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(54) Title: SELECTION OF TRAVEL PATHS FOR ELECTRIFIED MINING/CONSTRUCTION VEHICLES

(57) Abstract:



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SELECTION OF TRAVEL PATHS FOR ELECTRIFIED MINING/CONSTRUCTION VEHICLES

Technical Field

5 The disclosure relates to a control arrangement for selecting travel paths for electrified mining/construction vehicles and a first electrified mining/construction vehicle configured to travel according to a travel path. Furthermore, the disclosure also relates to corresponding methods for the control arrangement and the first electrified mining/construction vehicle.

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Background

Electrified mining/construction vehicles provide an opportunity to reduce the environmental footprint and create a healthier work environment in mining/construction environments. The electrified mining/construction vehicle is driven by one or more
15 electric motors which in turn may be powered by an electric grid system and/or an on-board electrical storage system (ESS) comprising e.g., battery packs. Compared to diesel vehicles, the electrified mining/construction vehicles are emission free and can hence bring considerable savings, especially for ventilation and cooling in mining/construction environments.

20

As the electrified mining/construction vehicle travels around the mining/construction site performing one or more tasks, the charge level of the on-board electrical storage systems decreases, and the electrified mining/construction needs to be re-charged at regular intervals. The charging may be performed at a charging station and the
25 mining/construction site typically comprises a number of charging stations in different location for this purpose.

Proper planning of tasks and charging schedules for electrified mining/construction vehicles at a mining/construction site can provide an effective utilization of a fleet of
30 electrified mining/construction vehicles and ensure continuous operation at a mining/construction site.

Summary

An objective of embodiments of the disclosure is to provide a solution which mitigates or solves the drawbacks of conventional solutions.

- 5 Another objective of embodiments of the disclosure is to provide a solution to optimize travel paths for electrified mining/construction vehicles.

The above and further objectives are solved by the subject matter of the appended independent claims.

10

According to a first aspect of the disclosure, the above mentioned and other objectives are achieved with a control arrangement for selecting travel paths for electrified mining/construction vehicles, the control arrangement being configured to:

- 15 interchange a first planned travel path for a first electrified mining/construction vehicle with a second planned travel path for a second electrified mining/construction vehicle based on a battery status of the first electrified mining/construction vehicle and/or a battery status of the second electrified mining/construction vehicle.

- 20 An advantage of the control arrangement according to the first aspect is that travel paths for different electrified mining/construction vehicles may be optimized due to the consideration of their battery status. Especially, the case that different electrified mining/construction vehicles switches paths with each other make it possible for improved planning of travel paths for mining vehicles. Thereby, e.g., the power consumption in the electrified mining/construction vehicles can be reduced and
25 optimized. Further, tasks scheduled for the mining vehicles can be performed more efficient and without interruptions.

In an embodiment of a control arrangement according to the first aspect, the control arrangement is configured to:

- 30 transmit a first travel command to the first electrified mining/construction vehicle, the first travel command indicating the second planned travel path; and/or
transmit a second travel command to the second electrified mining/construction vehicle, the second travel command indicating the first planned travel path.

An advantage with this embodiment is that a communication procedure is provided for controlling the travel paths for mining/construction vehicles. This is especially the case when the control arrangement is a central controller for the mining/construction vehicles.

5

In an embodiment of a control arrangement according to the first aspect, the control arrangement is configured to:

interchange the first planned travel path with the second planned travel path further based on a state-of-charge threshold value.

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An advantage with this embodiment is that further relevant parameters are considered for improved travel path planning.

In an embodiment of a control arrangement according to the first aspect, the first planned travel path comprises a first battery charging station and the second planned travel path comprises a second battery charging station.

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An advantage with this embodiment is that the charging of the mining/construction vehicles can be optimized since the planned travel paths comprise charging stations.

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In an embodiment of a control arrangement according to the first aspect, the first battery charging station and the second battery charging station are the same battery charging station or different battery charging stations.

An advantage with this embodiment is that flexibility in the selection of charging stations is provided.

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In an embodiment of a control arrangement according to the first aspect,

the first planned travel path comprises a first grid connection, and

the second planned travel path comprises a second grid connection.

30

An advantage with this embodiment is that the mining/construction vehicles can be powered by a grid in a more optimized way since the planned travel paths comprise grid connections.

In an embodiment of a control arrangement according to the first aspect, the control arrangement is configured to:

interchange the first planned travel path with the second planned travel path
5 further based on a measurement of the first grid connection and/or a measurement of the second grid connection.

An advantage with this embodiment is that the powering of the mining/construction vehicles can be optimized due to the consideration of grid connection measurements.

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In an embodiment of a control arrangement according to the first aspect, the control arrangement is configured to:

interchange the first planned travel path with the second planned travel path
further based on a grid voltage threshold value.

15

An advantage with this embodiment is that the powering of the mining/construction vehicles can be even more optimized due to the consideration of the grid voltage threshold value. Further, the threshold value may be adapted to different applications.

20 In an embodiment of a control arrangement according to the first aspect, the first grid connection and the second grid connection are the same grid connections or different grid connections.

An advantage with this embodiment is that flexibility in the selection of grid connections
25 can be provided.

In an embodiment of a control arrangement according to the first aspect, the control arrangement is configured to:

interchange the first planned travel path with the second planned travel path
30 further based on any of: a mining operator command, a renewable power generation of a renewable power source, a fault indication of the first electrified mining/construction vehicle, a fault indication of the second electrified mining/construction vehicle, a grid measurement, and a grid service request.

An advantage with this embodiment is that even further relevant parameters are considered when deciding to interchange the planned travel paths. Thus, even more optimized planning of travel paths is possible.

5 In an embodiment of a control arrangement according to the first aspect, the control arrangement is configured to:

transmit a path interchange request indicating the first planned travel path;
receive path interchange responses from two or more second electrified
mining/construction vehicles, each path interchange response indicating a second
10 planned travel path; and

select the second planned travel path among the two or more second planned
travel paths.

15 An advantage with this embodiment is that a communication procedure is provided which enables the control arrangement to use information from the mining/construction vehicles for optimized selection of travel paths.

In an embodiment of a control arrangement according to the first aspect, the first
planned travel path and the second planned travel path comprise a task for a
20 mining/construction vehicle.

An advantage with this embodiment is that also tasks besides travel paths for the
mining/construction vehicles can be optimized according to the present solution.

25 According to a second aspect of the disclosure, the above mentioned and other objectives are achieved with a first electrified mining/construction vehicle being configured to travel according to a first planned travel path for the first electrified mining/construction vehicle, and further being configured to:

interchange the first planned travel path with a second planned travel path for a
30 second electrified mining/construction vehicle based on a battery status of the first electrified mining/construction vehicle and/or a battery status of the second electrified mining/construction vehicle; and

travel according to the second planned travel path.

An advantage of the first electrified mining/construction vehicle according to the second aspect is that that travel paths for different electrified mining/construction vehicles including the first electrified mining/construction vehicle may be optimized due to the consideration of their battery status. Especially, the case that different electrified mining/construction vehicles switches paths with each other make it possible for improved planning of travel paths for mining vehicles. Thereby, e.g., the power consumption in the electrified mining/construction vehicles can be reduced and optimized. Further, tasks scheduled for the mining vehicles can be performed more efficient and without interruptions.

In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first electrified mining/construction vehicle is configured to:

interchange the first planned travel path with the second planned travel path further based on a state-of-charge threshold value.

An advantage with this embodiment is that further relevant parameters are considered for improved travel path planning.

