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(71) Applicant: **CNH Industrial Italia S.p.A.**
10156 Torino (IT)

(72) Inventors:
- **Liberti, Stefano**
  10156 Turin (IT)
- **Gravili, Andrea**
  10156 Turin (IT)
- **De Giorgi, Simone**
  10156 Turin (IT)
- **Nistler, Jonathan**
  10156 Turin (IT)
- **Venezia, Antonio**
  10156 Turin (IT)

(74) Representative: **CNH Industrial IP Department**
Leon Claeysstraat 3A
8210 Zedelgem (BE)

(54) **THERMAL MANAGEMENT METHOD FOR A HYDRAULIC CIRCUIT OF AN AGRICULTURAL OR WORK VEHICLE AND A CONTROL UNIT IMPLEMENTING THE METHOD**

(57) Method of supporting the completion of a mission of an agricultural or work vehicle operated by computer, in which the vehicle is equipped with an articulated arm (A) connected to a chassis (F) of the vehicle such as to assume a plurality of operational configurations, a propulsion system such as to allow movement of the vehicle with respect to a support surface, a hydraulic circuit (HC) including a source (P) of pressurized hydraulic oil and a collection tank (T) and at least one auxiliary hydraulic circuit (AUXC) comprising a valve (V3) for powering an auxiliary user (AUX, ADAUX), a human/machine interface device (20) for administering a recorded message, the method including: Determination of a current mission of the vehicle, verification if said vehicle mission coincides with a reading mission, and if so then suggestion of enabling a hydraulic oil warm-up function by lamination of hydraulic oil through said auxiliary circuit (AUXC) .

