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(71) Applicant: **BREMBO S.P.A.** [IT/IT]; Via Brembo, 25, I-24035 Curno, Bergamo (IT).

(72) Inventors: **DOSSI, Stefano**; c/o Brembo S.p.A., Via Brembo, 25, I-24035 Curno, Bergamo (IT). **MANZONI, Corrado**; c/o Brembo S.p.A., Via Brembo, 25, I-24035 Curno, Bergamo (IT). **BRESCIANI, Tommaso**; c/o Brembo S.p.A., Via Brembo, 25, I-24035 Curno, Bergamo (IT). **TARANTINI, Alfonso**; c/o Brembo S.p.A., Via Brembo, 25, I-24035 Curno, Bergamo (IT).

(74) Agent: **PENNACCHIO, Salvatore Giovanni** et al.; c/o Jacobacci & Partners S.p.A., Via Senato, 8, I-20121 Milano (IT).

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(54) Title: ELECTRONIC DEVICE FOR SELECTING AND COMMANDING ELECTRICAL SIGNALS TO ACTUATE ELECTRICALLY ACTUATED BRAKE CALIPERS OF A PARKING BRAKE SYSTEM

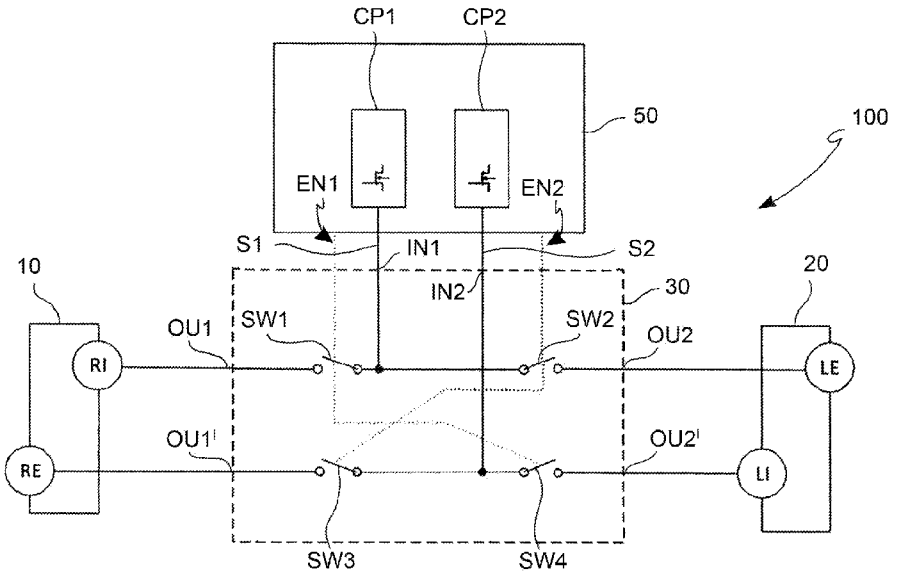

FIG. 1

(57) Abstract: The invention relates to an electronic device (30) for selecting and routing electrical signals for the actuation of electro-actuated brake calipers of a parking brake apparatus (100) of a vehicle, in particular a motor vehicle. The device comprises: - a first (IN1) and a second (IN2) input to receive electrical signals (S1, S2) for actuating the electro-actuated brake calipers; - a first (OU1) and at least a further first (OU1') output connected to a first electro-actuated brake caliper (10) comprising at least two electric motors; - a second (OU2) and at least a further second (OU2') output connected to a second electro-actuated brake caliper (20) comprising at least two electric motors. The device comprises electronic connection means (SW1, SW2, SW3, SW4) which are controllable to take an open state and a closed state. When the parking brake apparatus is deactivated, the electronic connection means are controlled to

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take the open state to isolate said first and second inputs from the aforesaid outputs; When the parking brake apparatus is activated, the electronic connection means are selectively controlled to switch from the open state to the closed state to connect said first and second inputs to any two of: first output, second output, at least a further first output, and at least a further second output. Thereby, the electrical actuation signals are routed towards selected electric motors of the electro-actuated brake calipers.

DESCRIPTION

ELECTRONIC DEVICE FOR SELECTING AND COMMANDING ELECTRICAL SIGNALS TO ACTUATE ELECTRICALLY ACTUATED BRAKE CALIPERS OF A PARKING BRAKE SYSTEM

[0001]. Field of the invention

[0002]. The present invention relates to the field of electric brakes, and in particular, of electric park brakes (EPBs) of a vehicle, even more particularly of a motor vehicle. In greater detail, the present invention relates to an electronic device for selecting and routing electrical signals for actuating the electro-actuated brake calipers of a brake apparatus, in particular a parking brake of a motor vehicle, even more particularly a motorcar.

[0003]. Background art

[0004]. As known, the brake systems primarily serve two purposes: service braking and parking braking. The term "service braking" means any action on the braking system to apply braking or deceleration to a moving vehicle which produces a modulable vehicle deceleration and which is reversible, i.e., by removing the command, the action is cancelled. On the other hand, the term "parking braking" means a braking action with the vehicle being stationary, which produces a force adapted to prevent the vehicle from moving even after the command has been removed. Such a braking action is of irreversible type and the removal of the force which prevents the vehicle from moving requires a specific release command. Both braking types can be activated upon the

driver's command or the command of other driver assistance systems.

[0005]. Nowadays, electric park brakes (EPBs) are used on motor vehicles, in particular motorcars, to keep the vehicle stationary on both sloping and flat roads. The same function was accomplished in the past using a manual parking brake.

[0006]. Such electric park brakes involve the use of electro-actuated brake calipers, i.e. actuated by electric motors dedicated to the parking brake function.

[0007]. The retaining mechanism of the electric park brake of a motorcar is activatable by the driver acting on a button. As a result of such an activation, an electronic control system is configured to activate electric motors positioned on the brake calipers to move forward the pistons which apply a bias to the respective brake pads which abut on braking surfaces of the brake disc, associated with the wheel of the motorcar, and thus stop the movement thereof. In most cases, the either manual or EPB parking brake acts on the rear axle wheels of the motorcar.

[0008]. In some cases, the brake calipers used to apply a parking brake action are specially made brake calipers separate from the brake calipers used to apply the service braking action. Indeed, since there are no moving masses, the energy involved in parking braking is decidedly less than the energy that the service brake must apply.

[0009]. Service brake calipers which are also used as parking brake calipers are known, e.g. as described in US3734248,

US5343985, US2016167632, US5090518, US2009242338, US2014076672, US10525958, and US2019120311.

[0010]. An apparatus for an electric park brake EPB involves the use of an electronic control unit (ECU) and an actuator adapted to act on the electric motors of the electro-actuated calipers. For this reason, EPB systems can be considered as a subset of braking systems operating with brake-by-wire (BBW) technology.

[0011]. To drive an electric motor for actuating an electro-actuated caliper of an EPB parking brake, it is known to use a dedicated power electronic circuit, e.g. an electronic circuit in a full-bridge transistor configuration (in case of driving using a circuit which includes solid-state components) or an electronic circuit using diverter relays (in case of driving using a switch).

[0012]. In particular, the known and currently available EPB parking brake apparatuses are made according to two different implementation types:

- a first type of parking brake includes the use of a specific electronic control unit, or ECU, dedicated to it, which includes two power electronic circuits in a full-bridge transistor configuration, each of which is usable to drive an electric motor associated with a brake caliper;
- a second type of parking brake involves the use of two power electronic circuits in a full-bridge configuration with transistors either included or integrated into an ABS/ESP control unit which already equips the motorcar. Again, each full-bridge power circuit is usable to drive a single electric motor

associated with a brake caliper.

[0013]. The search for new actuation solutions for an electric park brake to be applicable to brake calipers of the monobloc or floating type has recently led to devise electro-actuated calipers which include two or more electric motors for each caliper, dedicated to the parking brake function.

[0014]. To be controlled, this type of calipers would require a new electronic control unit capable of driving four or more motors, or the use of a standard electronic control unit for each caliper, because the known apparatuses currently used to control the EPB only drive two electric motors.

The control of such calipers would, thus, require a too complex and economically disadvantageous EPB electric park brake apparatus.

[0015]. First, the need to improve the braking action and in particular the parking braking action is still felt.

[0016]. Therefore, the need is strongly felt to control electro-actuated calipers which include two or more electric motors for each caliper, dedicated to the parking brake function of vehicles which allows overcoming the limitations and drawbacks of the known solutions mentioned above.

[0017]. The need is also felt to avoid the anomalous behavior of the brake caliper when it is also used as a parking brake caliper. For example, the need is felt where the caliper has more than one electric motor for actuating the caliper to ensure that the resulting action on the pad does not result in "skewing" of the

pad itself, i.e. an action of the pad which results in the abnormal movement thereof in its seat provided in the caliper body, thus generating inter alia excessive dissymmetrical or asymmetrical loads on the brake caliper body.

[0018]. Solution

[0019]. It is a first object of the present invention to devise and provide an electronic device configured to select and route electrical signals for actuating electro-actuated brake calipers of a parking brake apparatus of a vehicle, in particular a motor vehicle, e.g., a motorcar, which allows efficiently driving electro-actuated brake calipers which each include at least two electric motors while limiting the complexity of the brake apparatus.

[0020]. Such an object is achieved by an electronic device for selecting and routing electrical signals for the actuation of electro-actuated brake calipers of a parking brake apparatus, according to claim 1.

[0021]. In particular, such an electronic device (30) for selecting and routing electrical signals comprises:

- a first (IN1) and a second (IN2) input to receive electrical signals (S1, S2) for actuating electro-actuated brake calipers;
- a first (OU1) and at least a further first (OU1') output connected to a first electro-actuated brake caliper (10);
- a second (OU2) and at least a further second (OU2') output connected to a second electro-actuated brake caliper (20);
- electronic connection means (SW1, SW2, SW3, SW4) which are

controllable to take an open state and a closed state, where:

- when the parking brake apparatus (100) is deactivated, said electronic connection means (SW1, SW2, SW3, SW4) are controlled to take the open state to isolate said first (IN1) and second (IN2) inputs from the aforesaid outputs (OU1, OU2, OU1', OU2');
- when the parking brake apparatus (100) is activated, said electronic connection means (SW1, SW2, SW3, SW4) are selectively controlled to switch from the open state to the closed state to connect said first (IN1) and second (IN2) inputs to any two of said: first output (OU1), second output (OU2), at least a further first output (OU1'), and at least a further second output (OU2').

Thereby, the electrical actuation signals (S1, S2) are routed towards two electric motors of the electro-actuated brake calipers each time.

[0022]. It is a further object of the invention to be able to alternately drive the electric motors of the two brake calipers of the EPB parking brake apparatus.

[0023]. It is yet another purpose to be able to drive the electric motors of the two brake calipers for prefixed time intervals, between a few tens of milliseconds and hundreds of milliseconds, to produce a more homogeneous forward movement of the pistons.

[0024]. It is a further object of the present invention an EPB parking brake apparatus according to claim 8 and a motor vehicle including the aforesaid apparatus according to claim 14.

[0025]. Some advantageous embodiments are the subject of the dependent claims.

