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(54) **METHOD AND CONTROL SYSTEM OF AN ARM OF A WORK VEHICLE**

(57) Control method of an articulated user (B, BK) of a work vehicle (WL) comprising a step (reduction) of reduction of a response dynamics of the movement of the user, when a front axle of the vehicle (AX1) is raised above the ground (SO).

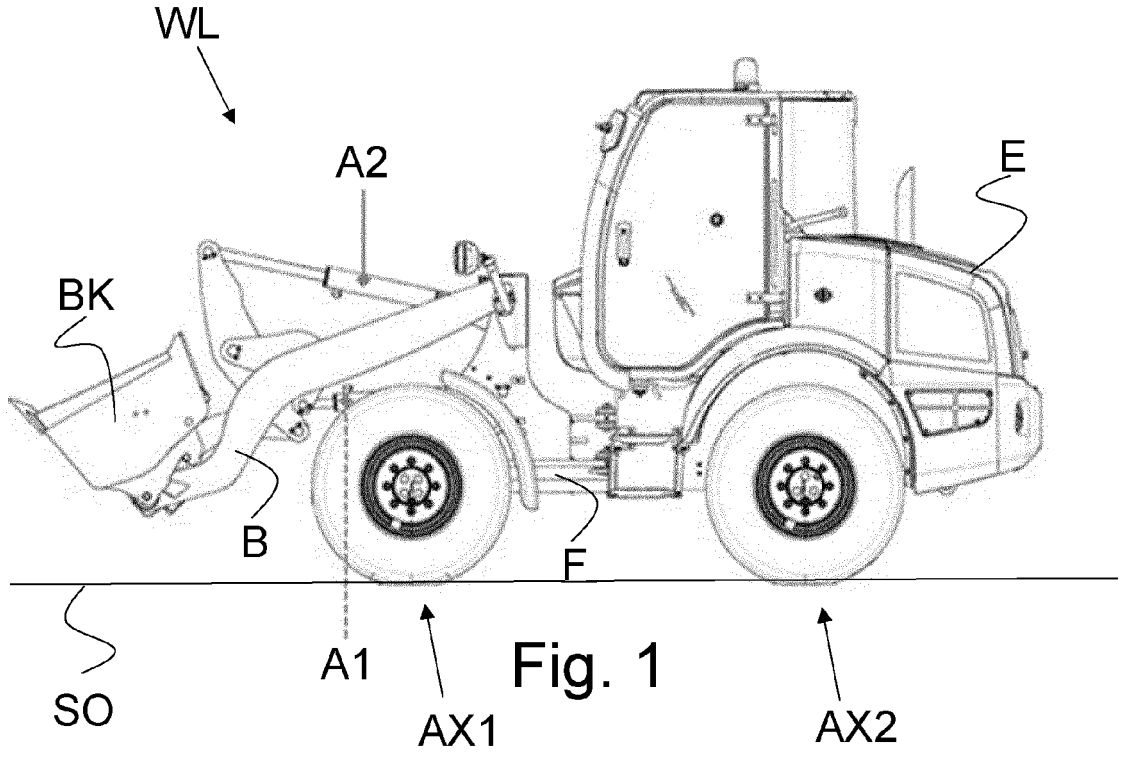

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to the field of methods and systems for controlling the arms of work vehicles.

State of the art

[0002] In the field of work and agricultural vehicles, the operation of users, such as arms and related tools, is carried out by means of a hydraulic circuit.

[0003] The hydraulic circuit is powered by a hydraulic pump driven in rotation by a prime mover, very often an internal combustion engine.

[0004] The hydraulic actuators implemented for moving the users are of the double chamber type, namely a movable piston divides two closed chambers that can be fed alternately by the hydraulic pump.

[0005] When a first chamber is operatively connected to the pump, the second chamber, opposite the first, is connected to a collection tank, where the excess hydraulic liquid is collected.

[0006] A control valve controls the selective filling of one of the two chambers of an actuator. The valve is proportional, in the sense that there is a first factor of proportionality with the position of a control lever, typically a joystick, arranged in the vehicle cabin.

[0007] Therefore, there is a first factor of proportionality between the opening of the valve and the deviation of the control lever with respect to a rest position thereof.

[0008] There is also a second factor of proportionality between the speed of actuation of the control lever and the speed of actuation of the control valve.