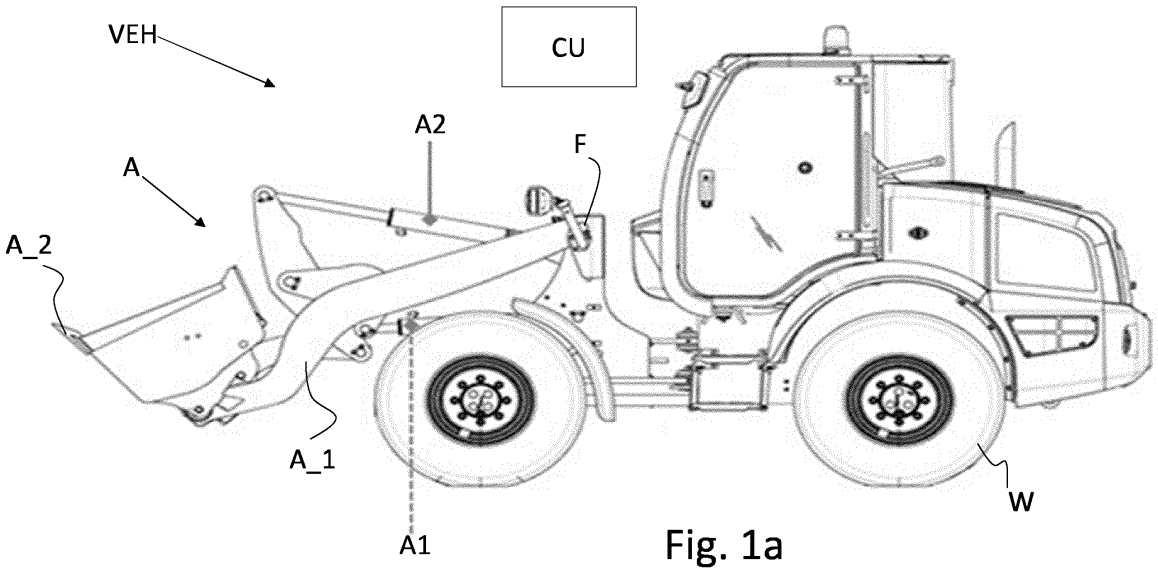

Fig. 1a

EP 4 575 105 A1

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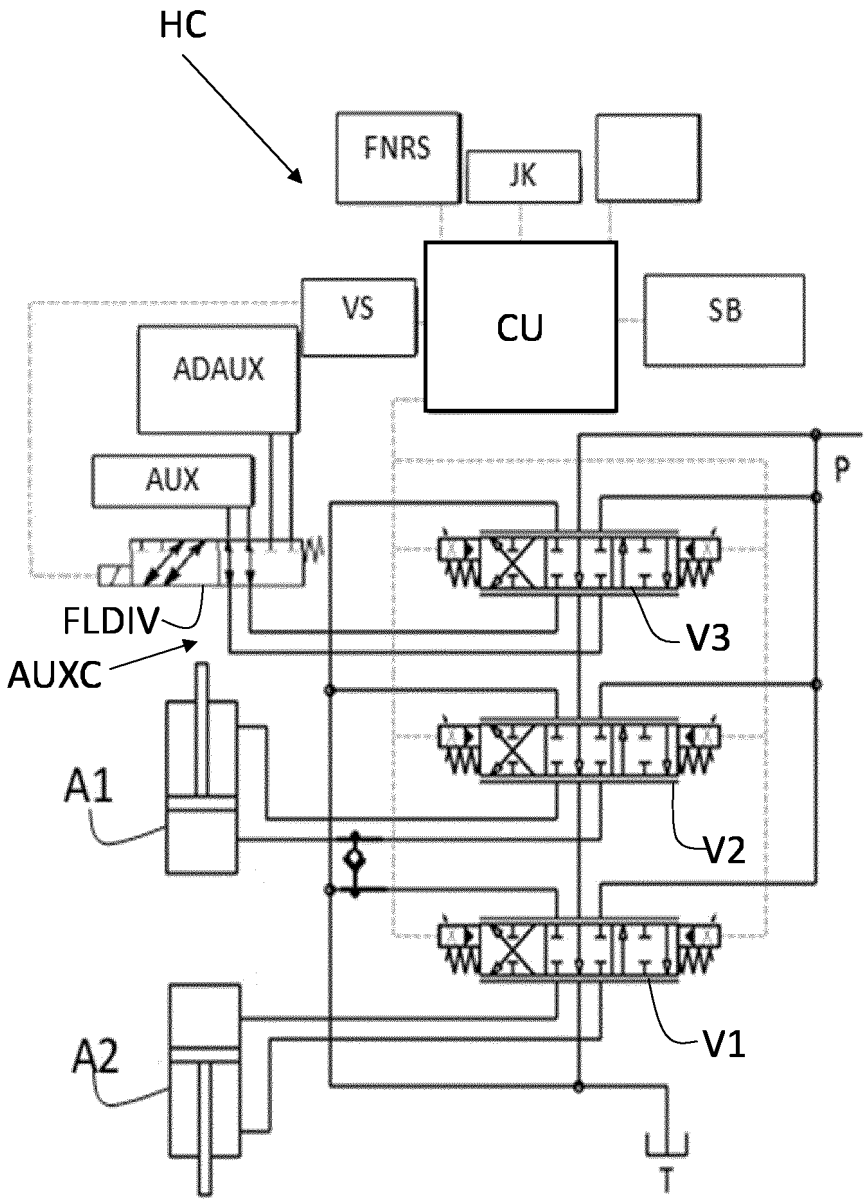


Fig. 1b

Description

Field of the invention

[0001] The present invention relates to a method for thermal management of a hydraulic circuit of an agricultural or work vehicle and a control unit implementing the method.

State of the art

[0002] Agricultural or work vehicles are equipped with at least one work tool, such as for example an arm or a lift and a transmission which has the purpose of allowing the travelling of the vehicle.

[0003] The transmission can be driven by a prime mover, usually internal combustion engine, although in recent years vehicles have been developed in which the prime mover is defined by an electric motor.

[0004] A directional valve is arranged to connect one of the opposing chambers of a hydraulic actuator to a source of pressurized hydraulic oil and at the same time the other chamber to a hydraulic oil collection tank, generally arranged at low pressure, i.e. at ambient pressure.

[0005] When the vehicle reaches the workplace, the hydraulic functions are activated to allow the movement of the hydraulic parts, such as an articulated arm, but if the oil temperature is very low, there is a risk of damaging the hydraulic circuit. In fact, in cold climates, in the winter period, the temperature of the oil can drop well below zero, with a significant variation in the viscosity of the oil and a consequent increase in operating pressures.

[0006] It is known that the same vehicle can be involved in several missions. Some missions involve cycling through a sequence of vehicle movements.

[0007] Some operational missions can be preceded by the reading mission, i.e. the transfer of the vehicle, using its propulsion means from one workplace to another one.

[0008] During the reading mission, the hydraulic functions are deactivated.

[0009] The same Applicant is the owner of a European patent application no. 21217267, which describes a signal conditioning technique to be input to a neural network, for the purpose of recognizing a current mission of the vehicle. The Applicant, after long experimentation, has identified parameters and functions relating to the work tools and/or transmission and/or on-board systems that can facilitate the current mission of the vehicle.

[0010] Unless 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

[0011] The main purpose of the present invention is to facilitate the completion of a mission of an agricultural or work vehicle.

[0012] The basic idea of the present invention is to monitor the operations performed by a work vehicle within a predetermined time interval and when it turns out that the mission coincides with a reading mission and the oil temperature is lower than a predetermined threshold, then enabling of the auxiliary hydraulic functions is suggested such that the circulation of hydraulic oil is forced so as to cause warm-up of the hydraulic oil for lamination.

[0013] These and other objectives are achieved by means of the attached claims, which describe preferred embodiments of the invention, forming an integral part of the present description.

Brief description of the figures

[0014] The invention will be fully clear from the following detailed description, provided as a purely illustrative and nonlimiting example, to be read with reference to the attached drawing figures, in which:

- Fig. 1a shows a work vehicle with its arm in any of the possible configurations it can assume,
- Fig. 1b shows a hydraulic circuit for implementing an articulated arm and auxiliary functions according to Fig. 1a;
- Figs. 2 - 4 show examples of human/machine interfaces. In particular, Fig. 2 shows a button panel, Fig. 3 an instrument panel and Fig. 4 a joystick;
- Fig. 5 shows an example of a flow diagram representative of the method object of the present invention.

