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(54) **METHOD FOR SUPPORTING COMPLETION OF A MISSION 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 the 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, the method includes (Step 1) Observation, for a predetermined time interval, of a frequency and duration of each operational

configuration, and of activation of the propulsion system; (Step 2) Determining a current mission of the vehicle; (Step 3) checking whether said vehicle mission coincides with a truck loading mission, and if so then Suggesting or enabling an automatic boom return function, wherein said automatic return function Return includes a procedure of moving the arm from any configuration to a prestored configuration.

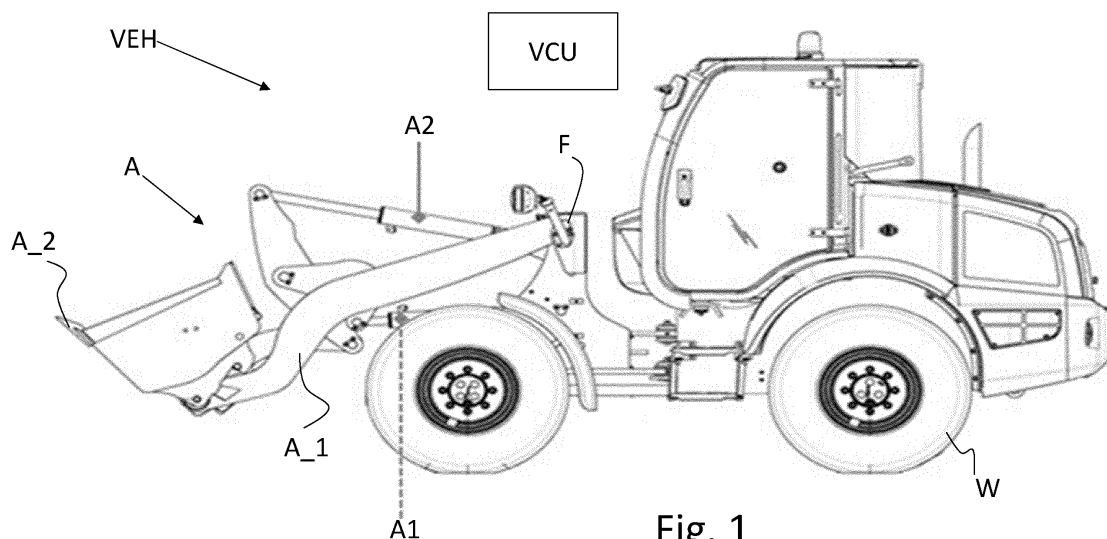


Fig. 1

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Description

Field of the invention

[0001] The present invention relates to a method of supporting the completion of a mission 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 component, 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] As regards the movement of work tools, such as arms, lifters, blades, etc., they are operated by double-action hydraulic actuators.

[0005] 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, arranged at low pressure, generally at ambient pressure.

[0006] The source of pressurized hydraulic oil is generally a hydraulic pump driven in rotation by the internal combustion prime mover or a dedicated electric motor.

[0007] It is known that the same vehicle can be involved in several missions. Some missions involve cycling through a sequence of vehicle movements. Furthermore, in the same mission, similar movements, for example the advancement of the vehicle, may require two different execution speeds. In fact, while a shovel loads the material with the bucket in the excavation or "dig" position, the forward movement of the vehicle requires low speed and high torque. On the contrary, when the vehicle needs to move from the loading place to the unloading place, the forward movement of the vehicle requires a relatively higher speed and lower driving torque.

[0008] The vehicle kinematic chain is designed to adapt to working conditions, for example the displacement of the hydraulic motor is a function of the resistance torque detected, however adaptation requires time, time lost in the execution of the mission and therefore in vehicle productivity.

[0009] More specifically, for construction vehicles equipped with an articulated arm, the speed of movement and precision of the arm depend on the type of mission.

[0010] The main missions for wheel loaders and excavators are:

- Loading onto trucks: removing material or soil by throwing it directly into a truck through a bucket;
- Hauling: transporting a load of material at various

- distances across a construction site using a bucket;
- Pick & Place: using the fork or the bale clamp accessory to pick up and lift the material and then place it in a destination on the ground or on a shelf;
- Stock Pile: Defining a pile by means of the bucket, in a storage location for bulk materials, which is part of the bulk material handling process.