[0009] All these factors of proportionality make the actuator's behavior more or less aggressive.

[0010] In some cases, the vehicle gives the operator the opportunity to set the so-called response aggressiveness of the actuators, that is, the response speed.

[0011] The variation in aggressiveness obviously concerns one or both of the above-mentioned factors of proportionality.

[0012] Work machines such as mechanical shovels, generally referred to as "wheel loaders" are equipped with an arm and a bucket hinged to the arm.

[0013] During ground flattening operations, generally referred to as "grading", the boom is pushed down and the bucket is rotated forward to the dump position as the vehicle rolls back.

[0014] In these conditions, the front axle of the vehicle is raised from the ground, i.e. spaced apart from the ground, and the front of the vehicle rests on the bucket, which exerts a corresponding force on the ground to be flattened.

[0015] However, when the operator commands the bucket actuator to rotate backwards the bucket, the actuation force is added to the weight of the vehicle with the result that the front axle of the vehicle hits the ground violently. Even if the operator tries to gently control the lowering of the vehicle, the result is unsatisfactory.

[0016] During a processing cycle, the operator must perform this lifting and lowering operation of the front axle of the vehicle several times, with significant stress on the musculoskeletal system.

[0017] Even when it is possible to vary the aggressiveness of the response of the actuators, the operator finds it annoying to have to act on the aggressiveness selector every time he has to finish the grading operation by bringing the front axle of the vehicle back into contact with the ground.

[0018] Providing the vehicle with a seat connected to the vehicle chassis by means of a shock absorber proves to be an insufficient solution.

[0019] Therefore, in the long run, the operator can suffer damage to the backbone.

[0020] If not specifically excluded in the detailed description that follows, what is described in this chapter is to be considered as an integral part of the detailed description.

Summary of the invention

[0021] The purpose of the present invention is to make the lowering of the vehicle more delicate, avoiding possible consequences for the operator's health.

[0022] The basic idea of the present invention is to automatically attenuate the response dynamics of the articulated organ, i.e. the aggressiveness of the actuation, in the movement of the articulated organ aimed at bringing the front axle of the vehicle to contact the ground, when it is detected that the front axle is raised from the ground. In this way, the front axle gradually comes into contact with the ground, significantly reducing the strain on the operator's musculoskeletal system. The term "when" means that the reduction of aggressiveness occurs when, that is, "in response" or to the detection of the lifting of the front axle from the ground, clearly indicating a causal relationship.

[0023] Preferably, if the lifting of the front axle is due to the over-travel of the arm, then only the aggressiveness of the arm actuator is attenuated.

[0024] Preferably, if the lifting of the front axle is due only to the forward rotation of the bucket, then only the aggressiveness of the bucket actuator is attenuated. Alternatively, when the front axle is raised, then the aggressiveness of both the arm and bucket actuators is attenuated at the same time.

[0025] The detection of the lifting of the front axle of the vehicle can be achieved in different ways. It is preferred to detect the lifting of the front axle taking into account the composition of the mutual position between the arm and the vehicle frame and of the bucket with respect to the arm. The dependent claims describe preferred variants of the invention, forming an integral part of this description.

Brief description of the figures

[0026] Further objects and advantages of the present invention will become clear from the following detailed description of an example of its embodiment (and its variants) and from the annexed drawings given purely for explanatory and non-limiting purposes, in which:

Figure 1 shows an example of a work vehicle in a situation where the front axle is raised off the ground;
Figure 2 shows an example of an electro-hydraulic actuation circuit;
Figure 3 shows an example of a flow chart representative of the method object of the present invention.

[0027] The same reference numbers and letters in the figures identify the same elements or components or functions.

[0028] It should also be noted that the terms "first", "second", "third", "upper", "lower" and the like can be used here to distinguish various elements. These terms do not imply a spatial, sequential or hierarchical order for the modified elements unless specifically indicated or inferred from the text.

[0029] The elements and features illustrated in the various preferred embodiments, including the drawings, can be combined with each other without however departing from the scope of this application as described below.