[0015] The same reference numbers and letters in the figures designate equal or functionally equivalent parts.

[0016] According to the present invention, the term "second element" does not imply the presence of a "first element", first, second, etc. They are used only to enhance the clarity of the description and should not be construed in a restrictive manner.

Detailed description

[0017] Figure 1a illustrates a construction vehicle such as a VHE wheel loader equipped with an arm A including a first element A_1, substantially elongated, hinged to the vehicle chassis F and a second element A_2, such as a bucket or a fork, hinged to the first element. More specifically, a first end of the first element A_1 is connected to the chassis F of the vehicle, while a second end, opposite to the first, supports the second element.

[0018] It is clear that the first element can assume more angular positions with respect to the frame F.

[0019] The hydraulic actuator A1 is arranged to control the angular position of the first element A_1 with respect to the vehicle chassis.

[0020] The hydraulic actuator A2 is arranged to control the angular position of the second element A_2 with respect to the first element A_1.

[0021] The hydraulic actuators A1, A2 are of the double action type, with two opposing chambers separated by a mobile partition integral with the stem of the respective actuator.

[0022] With reference to the hydraulic circuit HC shown in Fig. 1b, a first electro-hydraulic valve V1 is arranged to control the connection of each of said opposite chambers of the actuator A1 alternatively with a source of hydraulic oil P or with the hydraulic oil collection tank T.

[0023] The first valve is therefore arranged to control the raising or lowering of the arm.

[0024] Generally, when one chamber is connected with the hydraulic oil source, the opposite chamber is connected with the collection tank. This allows to raise or lower the articulated arm. However, when the arm is stationary, i.e. in static conditions, and at least partially raised, the first chamber of the hydraulic actuator is kept pressurized and closed, i.e. disconnected from both the source of hydraulic oil and the collection tank.

[0025] A second electro-hydraulic valve V2 is arranged to control the oscillation of the bucket with respect to the arm.

[0026] A third electro-hydraulic valve V3 is arranged to control the connection with each of the opposing chambers of an auxiliary device alternatively with the hydraulic oil source P or with the hydraulic oil collection tank T.

[0027] A further valve FLDIV is arranged to switch the hydraulic connection between a first auxiliary hydraulic device AUX and a second auxiliary hydraulic device ADAUX via the aforementioned third electro-hydraulic valve V3.

[0028] AUXC indicates the portion of the electro-hydraulic circuit HC relating to the power supply and control of at least one auxiliary device.

[0029] An electro-hydraulic valve, generally with an open centre, therefore takes care of the control of the respective hydraulic actuator.

[0030] The activation of valves V1, V2 is controlled by a human/machine interface device, such as a joystick JK, shown in Fig. 4.

[0031] Similarly, a human/machine interface device, which may or may not coincide with a button or lever, for example the wheel 26 present on the joystick, allows you to control the operation of an auxiliary hydraulic device.

[0032] According to the present invention, the processing unit CU is configured to monitor the operation of the vehicle to recognize a reading mission, i.e. a mission in which the vehicle moves from one work location to another for a predetermined time interval, not necessarily continuous. When the processing unit recognizes that the vehicle is in reading conditions and the oil temperature is lower than a predetermined threshold, it suggests the activation of the hydraulic oil warm-up function.

[0033] The hydraulic oil warm-up function is achieved by controlling the third valve V3 in order to power the auxiliary hydraulic device, which, not being connected to the vehicle, involves the lamination of the oil through an overpressure valve (not shown).

[0034] In fact, it is the operator's responsibility to activate the hydraulic oil warm-up function after having ascertained that there is no auxiliary device actually connected to the auxiliary hydraulic circuit, otherwise, the circulation of hydraulic oil in the auxiliary circuit would lead to the movement of the auxiliary device.

[0035] For this purpose, the message shown on the display can preferably remind the operator to activate the hydraulic oil warm-up function after having verified that there is no auxiliary device connected to the auxiliary hydraulic circuit. There may be various buttons on the joystick, the functionality of which may be fixed or programmable depending on the settings given by the operator via the panel 21 in Fig. 2 or the instrument panel 20 shown in Fig. 3.

[0036] Preferably, the joystick further comprises at least one button 23, 24, 25.

[0037] According to the present invention, a first software module is responsible for monitoring the configurations assumed by the arm and the activation of the propulsion system and determining the current mission of the vehicle.

[0038] Based on this recognition, it is verified whether the current mission coincides with a reading mission.

[0039] Evidently, a second software module can be provided configured to receive the current recognized mission as input and to access a look up table in which the functions relating to this mission are listed.

[0040] More preferably, a processing unit CU is configured to implement the first and second software modules and to control the instrument panel 20 in particular to play messages via the respective display 22.

[0041] In particular, the processing unit is configured to check whether the oil temperature is lower than a predetermined threshold, for example 25°C and, consequently, to suggest the activation of the hydraulic oil warm-up function by the activation of the aforementioned third electro-hydraulic valve V3.