[0026]. Drawings

[0027]. Further features and advantages of the invention will become apparent from the description provided below of preferred embodiments thereof, given by way of non-limiting indication, with reference to the accompanying drawings, in which:

[0028]. - **figure 1** diagrammatically shows an example of an EPB parking brake apparatus comprising an electronic device for selecting and routing electrical signals for actuating electro-actuated brake calipers according to the present invention, connected between an electronic control unit of the EPB apparatus and electro-actuated brake calipers of a motor vehicle including two electric motors for each caliper;

[0029]. - **figure 2** shows a time-dependent diagram of the control signals of electronic switches controlled in switching included in the electronic selection and routing device in figure 1;

[0030]. - **figure 3** diagrammatically depicts a vehicle and, with greatly enlarged, separate parts, the two brake calipers, each of which of the monobloc type with four pistons and four independent electric motors, each associated with a respective front wheel, and the two floating brake calipers each with only one piston and the respective electric motor associated with the two rear wheels;

[0031]. - **figure 4** again diagrammatically shows a second vehicle configuration and, with greatly enlarged, separate parts, two brake calipers, each of which of the floating type with two

pistons and four independent electric motors, each associated with a respective front wheel, and the two floating brake calipers each with one only piston and the respective electric motor, each associated with each rear wheel;

[0032]. - **figure 5** depicts an axonometric view of a monobloc brake caliper associated with a brake disc with four pistons driven by four independent electric motors;

[0033]. - **figure 6** shows an axonometric view of a floating brake caliper with two pistons driven by two independent electric motor-reducers;

[0034]. - **figure 7** depicts an axonometric view of a floating brake caliper with a single piston driven by an electric motor-reducer;

[0035]. - **figure 8** depicts an axonometric view of a hydraulic and electromechanical service and parking disc brake comprising a monobloc brake caliper with two hydraulically actuated pistons (service brake) and two independent electric motors (parking brake);

[0036]. - **figure 9** depicts a section view of the brake caliper for disc brake in figure 8;

[0037]. - **figure 10** depicts an enlarged view of a detail in figure 9.

[0038]. Similar or equivalent elements in the aforesaid figures are indicated by the same reference numerals.

[0039]. Description of some preferred embodiments

[0040]. With reference to figure 1, a simplified block diagram of an apparatus for parking brake (Electric Park Brake or EPB) of a motor vehicle 2, in particular a motorcar, according to the present invention is indicated by reference numeral 100 as a whole.

[0041]. In the present description, the term "stationary" is used to indicate that the motorcar is parked and with the engine off. In such conditions, the retaining mechanism of the electric park brake of a motorcar is activatable by the driver, e.g., by acting on a button. Following such an activation, the brake calipers are actuated by the electric motors to apply the respective pads to the brake discs of the wheels of the motorcar and thus block them.

[0042]. Similarly, the electric parking brake retaining mechanism is deactivated by the driver by pressing the button again.

[0043]. It is worth noting that the aforesaid parking brake apparatus 100 is configured to implement the electric park brake function by employing components already included in the electro-actuated brake apparatus which equips the motorcar, including an electronic control unit 50 of the brake apparatus and electro-actuated brake calipers 10, 20 acting on the brake discs of the wheels of the motorcar.

[0044]. In the present invention, in particular, the aforesaid electro-actuated brake calipers 10, 20 of the apparatus 100 may

include one, two, or more electric motors for each caliper. Referring to the example in figure 1, each of the electro-actuated brake calipers 10, 20 comprise two electric motors. As known, each of such motors is adapted to actuate a respective piston (not shown in figure 1) which, by acting on one or another of the semi-calipers which form each brake caliper 10, 20, causes the tightening of the caliper on the brake disc or, vice versa, the releasing from the disc.

[0045]. In particular, in the example in figure 1, the parking brake apparatus 100 comprises a first 10 and a second 20 electro-actuated brake caliper.

The first electro-actuated brake caliper 10 comprises, for example, a first RI and at least a further first RE electric motor. The second electro-actuated brake caliper 20 comprises, for example, a second LE and at least a further second LI electric motor.

In other words, each caliper 10, 20 comprises a first electric motor RI, LI adapted to act on the semi-caliper facing the inside of the motorcar, and a second electric motor RE, LE adapted to act on the semi-caliper facing the outside of the motorcar.

[0046]. In an exemplary embodiment, the aforesaid first 10 and second 20 electro-actuated brake calipers are associated with the wheels of the rear axle 5 of the motorcar 2.

[0047]. In a different exemplary embodiment, the aforesaid first 10 and second 20 electro-actuated brake calipers are associated

with the wheels of the front axle 6 of the motorcar 2.

[0048]. These solutions are both equivalently applicable to keep the vehicle stationary on both sloping and flat roads.

[0049]. In yet a different example embodiment, the first electro-actuated brake caliper 10 is associated with a wheel of the rear axle 5 of the motorcar 2, and the second electro-actuated brake caliper 20 is associated with a wheel of the front axle 6 of the motorcar 2.

[0050]. Such a configuration is particularly advantageous because it allows keeping the motorcar stationary if it is parked on uneven roads which have different slopes at the wheels of the rear and front axles.

[0051]. Furthermore, the parking brake apparatus 100 comprises the aforesaid electronic control unit 50 (or ECU), which comprises, for example, a microcontroller or microprocessor, configured to generate a first S1 and a second S2 electrical signal for actuating the electro-actuated brake calipers 10, 20.

[0052]. Hereafter, reference will be generally made to the aforementioned electrical actuation signals S1, S2, meaning that such signals can indifferently actuate the electric motors (and the respective pistons) to cause the tightening of the caliper on the brake disc, or vice versa, the release from the disc.

[0053]. In an exemplary embodiment, such an electronic control unit 50 is embodied in a dedicated electronic control unit which includes a first CP1 and a second CP2 power electronic circuit,

e.g. in a full-bridge transistor configuration, configured to generate the first S1 and second S2 electrical signals, respectively, for actuating the electro-actuated brake calipers 10, 20.

[0054]. In a different exemplary embodiment, such an electronic control unit 50 is embodied in an ABS/ESP control unit which already equips the motorcar. In such a case, the use a first CP1 and a second CP2 additional power electronic circuit is included, e.g. in a full-bridge transistor configuration, either included or integrated into such an ABS/ESP control unit and adapted to generate the first S1 and second S2 electrical signals for actuating the electro-actuated brake calipers 10, 20.

[0055]. Furthermore, the parking brake apparatus 100 of the invention advantageously comprises an electronic device 30 for selecting and routing the electrical signals for actuating the electro-actuated brake calipers 10, 20 of the apparatus.

[0056]. In particular, such an electronic device 30 comprises a first IN1 and a second IN2 input for receiving the above-mentioned first S1 and second S2 electrical drive signals generated by the electronic control unit 50.

[0057]. Furthermore, the electronic device 30 comprises:

- a first OU1 and at least a further first OU1' output connected to the first RI and the at least a further first RE electric motors, respectively, of the first electro-actuated brake caliper 10;

- a second OU2 and at least a further second OU2' output connected to the second LE and the at least a further second LI electric motors, respectively, of the second electro-actuated brake caliper 20.

[0058]. Furthermore, the electronic device 30 of the invention comprises electronic connection means SW1, SW2, SW3, SW4 which are controllable to take an open state and a closed state.

In particular, when the parking brake apparatus 100 is deactivated, such electronic connection means SW1, SW2, SW3, SW4 are controlled to take the open state. Thus, the first IN1 and second IN2 inputs are isolated from the aforesaid outputs OU1, OU1', OU2, OU2'.

Instead, when the parking brake apparatus 100 is activated, such electronic connection means SW1, SW2, SW3, SW4 are selectively controlled to switch from the open state to the closed state to connect the aforesaid first IN1 and second IN2 inputs of the device 30 to any two of: first output OU1, second output OU2, at least a further first output OU1', and at least a further second output OU2'.

Thereby, the electrical actuation signals S1, S2 are routed towards the selected electric motors of the electro-actuated brake calipers.

[0059]. In an exemplary embodiment provided by way of a non-limiting example of the present invention, the aforesaid electronic switching means comprise a first SW1, a second SW2, at

least a third SW3, and at least a fourth SW4 switch controlled in switching.

[0060]. In particular, such electronic switches are controllable in switching based on a first EN1 and a second EN2 control signal generated by the electronic control unit 50 and having time trends shown, for example, in figure 2.

[0061]. In the example in figure 1, the parking brake apparatus 100 comprises two calipers, and each of those calipers includes two electric motors. Therefore, the selection and routing device 30 comprises a total of four electronic switches.

However, the teachings of the present invention are also applicable to the case of brake apparatuses employing calipers each of which comprises more than two electric motors. Those skilled in the art can modify the number and configuration of the electronic switches of the selecting device 30 so that the two actuation signals S1, S2 are always routed to any two of these motors.

[0062]. In the exemplary embodiment in figure 1, the first control signal EN1 is adapted to act simultaneously on the first SW1 and fourth SW4 switches, the second control signal EN2 can simultaneously act on the second SW2 and third SW3 switches.

[0063]. In such an exemplary embodiment, when the parking brake apparatus 100 is activated:

the first SW1 and fourth SW4 switches are controlled by means of the first control signal EN1 to switch from the open state to the

closed state to connect, during a first time interval T1, the first input IN1 to the first output OU1 of the device 30 and to connect the second input IN2 to the at least a further second output OU2', respectively.

In this case, the second SW2 and third SW3 switches are controlled by the second control signal EN2 to take the open state.

[0064]. In the same example, when the parking brake apparatus 100 is activated, at the end of the first time interval T1:

the first SW1 and fourth SW4 switches are controlled by the first control signal EN1 to switch from the closed state to the open state,

the second SW2 and third SW3 switches are controlled by the second control signal EN2 to switch from the open state to the closed state to connect, during a second time interval T2 following the first time interval T1, the first input IN1 to the second output OU2 of the device 30 and to connect the second input IN2 to said at least a further first output OU1', respectively.

[0065]. In a different exemplary embodiment, not shown in figure 1, the first control signal EN1 can simultaneously act on the first SW1 and third SW3 switches, the second control signal EN2 is adapted to act simultaneously on the second SW2 and fourth SW4 switches.

[0066]. In such an exemplary embodiment, when the parking brake apparatus 100 is activated:

the first SW1 and third SW3 switches are controlled by means of

the first control signal EN1 to switch from the open state to the closed state to connect, during a first time interval T1, the first input IN1 to the first output OU1 of the device 30 and to connect the second input IN2 to said at least a further first output OU1', respectively;

the second SW2 and fourth SW4 switches are controlled to take the open state.

[0067]. In the same example, when the parking brake apparatus 100 activated, at the end of the first time interval T1:

the first SW1 and third SW3 switches are controlled to switch from the closed state to the open state,

the second SW2 and fourth SW4 switches are controlled to switch from the open state to the closed state to connect, during a second time interval T2 following the first time interval T1, the first input IN1 to the second output OU2 of the device 30 and to connect the second input IN2 to said at least a further second output OU2', respectively.

[0068]. In view of the above, the electronic device 30 for selecting and routing the input signals IN1, IN2 is adapted to operate as a demultiplexer on such signals.

[0069]. In the aforesaid exemplary embodiments, with reference to figure 2, the first EN1 and second EN2 control signals are, for example, square wave signals having the same frequency, but mutually shifted by 180°.

[0070]. In such a case, the first T1 and second T2 time

intervals are equal to each other and coincide with a half-period of such square wave signals.

[0071]. The duration of this semi-period is fixed and, for example, is in the range 10 msec - 100 msec.

[0072]. In a yet different exemplary embodiment, the first control signal EN1 coincides with the second control signal EN2. In other words, the first SW1 and fourth SW4 switches are controlled to take the closed state at the same time as the second SW2 and third SW3 switches.