In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first electrified mining/construction vehicle is configured to:

interchange the first planned travel path with the second planned travel path upon receiving a first travel command from a control arrangement, the first travel command indicating the second planned travel path.

An advantage with this embodiment is that a communication procedure is provided for controlling the travel paths for mining/construction vehicles. This is especially the case when the control arrangement is a central controller for the mining/construction vehicles.

In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first planned travel path comprises a first battery charging station and the second planned travel path comprises a second battery charging station.

An advantage with this embodiment is that the charging of the mining/construction vehicles can be optimized since the planned travel paths comprise charging stations.

5 In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first battery charging station and the second battery charging station are the same battery charging station or different battery charging stations.

An advantage with this embodiment is that flexibility in the selection of charging stations is provided.

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In an embodiment of a first electrified mining/construction vehicle according to the second aspect,

the first planned travel path comprises a first grid connection, and
the second planned travel path comprises a second grid connection.

15

An advantage with this embodiment is that the mining/construction vehicles can be powered by a grid in a more optimized way since the planned travel paths comprise grid connections.

20 In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first electrified mining/construction vehicle is configured to:

interchange the first planned travel path with the second planned travel path further based on a measurement of the first grid connection and/or a measurement of the second grid connection.

25

An advantage with this embodiment is that the powering of the mining/construction vehicles can be optimized due to the consideration of grid connection measurements.

30 In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first electrified mining/construction vehicle is configured to:

interchange the first planned travel path with the second planned travel path further based on a grid voltage threshold value.

An advantage with this embodiment is that the powering of the mining/construction vehicles can be even more optimized due to the consideration of the grid voltage threshold value. Further, the threshold value may be adapted to different applications.

- 5 In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first grid connection and the second grid connection are the same grid connection or different grid connections.

10 An advantage with this embodiment is that flexibility in the selection of grid connections can be provided.

In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first electrified mining/construction vehicle is configured to:

- 15 interchange the first planned travel path with the second planned travel path further based on any of: a mining operator command, a renewable power generation of a renewable power source, a fault indication of the first electrified mining/construction vehicle, a fault indication of the second electrified mining/construction vehicle, a grid measurement, and a grid service request.

- 20 An advantage with this embodiment is that even further relevant parameters are considered when deciding to interchange the planned travel paths. Thus, even more optimized planning of travel paths is possible.

25 In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first electrified mining/construction vehicle is configured to:

- transmit a path interchange request indicating the first planned travel path;
receive path interchange responses from two or more second electrified mining/construction vehicles, each path interchange response indicating a second planned travel path; and
30 select the second planned travel path among the two or more second planned travel paths.

An advantage with this embodiment is that a communication procedure is provided which enables the first electrified mining/construction vehicle to use information from other mining/construction vehicles for optimized selection of travel paths.

- 5 In an embodiment of a first electrified mining/construction vehicle according to the second aspect, the first planned travel path and the second planned travel path comprise a task for a mining/construction vehicle.

10 An advantage with this embodiment is that also tasks besides travel paths for the mining/construction vehicles can be optimized according to the present solution.

According to a third aspect of the disclosure, the above mentioned and other objectives are achieved with a method for a control arrangement, the method comprises:

- 15 interchanging a first planned travel path for a first electrified mining/construction vehicle with a second planned travel path for a second electrified mining/construction vehicle based on a battery status of the first electrified mining/construction vehicle and/or a battery status of the second electrified mining/construction vehicle.

20 The method may be adapted in accordance with the above-mentioned embodiments of the control arrangement. The advantages of the method are the same as the advantages of the corresponding embodiments of the control arrangement.

25 According to a fourth aspect of the disclosure, the above mentioned and other objectives are achieved with a method for a first electrified mining/construction vehicle being configured to travel according to a first planned travel path for the first electrified mining/construction vehicle, the method comprises:

- 30 interchanging the first planned travel path with a second planned travel path for a second electrified mining/construction vehicle based on a battery status of the first electrified mining/construction vehicle and/or a battery status of the second electrified mining/construction vehicle; and
travelling according to the second planned travel path.

The method may be adapted in accordance with the above-mentioned embodiments of the first electrified mining/construction vehicle. The advantages of the method are

the same as the advantages of the corresponding embodiments of the first electrified mining/construction vehicle.

According to an aspect of the invention, the above mentioned and other objectives are achieved with one or more control units arranged to control the control arrangement and/or the first electrified mining/construction vehicle to carry out the methods according to any embodiment of the method aspects.

According to further aspects of the present invention, the herein described methods are implemented by use of computer program products comprising instructions which, when the programs are executed by a computer, such as e.g., a herein mentioned control unit, cause the computer to carry out the steps of the methods according to any one of the herein described embodiments.

Further applications and advantages of embodiments of the disclosure will be apparent from the following detailed description.

Brief Description of the Drawings

The appended drawings are intended to clarify and explain different embodiments of the disclosure, in which:

- Figs. 1a-b show a control arrangement according to an embodiment of the invention;
- Fig. 2 shows a control arrangement according to another embodiment of the invention;
- Fig. 3 shows signalling of a control arrangement according to an embodiment of the invention;
- Fig. 4 shows signalling of a first electrified mining/construction vehicle according to an embodiment of the invention;
- Fig. 5 shows a flow chart of a method for a control arrangement according to an embodiment of the invention;
- Fig. 6 shows a flow chart of a method for a first electrified mining/construction vehicle according to an embodiment of the invention; and
- Fig. 7 shows non-limiting examples of electrified mining/construction vehicles according to an embodiment of the invention.

Detailed Description

According to embodiments of the disclosure a control arrangement 100 for selecting travel paths for electrified mining/construction vehicles is provided. Figs. 1a-b shows the control arrangement 100 according to an embodiment of the disclosure where the control arrangement 100 is configured to interchange a first planned travel path P1 for a first electrified mining/construction vehicle 300 with a second planned travel path P2 for a second electrified mining/construction vehicle 300'. The interchanging of the planned travel paths P1, P2 is based on a battery status B1 of the first electrified mining/construction vehicle 300 and a battery status B2 of the second electrified mining/construction vehicle 300'.

With reference to Fig. 1a, at a first time T1, the first electrified mining/construction vehicle 300 is configured to travel according to the first planned travel path P1 and the second electrified mining/construction vehicle 300' is configured to travel according to the second planned travel path P2. A travel path may comprise a start position and an end position. The travel path may also comprise one or more intermediate positions between the start and end positions. A planned travel path may be understood as a travel path that has previously been determined or selected for an electrified mining/construction vehicle 300 and may therefore also be denoted a predetermined travel path. The planned travel path may have been determined using a general scheduling algorithm for one or multiple electrified mining/construction vehicles.

The first planned travel path P1 may comprise a first battery charging station 120 and the second planned travel path P2 may comprise a second battery charging station 120' in embodiments. With reference to Figs. 1a-b, the first battery charging station 120 and the second battery charging station 120' may be the same battery charging station, i.e., the first planned travel path P1 and the second planned travel path P2 may comprise or lead to the same battery charging station. However, the first battery charging station 120 and the second battery charging station 120' may in embodiments instead be different battery charging stations. The first battery charging station 120 and the second battery charging station 120' may e.g., be geographically separated, i.e., at different locations/positions, as indicated in Fig. 2. Thus, the first planned travel path P1 may in embodiments comprise a first battery charging station 120 and the second

planned travel path P2 may comprise a second battery charging station 120' different from the first battery charging station 120.