Detailed description of examples of realization

[0030] According to the present invention, a work vehicle WL such as a mechanical shovel or an agricultural vehicle provided of arm and bucket, see figure 1, preferably a wheel loader, comprises a frame F, a front axle AX1, a rear axle AX2, a prime mover E which drives in rotation a hydraulic pump P which allows to pressurize a hydraulic circuit which powers the hydraulic actuators A1, A2 for the movement of an organ B, BK comprising an arm B, having a first end hinged to the frame and a shovel or bucket BK hinged to a second end of the arm, opposite the first end of the arm.

[0031] Figure 2 shows an example of a simplified electro-hydraulic diagram for controlling the organ B, BK.

[0032] The hydraulic actuator A1, also called double action hydraulic cylinder, includes two opposing chambers: one arranged to obtain the lifting of the arm and the other to obtain the lowering of the arm.

[0033] While one chamber is operational thanks to the oil pumped by the hydraulic pump P, the other chamber, by shrinking, releases the oil into the collection tank.

[0034] The actuator A1 is controlled by a proportional control valve V1, while the actuator A2 is controlled by a proportional control valve V2. These are preferably of the three-position type with a rest position which puts in direct connection the supply pipe connected with the hydraulic pump P to the collection tank T. Therefore, the pumped liquid is sent directly to the collection tank.

[0035] In a first lateral position of the valve V1, for example on the left, the hydraulic pump feeds a first chamber which brings the arm B to rise, while the second chamber, opposite to the first, is connected to the collection tank T. In the second lateral position, for example right, the hydraulic pump feeds the second chamber which brings the arm to lower, while the first chamber is connected with the collection tank T.

[0036] When the control valve V1 is in the central or rest position, the first and second chambers are closed, opposing any further movement of the arm.

[0037] The same concepts can be applied to the actuator A2 and the relative valve V2 of the bucket BK.

[0038] With reference to Figure 2, each actuator is connected to a position sensor S1 and S2 respectively for the actuators A1 and A2.

[0039] By knowing the position of the actuators A1 and A2 it is possible to know if the arm presses against the ground SO bringing the front axle AX1 of the vehicle to detach itself from the ground SO, rising.

[0040] The valves V1 and V2 are proportional to a deflection of a relative JOYSTICK control lever, for example in the form of a joystick.

[0041] More specifically, the control lever is operationally connected with the processing unit CONTROL UNIT and generates an electrical signal that the processing unit processes to control the operation of the control valves V1 and V2. The diagram shown in figure 2 provides for the use of open center directional valves V1 and V2, however other hydraulic diagrams can be implemented while maintaining the setting object of the present invention.

[0042] The processing unit is configured to control the control valves V1 and V2 according to a first factor of proportionality with the signal generated by the control lever and therefore with a deflection angle of the control lever with respect to a respective rest position.

[0043] According to the present invention, the processing unit is configured to recognize a condition of detachment of the front axle AX1 from the ground SO as a function of a plurality of combinations of the positions of the actuators A1 and A2.

[0044] Furthermore, the processing unit is configured to apply a second proportionality factor lower than the first proportionality factor when it detects that the front axle is detached from the ground.

[0045] Preferably, the second proportionality factor is applied only to the movements of the actuator (s) that causes the front axle of the vehicle to impact with the ground. Thus, if the operator commands the actuators A1 and A2 to further move the front axle away from the ground, there is no change in the response aggressiveness of the arm and bucket. Conversely, if the operator commands the lowering of the vehicle's front axle to bring it into contact with the ground, the control valves V1 and V2 operate more slowly, obtaining a smoother and more gradual axle lowering.

[0046] In other words, according to this preferred variant of the invention, the behaviour of the valves is asymmetrical. Evidently, when the front axle of the vehicle returns to contact with the ground, the processing unit is configured to restore the behaviour of valves V1 and V2, to the conditions prior to the detection of the detachment of the front axle from the ground.

[0047] Preferably, the reset provides that the behaviour of the valves is symmetrical according to the first proportionality factor.

[0048] According to a preferred variant of the invention, the detachment of the front axle of the vehicle can be caused only by one between the arm and the bucket. In this case, a change in the behaviour of the control valves may be expected, only of the valve relating to the component, arm or bucket, causing the detachment of the vehicle's front axle from the ground.

[0049] According to another preferred variant of the invention, however, the change in the behaviour of the control valves is applied to both control valves, regardless of the component causing the detachment of the front axle AX1 of the vehicle from the ground.

[0050] Figure 3 shows an example of a flow chart of an example of a control method object of the present invention.