[0073]. In such a case, when the parking brake apparatus 100 is activated, the first SW1, second SW2, third SW3, and fourth SW4 switches are controlled to switch from the open state to the closed state and remain simultaneously closed during a third time interval T3 (not shown in the figures). Thus, the first input IN1 is simultaneously connected to the first OU1 and second OU2 outputs, and the second input IN2 is simultaneously connected to the at least a further first OU1' and the at least a further second OU2' outputs.

[0074]. In particular, the Applicant has verified that by introducing the electronic device 30 for selecting and routing electrical actuation signals described above, it is possible to effectively drive two electro-actuated brake calipers each including at least two electric motors employing the same electronic control unit 50 already provided in the electro-actuated brake control apparatus, without excessively increasing

the complexity of the brake apparatus.

[0075]. Furthermore, the electronic selection and routing device 30 can be used to alternately drive the electric motors of any two brake calipers of the EPB parking brake apparatus. For example, it is possible to control first the actuation of the motors RI, LI facing the inside of the motorcar and then the motors RE, LE facing the outside of the vehicle. Alternatively, the electronic selection and routing device 30 allows driving one inner motor and one outer motor.

[0076]. Furthermore, with the electronic selection and routing device 30 it is possible to drive simultaneously the motors of the same caliper and then the motors of the other caliper.

[0077]. Furthermore, the electronic selection and routing device 30 allows driving the electric motors of the two brake calipers for time intervals T1, T2 of pre-set duration, between a few tens of milliseconds and hundreds of milliseconds. Thereby, a more uniform forward movement of the pistons can be produced.

[0078]. The present invention further relates to a motor vehicle which comprises an electro-actuated brake apparatus 100 according to any one of the embodiments described above.

[0079]. The aforementioned electronic control unit 50 stored in a respective memory application software configured to implement the method which implements the control logic of the present invention. Such application software is implemented, in particular, by means of functional blocks.

[0080]. In an exemplary embodiment, the parking braking method of the vehicle 2 comprising the steps of:

- providing at least a first electro-actuated brake caliper 10 associated with a first wheel 3 of the vehicle 2;
- providing at least a second electro-actuated brake caliper 20 associated with a second wheel 4 of the vehicle 2;
- providing an electronic device 30 for selecting and routing electrical signals, which comprises:
- a first IN1 and a second IN2 input to receive electrical signals S1, S2 for actuating electro-actuated brake calipers, 10, 20;
- a first OU1 and at least a further first OU1' output connected to a first RI and at least a further first RE electric motor, respectively, of such at least a first electro-actuated brake caliper 10;
- a second OU2 and at least a further second OU2' output connected to a second LE and at least a further second LI electric motor, respectively, of such at least a second electro-actuated brake caliper 20.

[0081]. The method is characterized in that it comprises the further step of selectively routing, by the electronic device 30, the aforesaid electrical actuation signals S1, S2 towards any two of said: first output OU1, second output OU2, at least a further first output OU1' and at least a further second output OU2' to activate the electric motors of both said at least a first brake

caliper 10 and said at least a second brake caliper 20 to generate a parking braking action to the vehicle 2.

[0082]. In an exemplary embodiment, the method further comprises the steps of:

- applying an at least temporary parking braking action with: the first RI and the at least further first RE electric motors of the at least a first electro-actuated brake caliper 10, the second LE and the at least further second LI electric motors of the at least a second electro-actuated brake caliper 20;
- applying a permanent parking braking action, i.e., until deactivation by the user, with at least one of the first RI, at least a further first RE, second LE, and at least a further second LI electric motors to generate a parking braking action to the vehicle 2.

[0083]. In an exemplary embodiment, the method comprises:

- defining a first amount of a temporary braking action F1, i.e. a first braking force;
- defining a second amount of a permanent braking action F2, i.e. a second braking force.

[0084]. Such a first amount of a temporary braking F1 is less than the second amount of a permanent braking action F2.

[0085]. In an exemplary embodiment, the aforesaid step of applying an at least temporary parking braking action comprises the further steps of:

- activating, during a first time interval T1, the first RI and

the at least further second LI electric motors to apply said first amount of temporary braking action F1 to the first 10 and second 20 electro-actuated brake calipers;

- keeping deactivated, during the first time T1, the at least further RE and second LE electric motors;

- activating, during a second time interval T2 following and equal to the first time interval T1, the at least a first RE and second LE electric motors to apply the first amount of temporary braking action F1 to the first 10 and second 20 electro-actuated brake calipers;

- keeping deactivated, during the second time T2, the first RI and the at least a further LI electric motors.

[0086]. In an embodiment, the step of applying a permanent parking braking action comprises the further step of activating, until deactivation by the user, at least one of the aforesaid first RI, at least a further first RE, second LE, and at least further second LI electric motors to apply the second amount of permanent braking action F2 to the first 10 or second 20 electro-actuated brake caliper or both to generate a parking braking action to the vehicle 2.

[0087]. Furthermore, it is provided to release the temporary parking braking action only from the electric motors not concerned by said permanent parking braking action.

[0088]. Referring to figures 8, 9, and 10, an example of a hydraulic and electromechanical service and parking disc brake 200

comprising a monobloc brake caliper 101 is described. Such a brake caliper 101 comprises two pistons actuated by two electric motors 117 which are controllable by an electronic control unit 120. Such an electronic control unit 120, which substantially corresponds to the electronic unit 50 described above, can control the electric motors 117 through the electronic routing device 30 suggested by the present invention.

[0089]. Although a monobloc hydraulic and electromechanical disc brake caliper 101 with two electric motors is shown in figure 8, the present invention may also advantageously be applied to hydraulic and electromechanical disc brake calipers having a greater number of pistons, e.g. four or six pistons and, possibly a corresponding greater number of electric actuating motors.

[0090]. The hydraulic and electromechanical service and parking disc brake 200 comprises the caliper 101 with two side walls 102 which mutually delimit a disc space 103 for accommodating a portion of a brake disc 104.

[0091]. Furthermore, the disc brake 200 comprises means for fixing the caliper 101 to the suspension of a vehicle and at least two pads 105 each supported to one of the side walls 102, respectively.

[0092]. The disc brake 200 comprises a service braking system 106, having at one hydraulic actuator 107 positioned in each of the side walls 102. Each of the two hydraulic actuator 107 shown in figure 9 comprises a hydraulic cylinder 108 formed in the side

wall 102 and a piston 109 accommodated in the hydraulic cylinder 108 and having a free end 110 facing the pad 105.

[0093]. Such a hydraulic cylinder 108 is in communication with a system 111 for feeding and pressurizing a hydraulic fluid for applying hydraulic pressure to the piston 109 and causing the piston 109 to translate in an actuating direction 112 towards the brake disc 104 and tightening the pad 105 against the brake disc 104.

[0094]. Furthermore, the disc brake 200 comprises a service braking system 113 having an electromechanical actuator 114 positioned in each of the side walls 102, respectively. The caliper 101 comprises two electro-mechanical actuators 114.

[0095]. Each electromechanical actuator 114 comprises a screw-nut screw assembly 115, 116 having a rotary member 116 and a translational member 115 and configured to convert a rotary motion of the rotary member 116 into a translational motion of the translational member 115.

[0096]. The screw-nut screw assembly 115, 116 is connected in the hydraulic cylinder 108 so as to translate and tighten the translational member 115 in the actuating direction 112 against the piston 109 to lock it.

[0097]. The two electric motors 117 of the disc brake 200 are each connected to a power supply 118 to actuate the screw-nut screw assembly 115, 116 associated with each piston. The disc brake 200, further comprises transmission mechanism 119 connected

between the electric motor 117 and the rotary member 116.

[0098]. It is worth noting that the electromechanical actuator 114 is self-locking due to transmission irreversibility thereof so that, when the electric motor 117 is off, a translational bias of the translational member 115 cannot cause the translational member 115 to move back from the brake disc 104.

[0099]. According to an alternative embodiment, e.g. if the caliper and a so-called floating caliper, the parking brake system 113 may comprise a single electromechanical actuator 114 positioned at only one of the side walls 102 which is activatable to block the pads 105 against the brake disc 104. In this case, the single electromechanical actuator 114 can be configured as described above.

[00100]. The electronic control unit 120 of a disc brake 200 is connected to the service braking system 106 and to brake the parking system 113 and a user interface 121. Such a user interface 121 comprises, for example, a user interface 122, having, for example, a service braking control interface, e.g. a service pedal or a service button or a service lever, and a parking braking control interface 123, e.g. a parking pedal or a parking button or a parking lever.

[00101]. Such a control unit 120 may comprise an electric, electromechanical, electro-hydraulic and/or electronic control system suited to control the pressurization of the hydraulic fluid and the drive of the electric motor 117. Such a control unit 120

is configured and/or programmed to perform the control functions of the brake 200 in the desired manner.

[00102]. In the case of the hydraulic and electromechanical service and parking disc brake 200 comprising the brake caliper 101 in figures 8–10, a step of defining a pressure target value in the hydraulic circuit of the caliper 101 is provided before the steps of controlling described above.

[00103]. It is worth noting that the hydraulic pressure can be generated by hydraulic modulators on the vehicle, e.g., stability control (ESC) modulators, or electric power brakes, or electro-hydraulic actuators hydraulically connected to the caliper.

[00104]. In particular, in response to a parking brake user command, the control unit 120 is configured to actuate:

- the service braking system 106 to move the piston 109 in the actuating direction 112 towards the brake disc 104 in a parking position in which it tightens the pad 105 against the brake disc 104, and
- the parking braking system 113 for locking the piston 109 in the parking position and for preventing a return movement of the piston 109.

[00105]. In response to the parking brake user command, the control unit 120 is configured for:

- actuating the service braking system 106 by moving the piston 109 to the parking position in which it pushes the pad 105 against the brake disc 104;

- when the target pressure is reached in the hydraulic circuit of the caliper 101, actuating the electric motor 117 in a forward direction upon the actuation of the service braking system 106 and with the piston 109 already in the parking position, by translating a translational member 115 in the actuating direction 112 against the piston 109 to lock it in the parking position and prevent a return movement thereof;
- once the piston 109 has been locked in the parking position, deactivating the service braking system 106 by reducing the pressure of the hydraulic fluid, and turning the electric motor 117 off.

[00106]. Thereby, the piston 109 remains locked due to the transmission irreversibility of the electromechanical actuator 114.

[00107]. In response to a user command to release the parking condition, the control unit 120 is configured for:
- firstly actuating the hydraulic actuator 107 to provide pressure on the piston 109 and unloads the screw-nut screw assembly 115, 116 of the electromechanical actuator 114;
- when the screw-nut screw assembly 115, 116 is unloaded, actuating the electromechanical actuator 114 to detach the translational member 115 from the piston 109;
- when the translational member 115 is detached from the piston 109, actuating the hydraulic actuator 107 to lower the hydraulic pressure again and interrupt the parking.

[00108]. A possible parking brake assembly according to the invention is described below with reference to figures 3-7.

[00109]. According to a general embodiment, a parking brake assembly 1 of a vehicle 2 comprises at least a first brake caliper 10 associated with a wheel 3 of the rear axle 5 of vehicle 2.

[00110]. Furthermore, said assembly comprises at least a further first brake caliper 11 associated with a wheel 4 of the front axle 6 of said vehicle 2.

[00111]. In an exemplary embodiment, all the brake calipers 10, 11, 20, 21 of the braking system 1 of the vehicle 2 are electro-actuated brake calipers so as to avoid hydraulic braking devices and circuits on the vehicle 2.

[00112]. In a different exemplary embodiment, the brake calipers of the brake system 1 of the vehicle 2 comprise both electro-actuated brake calipers and hydraulic and electromechanical service and parking brake calipers 101 similar to that described with reference to figures 8-10.