5 In embodiments, the first planned travel path P1 and the second planned travel path P2 also comprise a task for a mining/construction vehicle 300. Thus, the first planned travel path P1 may comprise one or more task to be performed by the first electrified mining/construction vehicle 300 when travelling along the first planned travel path P1 and the second planned travel path P2 may comprise one or more task to be performed by the second electrified mining/construction vehicle 300' when travelling along the
10 second planned travel path P2. Each task may comprise one or more actions to be performed by the mining/construction vehicle 300, 300'. One task may be to charge the mining/construction vehicle 300, 300' at a battery charging station 120, 120'. Other non-limiting examples of tasks are drilling, loading, carrying, moving, etc.

15 The battery status B1 of the first electrified mining/construction vehicle 300 and the battery status B2 of the second electrified mining/construction vehicle 300' may be monitored as they travel according to their respective planned travel paths P1, P2. Based on the battery status B1 of the first electrified mining/construction vehicle 300 and the battery status B2 of the second electrified mining/construction vehicle 300',
20 the control arrangement 100 interchanges the first planned travel path P1 for the first electrified mining/construction vehicle 300 with the second planned travel path P2 for the second electrified mining/construction vehicle 300'. The battery status B1 of the first electrified mining/construction vehicle 300 may e.g., indicate that the state of charge of the first electrified mining/construction vehicle 300 is too low to complete the
25 first planned travel path P1.

With the interchanging of travel paths, the first electrified mining/construction vehicle 300 and the second electrified mining/construction vehicle 300' swaps travel paths with each other. Thus, after the interchanging of travel paths at a second time T2, the
30 first electrified mining/construction vehicle 300 travels according to the second planned travel path P2 and the second electrified mining/construction vehicle 300' travels according to the first planned travel path P1, as shown in Fig. 1b. The interchanging of travel paths may be from start to end positions in one example. In another example the

travel paths are swapped after the electrified mining/construction vehicles already have started the predetermined planned travel path.

5 The control arrangement 100 may be a central controller or a distributed controller in one or more control nodes or mining/construction vehicles. The control arrangement 100 may have access to information related to travel path and battery status of a plurality of electrified mining/construction vehicles 300, e.g., a fleet of electrified mining/construction vehicles. The travel path and battery status information may be collected by the control arrangement 100 or communicated to the control arrangement 100 from the electrified mining/construction vehicles 300. The first electrified mining/construction vehicle 300 and the second electrified mining/construction vehicle 300' may e.g., report their respective battery status B1, B2 to the control arrangement 100, either directly or via one or more other vehicles or nodes. The battery status B1, B2 may e.g., be reported or collected periodically, in real-time and/or upon a request 15 from the control arrangement 100.

The control arrangement 100 may inform the first electrified mining/construction vehicle 300 and the second electrified mining/construction vehicle 300' about the interchanging of travel paths using a travel command 510. With reference to Fig. 2, the control arrangement 100 may transmit a first travel command 510 to the first electrified mining/construction vehicle 300. The first travel command 510 indicates the second planned travel path P2. The control arrangement 100 may further transmit a second travel command 510' to the second electrified mining/construction vehicle 300'. The second travel command 510' indicates the first planned travel path P1. 25

Upon receiving the first travel command 510 indicating the second planned travel path P2 from the control arrangement 100, the first electrified mining/construction vehicle 300 interchanges the first planned travel path P1 with the second planned travel path P2, as shown in Fig. 2. In the embodiment shown in Fig. 2, the second planned travel path P2 comprise the second battery charging station 120' and the first electrified mining/construction vehicle 300 travelling along the second planned travel path P2 based on the received first travel command 510 hence travels towards the second battery charging station 120'. In a similar way, upon receiving the second travel command 510' indicating the first planned travel path P1 from the control arrangement 30

100, the second electrified mining/construction vehicle 300' interchanges the second planned travel path P2 with the first planned travel path P1 and starts to travel according to the first planned travel path P1 towards the first battery charging station 120. Thus, a travel command includes necessary information so that an electrified mining/construction vehicle 300 can travel follow the indicated travel path. This information may therefore comprise location data, position data, positioning data, tracking data, timing data, synchronization data, etc.

As previously described, the interchanging of the planned travel paths P1, P2 for the first and second electrified mining/construction vehicles 300, 300' is based on their respective battery status B1, B2. The battery status B1, B2 may e.g., comprise one or more of a state-of-charge, a state-of-health, a failure indication of the battery, connected power electronics configured to supply power and of a battery control system. In embodiments, the control arrangement 100 may interchange the first planned travel path P1 with the second planned travel path P2 further based on a state-of-charge threshold value. Thus, the control arrangement 100 may compare the battery status B1 of the first electrified mining/construction vehicle 300 and/or the battery status B2 of the second electrified mining/construction vehicle 300' with the state-of-charge threshold value and determine to interchange the first planned travel path P1 with the second planned travel path P2, if the battery status B1 and/or the battery status B2 is below or above the state-of-charge threshold value. For example, the control arrangement 100 may interchange the first planned travel path P1 with the second planned travel path P2, upon determining that the battery status B1 of the first electrified mining/construction vehicle 300 is below the state-of-charge threshold value and the battery status B2 of the second electrified mining/construction vehicle 300' is above the state-of-charge threshold value, or vice versa.

In embodiments, the first planned travel path P1 comprises a first grid connection 130, and the second planned travel path P2 comprises a second grid connection 130'. The first grid connection 130 and the second grid connection 130' may be the same grid connections or different grid connections providing DC or AC power.

Fig. 2 shows an embodiment where the first grid connection 130 and the second grid connection 130' are different grid connections. In the embodiment shown in Fig. 2, the

first planned travel path P1 comprises the first battery charging station 120 connected to the first grid connection 130 and the second planned travel path P2 comprises the second battery charging station 120' connected to the second grid connection 130'. The first battery charging station 120 is different from the second battery charging station 120' and the first grid connection 130 is different from the second grid connection 130'. The charging capability of the battery charging stations 120, 120' may hence be different as the charging capability is dependent on conditions such as power availability in the respective grid connections 130, 130'.

In embodiments, the control arrangement 100 may interchange the first planned travel path P1 with the second planned travel path P2 further based on a measurement M1 of the first grid connection 130 and a measurement M2 of the second grid connection 130', as indicated in Fig. 2. A grid measurement may e.g., comprise a grid voltage, a grid current, a grid frequency, a power flow or any other parameter indicating a condition of the grid. The control arrangement 100 may obtain the measurements M1, M2 of the grid connections 130, 130' e.g., from the grid connections 130, 130' or a controller of the grid connections 130, 130', either directly or via one or more other nodes or vehicles. Based on the measurement M1 of the first grid connection 130 and the measurement M2 of the second grid connection 130', the control arrangement 100 may determine whether to interchange the first planned travel path P1 with the second planned travel path P2. In embodiments, the determination may be based on a grid voltage threshold value. Thus, the control arrangement 100 may interchange the first planned travel path P1 with the second planned travel path P2 further based on a grid voltage threshold value. The control arrangement 100 may e.g., interchange the first planned travel path P1 with the second planned travel path P2 based on a grid voltage of the first grid connection 130 and/or the second grid connection 130' being below and/or above the grid voltage threshold value.

The control arrangement 100 may consider further information/data when determining whether to interchange travel paths. In embodiments, the control arrangement 100 may interchange the first planned travel path P1 with the second planned travel path P2 further based on any parameters relating to:

- A mining operator command.
- A renewable power generation of a renewable power source.