[0042] In particular, when the vehicle carries out a reading mission repetitively for at least a predetermined time interval, for example 30 minutes, the suggestion message is shown on the display.

[0043] The message, in particular, suggests activating the automatic oil warm-up function after verifying the absence of any auxiliary device connected to the hydraulic circuit. Enabling the hydraulic oil warm-up function can also be suggested when the hydraulic oil temperature exceeds the aforementioned threshold, for example 25°C. So when the temperature drops below this threshold of 25°C then the function, previously enabled, is automatically activated by the processing unit CU.

[0044] Therefore, enabling this function, in itself, does not cause the activation of the function as long as the oil temperature is higher than the aforementioned tempera-

ture threshold.

[0045] The auxiliary devices are generally connected to the hydraulic circuit through quick-connection valves, which allow the auxiliary device to be powered automatically upon connection with the vehicle.

[0046] These quick connection valves close automatically when no auxiliary device is connected therewith.

[0047] Upstream of the quick-connection valves there is generally an overpressure valve designed to discharge excess oil into the collection tank.

[0048] Therefore, when the circulation of hydraulic oil in the auxiliary circuit is enabled, the oil is entirely laminated through the pressure relief valve causing the hydraulic oil to heat up.

[0049] With reference to Fig. 5, an exemplary flow diagram of the present invention is shown. The dotted blocks are optional:

- Step 1: Observation of frequency and time duration of each operational configuration of the articulated arm and activation of the propulsion system and acquisition of a current hydraulic oil temperature value;
- Step 2: determination of the vehicle's current mission;
- Step 3: checking whether said vehicle mission coincides with a reading mission; in positive case:
- Step 4: Suggestion to enable the hydraulic oil warm-up function, then
- Step 5: checking if the hydraulic oil warm-up function is enabled and the oil temperature is lower than a predetermined threshold, then if so:
- Step 6: activation of the hydraulic oil warm-up function by activating said auxiliary hydraulic circuit and then starting again from step 1, while if not, starting again directly from step 1.

[0050] After the automatic or operator enabling of hydraulic oil warm-up function, the system returns to determining the current mission and monitoring the hydraulic oil temperature. Only when the oil temperature drops below said predetermined threshold is the oil warm-up function actually activated. According to a preferred variant of the invention, the first software module is configured to detect the vehicle mission as a function of the frequency balance of the arm configurations and the respective time durations and as a function of the transmission enablement and the frequency of the values discrete vehicle speeds and respective durations. A position sensor is associated with each hydraulic actuator, therefore, it is immediate to acquire the operating configurations of the arm over time and analyse the frequency in discrete domains.

[0051] To make the solution easily implementable, the domains are segmented in such a way that the mutual positions of the elements composing the arm, which fall within a segment, are assumed to be approximately in the middle of the same segment. For further details, see the Applicant's European patent application n.21217267.

[0052] It is worth highlighting that suggestions can be given to the operator not only through writings that appear on the instrument panel or by the flashing of a light associated with an automatic function enable button, but also through voice messages.

[0053] Likewise, the operator can confirm the enablement of the hydraulic oil warm-up function vocally.

[0054] Therefore, the processing unit can advantageously be equipped with a speech synthesis module, an acoustic speaker and/or a microphone to give suggestions to the operator or to receive orders given by the operator.

[0055] The present invention may advantageously be implemented in a computer program comprising program code means for performing one or more steps of such method, when such program is executed on a computer. For this reason, the patent will also cover such computer program and computer readable medium comprising a recorded message, such computer readable medium comprising program code means for carrying out one or more steps of such method, when such program is run on a computer.

[0056] Many changes, modifications, variations and other uses and applications of the subject invention will be apparent to those skilled in the art after considering the accompanying description and drawings, which describe preferred embodiments thereof as described in the accompanying claims.

[0057] The features disclosed in the background of the prior art are introduced only to better understand the invention and not as a statement about the existence of the prior art. Furthermore, said characteristics define the context of the present invention, therefore such characteristics will be considered in common with the detailed description.

[0058] Further implementation details will not be described, as the person skilled in the art is able to implement the invention starting from the teaching of the above description.

Claims

1. Computer-operated method for thermal management of a hydraulic circuit of an agricultural or work vehicle, wherein the vehicle is equipped with

   - an articulated arm (A) connected to a chassis (F) of the vehicle such as to assume a plurality of operating configurations,
   - a propulsion system that allows the vehicle to be moved with respect to a support surface,
   - a hydraulic circuit (HC) including a source (P) of pressurized hydraulic oil and a collection tank (T) and at least one auxiliary hydraulic circuit (AUXC) including a valve (V3) for supplying an auxiliary user (AUX , ADAUX),

- a human/machine interface device (20) to administer a recorded message,

the method including in cyclic succession:

- (Step 1) Observation, for a predetermined time interval, of a frequency and duration of each operational configuration and activation of the propulsion system,
- (Step 2) Determining a current mission of the vehicle,
- (Step 3) checking whether said vehicle mission coincides with a reading mission, and if so, then
- (Step 4) suggestion via said human/machine interface device (20) to enable a hydraulic oil warm-up function;

wherein said hydraulic oil warm-up function includes the opening of said valve (V3) for the circulation of hydraulic oil in said at least one auxiliary hydraulic circuit (AUXC).