Although reference is made hereafter to the exemplary embodiment in which all vehicle brake calipers 2 are electro-actuated calipers, the properties of the invention are also applicable to hydraulic and electromechanical service and parking brake calipers 101.

[00113]. With further advantage, both said first brake caliper 10 and said further said first brake caliper 11 also are at least parking brake calipers.

[00114]. According to an embodiment, said system 1 comprises an electronic control unit 50 configured to generate a first S1 and a second S2 electrical parking command signal to actuate said electro-actuated brake calipers 10, 11, 20, 21.

[00115]. According to an embodiment, said electro-actuated brake calipers 10, 11, 20, 21 and/or said electronic control unit 50 are configured to apply a constant parking action to the vehicle 2 also when the vehicle is parked.

[00116]. According to an embodiment, said electro-actuated brake calipers 10, 11, 20, 21 and/or said electronic control unit 50 are configured to apply a constant parking action to the vehicle 2 also when the vehicle is parked and off.

[00117]. According to an embodiment, each electro-actuated caliper 10, 11, 20, 21 comprises at least one electric motor RI, RE, LE, LI, 12, 13, 14, 15 which acts, either directly or by means of a reducer 60, on a piston 61 which biases a brake pad 62, which, during the braking action, abuts against a braking surface 63 of a brake disc 64.

[00118]. Alternately, said at least one electric motor RI, RE, LE, LI, 12, 13, 14, 15 comprises a motor locking device 65 (not shown in the figures) which acts by blocking the movement of the electric motor when the electric motor RI, RE, LE, LI, 12, 13, 14, 15 with the vehicle 2 stopped; or said reducer 60 is an irreversible reducer, i.e. it allows a movement of the piston 61 if it is actuated by the electric motor RI, RE, LE, LI, 12, 13,

14, 15, but it does not allow the piston 61 to retract with the sole bias of the brake pad 62 on which said piston acts.

[00119]. According to an embodiment, at least a second brake caliper 20 is associated with a wheel 3 of the rear axle 5 of said vehicle 2.

[00120]. The at least a further second brake caliper 21 is associated with a wheel 4 of the front axle 6 of said vehicle 2.

[00121]. All four brake calipers 10, 11, 20, 21 of the braking system 1 of the vehicle 2 are electro-actuated brake calipers.

[00122]. At least one electro-actuated brake caliper 10 or 11 of said rear axle 5 and at least one electro-actuated brake caliper 20 or 21 of said front axle 6 are at least also parking brake calipers of the vehicle 2.

[00123]. According to an embodiment, at least two electro-actuated brake calipers 10 and 11 of said rear axle 5 and at least two electro-actuated brake calipers 20 and 21 of said front axle 6 are at least also parking brake calipers of the vehicle 2.

[00124]. According to an embodiment, at least one electro-actuated caliper 10, 11, 20, 21 comprises at least two electric motors RI, RE, LE, LI, 12, 13, 14, 15.

[00125]. At least one of said at least two electric motors RI, RE, LE, LI, 12, 13, 14, 15 generates a parking action of the vehicle 2.

[00126]. According to an embodiment, said rear axle 5 comprises two opposite rear wheels 3 and each rear wheel 3 cooperates with

at least one electro-actuated rear axle caliper 10, 11.

[00127]. Each of said electro-actuated calipers 10, 11 comprises at least two electric motors RI, RE, LE, LI.

[00128]. At least one of said at least two electric motors RI, RE, LE, LI of each of said electro-actuated calipers 10, 11 generates a parking action of the vehicle 2.

[00129]. According to an embodiment, said front axle 6 comprises two opposite front wheels 4 and each front wheel 4 cooperates with at least one electro-actuated front axle caliper 20, 21.

[00130]. Each of said electro-actuated calipers 20, 21 comprises at least two electric motors 12, 13, 14, 15.

[00131]. At least one of said at least two electric motors 12, 13, 14, 15 of each of said electro-actuated calipers 20, 21 generates a parking action of the vehicle 2.

[00132]. According to an embodiment, at least one electro-actuated caliper 10, 11, 20, 21 comprises at least two electric motors RI, RE, LE, LI, 12, 13, 14, 15.

[00133]. Both said at least two electric motors RI, RE, LE, LI, 12, 13, 14, 15 generate an at least temporary parking action of the vehicle 2.

[00134]. According to an embodiment, said front axle 6 comprises two opposite front wheels 4 and each front wheel 4 cooperates with at least one electro-actuated front axle caliper 20, 21.

[00135]. Each of said electro-actuated calipers 20, 21 comprises at least two electric motors 12, 13, 14, 15.

[00136]. Both said at least two electric motors 12, 13, 14, 15 of each of said electro-actuated calipers 20, 21 generate an at least temporary parking action of the vehicle 2.

[00137]. According to an embodiment, said rear axle 5 comprises two opposite rear wheels 3 and each rear wheel 3 cooperates with at least one electro-actuated rear axle caliper 10, 11.

[00138]. Each of said electro-actuated calipers 10, 11 comprises at least two electric motors RI, RE, LE, LI.

[00139]. Both said at least two electric motors RI, RE, LE, LI of each of said electro-actuated calipers 10, 11 generates an at least temporary parking action of the vehicle 2.

[00140]. According to an embodiment, said front axle 6 comprises two opposite front wheels 4 and each front wheel 4 cooperates with at least one electro-actuated front axle caliper 20, 21.

[00141]. Said electro-actuated front axle calipers 20, 21 are floating calipers.

[00142]. Said electro-actuated front axle calipers 20, 21 each comprise two electric motors 12, 13, 14, 15.

[00143]. At least one of said at least two electric motors 12, 13, 14, 15 of each of said electro-actuated calipers 20, 21 generates a parking action of the vehicle 2.

[00144]. According to an embodiment, said front axle 6 comprises two opposite front wheels 4 and each front wheel 4 cooperates with at least one electro-actuated front axle caliper 20, 21.

[00145]. Said electro-actuated calipers 20, 21 of the front axle

are one-piece calipers or fixed with respect to a support thereof, such as a vehicle stub axle.

[00146]. Said electro-actuated front axle calipers 20, 21 each comprise two opposed pairs of electric motors 12, 13, 14, 15.

[00147]. At least two of said electric motors 12, 13, 14, 15, arranged opposite to each other, of each of said electro-actuated calipers 20, 21 generates a parking action of the vehicle 2.

[00148]. According to an embodiment, said rear axle 5 comprises two opposite rear wheels 3 and each rear wheel 3 cooperates with at least one electro-actuated rear axle caliper 10, 11.

[00149]. Said electro-actuated rear axle calipers 10, 11 are floating calipers.

[00150]. Said electro-actuated rear axle calipers 10, 11 each comprise a single electric motor RI, RE, LE, LI.

[00151]. Said electric motor RI, RE, LE, LI of each of said electro-actuated calipers 10, 11 generates a parking action of the vehicle 2.

[00152]. A procedure for activating the parking brake assembly will be described below.

[00153]. According to a general embodiment, a parking-braking method of a vehicle 2 comprises the following steps:

[00154]. - providing at least one electro-actuated first brake caliper 10 associated with a wheel 3 of the rear axle 5 of said vehicle 2;

[00155]. - providing at least a further electro-actuated first

brake caliper 11 associated with a wheel 4 of the front axle 6 of said vehicle 2;

[00156]. - avoiding hydraulic braking devices and circuits on the vehicle 2;

[00157]. - applying a parking-braking action with both said brake caliper 10 and said further first brake caliper 11 to generate a parking-braking action to said vehicle 2.

[00158]. According to a further embodiment, the method includes the following steps:

[00159]. - providing two opposite rear wheels 4 in said front axle 6, where each front wheel 4 cooperates with at least one electro-actuated front axle caliper 20, 21;

[00160]. - providing two opposite rear wheels 3 in said rear axle 5, where each rear wheel 3 cooperates with at least one electro-actuated rear axle caliper 10, 11;

[00161]. - applying a parking-braking action with all the electro-actuated calipers 20, 21 of front axle and all the electro-actuated calipers 10, 11 of rear axle.

[00162]. According to a further embodiment, the method includes the following steps:

[00163]. - providing at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 for each electro-actuated caliper 10, 11, 20, 21;

[00164]. - applying a parking-braking action with at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 to generate a parking-braking action to said vehicle 2.

[00165]. According to a further embodiment, the method includes the following steps:

[00166]. - providing at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 for each electro-actuated caliper 10, 11, 20, 21;

[00167]. - applying an at least temporary parking-braking action with said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15;

[00168]. - applying a permanent parking-braking action, i.e. until deactivation by the user, with at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 to generate a parking-braking action to said vehicle 2.

[00169]. According to a further embodiment, the method includes the following steps:

[00170]. - providing at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 for each electro-actuated caliper 10, 11, 20, 21;

[00171]. - applying an at least temporary parking-braking action with said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15;

[00172]. - applying a permanent parking-braking action, i.e. until deactivation by the user, with at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 to generate a parking-braking action on said vehicle 2;

[00173]. - releasing the temporary parking braking action only from electric motors RI, RE, LI, LE, 12, 13, 14, 15 not concerned by said permanent parking braking action.

[00174]. According to a further embodiment, the method includes the following steps:

[00175]. - defining a first amount of a temporary braking F1;

[00176]. - defining a second amount of a permanent braking F2;

[00177]. - providing at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 for at least one electro-actuated caliper 10, 11, 20, 21;

[00178]. - applying said temporary parking-braking action F1 with said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15;

[00179]. - applying said permanent parking-braking action F2, i.e. until deactivation by the user, with at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 to generate a parking-braking action to said vehicle 2;

[00180]. - releasing the temporary parking braking action F1 only from electric motors RI, RE, LI, LE, 12, 13, 14, 15 not concerned by said permanent parking braking action.

[00181]. According to a further embodiment, the method includes the following steps:

[00182]. - defining a first amount of a temporary braking F1;

[00183]. - defining a second amount of a permanent braking F2;

[00184]. - where said first amount of a temporary braking action F1 is defined to be equal to half the second amount of a permanent braking action F2;

[00185]. - providing at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 for at least one electro-actuated caliper 10, 11,

20, 21;

[00186]. - applying said temporary parking-braking action F1 with said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15;

[00187]. - applying said permanent parking-braking action F2, i.e. until deactivation by the user, with at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 to generate a parking-braking action to said vehicle 2;

[00188]. - releasing the temporary parking braking action F1 only from electric motors RI, RE, LI, LE, 12, 13, 14, 15 not concerned by said permanent parking braking action.

[00189]. According to a further embodiment, the method includes the following steps:

[00190]. - defining a first amount of a temporary braking F1;

[00191]. - defining a second amount of a permanent braking F2;

[00192]. - providing at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 for at least one electro-actuated caliper 10, 11, 20, 21;

[00193]. - applying said temporary parking-braking action F1 with said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15;

[00194]. - applying said permanent parking-braking action F2, i.e. until deactivation by the user, with at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 to generate a parking-braking action to said vehicle 2;

[00195]. - releasing the temporary parking braking action F1 only from electric motors RI, RE, LI, LE, 12, 13, 14, 15 not concerned

by said permanent parking braking action;

[00196]. - at the end of the parking, releasing said permanent parking-braking action F2 with said at least one of said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15 until said temporary parking braking action F1 is achieved; and thus

[00197]. - releasing said temporary parking braking action F1 with said at least two electric motors RI, RE, LI, LE, 12, 13, 14, 15.

[00198]. In order to meet contingent, specific needs, those skilled in the art may make many changes and adaptations to the embodiment of the electronic device for selecting and routing electrical signals for actuating electro-actuated calipers of an electric parking brake apparatus described above, or may replace elements with others which are functionally equivalent, without however departing from the scope of the following claims.