- A fault indication of the first electrified mining/construction vehicle 300.
- A fault indication of the second electrified mining/construction vehicle 300'.
- A grid measurement.
- A grid service.

5

Thus, the control arrangement 100 may interchange the first planned travel path P1 with the second planned travel path P2 based on one or more conditions, parameters and/or triggers.

- 10 For example, a mining operator may determine to interchange the first planned travel path P1 with the second planned travel path P2 and issue a mining operator command to initiate the interchange of travel paths. Thus, the mining operator command may command two or more electrified mining/construction vehicles to swap planned travel paths e.g., based on change in operation plan. Also, the mining operator command
- 15 comprises necessary information as previously stated.

- The interchange of travel paths can further be initiated based on the power generation of a renewable source connected to the first grid connection 130 and/or the second grid connection 130'. The power generation of the renewable source may affect the
- 20 charging capability of charging stations which in turn may affect the allocation of travel paths to electrified mining/construction vehicles. For example, the change in connected renewable power generation will change the available grid power and thus the change of planned travel path can be initiated to accommodate the change in charging plan and/or grid connection plan.

25

The fault indication may e.g., indicate that an electrified mining/construction vehicle cannot finish planned tasks associated with a planned travel path. This may trigger the change of planned travel paths.

- 30 In a similar way, grid measurements and/or grid service may affect the charging capability of charging stations and hence trigger a change in travel paths for one or more electrified mining/construction vehicles. The grid measurements such as the voltage of the grid can indicate the need of change in travel path so that an electrified mining/construction vehicle can be connected to another grid point. The grid service

such as reactive support and frequency support. A request for the grid service may initiate a travel path swap so that e.g., an electrified mining/construction vehicles can travel to a charging station for providing the grid service.

5 Fig. 3 shows signalling of the control arrangement 100 for interchanging the first planned travel path P1 of the first electrified mining/construction vehicle 300 according to an embodiment of the invention. In the embodiment shown in Fig. 3, the interchanging of the first planned travel path P1 is performed based on a request and accept procedure with two or more second electrified mining/construction vehicles
10 300'. The interchanging of the first planned travel path P1 may be initiated based on a detection that the first planned travel path P1 is no longer suitable for the first electrified mining/construction vehicle 300. The first electrified mining/construction vehicle 300 may e.g., not have enough battery to complete the first planned travel path P1.

15 In step I in Fig. 3, the control arrangement 100 transmits a path interchange request 520 indicating the first planned travel path P1. The control arrangement 100 may transmit the path interchange request 520 to request and obtain information about second electrified mining/construction vehicles 300' available to take over the first planned travel path P1. The path interchange request 520 may be broadcasted or
20 transmitted directly to two or more second electrified mining/construction vehicles 300'. The path interchange request 520 may e.g., be broadcasted to a plurality of second electrified mining/construction vehicles 300' of similar type or able to perform similar tasks as the first electrified mining/construction vehicle 300. The path interchange request 520 may further be broadcasted or transmitted to second electrified
25 mining/construction vehicles 300' located in a specific area, e.g., in an area around the first electrified mining/construction vehicle 300.

In step II in Fig. 3, the control arrangement 100 receives path interchange responses 530 from two or more second electrified mining/construction vehicles 300'. Each path
30 interchange response 530 indicating a second planned travel path P2'. The two or more second electrified mining/construction vehicles 300' responding to the path interchange request 520 with the path interchange response 530 may be second electrified mining/construction vehicles 300' which are available and/or suitable for the interchange of travel paths, i.e., capable of taking over the first travel path P1. Thus,

the path interchange response 530 may be seen as a confirmation or acceptance that the second electrified mining/construction vehicle 300' can participate in the interchange of travel paths. The path interchange response 530 further indicates the second planned travel path P2' of the responding second electrified mining/construction vehicle 300', i.e., the travel path which the second electrified mining/construction vehicle 300' is currently configured to travel according to.

In step III in Fig. 3, the control arrangement 100 selects the second planned travel path P2 among the two or more second planned travel paths P2' indicated in the path interchange responses 530, i.e., the control arrangement 100 selects the travel path to be interchanged with the first planned travel path P1. The control arrangement 100 may consider one or more of the previously described factors when selecting the second planned travel path P2 among a plurality of second planned travel paths, i.e., battery status, grid measurements, a mining operator command, etc.

In step IV in Fig. 3, the control arrangement 100 transmits a first travel command 510 to the first electrified mining/construction vehicle 300. The first travel command 510 indicates the second planned travel path P2 selected in step III in Fig. 3. The control arrangement 100 may further transmit a second travel command 510' indicating the first planned travel path P1 to the second electrified mining/construction vehicle 300'.

Based on the received first travel command 510, the first electrified mining/construction vehicle 300 interchanges the first planned travel path P1 with the second planned travel path P2 indicated in the first travel command 510 in step V in Fig. 3. In a similar way, based on the received second travel command 510', the second electrified mining/construction vehicle 300 interchanges the second planned travel path P2 with the first planned travel path P1 indicated in the second travel command 510' in step VI in Fig. 3.

Figs. 1 to 3 show embodiments where the control arrangement 100 selects travel paths for electrified mining/construction vehicles and controls the interchanging of travel paths between electrified mining/construction vehicles. However, in embodiments the interchanging of travel paths may further be performed directly between electrified mining/construction vehicles. For example, the first electrified mining/construction

vehicle 300 may be configured to control the interchanging of its travel path with the travel path of another electrified mining/construction vehicle.

According to embodiments of the disclosure the first electrified mining/construction vehicle 300 is therefore configured to interchange the first planned travel path P1 according to which it is travelling with a second planned travel path P2 for a second electrified mining/construction vehicle 300' based on the battery status B1 of the first electrified mining/construction vehicle 300 and the battery status B2 of the second electrified mining/construction vehicle 300'. After the interchanging, the first electrified mining/construction vehicle 300 travels according to the second planned travel path P2.

In addition to battery status, the first electrified mining/construction vehicle 300 may interchange the first planned travel path P1 with the second planned travel path P2 based on one or more of the parameters and triggers described above with reference to the control arrangement 100. The first electrified mining/construction vehicle 300 may hence interchange the first planned travel path P1 with the second planned travel path P2 further based on a state-of-charge threshold value and/or a grid voltage threshold value. The first electrified mining/construction vehicle 300 may further interchange the first planned travel path P1 with the second planned travel path P2 based on any of: a mining operator command, a renewable power generation of a renewable power source, a fault indication of the first electrified mining/construction vehicle 300, a fault indication of the second electrified mining/construction vehicle 300', a grid measurement, and a grid service. The grid measurements may comprise a measurement M1 of the first grid connection 130 and a measurement M2 of the second grid connection 130'.

Furthermore, the first planned travel path P1 and the second planned travel path P2 may correspond to the first planned travel path P1 and the second planned travel path P2 described with reference to Fig. 1 and 2. Thus, the first planned travel path P1 may comprise a first battery charging station 120 and the second planned travel path P2 may comprise a second battery charging station 120', where the first battery charging station 120 and the second battery charging station 120' may be the same battery charging station or different battery charging stations. The first planned travel path P1

may comprise a first grid connection 130 and the second planned travel path P2 comprises a second grid connection 130', where the first grid connection 130 and the second grid connection 130' are the same grid connection or different grid connections. In addition, the first planned travel path P1 and the second planned travel path P2 may comprise a task for a mining/construction vehicle.