2. Method according to claim 1, wherein said observation step (Step 1) comprises an acquisition of a current temperature value of the hydraulic oil and wherein the method comprises

- (Step 5) checking whether the hydraulic oil warm-up function is enabled and whether said temperature value is lower than a predetermined threshold and if so,
- (Step 6) activation of the hydraulic oil warm-up function.

3. Method according to claim 1 or 2, wherein said suggestion comprises a recorded message which includes a warning to verify in advance the absence of any auxiliary user connected to said auxiliary circuit.

4. Method according to any one of the preceding claims 1-3, comprising a preliminary step of arranging in said auxiliary circuit at least one overpressure valve arranged to laminate hydraulic oil into a collection tank (T), when said valve (V3) is open and no auxiliary user is connected to said auxiliary circuit.

5. A computer program comprising computer program code means adapted to perform all steps of claims 1 - 3, when said program is executed on a control unit of an agricultural or work vehicle.

6. A computer readable medium having stored the program of claim 5.

7. Work or agricultural vehicle (VEH) comprising an articulated arm (A) connected to a chassis (F) of the vehicle such as to assume a plurality of operating configurations, a propulsion system such as to allow movement of the vehicle with respect to a surface support, a hydraulic circuit (HC) including a source (P) of pressurized hydraulic oil and a collection tank (T) and at least one auxiliary hydraulic circuit (AUXC) including a valve (V3) for supplying an auxiliary user (AUX, ADAUX), a human/machine interface device (20), associated with a vehicle dashboard to administer a recorded message, a processing unit (VCU) configured to observe, for a predetermined time interval, a frequency and time duration of each operational configuration, and a frequency and duration of activation of the propulsion system and consequently to determine a current mission of the vehicle and to verify whether said mission of the vehicle coincides with a reading mission, and if so to suggest an enabling of a hydraulic oil warm-up function, wherein the warm-up function includes circulating hydraulic oil through said auxiliary hydraulic circuit (AUXC).