REFERENCE SYMBOLS

1 braking system

2 vehicle

3 rear wheel

4 front wheel

5 rear axle

6 front axle

10 first electro-actuated brake caliper of rear axle

11 further first electro-actuated brake caliper of rear axle

12 electric motor of front caliper

13 electric motor of front caliper

14 further electric motor of front caliper

15 further electric motor of front caliper

20 second electro-actuated brake caliper of front axle

21 further second electro-actuated brake caliper of front axle

30 electronic device

50 electronic control unit

60 reducer

61 piston

62 brake pad

63 braking surface

64 brake disc

100 parking brake apparatus

IN1 first input

IN2 second input

S1 first electrical signal

S2 second electrical signal

CP1 first power circuit

CP2 second power circuit

OU1 first output

OU1' further first output

OU2 second output

OU2' further second output

RI first electric motor of first rear caliper

RE further first electric motor of first rear caliper

LE second electric motor of second rear caliper

LI further second electric motor of second rear caliper

SW1 electrical connection means, first switch controlled in switching

SW2 electrical connection means, second switch controlled in switching

SW3 electrical connection means, third switch controlled in switching

SW4 electrical connection means, fourth switch controlled in switching

EN1 first control signal

EN2 second control signal

T1 first time interval

T2 second time interval

100 parking brake apparatus

200 hydraulic and electromechanical service and parking disc brake

101 monobloc brake caliper

102 side wall

103 disc space

104 brake disc

105 pads

106 service braking system

107 hydraulic actuator

108 hydraulic cylinder

109 piston

110 free end

111 hydraulic fluid supply and pressurization system

112 actuating direction

113 parking brake system

114 electro-mechanical actuator

115 translational member of screw-nut screw assembly

116 rotary member of screw-nut screw assembly

117 electric motor

118 power supply

119 transmission mechanism

120 electronic control unit

121 user interface

122 service braking control interface

123 parking braking control interface

CLAIMS

1. An electronic device (30) for selecting and routing electrical signals for the actuation of electro-actuated brake calipers of a parking brake apparatus (100) of a vehicle (2), said device comprising:

- a first (IN1) and a second (IN2) input to receive electrical signals (S1, S2) for actuating electro-actuated brake calipers;
- a first (OU1) and at least a further first (OU1') output connected to a first electro-actuated brake caliper (10) comprising at least two electric motors (RI, RE);
- a second (OU2) and at least a further second (OU2') output connected to a second electro-actuated brake caliper (20) comprising at least two electric motors (LI, LE);
- electronic connection means (SW1, SW2, SW3, SW4) which are controllable to take an open state and a closed state, where:
- when the parking brake apparatus (100) is deactivated, said electronic connection means (SW1, SW2, SW3, SW4) are controlled to take the open state to isolate said first (IN1) and second (IN2) inputs from the aforesaid outputs (OU1, OU1', OU2, OU2');
- when the parking brake apparatus (100) is activated, said electronic connection means (SW1, SW2, SW3, SW4) are selectively controlled to switch from the open state to the closed state to connect said first (IN1) and second (IN2) inputs to any two of said: first output (OU1), second output (OU2), at least a further first output (OU1'), and at least a further second output (OU2'),

the aforesaid electrical actuation signals (S1, S2) being routed towards selected electric motors of the electro-actuated brake calipers.

2. An electronic device (30) for selecting and routing electrical signals according to claim 1, wherein said electronic connection means comprise a first (SW1), a second (SW2), at least a third (SW3), and at least a fourth (SW4) switch controlled in switching.

3. An electronic device (30) for selecting and routing electrical signals according to claim 2, wherein, when the parking brake apparatus (100) is activated:

said first (SW1) and at least a fourth (SW4) switches are controlled to switch from the open state to the closed state to connect, during a first time interval (T1), the first input (IN1) to the first output (OU1) and to connect the second input (IN2) to said at least a further second output (OU2'), respectively;

said second (SW2) and at least a third (SW3) switches are controlled to take the open state.

4. An electronic device (30) for selecting and routing electrical signals according to claim 3, wherein, at the end of said first time interval (T1):

said first (SW1) and at least a fourth (SW4) switches are controlled to switch from the closed state to the open state,

said second (SW2) and at least a third (SW3) switches are controlled to switch from the open state to the closed state to connect, during a second time interval (T2) following the first

time interval (T1), the first input (IN1) to the second output (OU2) and to connect the second input (IN2) to said at least a further first output (OU1'), respectively.

5. An electronic device (30) for selecting and routing electrical signals according to claim 2, wherein, when the parking brake apparatus (100) is activated:

said first (SW1) and at least a third (SW3) switches are controlled to switch from the open state to the closed state to connect, during a first time interval (T1), the first input (IN1) to the first output (OU1) and to connect the second input (IN2) to said at least a further first output (OU1'), respectively;

said second (SW2) and at least a fourth (SW4) switches are controlled to take the open state.

6. An electronic device (30) for selecting and routing electrical signals according to claim 5, wherein, at the end of said first time interval (T1):

said first (SW1) and at least a third (SW3) switches are controlled to switch from the closed state to the open state,

said second (SW2) and at least a fourth (SW4) switches are controlled to switch from the open state to the closed state to connect, during a second time interval (T2) following the first time interval (T1), the first input (IN1) to the second output (OU2) and to connect the second input (IN2) to said at least a further second output (OU2'), respectively.

7. An electronic device (30) for selecting and routing electrical

signals according to claim 2, wherein, when the parking brake apparatus (100) is activated, during a third time interval (T3), said first (SW1), second (SW2), at least a third (SW3), and at least a fourth (SW4) switches are controlled to switch from the open state to the closed state to connect simultaneously the first input (IN1) to the first (OU1) and second (OU2) outputs and to connect simultaneously the second input (IN2) to at least a further first output (OU1') and at least a further second output (OU2').

8. A parking brake apparatus (100) of a motor vehicle, comprising:

- a first (10) and a second (20) electro-actuated brake caliper, wherein:

said first electro-actuated brake caliper (10) comprises a first (RI) and at least a further first (RE) electric motor,

said second electro-actuated brake caliper (20) comprises a second (LE) and at least a further second (LI) electric motor;

- an electronic control unit (50) configured to generate a first (S1) and a second (S2) electrical signal to actuate said electro-actuated brake calipers (10, 20);

- an electronic device (30) for selecting and routing electrical signals according to any one of the claims 1-7, said device comprising:

- a first (IN1) and a second (IN2) input to receive said first (S1) and second (S2) electrical actuation signals;

- a first (OU1) and at least a further first (OU1') output connected to the first (RI) and the at least a further first (RE) electric motors, respectively, of the first electro-actuated brake caliper (10);
- a second (OU2) and at least a further second (OU2') output connected to the second (LE) and the at least a further second (LI) electric motors, respectively, of the second electro-actuated brake caliper (20).

9. A parking brake apparatus (100) of a motor vehicle according to claim 8, wherein said motor vehicle is a motorcar and said first (10) and second (20) electro-actuated brake calipers are associated with the wheels of the rear axle of said motorcar.

10. A parking brake apparatus (100) of a motor vehicle according to claim 8, wherein said motor vehicle is a motorcar and said first (10) and second (20) electro-actuated brake calipers are associated with the wheels of the front axle of said motorcar.

11. A parking brake apparatus (100) of a motor vehicle according to claim 8, wherein said motor vehicle is a motorcar and said first electro-actuated brake caliper (10) is associated with a wheel of the rear axle of the motorcar and the second electro-actuated brake caliper (20) is associated with a wheel of the front axle of the motorcar.

12. A parking brake apparatus (100) of a motor vehicle according to claim 8, wherein said electronic control unit (50) comprises a first (CP1) and a second (CP2) electronic power circuit in a full-

bridge transistor configuration, configured to generate said first (S1) and second (S2) electrical actuation signals.

13. A parking brake apparatus (100) of a motor vehicle according to claim 8, wherein:

- said first electro-actuated brake caliper comprises a first (10) and a further first (11) electro-actuated brake caliper, each associated with a wheel (3) of the rear axle (5) of the vehicle (2),
- said second electro-actuated brake caliper comprises a second (20) and a further second (21) electro-actuated brake caliper, each associated with a wheel (4) of the front axle (6) of the vehicle (2);

the first (RI) and the further first (RE) electric motors are associated with the first (10) and the further first (11) electro-actuated brake calipers, respectively,

the second (LE) and the further second (LI) electric motors are associated with the second (20) and the further second (21) electro-actuated brake calipers, respectively.

14. A motor vehicle comprising a parking brake apparatus (100) according to claim 8.

15. A parking braking method for a vehicle (2) comprising the steps of:

- providing at least a first electro-actuated brake caliper (10) associated with a first wheel (3) of said vehicle (2);
- providing at least a second electro-actuated brake caliper (20) associated with a second wheel (4) of said vehicle (2);

- providing an electronic device (30) for selecting and routing electrical signals, said device comprising:

- a first (IN1) and a second (IN2) input to receive electrical signals (S1, S2) for actuating said electro-actuated brake calipers;

- a first (OU1) and at least a further first (OU1') output connected to a first (RI) and at least a further first (RE) electric motor, respectively, of said at least a first electro-actuated brake caliper (10);

- a second (OU2) and at least a further second (OU2') output connected to a second (LE) and at least a further second (LI) electric motor, respectively, of said at least a second electro-actuated brake caliper (20);

characterized in that it comprises the further step of selectively routing, by the electronic device (30), the aforesaid electrical actuation signals (S1, S2) towards any two of said: first output (OU1), second output (OU2), at least a further first output (OU1'), and at least a further second output (OU2') to activate the electric motors of both said at least a first brake caliper (10) and said at least a second brake caliper (20) to generate a parking braking action to the vehicle (2).

16. A method according to claim 15, further comprising the steps of:

- applying an at least temporary parking braking action with said: first (RI) and at least further first (RE) electric motors of said at least a first electro-actuated brake caliper (10), second (LE)

and at least further second (LI) electric motors of said at least a second electro-actuated brake caliper (20);

- applying a permanent parking braking action, i.e., until deactivation by the user, with at least one of said first (RI), at least a further first (RE), second (LE), and at least a further second (LI) electric motors to generate a parking braking action to the vehicle (2).

17. A method according to claim 16, further comprising the steps of:

- defining a first amount of a temporary braking action (F1);
- defining a second amount of a permanent braking action (F2);
- wherein said first amount of a temporary braking action (F1) is less than the second amount of a permanent braking action (F2).

18. A method according to claim 17, wherein said step of applying an at least temporary parking braking action comprises the further steps of:

- activating, during a first time interval (T1), said first (RI) and said at least further second (LI) electric motors to apply said first amount of temporary braking action (F1) to the first (10) and second (20) electro-actuated brake calipers;
- keeping deactivated, during the first time interval (T1), said at least further first (RE) and said second (LE) electric motors;
- activating, during a second time interval (T2) following and equal to the first time interval (T1), said at least a first (RE) and said second (LE) electric motors to apply said first amount of temporary braking action (F1) to the first (10) and second (20)

electro-actuated brake calipers;

- keeping deactivated, during the second time interval (T2), said first (RI) and said at least further second (LI) electric motors.

19. A method according to claim 17, wherein said step of applying a permanent parking braking action comprises the further step of activating, until deactivation by the user, at least one of said first (RI), at least a further first (RE), second (LE), and at least a further second (LI) electric motors to apply said second amount of permanent braking action (F2) to the first (10) or second (20) electro-actuated brake caliper or both to generate a parking braking action to the vehicle (2);

- releasing the temporary parking braking action only from the electric motors not concerned by said permanent parking braking action.