Fig. 4 shows signalling of the first electrified mining/construction vehicle 300 for interchanging the first planned travel path P1 according to an embodiment of the invention. The first electrified mining/construction vehicle 300 is configured to travel according to the first planned travel path P1 but may based on one or more of the above-described factors determine that the first planned travel path P1 is no longer suitable or possible for the first electrified mining/construction vehicle 300. The first electrified mining/construction vehicle 300 may e.g., not have enough battery charge for the first planned travel path P1.

In step I in Fig. 4, the first electrified mining/construction vehicle 300 transmits a path interchange request 520 indicating the first planned travel path P1. The first electrified mining/construction vehicle 300 may transmit the path interchange request 520 to request and obtain information about second electrified mining/construction vehicles 300' available to take over the first planned travel path P1. The path interchange request 520 may be broadcasted or transmitted directly to two or more second electrified mining/construction vehicles 300'. The path interchange request 520 may e.g., be broadcasted to a plurality of second electrified mining/construction vehicles 300' of similar type or able to perform similar tasks as the first electrified mining/construction vehicle 300. The path interchange request 520 may further be broadcasted or transmitted to second electrified mining/construction vehicles 300' located in a specific area, e.g., in an area around the first electrified mining/construction vehicle 300.

In step II in Fig. 4, the first electrified mining/construction vehicle 300 receives path interchange responses 530 from two or more second electrified mining/construction vehicles 300'. Each path interchange response 530 indicating a second planned travel path P2'. The two or more second electrified mining/construction vehicles 300' responding to the path interchange request 520 with the path interchange response

530 may be second electrified mining/construction vehicles 300' which are available and/or suitable for the interchange of travel paths, e.g., capable of taking over the first travel path P1. Thus, the path interchange response 530 may be seen as a confirmation or acceptance that the second electrified mining/construction vehicle 300' can participate in the interchange of travel paths. The path interchange response 530 further indicates the second planned travel path P2' of the responding second electrified mining/construction vehicle 300', i.e., the travel path which the second electrified mining/construction vehicle 300' is currently configured to travel according to.

In step III in Fig. 4, the first electrified mining/construction vehicle 300 selects the second planned travel path P2 among the two or more second planned travel paths P2', i.e., the first electrified mining/construction vehicle 300 selects the travel path to be interchanged with the first planned travel path P1. The first electrified mining/construction vehicle 300 may consider one or more of the previously described factors when selecting the second planned travel path P2, i.e., battery status, grid measurements, a mining operator command, etc.

Based on the selected second planned travel path P2, the first electrified mining/construction vehicle 300 interchanges the first planned travel path P1 with the second planned travel path P2 in step IV in Fig. 4. Thus, the first electrified mining/construction vehicle 300 starts to travel according to the second planned travel path P2.

According to an aspect of the disclosure a method 200 for the control arrangement 100 according to any of the herein described embodiments is provided. Fig. 5 shows a flow chart of the method 200. The method 200 comprises interchanging 202 a first planned travel path P1 for a first electrified mining/construction vehicle 300 with a second planned travel path P2 for a second electrified mining/construction vehicle 300' based on a battery status B1 of the first electrified mining/construction vehicle 300 and a battery status B2 of the second electrified mining/construction vehicle 300'.

According to another aspect of the disclosure a method 400 for the first electrified mining/construction vehicle 300 according to any of the herein described embodiments

is provided. The first electrified mining/construction vehicle 300 being configured to travel according to a first planned travel path P1 for the first electrified mining/construction vehicle 300. Fig. 6 shows a flow chart of the method 400. The method 400 comprises interchanging 402 the first planned travel path P1 with a second planned travel path P2 for a second electrified mining/construction vehicle 300' based on a battery status B1 of the first electrified mining/construction vehicle 300 and battery status B2 of the second electrified mining/construction vehicle 300'. The method 400 further comprises travelling 404 according to the second planned travel path P2.

According to embodiments of the invention, the control arrangement 100 and/or the first electrified mining/construction vehicle 300 may comprise or be connected to a control unit arranged to control the control arrangement 100 and/or the first electrified mining/construction vehicle 300 to carry out one or more of the steps of the method 200 and the method 400, respectively. The control unit may hence be arranged/configured/programmed with instruction to control the control arrangement 100 and/or the first electrified mining/construction vehicle 300 to perform the steps of any of the herein described embodiments.

The first electrified mining/construction vehicle 300 and/or the second electrified mining/construction vehicles 300' may be any type of electrified vehicle used in a mining and/or construction environment/site such as e.g., a drill rig, a truck, a loader, a digging machine, etc.

With reference to Fig. 7, the first electrified mining/construction vehicle 300 and/or the second electrified mining/construction vehicles 300' may e.g., be a drill rig, a loading, hauling and dumping (LHD) machine or a mine truck but is not limited thereto. The first electrified mining/construction vehicle 300 and/or the second electrified mining/construction vehicles 300' may further be the same type of vehicle or different types of vehicles.

In embodiments of the disclosure when communication is performed between the control arrangement 100 and the electrified mining/construction vehicles any suitable communication protocols and communication interfaces may be used. The

communication may be performed using wired and/or wireless communications and be based on standardised communication systems.

5 Finally, it should be understood that the disclosure is not limited to the embodiments described above, but also relates to and incorporates all embodiments within the scope of the appended independent claims.

CLAIMS

1. A control arrangement (100) for selecting travel paths for electrified mining/construction vehicles, the control arrangement (100) being configured to:

interchange a first planned travel path (P1) for a first electrified mining/construction vehicle (300) with a second planned travel path (P2) for a second electrified mining/construction vehicle (300') based on a battery status (B1) of the first electrified mining/construction vehicle (300) and/or a battery status (B2) of the second electrified mining/construction vehicle (300').

2. The control arrangement (100) according to claim 1, configured to:

transmit a first travel command (510) to the first electrified mining/construction vehicle (300), the first travel command (510) indicating the second planned travel path (P2); and/or

transmit a second travel command (510') to the second electrified mining/construction vehicle (300'), the second travel command (510') indicating the first planned travel path (P1).

3. The control arrangement (100) according to claim 1 or 2, configured to:

interchange the first planned travel path (P1) with the second planned travel path (P2) further based on a state-of-charge threshold value.

4. The control arrangement (100) according to any one of the preceding claims, wherein the first planned travel path (P1) comprises a first battery charging station (120) and the second planned travel path (P2) comprises a second battery charging station (120').

5. The control arrangement (100) according to claim 4, wherein the first battery charging station (120) and the second battery charging station (120') are the same battery charging station or different battery charging stations.

6. The control arrangement (100) according to any one of the preceding claims, wherein

the first planned travel path (P1) comprises a first grid connection (130), and

the second planned travel path (P2) comprises a second grid connection (130').

7. The control arrangement (100) according to claim 6, configured to

interchange the first planned travel path (P1) with the second planned travel path
5 (P2) further based on a measurement (M1) of the first grid connection (130) and/or a
measurement (M2) of the second grid connection (130').

8. The control arrangement (100) according to claim 7, configured to:

interchange the first planned travel path (P1) with the second planned travel path
10 (P2) further based on a grid voltage threshold value.

9. The control arrangement (100) according to any one of claims 6 to 8, wherein the
first grid connection (130) and the second grid connection (130') are the same grid
connections or different grid connections.

15

10. The control arrangement (100) according to any one of the preceding claims,
configured to:

interchange the first planned travel path (P1) with the second planned travel path
(P2) further based on any of: a mining operator command, a renewable power
20 generation of a renewable power source, a fault indication of the first electrified
mining/construction vehicle (300), a fault indication of the second electrified
mining/construction vehicle (300'), a grid measurement, and a grid service request.