[0051] The method is cyclical and includes:

- first step START: acquiring the signals generated by sensors S1 and S2 relating to actuators A1 and A2 and calculating the position of the bucket with respect to the vehicle chassis,
- second step CK; checking if the front axle is raised off the ground in relation to the calculation of the position of the bucket BK with respect to the chassis F of the vehicle, if so (Ck == yes), then
- reduction of the aggressiveness of the responsiveness of the valves V1 and V2 of the actuators A1 and A2, otherwise, in the negative case (Ck == no)
- restoration of aggressiveness.

[0052] The present invention can be advantageously carried out by means of a computer program which comprises coding means for carrying out one or more steps of the method, when this program is executed on a computer. Therefore, it is intended that the scope of protection extends to said computer program and further to computer readable means comprising a recorded message, said computer readable means comprising program coding means for carrying out one or more steps of the method, when said program is run on a computer. Implementation variants of the described non-limiting example are possible, without however departing from the scope of protection of the present invention, including all the equivalent embodiments for a person skilled in the art, to the content of the claims.

[0053] From the above description, the person skilled in the art is able to realize the object of the invention without introducing further construction details.

Claims

1. Method for controlling an articulated organ (B, BK) of a work vehicle (WL) comprising a reduction step (reduction) of an actuation dynamic of the organ movement, when a front axle of the vehicle (AX1) is in raised condition from the ground (SO).

2. Method according to claim 1, wherein said reduction step is operated only for a movement of the user aimed at bringing the front axle back to contact the ground (SO).

3. Method according to any one of the preceding claims, wherein said articulated user comprises an arm (B) having a first end hinged to a frame (F) of the vehicle and a shovel or bucket (BK) hinged to a second end of the arm, opposite the first end of the arm and wherein said attenuation step is applied only to a movement of said arm or bucket.

4. Method according to any one of the preceding claims, further comprising a restoration step (restoration) of the actuation dynamic of the articulated organ preceding said reduction step of the actuation dynamic, when said front axle returns in contact with the ground.

5. Control system of an articulated part (B, BK) of a work vehicle (WL) comprising means (Control Unit) configured to detect the lifting of a front axle (AX1) from the ground and configured to reduce an actuation dynamic of the movement of the organ, when the front axle of the vehicle (AX1) is raised from the ground (SO).

6. System according to claim 5, wherein said reduction is operated only for a movement of the organ aimed at bringing the front axle back to contact the ground (SO).

7. System according to any one of claims 5 or 6, wherein said means are further configured to restore an actuation dynamic of the articulated organ prior to said reduction, when said front axle returns in contact with the ground.

8. Work vehicle (WL) comprising a front axle (AX1) and an articulated organ (B, BK), wherein the vehicle is configured to reduce an actuation dynamic of the movement of the articulated user, when the front axle of the vehicle (AX1) is raised from the ground (SO).