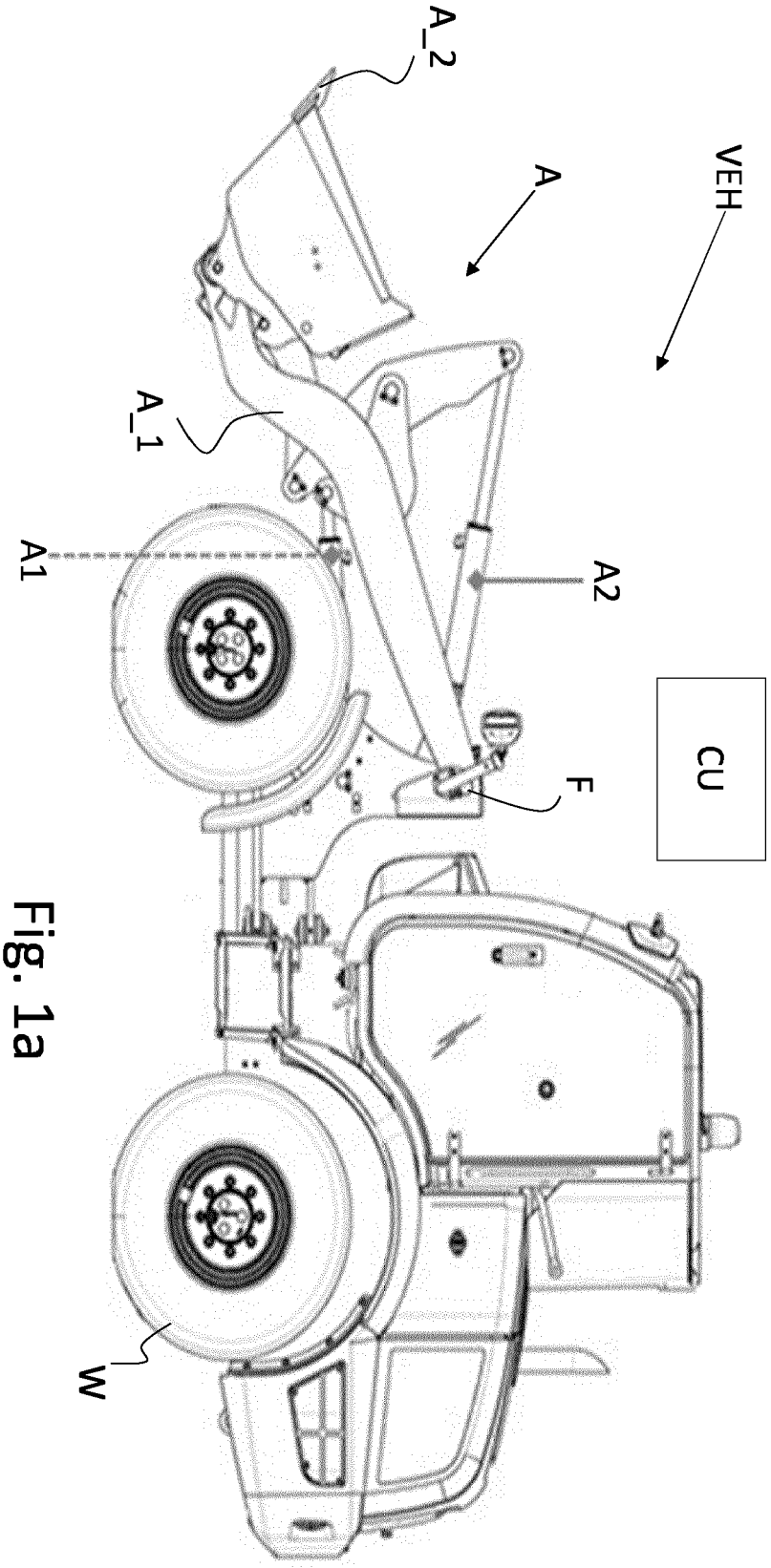


Fig. 1a

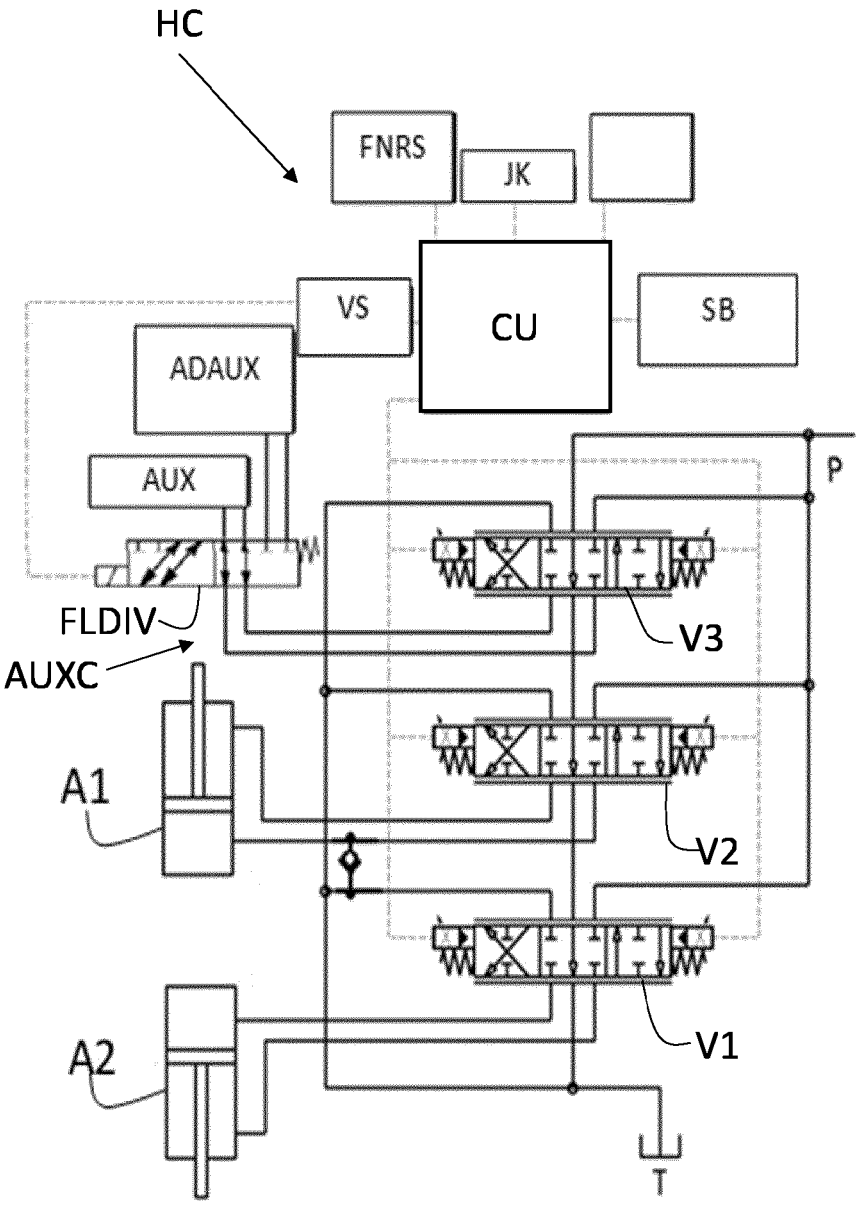


Fig. 1b