[0011] Machine learning and deep learning are well-known concepts. The implementation of deep learning in all fields seems to have remarkable development.

[0012] 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.

[0013] 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 a current mission of the vehicle.

[0014] 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

[0015] The main purpose of the present invention is to facilitate the completion of a mission of an agricultural or work vehicle.

[0016] The basic idea of the present invention is to monitor the operations carried out by a work vehicle within a continuous and predetermined time interval and when it turns out that the mission coincides with a "loading on a truck" mission, then it is enabled or it is suggested enabling to the operator at least one of the following functions:

- Return to height
- Return to travel
- Return to dig.

[0017] The aforementioned functions are known to those skilled in the art and have in common the fact of automatically repositioning a tool in a predetermined position starting from any remote position.

[0018] The first function, Return to Dig, automatically places the bucket or fork in a position suitable for loading loose material or a pallet.

[0019] US20020073833A1 describes the Return to Dig function.

[0020] The Return to Travel function is similar to the Return to Dig function, with the difference that it automatically lowers the arm to a position that does not prevent an adequate view of the surrounding environment while the vehicle is moving from one workplace to another one. It is generally recalled when the vehicle moves along a route.

[0021] The Return to Height function is still similar to the previous ones and has the purpose of bringing the arm to a predetermined height from the ground, for example, to unload the collected material inside a loading compartment of a track vehicle, or onto a shelving in a warehouse.

[0022] A joystick is placed in a vehicle cabin and is normally associated with the control of the movement of the articulated arm of the work or agricultural vehicle.

[0023] When at least one of the hydraulic functions is enabled, one of the buttons on the joystick is reprogrammed to perform the return function when pressed by the operator.

[0024] Once the operator recalls one of the aforementioned functions, he can reduce his level of attention with respect to the work operations, as an on-board processing unit takes care of returning the arm to the required position, be it Dig or Travel or Height.

[0025] Monitoring, as described in European patent application no. 21217267, is based on observation of time and frequency of permanence of the articulated arm in one of the possible operational configurations of the arm and also on the observation of said transmission, since, in relation to the speed of the vehicle and the configuration of the hydrostat, it is possible to discriminate between those missions having similar arm behaviour.

[0026] The loading mission of a truck-loading compartment is recognized due to the greater permanence, in terms of time, of the arm in predetermined positions in addition to the fact that the vehicle follows a Y-shaped trajectory.

[0027] Thanks to the present invention, the operator is at least suggested to enable these return functions.

[0028] It should be highlighted that the mere enabling of an automatic return function does not cause its execution, but allows its execution to be activated in response to the pressing of a corresponding joystick button by the operator. Conversely, disabling the automatic return function means that any press of the same button does not cause anything.

[0029] According to a preferred variant of the invention, the operator could set, via one of the buttons available to him on the vehicle dashboard, the automatic enabling of the functions by handing control over to the VCU processing unit. In this way, the VCU, recognizing the truck loading mission, autonomously decides to enable at least one of the aforementioned functions, therefore associating the corresponding enabled automatic return function to a joystick button.

[0030] 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

[0031] The invention will be fully clear from the follow-

ing detailed description, provided as a purely illustrative and nonlimiting example, to be read with reference to the attached drawing figures, in which:

- 5 - Fig. 1 shows a work vehicle with its arm in any of the possible configurations it can assume,
- 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;
- 10 - Fig. 5 shows an example of a flow diagram representative of the method object of the present invention.

[0032] The same reference numbers and letters in the figures designate equal or functionally equivalent parts.

[0033] 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

[0034] Fig. 1 illustrates a work vehicle such as a wheel loader VHE equipped with an arm A including a first element A₁, substantially elongated, hinged to the vehicle chassis F and a second element A₂, such as a bucket or a fork, hinged to the first element. More specifically, a first end of the first element is connected to the chassis F of the vehicle, while a second end, opposite to the first, supports the second element.

[0035] It is clear that the first element can assume more angular positions with respect to the frame F.

[0036] The hydraulic actuator A1 is arranged to control the angular position of the first element A₁ with respect to the vehicle chassis.