11. The control arrangement (100) according to any one of the preceding claims,
25 configured to:

transmit a path interchange request (520) indicating the first planned travel path
(P1);

receive path interchange responses (530) from two or more second electrified
mining/construction vehicles (300'), each path interchange response (530) indicating
30 a second planned travel path (P2'); and

select the second planned travel path (P2) among the two or more second
planned travel paths (P2').

12. The control arrangement (100) according to any one of the preceding claims, wherein the first planned travel path (P1) and the second planned travel path (P2) comprise a task for a mining/construction vehicle.

5 13. A first electrified mining/construction vehicle (300) being configured to travel according to a first planned travel path (P1) for the first electrified mining/construction vehicle (300), and further being configured to:

interchange the first planned travel path (P1) with a second planned travel path (P2) for a second electrified mining/construction vehicle (300') based on a battery status (B1) of the first electrified mining/construction vehicle (300) and/or a battery status (B2) of the second electrified mining/construction vehicle (300'); and
10 travel according to the second planned travel path (P2).

14. The first electrified mining/construction vehicle (300) according to claim 13,
15 configured to:

interchange the first planned travel path (P1) with the second planned travel path (P2) further based on a state-of-charge threshold value.

15. The first electrified mining/construction vehicle (300) according to claim 13 or 14,
20 configured to:

interchange the first planned travel path (P1) with the second planned travel path (P2) upon receiving a first travel command (510) from a control arrangement (100), the first travel command (510) indicating the second planned travel path (P2).

25 16. The first electrified mining/construction vehicle (300) according to any one of claims 13 to 15, wherein the first planned travel path (P1) comprises a first battery charging station (120) and the second planned travel path (P2) comprises a second battery charging station (120').

30 17. The first electrified mining/construction vehicle (300) according to claim 16, wherein the first battery charging station (120) and the second battery charging station (120) are the same battery charging station or different battery charging stations.

18. The first electrified mining/construction vehicle (300) according to any one of claims 13 to 17, wherein

the first planned travel path (P1) comprises a first grid connection (130), and
the second planned travel path (P2) comprises a second grid connection (130').

5

19. The first electrified mining/construction vehicle (300) according to claim 18, configured to:

interchange the first planned travel path (P1) with the second planned travel path (P2) further based on a measurement (M1) of the first grid connection (130) and/or a
10 measurement (M2) of the second grid connection (130').

20. The first electrified mining/construction vehicle (300) according to claim 18 or 19, configured to:

interchange the first planned travel path (P1) with the second planned travel path
15 (P2) further based on a grid voltage threshold value.

21. The first electrified mining/construction vehicle (300') according to any one of claims 18 to 20, wherein the first grid connection (130) and the second grid connection (130') are the same grid connection or different grid connections.

20

22. The first electrified mining/construction vehicle (300) according to any one of claims 13 to 21, configured to:

interchange the first planned travel path (P1) with the second planned travel path (P2) further based on any of: a mining operator command, a renewable power
25 generation of a renewable power source, a fault indication of the first electrified mining/construction vehicle (300), a fault indication of the second electrified mining/construction vehicle (300'), a grid measurement, and a grid service.

23. The first electrified mining/construction vehicle (300) according to any one of claims
30 13 to 22, configured to:

transmit a path interchange request (520) indicating the first planned travel path (P1);

receive path interchange responses (530) from two or more second electrified mining/construction vehicles (300'), each path interchange response (530) indicating a second planned travel path (P2'); and

5 select the second planned travel path (P2) among the two or more second planned travel paths (P2').

24. The first electrified mining/construction vehicle (300) according to any one of claims 13 to 23, wherein the first planned travel path (P1) and the second planned travel path (P2) comprise a task for a mining/construction vehicle.

10

25. A method (200) for a control arrangement (100), the method (200) comprising:

interchanging (202) a first planned travel path (P1) for a first electrified mining/construction vehicle (300) with a second planned travel path (P2) for a second electrified mining/construction vehicle (300') based on a battery status (B1) of the first
15 electrified mining/construction vehicle (300) and/or a battery status (B2) of the second electrified mining/construction vehicle (300').

26. A method (400) for a first electrified mining/construction vehicle (300) being configured to travel according to a first planned travel path (P1) for the first electrified
20 mining/construction vehicle (300), the method (400) comprising:

interchanging (402) the first planned travel path (P1) with a second planned travel path (P2) for a second electrified mining/construction vehicle (300') based on a battery status (B1) of the first electrified mining/construction vehicle (300) and/or a battery status (B2) of the second electrified mining/construction vehicle (300'); and
25 travelling (404) according to the second planned travel path (P2).

27. A computer program with a program code for performing a method according to claim 25 or 26 when the computer program runs on a computer.

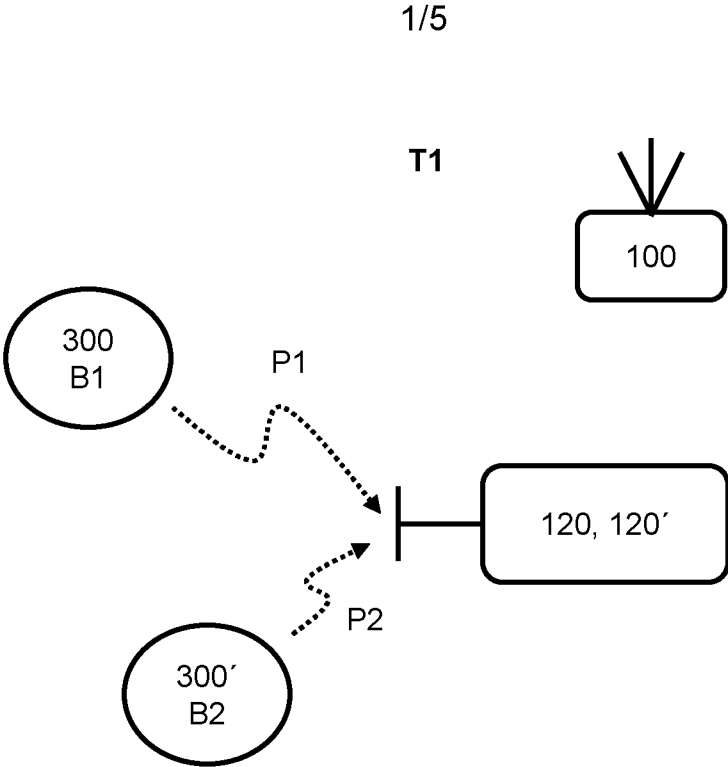


Fig. 1a

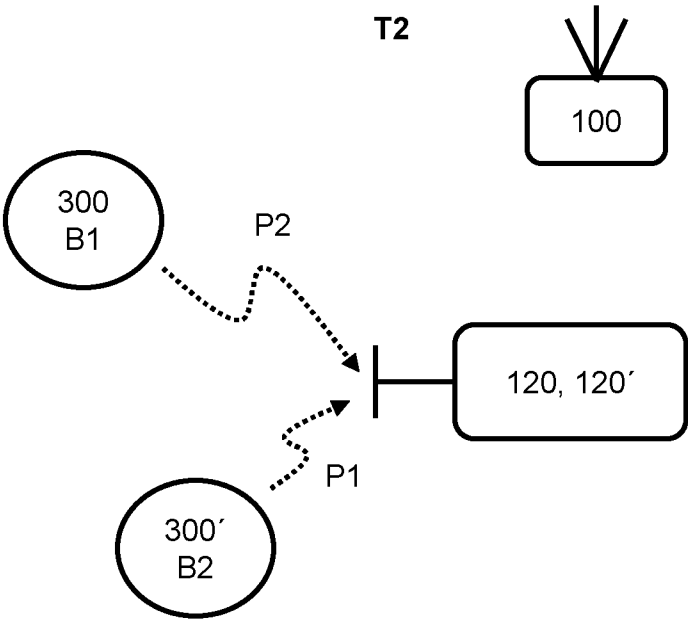
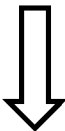