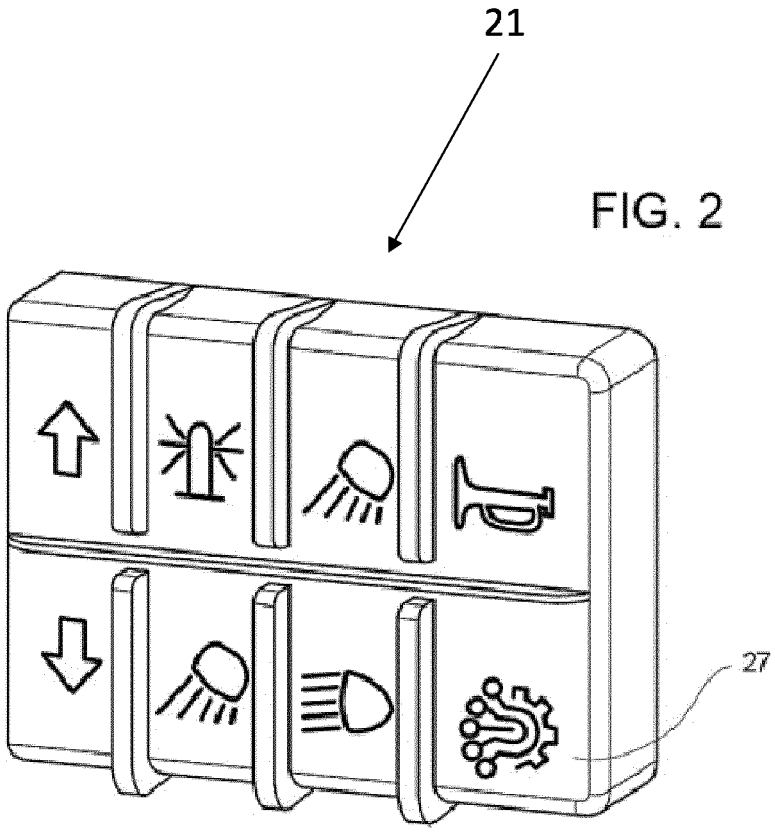


FIG. 2

FIG. 3

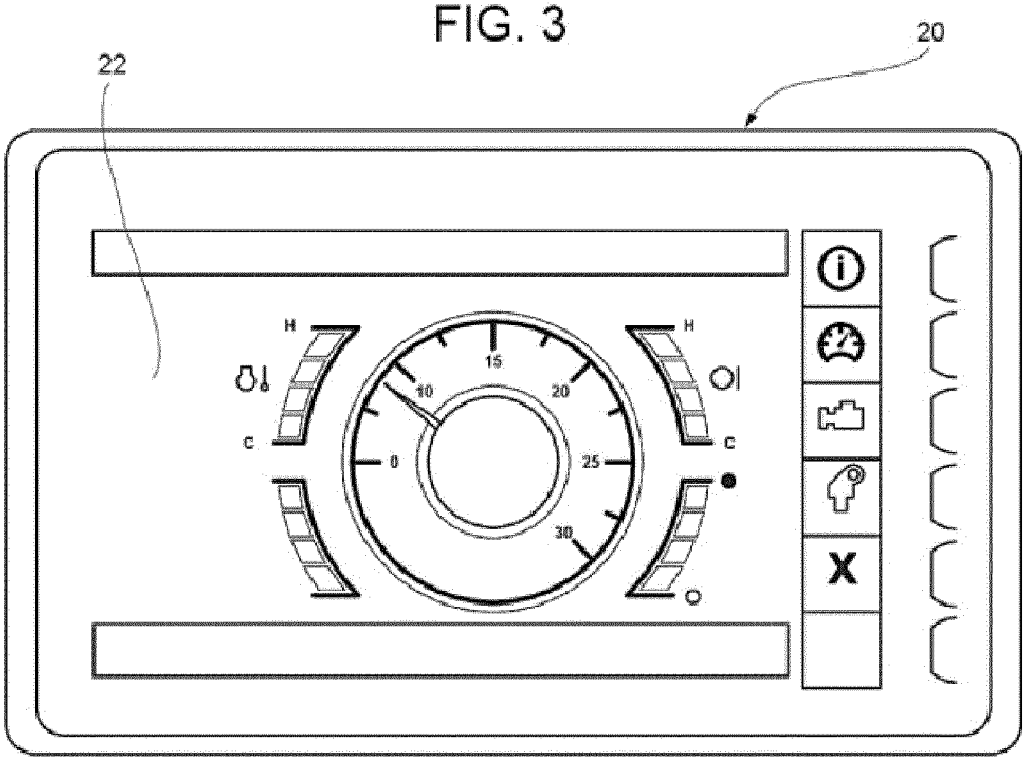
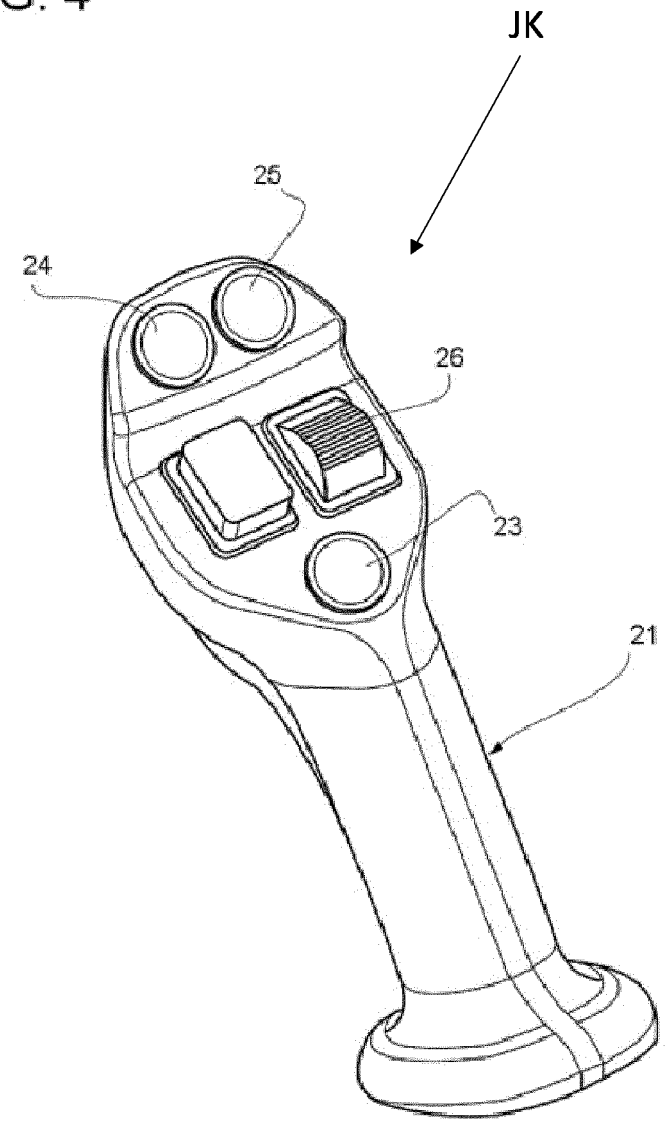