[0037] The hydraulic actuator A2 is arranged to control the angular position of the second element A₂ with respect to the first element A₁.

[0038] The hydraulic actuators A1, A2 are of the double action type, with two opposing chambers separated by a mobile septum integral with the stem of the respective actuator.

[0039] An electro-hydraulic valve, not shown, controls the connection of one of these opposing chambers alternatively with a source of hydraulic oil or with a hydraulic oil collection tank. Generally, when one chamber is connected with the hydraulic oil source, the opposite chamber is connected with the collection tank.

[0040] An electro-hydraulic valve, generally with an open centre, therefore takes care of the control of a respective actuator. The activation of the valve is instead controlled by a human/machine interface device, such as a joystick JK, shown in Fig. 4.

[0041] 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 button panel 21 in Fig. 2 and/or the instrument panel 20

shown in Fig. 3. The joystick includes at least one button 23, 24, 25. Often it also includes a wheel 26, which allows adjustments to be made on some operational settings.

[0042] 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.

[0043] Based on this recognition, it is checked whether the current mission coincides with a load loading mission on a truck. 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 automatic return functions correlated with the current mission are listed.

[0044] More preferably, a VCU processing unit is configured to implement the first and second software modules and to control the instrument panel 20 in particular to reproduce messages via the respective display 22.

[0045] In particular, the processing unit is configured to check whether the automatic return function(s) are enabled or not. In particular, the processing unit is configured to check whether at least one of the automatic return functions is already enabled. If it appears that it is already enabled, then its enablement is not suggested.

[0046] Evidently, this verification can be performed in succession or in parallel with all three return functions described above.

[0047] Using one of the available buttons, the operator can set the automatic enabling of the automatic return functions, giving up control to the processing unit VCU.

[0048] In this case, no suggestion is given, but the automatic return functions are automatically enabled and preferably this enabling is notified after its automatic enabling. Advantageously, the operator is given the possibility of deciding whether permitting the vehicle automatically deciding which functions to enable and parameters to set or to maintain the control of the enabling of the functions, so that the vehicle limits itself to making suggestions via the instrument panel.

[0049] Among the parameters that can be set, in the case of loading onto a truck, the displacement of the hydraulic pump and/or of the hydraulic motor of the hydrostat that makes up the vehicle transmission can be controlled.

[0050] Advantageously, without intervening on the vehicle speed set by the operator, the transmission ratio can be modified to more easily cope with resistance torque peaks, especially when inserting the bucket into a pile of material to be loaded into the bucket.

[0051] 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 duration of each operational configuration of the arm and activation of the propulsion system;
- Step 2: determination of the vehicle current mission;

- Step 3: Checking whether said vehicle mission coincides with a truck loading mission;
- Step 4: Automatically enabling an automatic return function or suggesting enabling the automatic return function.

[0052] After the automatic return function is enabled, either automatically or by the operator, the system returns to observing the operation of the arm and transmission and determining the current mission. If the current mission has changed then the flowchart is executed from Step 3, otherwise it returns to Step 1.

[0053] To generalize therefore, the flow diagram, there may be a further step, immediately after Step 1, in which the currently enabled automatic function(s) is acquired and immediately after step 3 there may be a step to check whether the automatic functions and possibly the relevant parameters currently active are related to the truck loading mission, if so the cycle starts again from step 1, while if not it continues with step 4.

[0054] Advantageously, in this way it is avoided giving excessive suggestions to the operator.

[0055] 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 analyze the frequency in discrete domains.

[0056] 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 center of the same segment. For further details, see the applicant's European patent application n.21217267.

[0057] 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 enabling button, but also through voice messages.

[0058] Likewise, the operator can confirm the enabling of an automatic function vocally.

[0059] 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.

[0060] 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.

[0061] 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.

[0062] 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.