20. A parking braking method for a vehicle (2) according to claim 15, wherein said at least a first electro-actuated brake caliper (10) or at least a second electro-actuated brake caliper (20) is a caliper (101) of a hydraulic and electromechanical service and parking disc brake (200);

the method comprising the steps of:

- providing a step of defining a pressure target value in the hydraulic circuit of the caliper (101);

in response to a user parking braking command,

- actuating a service braking system (106) of the disc brake (200) to move a piston (109) associated with the caliper (101) in an actuating direction (112) towards a brake disc (104) in a parking

position in which it tightens a pad (105) against the brake disc (104), and

- actuating a parking braking system (113) for locking the piston (109) in the parking position and preventing a return movement of the piston (109).

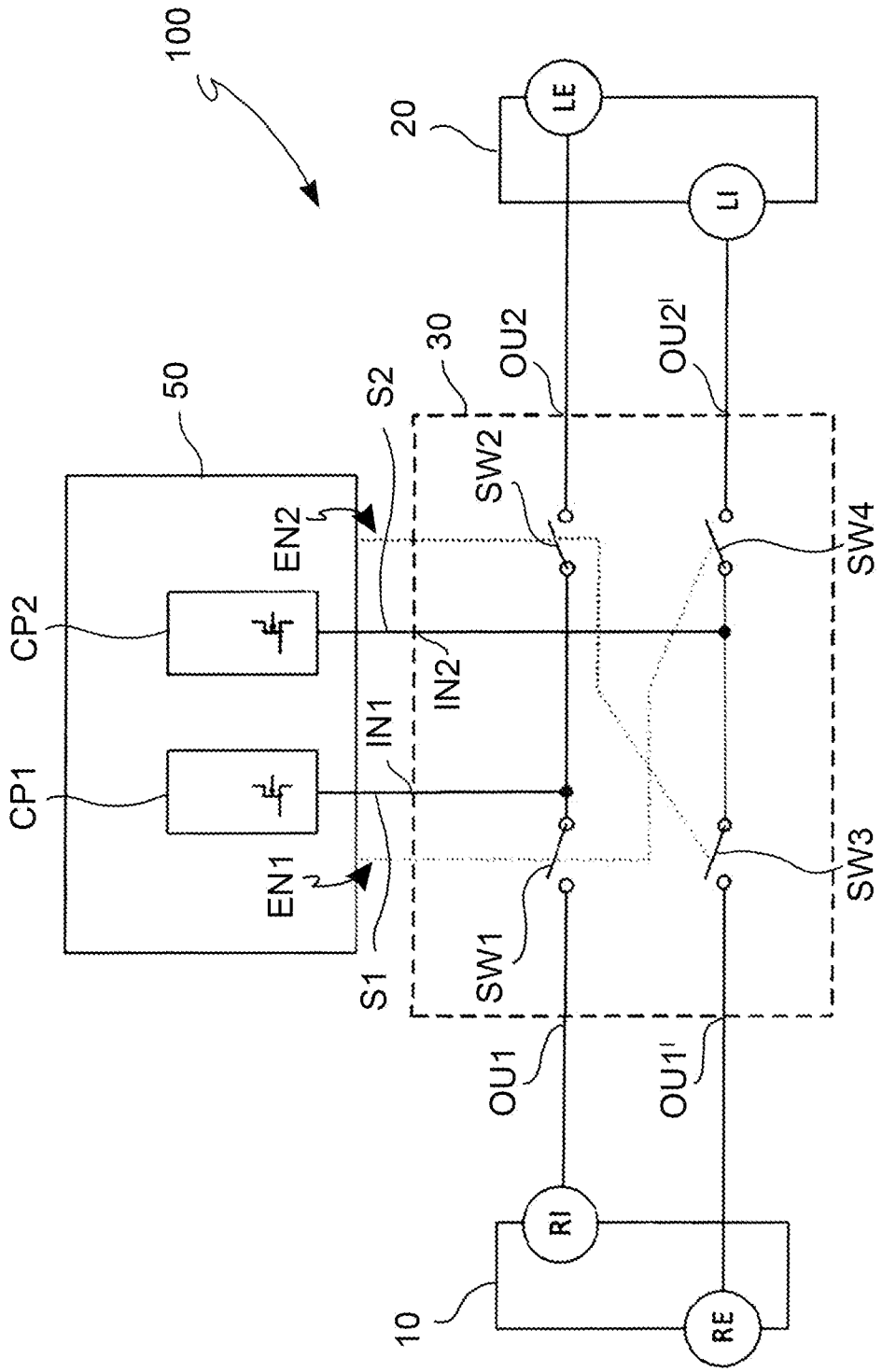
21. A parking braking method for a vehicle (2) according to claim 20, wherein, in response to the user parking braking command, the method comprises the steps of:

- actuating the service braking system (106) by moving the piston (109) to the parking position in which it pushes the pad (105) against the brake disc (104);

- when the target pressure is reached in the hydraulic circuit of the caliper (101), actuating an electric motor (117) in a forward direction upon the actuation of the service braking system (106) and with the piston (109) already in the parking position, by translating a translational member (115) in the actuating direction (112) against the piston (109) to lock it in the parking position and prevent a return movement thereof;

- once the piston (109) has been locked in the parking position, deactivating the service braking system (106) by reducing the pressure of the hydraulic fluid, and turning the electric motor (117) off,

said piston (109) remaining locked due to the transmission irreversibility of the electromechanical actuator (114).


100
20
LE
LI
30
OU2
OU2'
50
S2
SW2
SW4
EN2
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IN2
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CP1
EN1
SW1
SW3
S1
OU1
OU1'
RI
RE
10