FIG. 4



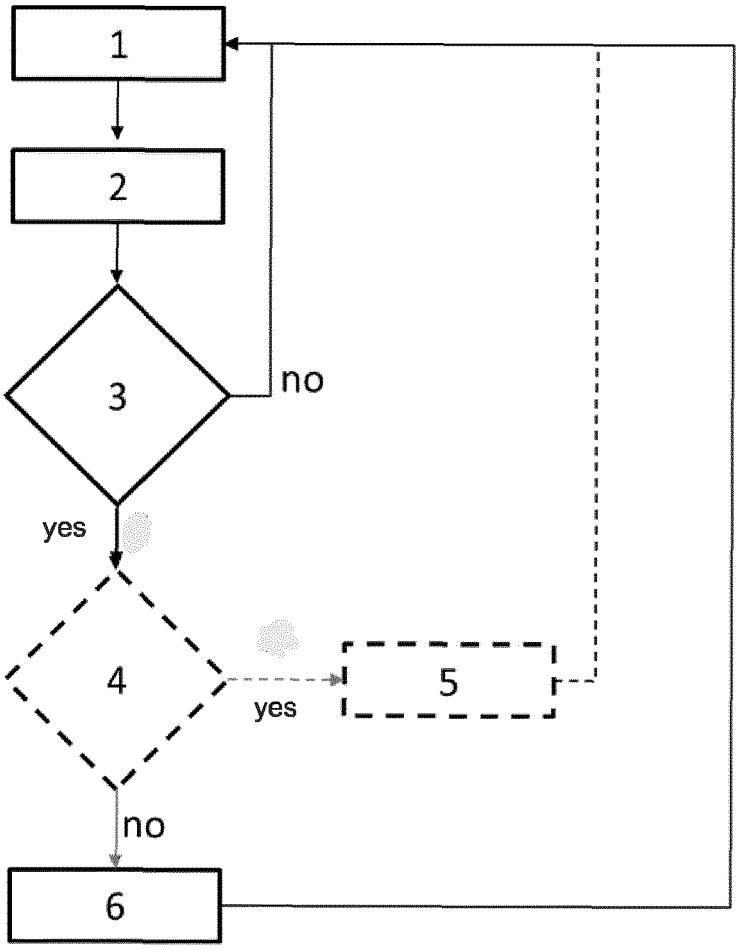


Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 24 22 1226

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	EP 4 026 954 A1 (CNH IND ITALIA SPA [IT]) 13 July 2022 (2022-07-13) * the whole document *	1-7	INV. E02F9/22 E02F9/26
A	JP 2021 156398 A (SUMITOMO SHI CONSTRUCTION MACHINERY CO LTD) 7 October 2021 (2021-10-07) * the whole document *	1-7	
A	JP 2022 033079 A (KUBOTA KK) 28 February 2022 (2022-02-28) * the whole document *	1-7	

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	15 April 2025	Dreyer, Christoph

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 4026954 A1	13-07-2022	EP 4026954 A1	13-07-2022
		US 2022215225 A1	07-07-2022
JP 2021156398 A	07-10-2021	JP 7463161 B2	08-04-2024
		JP 2021156398 A	07-10-2021
JP 2022033079 A	28-02-2022	JP 7413202 B2	15-01-2024
		JP 2022033079 A	28-02-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 21217267 A **[0009] [0051]**