[0063] 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. Method computer-operated for supporting completion of a mission of work or agricultural 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, 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 current vehicle mission coincides with a truck loading mission, and if so then
- (Step 4) automatic suggestion or enabling of an automatic return function,

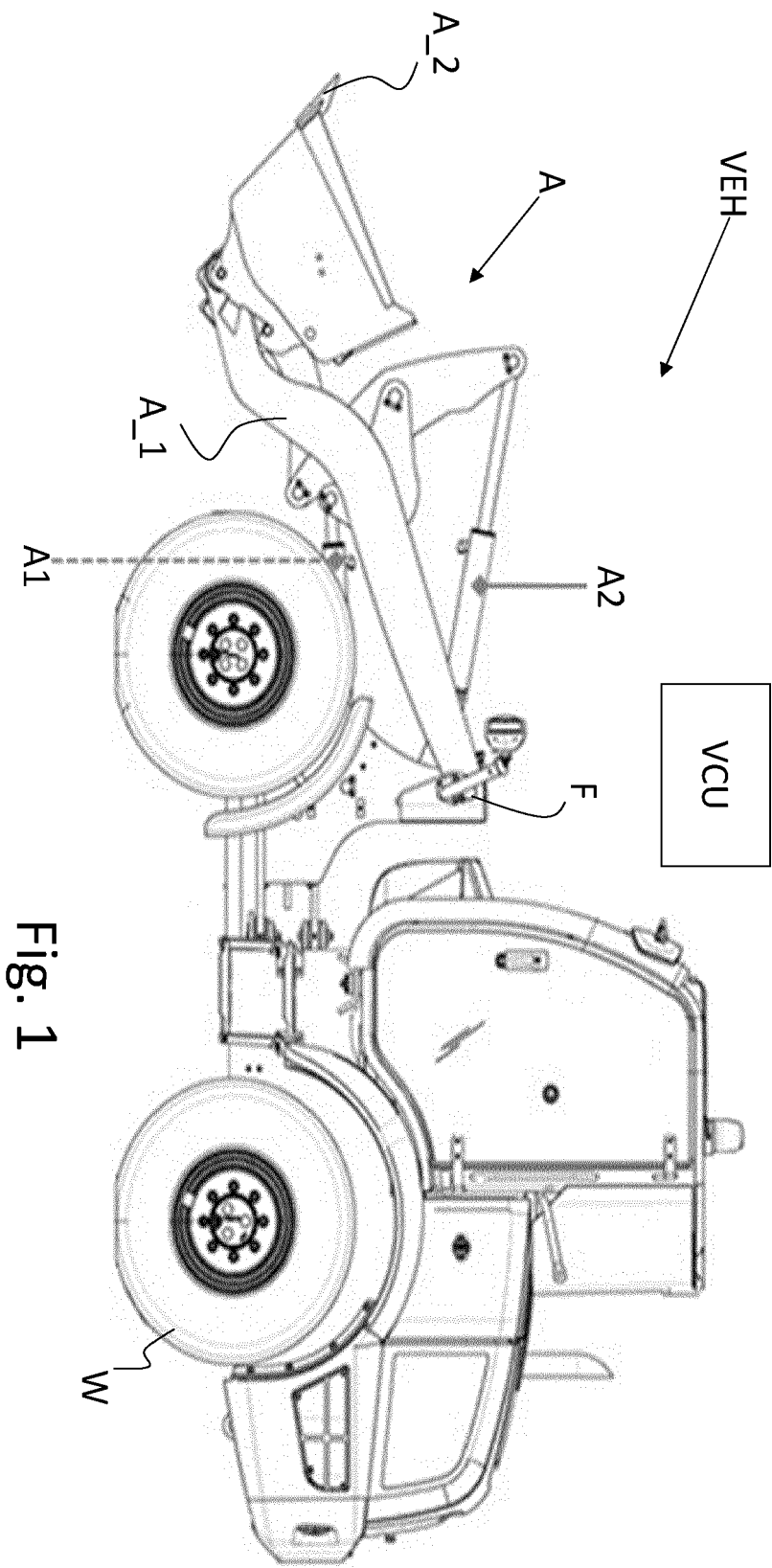
wherein said automatic return function comprises a procedure of moving the arm from any configuration to a pre-stored configuration.

2. The method of claim 1, wherein said enabling of the automatic return function comprises the procedure of configuring a button of a joystick to activate said automatic return function.

3. Method according to claim 1 or 2, wherein said enabling also includes the setting of at least one operating parameter of an actuator of said articulated arm.

lated arm.