Fig. 1b

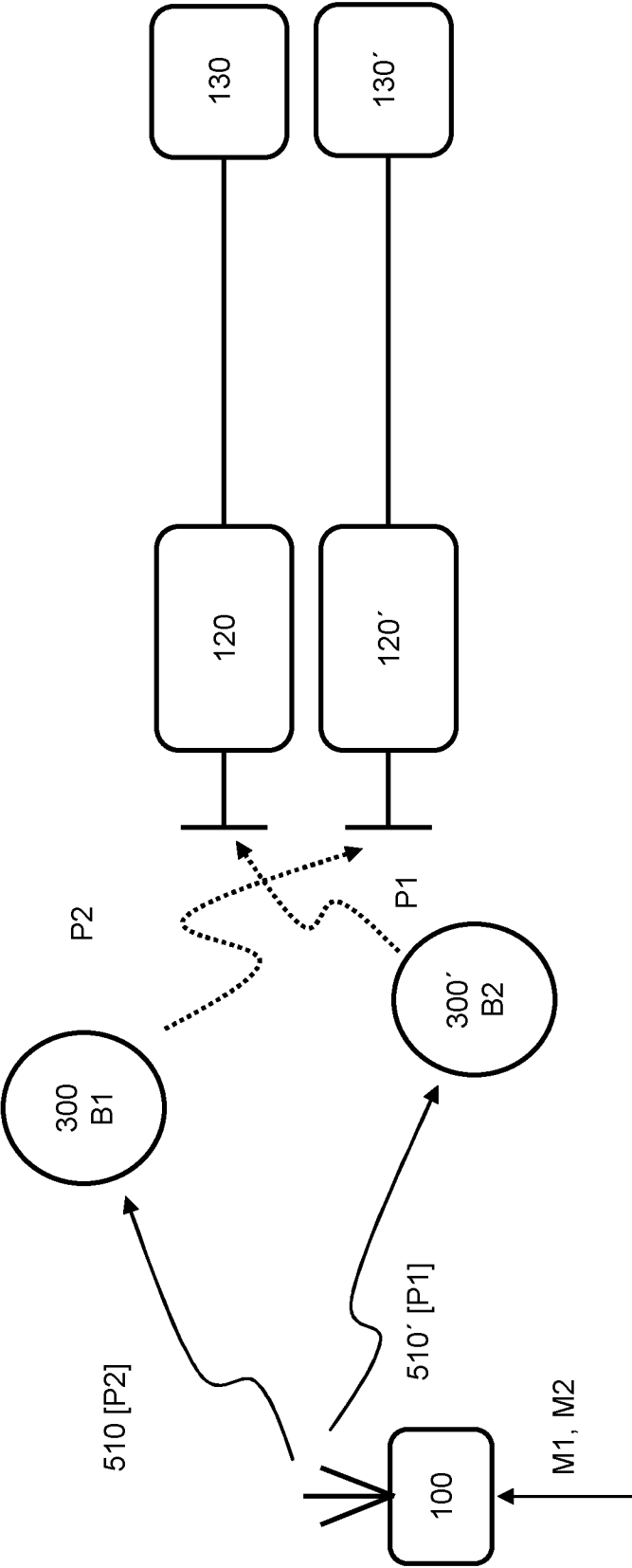
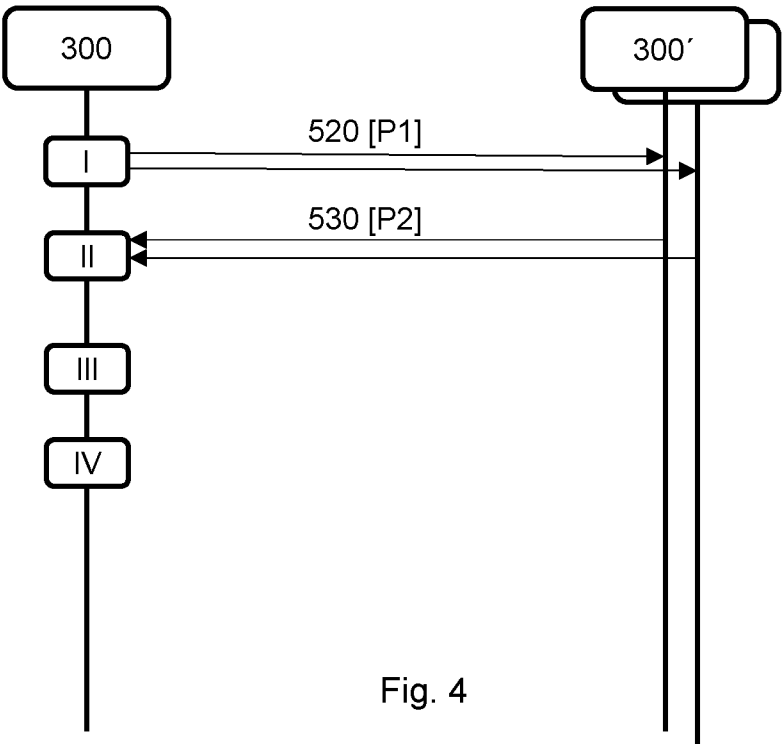
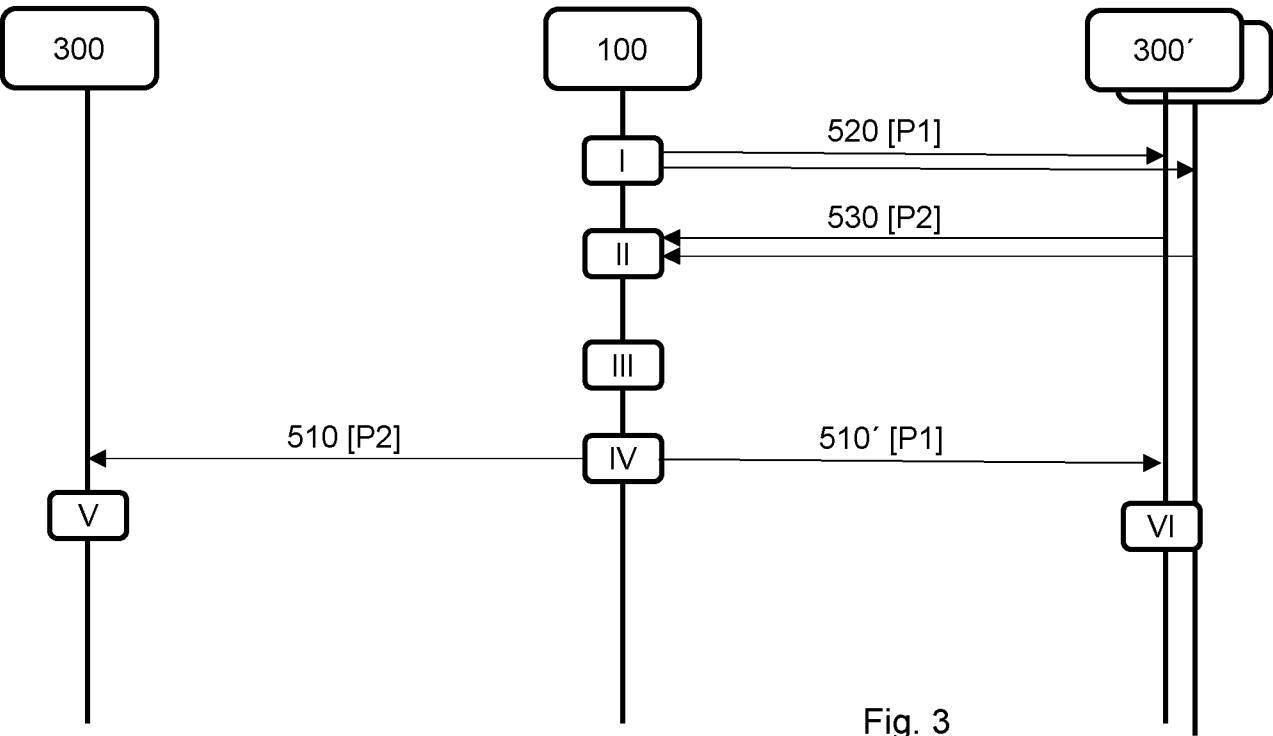