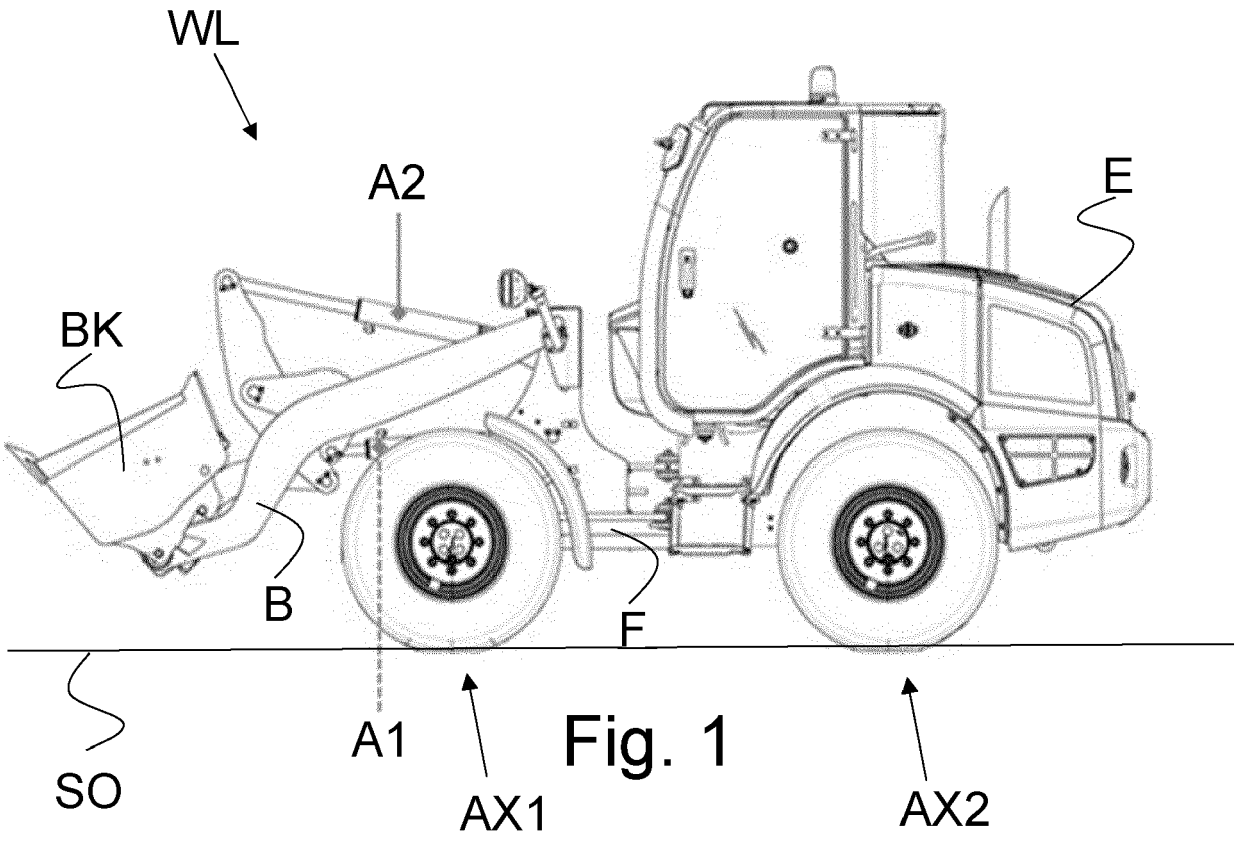

Fig. 1

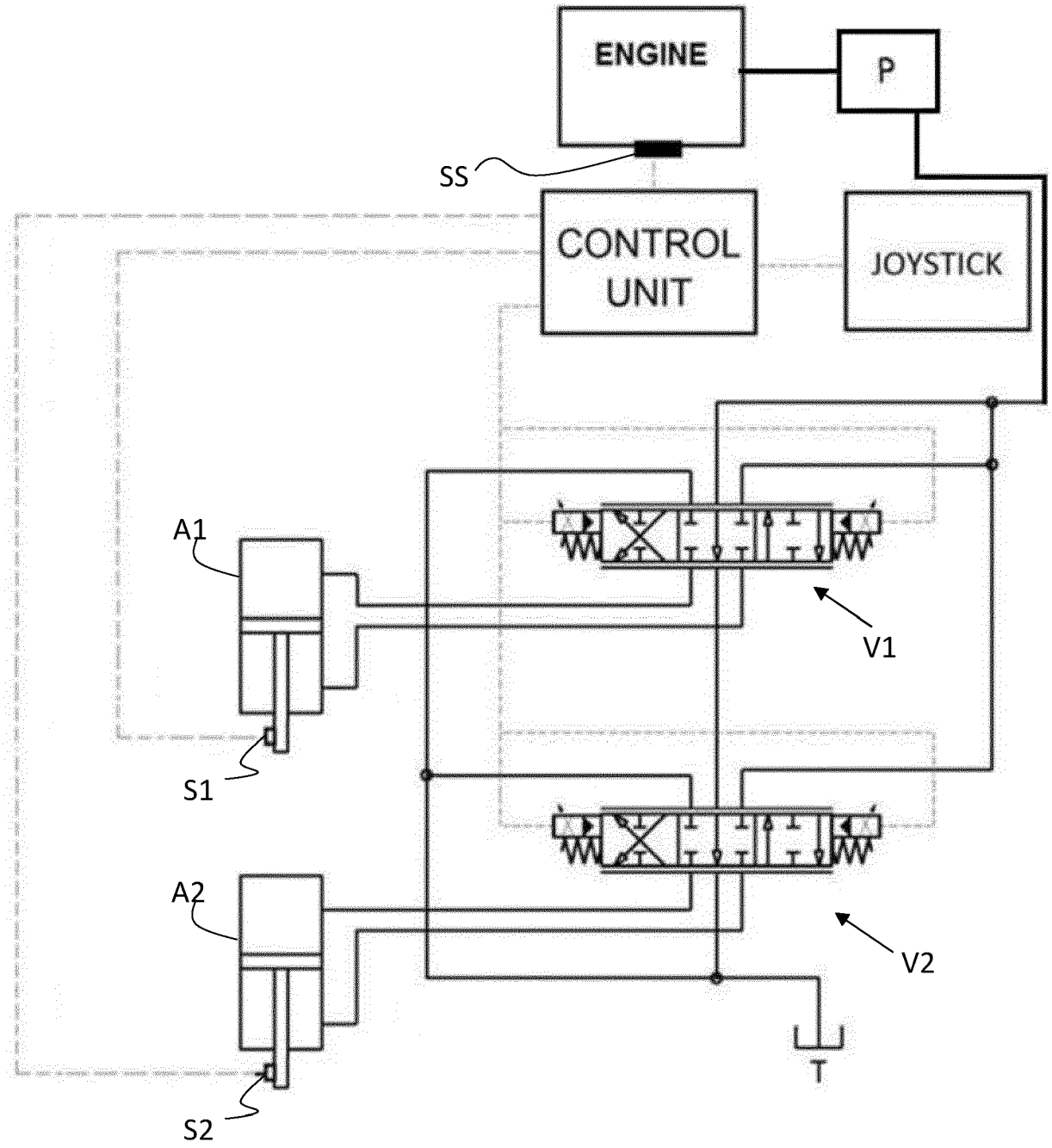

Fig. 2

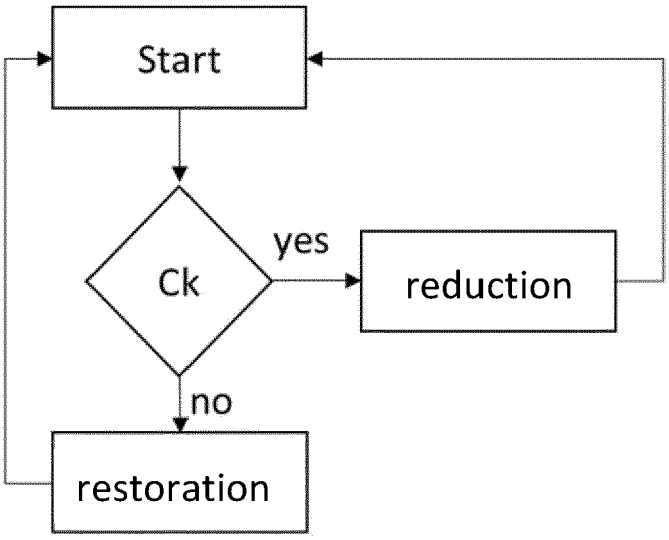

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 7382

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2020/407945 A1 (OKADA JUNICHI [JP]) 31 December 2020 (2020-12-31) * paragraphs [0003], [0033], [0068], [0069], [0073], [0074], [0077], [0078]; figures 1,2 *	1-8	INV. E02F9/22
X	JP 2011 236562 A (CATERPILLAR SARL) 24 November 2011 (2011-11-24) * paragraphs [0006], [0029]; figures 1,2 *	1-8	
A	JP 2009 256891 A (CATERPILLAR JAPAN LTD) 5 November 2009 (2009-11-05) * paragraph [0005]; figures 1,2 *	1-8	
			TECHNICAL FIELDS SEARCHED (IPC)
			E02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	31 August 2023	Luta, Dragos

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31-08-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2020407945 A1	31-12-2020	CN 111868338 A	30-10-2020
		EP 3770339 A1	27-01-2021
		JP 7216074 B2	31-01-2023
		JP WO2019182128 A1	11-03-2021
		KR 20200131243 A	23-11-2020
		US 2020407945 A1	31-12-2020
		WO 2019182128 A1	26-09-2019
JP 2011236562 A	24-11-2011	JP 5481269 B2	23-04-2014
		JP 2011236562 A	24-11-2011
JP 2009256891 A	05-11-2009	NONE	

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