4. A computer program comprising computer program code means adapted to perform all steps of claims 1 - 3, when said program is executed on a elaborating unit of a work or agricultural vehicle.
5. A computer readable medium having stored the program of claim 4.
6. Work or agricultural vehicle (VEH) 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 such as to allow movement of the vehicle with respect to a surface support, 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 vehicle mission coincides with a truck loading mission, and if so to automatically suggest or enable an automatic return function of the articulated arm, wherein said automatic return function comprises a procedure of moving the arm from any configuration to a pre-stored configuration.



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FIG. 2

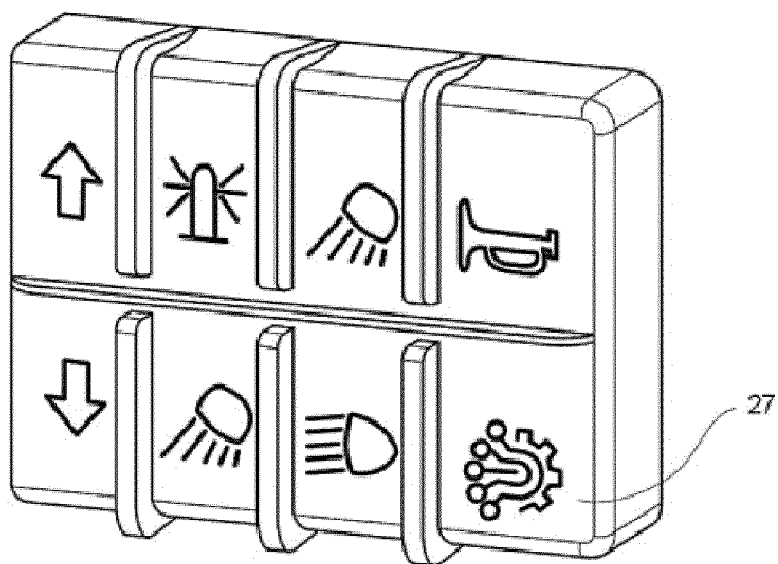


FIG. 3

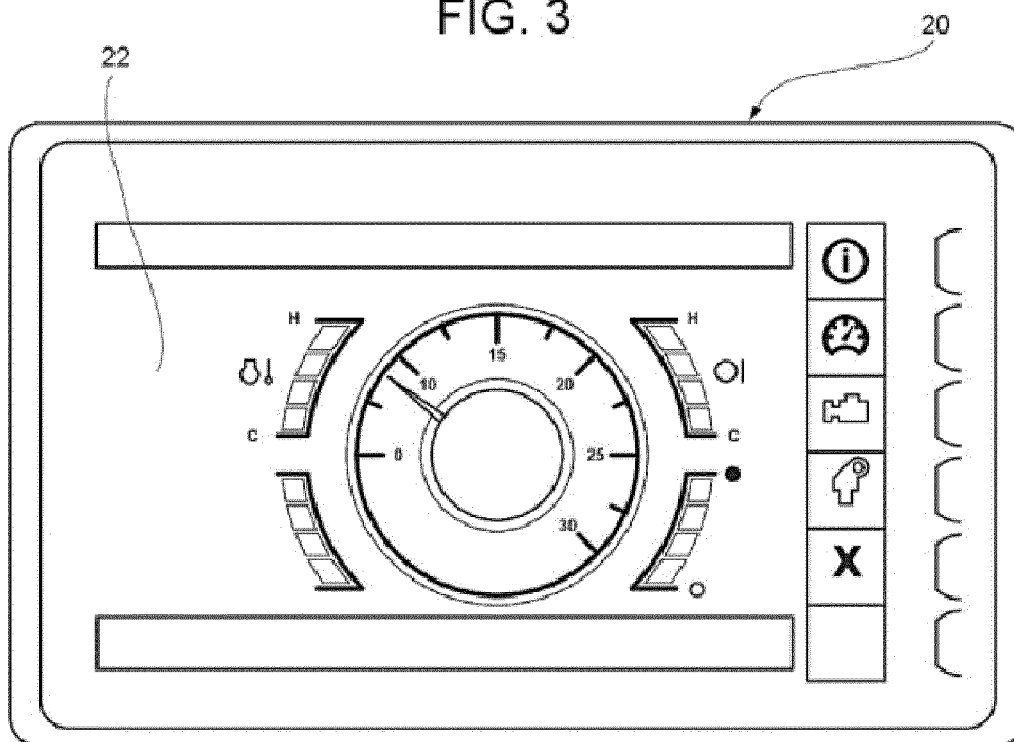
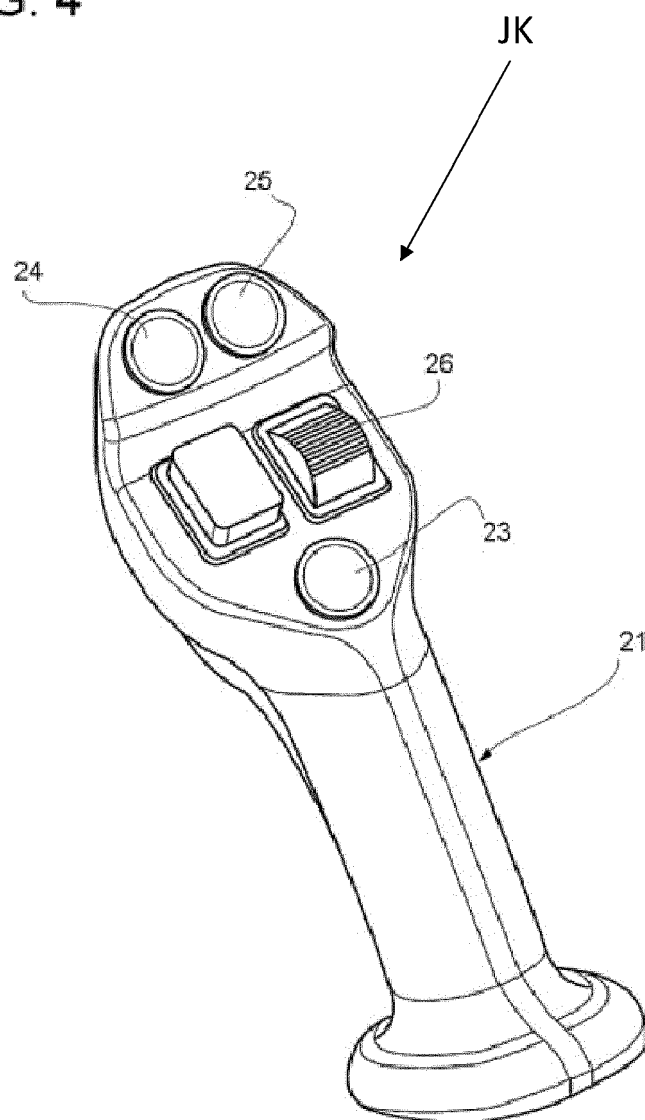


FIG. 4



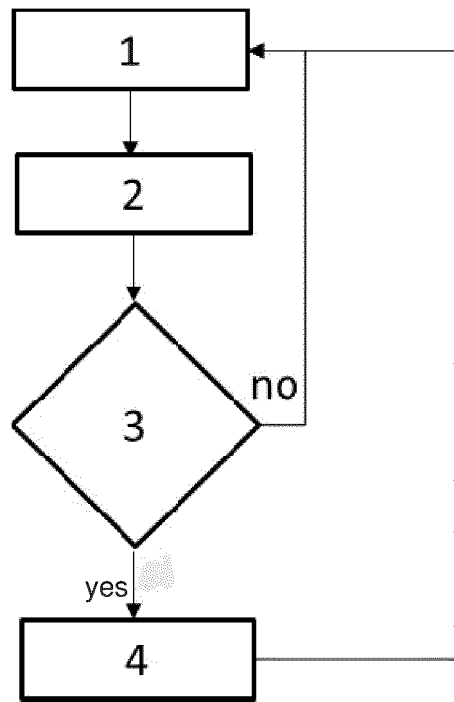


Fig. 5



EUROPEAN SEARCH REPORT

Application Number

EP 24 22 1220

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		14 April 2025	Dreyer, Christoph
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