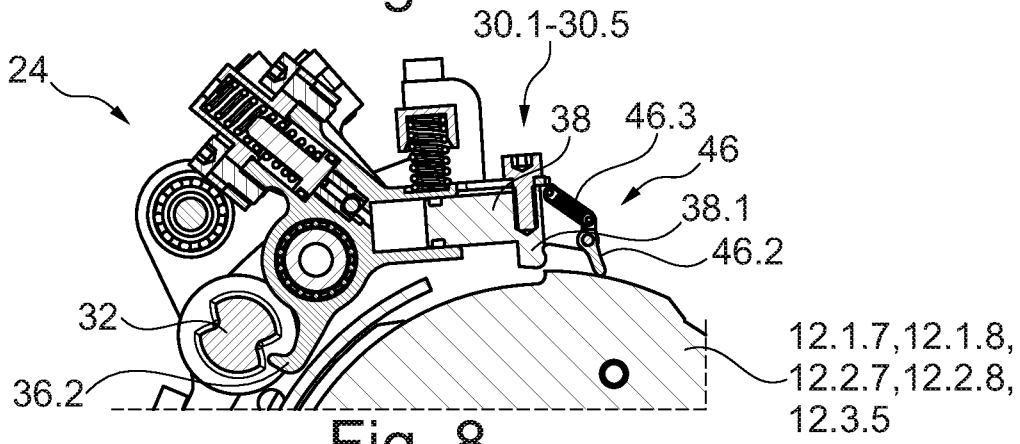

Fig. 8

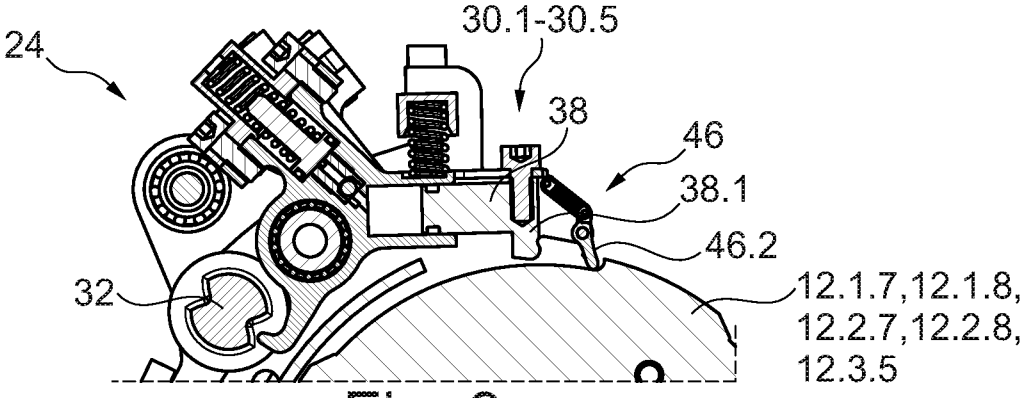

Fig. 9

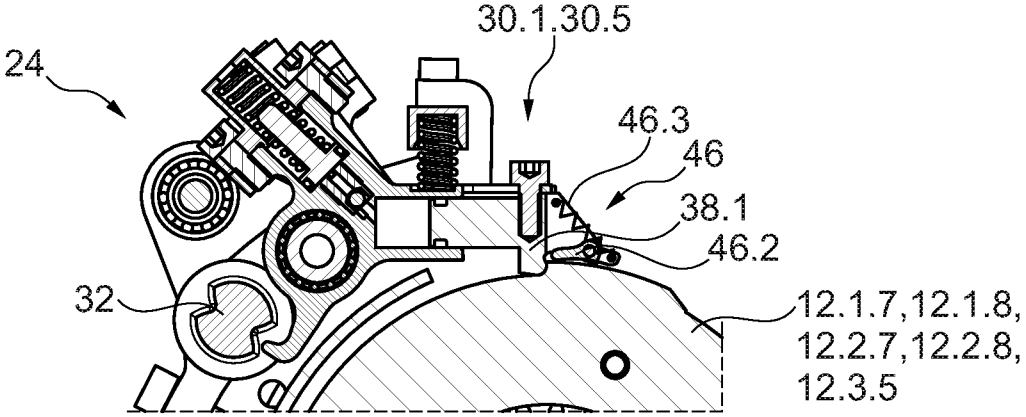

Fig. 10