Fig. 2



4/5

200



Fig. 5

400

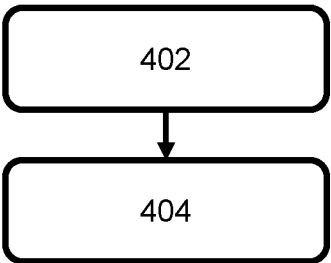


Fig. 6

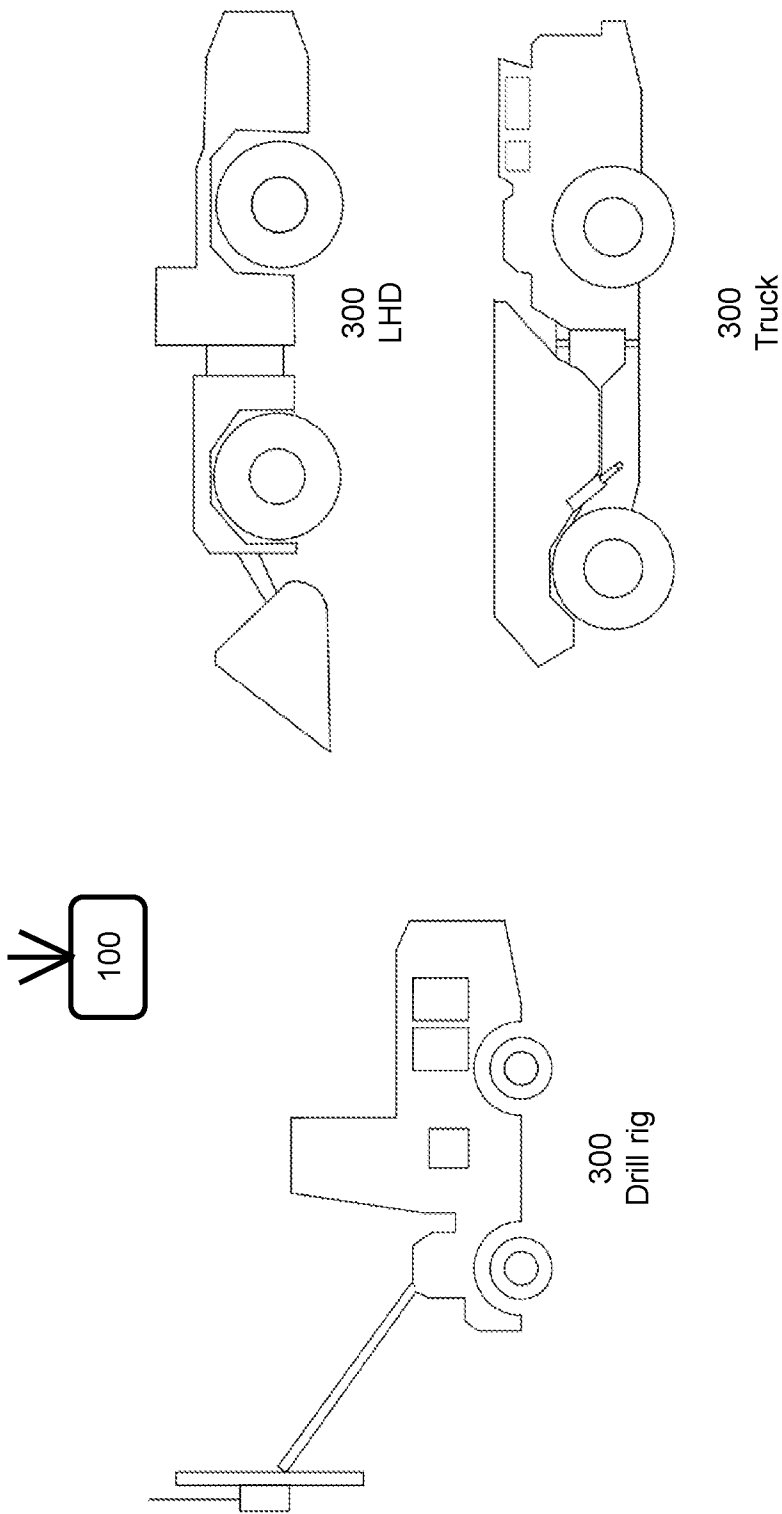


Fig. 7

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13^{ter}.1(c) and Rule 39)

Applicant's or agent's file reference P23073WO01	IMPORTANT DECLARATION	Date of mailing(day/month/year) 23 July 2024 (23-07-2024)
International application No. PCT/SE2024/050003	International filing date(day/month/year) 2 January 2024 (02-01-2024)	(Earliest) Priority date(day/month/year)
International Patent Classification (IPC) or both national classification and IPC B60L58/12 B60L15/32 B60L53/62 B60L53/67 B60W60/00		
Applicant EPIROC ROCK DRILLS AKTIEBOLAG		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below

1. ☐ The subject matter of the international application relates to:
- a. ☐ scientific theories
 - b. ☐ mathematical theories
 - c. ☐ plant varieties
 - d. ☐ animal varieties
 - e. ☐ essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes
 - f. ☐ schemes, rules or methods of doing business
 - g. ☐ schemes, rules or methods of performing purely mental acts
 - h. ☐ schemes, rules or methods of playing games
 - i. ☐ methods for treatment of the human body by surgery or therapy
 - j. ☐ methods for treatment of the animal body by surgery or therapy
 - k. ☐ diagnostic methods practised on the human or animal body
 - l. ☐ mere presentations of information
 - m. ☐ computer programs for which this International Searching Authority is not equipped to search prior art
2. ☒ The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:
- ☐ the description ☒ the claims ☐ the drawings
3. ☐ A meaningful search could not be carried out without the sequence listing; the applicant did not, within the prescribed time limit:
- ☐ furnish a sequence listing complying with WIPO Standard ST.26, and such listing was not available to the International Searching Authority in a form, language and manner acceptable to it.
 - ☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13^{ter}.1(a).

4. Further comments:

Name and mailing address of the International Searching Authority  European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040	Authorized officer MASTERSON-ZWINKELS, Claire Tel:+31 (0)70 340-2010
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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 203

The reasons are specified in the annexed provisional opinion accompanying the partial search results (Form PCT/ISA/237).

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.3), should the problems which led to the Article 17(2) PCT declaration be overcome.