FIG. 1

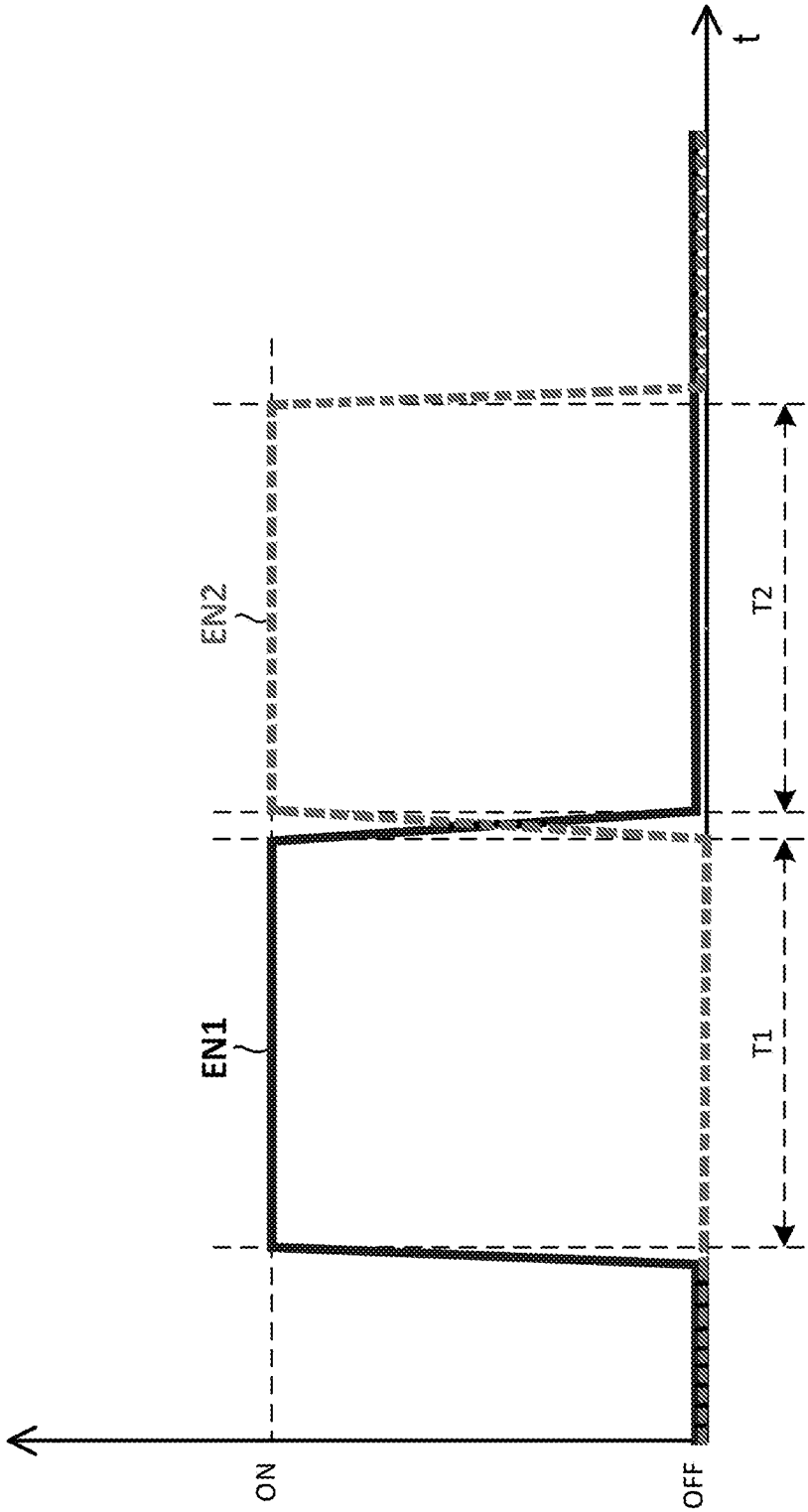


FIG. 2

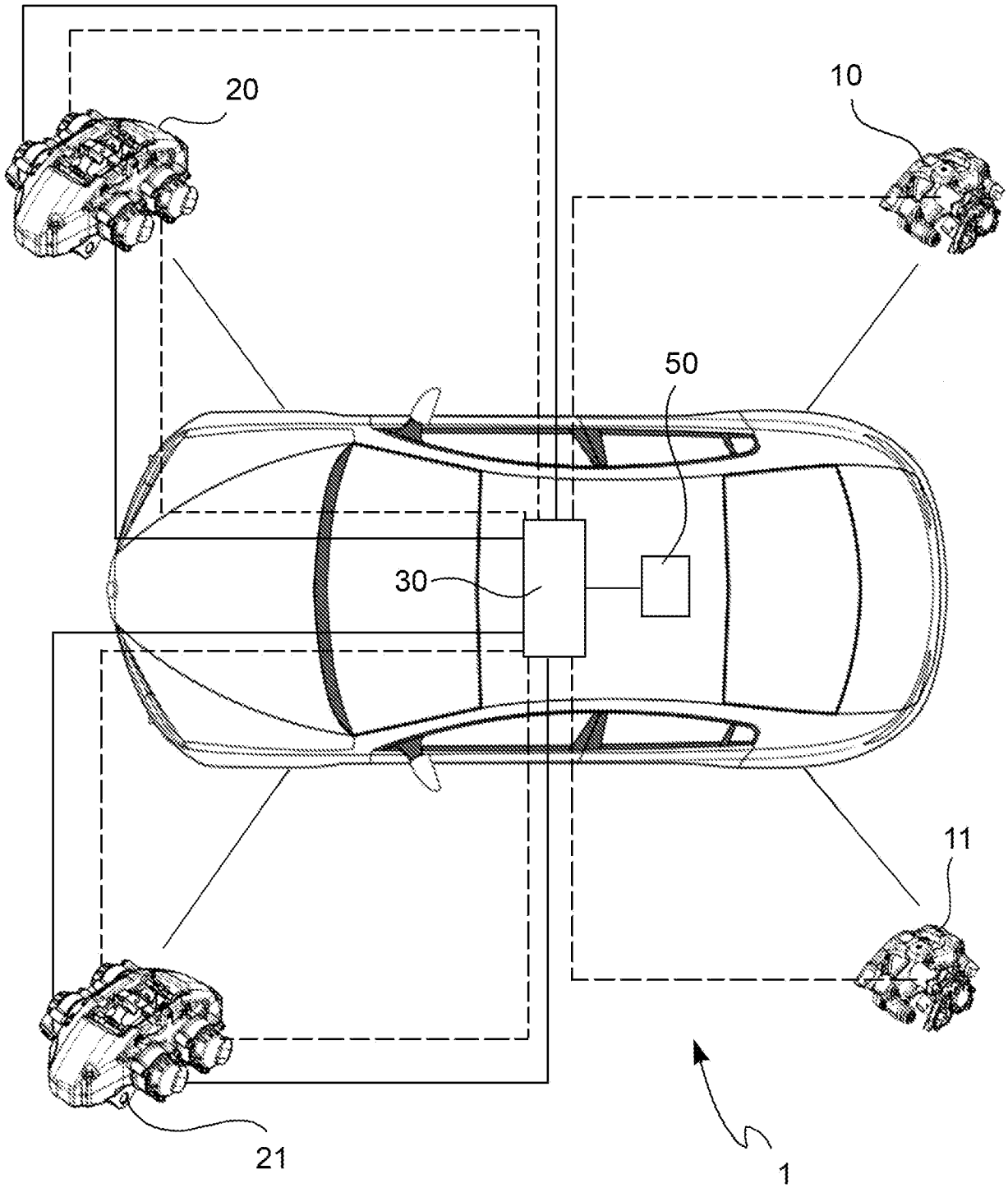


FIG. 3

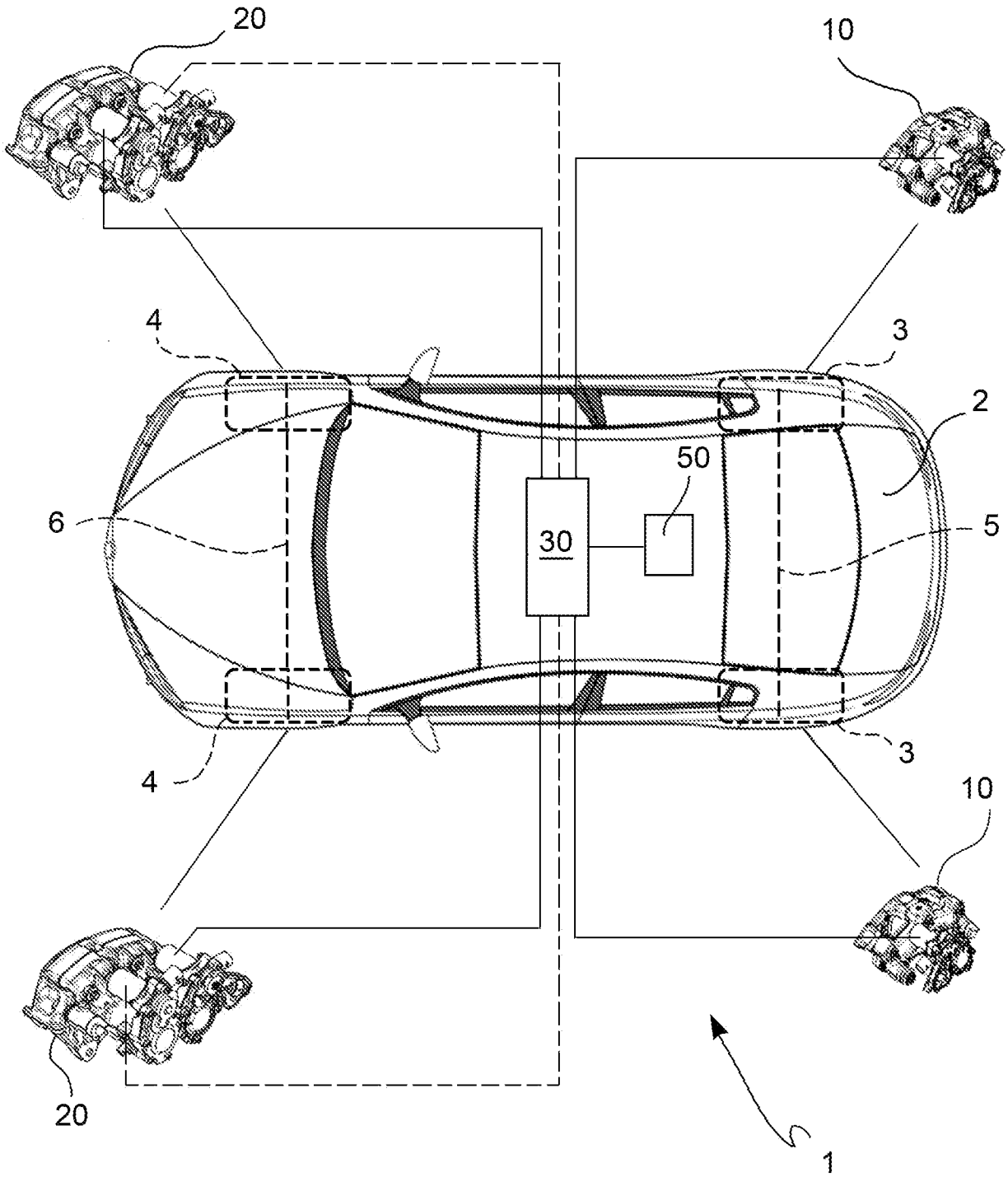


FIG. 4

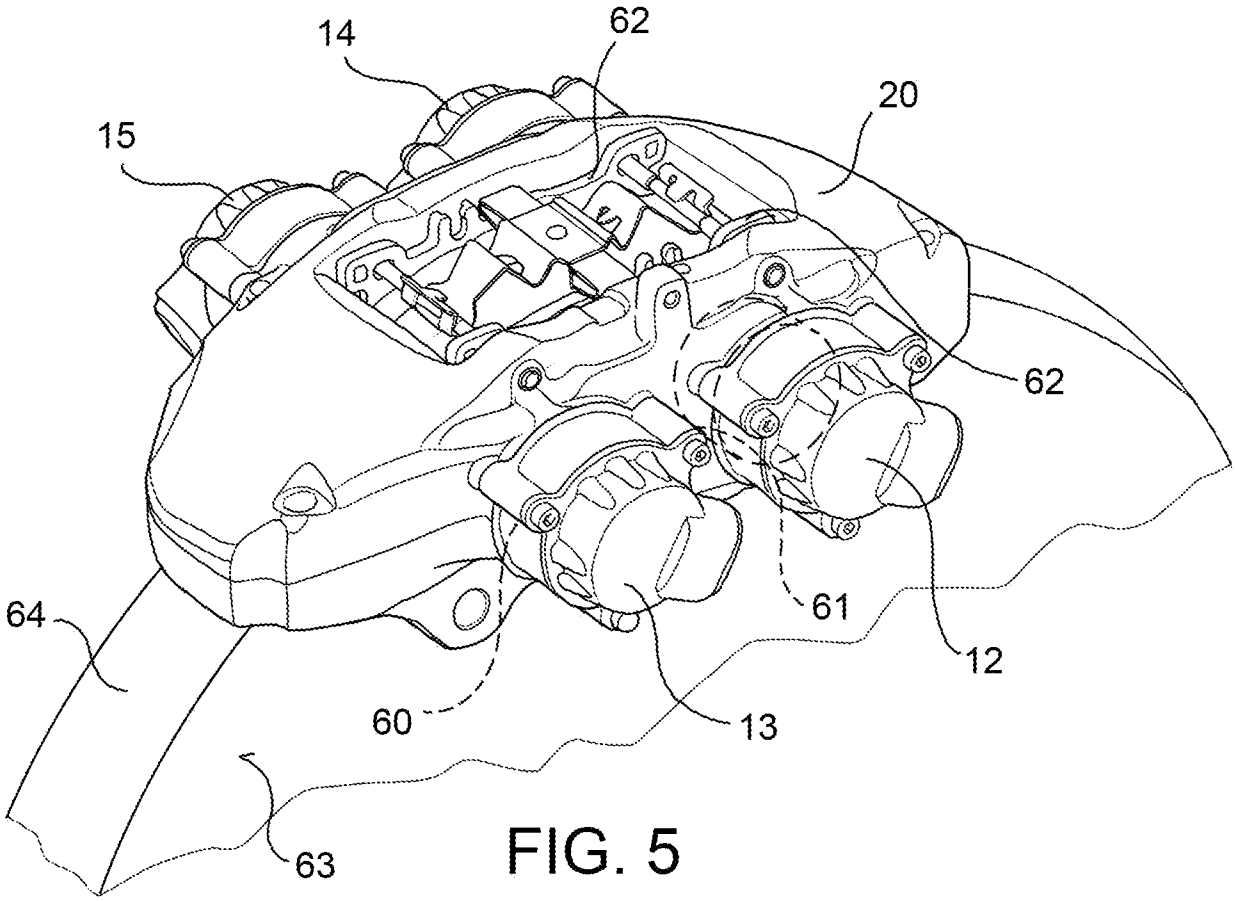


FIG. 5

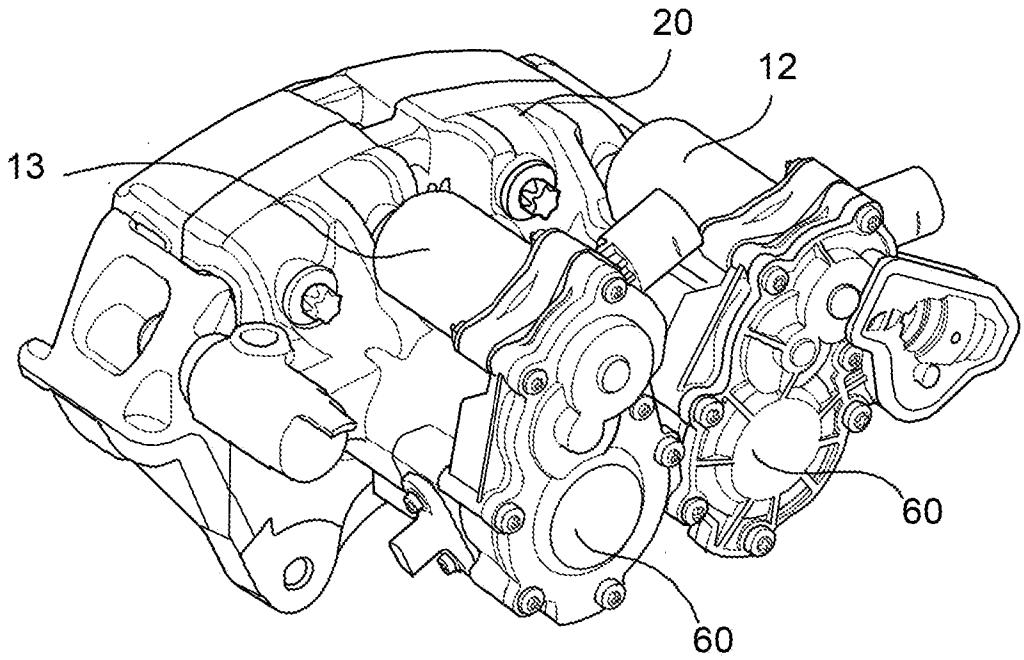


FIG. 6

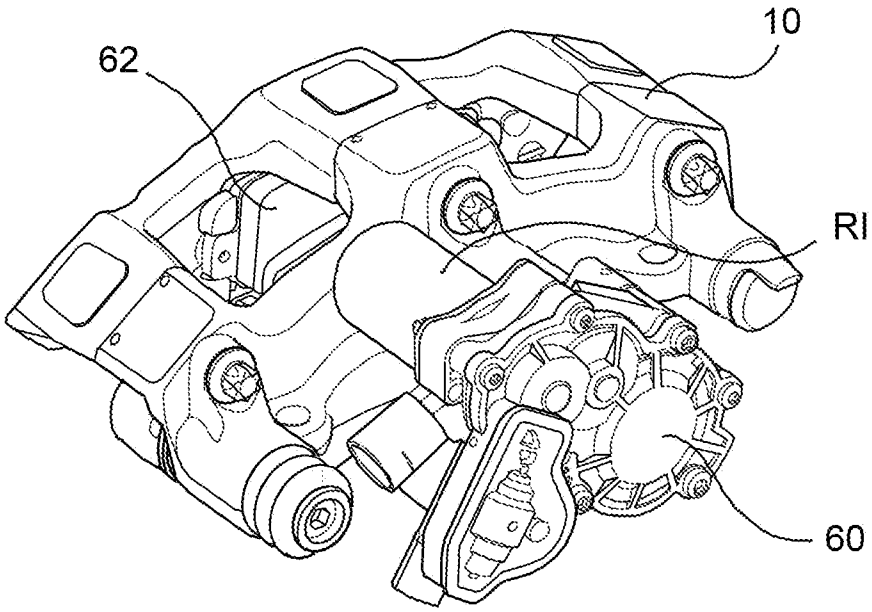


FIG. 7

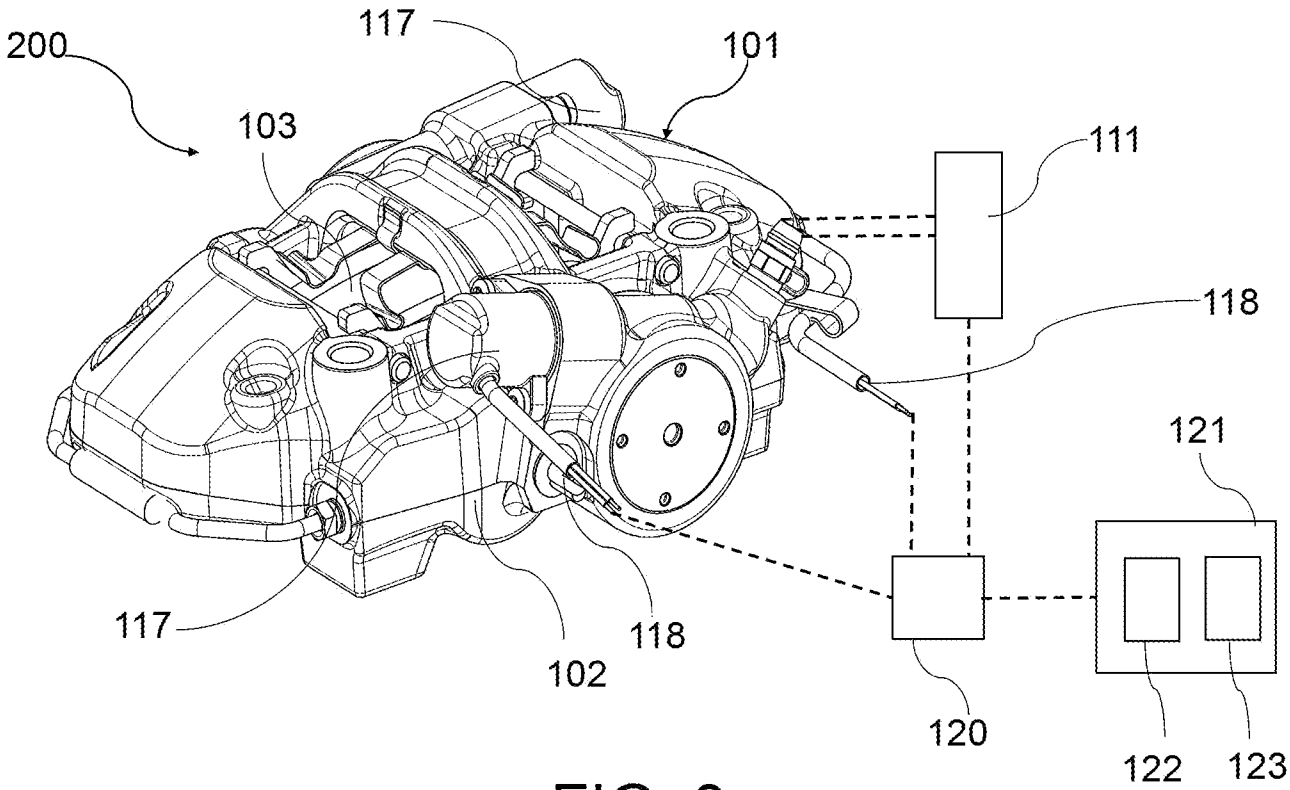
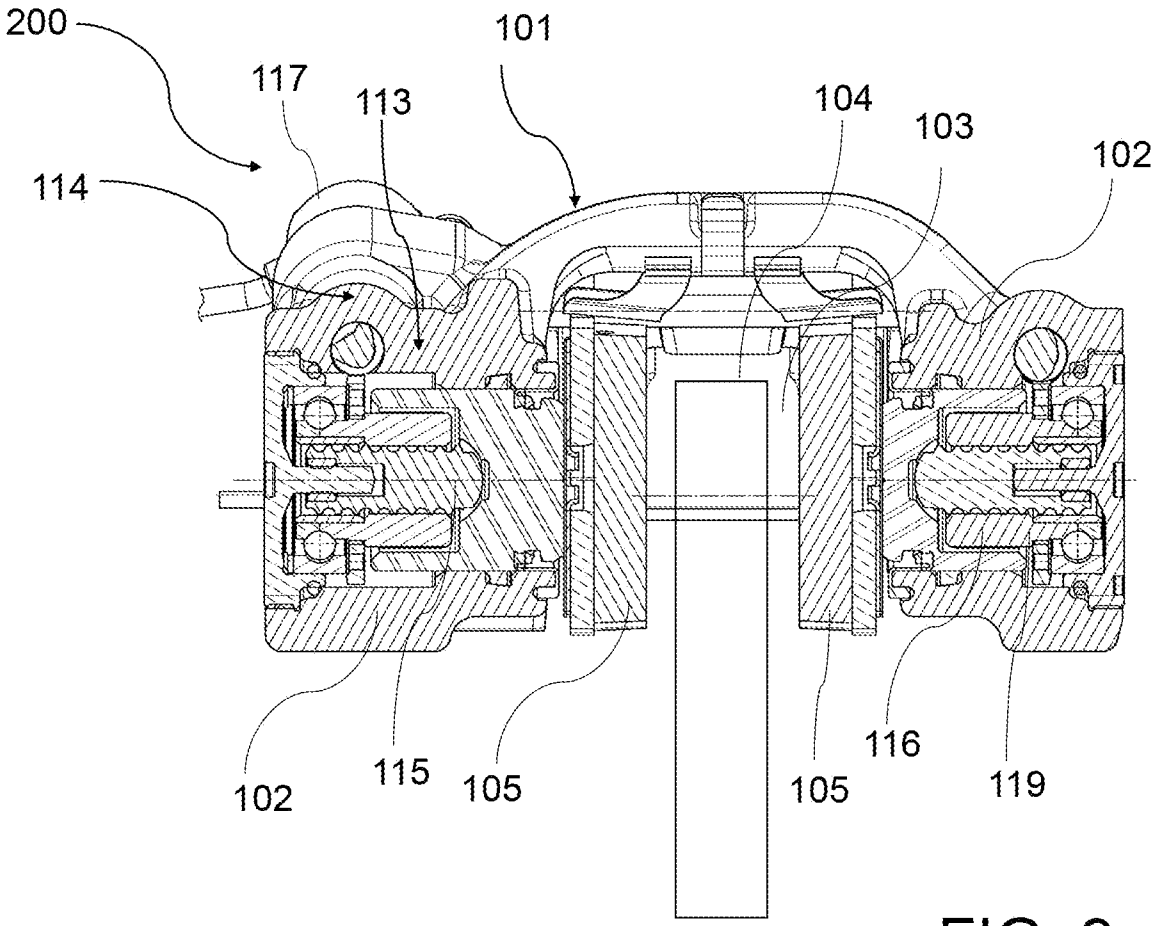


FIG. 8


200
117
113
101
104
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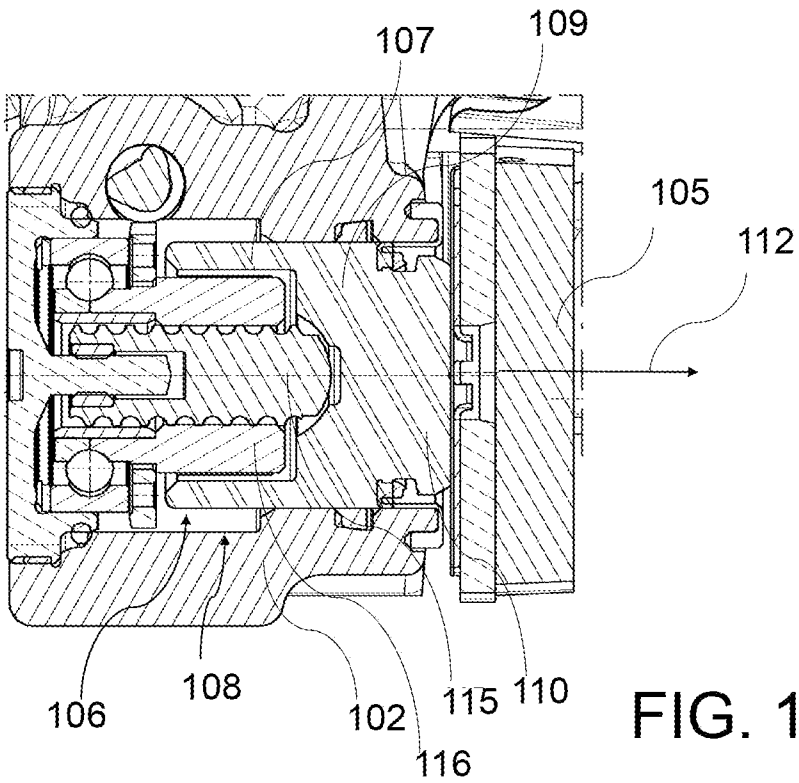
116
119

FIG. 9


107
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105
112
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115
110
116

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/060394

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60T7/10 B60T13/74 F16D65/14 B60T8/32
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)
B60T F16D

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 Y	US 2016/032995 A1 (NISHINO KIMIO [JP] ET AL) 4 February 2016 (2016-02-04) abstract; figures 1-4 paragraphs [0074], [0071]	1-7 8-21
Y A	DE 196 11 911 A1 (BOSCH GMBH ROBERT [DE]) 2 October 1997 (1997-10-02) abstract; claim 1; figure 1	8-21 1-7
A	US 2016/036357 A1 (JEONG HYEON SEOK [KR]) 4 February 2016 (2016-02-04) abstract; figure 1	1-21

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

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2022	11/02/2022

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	Gaillard, Alain

INTERNATIONAL SEARCH REPORT

Information on patent family members

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