

{Description}

{Title of Invention}

POWER FEEDING DEVICE AND RUBBER TIRED GANTRY CRANE INCLUDING THE SAME

{Technical Field}

{0001}

The present invention relates to a power feeding device and a rubber tired gantry crane including the power feeding device.

{Background Art}

{0002}

In a container yard (see Fig. 1; details will be described later) at a port container terminal, container handling operation is performed using rubber-tired gantry cranes (hereinafter, also referred to as RTGs). The RTG includes, as its own loads, a drive electric motor to drive tires, a hoist electric motor to hoist and lower (to lift up and down) a container, a transverse movement electric motor to transversely move a trolley, and the like.

{0003}

As one of such RTGs, a hybrid RTG has been actively promoted in its commercialization in recent years.

This hybrid RTG is equipped with a power generating device (a diesel engine and a generator) and a storage battery (a secondary battery) to supply power to loads such as a drive electric motor and a hoist electric motor. The storage battery is employed mainly for the purpose of peak-cut for the generator and collection of regenerated energy generated when a container is lowered. This enables reduction in load fluctuation on the generator, resulting in reduction in size of the generator. Accordingly, a fuel efficiency improving effect is achieved.

Meanwhile, methods for further improving the fuel efficiency have been invented in which during a standby state, a generator is stopped, and the energy required for the standby operation is covered solely by a storage battery.

{0004}

In these hybrid RTG techniques, a storage battery 3 is expected to behave as follows. Specifically, the storage battery 3 should be charged when a power generating device 1 is in operation and when the energy consumed by a load such as hoist electric motor 2 is small or regenerated energy is generated from the load as shown in Fig. 10. The storage battery 3 should discharge when the energy consumed by the load is large or the power generating device 1 is at rest as shown

in Fig. 11.

That is to say, these conventional techniques do not need charge and discharge to be performed simultaneously and therefore a single storage battery constitutes the storage battery 3. Note that in Figs. 10 and 11, reference numeral 4 denotes an inverter unit formed of a combination of a converter 5 which performs AC/DC conversion with an inverter 6 which performs DC/AC conversion.

{Citation List}

{Patent Literatures}

{0005}

The following are examples of conventional art literatures disclosed regarding conventional power feeding devices of RTGs.

{Patent Literature 1} Japanese Patent Application Publication No. 2009-242088

{Patent Literature 2} Japanese Patent Application Publication No. 2009-23816

{Summary of Invention}

{Technical Problems}

{0006}

In the hybrid RTGs configured as described above based on the conventional techniques, the power generating device 1 serves as the main source of energy for operating the loads whereas the storage battery 3 is in the position of supporting the power generating device 1. Thus, size reduction of the power generating device 1 has not been achieved to the ultimate level. As a result, the logical fuel efficiency improvement rate is staying at about 60% (substantially, about 40%).

{0007}

In consideration of these facts, the inventors of the present application have been attempting to develop a fully battery-powered RTG as a clean electric RTG from which the power generating device 1 is excluded. The fully battery-powered RTG refers to an RTG in which storage batteries cover the entire operation energy required by loads and which can therefore be operated solely by the storage batteries.

To attain the goal, the storage batteries are each required to have a high output as well as extremely long lasting performance. Moreover, since the time required to charge the storage batteries inevitably becomes longer along with large increase in capacity of the storage batteries, how to efficiently charge the storage batteries is remaining as a problem.

{0008}

The present invention has been made in view of the above circumstances, and thus has an object to provide a power feeding device with which a fully battery-powered RTG or the like can be achieved, and also a rubber tired gantry crane including the power feeding device.

{Solution to Problems}

{0009}

A first aspect of the present invention provides a power feeding device which is installed on a conveying machine, includes a plurality of storage batteries, and supplies power to a load of the conveying machine from at least one of the plurality of storage batteries, the power feeding device characterized in that

the other storage battery is connected to storage battery power feeding means and thus put in a chargeable state of being charged with power supplied from the storage battery power feeding means, and the power feeding device simultaneously allows discharge of the storage battery in the discharge state and charge of the other storage battery in the chargeable state,

the power feeding device characterized by comprising storage battery switching means for repeatedly performing storage battery switching to switch the storage battery in the discharge state to the chargeable state and at the same time to switch the storage battery in the chargeable state to the discharge state.

{0010}

A second aspect of the present invention provides the power feeding device according to the first aspect of the present invention, characterized in that the storage battery switching means is configured to perform the storage battery switching either at a regular time interval, or at timing when a residual capacity of the storage battery in the discharge state reaches or falls below a threshold, the residual capacity being detected by a residual capacity detector.

{0011}

A third aspect of the present invention provides the power feeding device according to the second aspect of the present invention, characterized in that the threshold of the residual capacity of the storage battery corresponds to a residual capacity with which power large enough for the conveying machine to complete one work unit is feedable.

{0012}

A fourth aspect of the present invention provides the power feeding device

according to any one of the first to third aspects of the invention, characterized in that the storage battery power feeding means is any one of a noncontact-type power feeding system, contact-type ground power feeding equipment, and power generating equipment which is installed on the conveying machine.

{0013}

A fifth aspect of the present invention provides a rubber tired gantry crane including, as its own loads, a drive electric motor to drive a tire, a hoist electric motor to hoist and lower a conveying target, and a transverse movement electric motor to transversely move a trolley, the rubber tired gantry crane characterized by comprising the power feeding device according to any one of claims 1 to 4, the rubber tired gantry crane being configured to supply power to the loads from the storage battery in the discharge state.

{Advantageous Effects of Invention}

{0014}

The power feeding device according to the first aspect provides a power feeding device which is installed on a conveying machine, includes a plurality of storage batteries, and supplies power to a load of the conveying machine from at least one of the plurality of storage batteries. The power feeding device is characterized in that: the other storage battery is connected to storage battery power feeding means and thus put in a chargeable state where the other storage battery is charged with power supplied from the storage battery power feeding means, and the power feeding device simultaneously allows discharge of the storage battery in the discharge state and charge of the other storage battery in the chargeable state; and the power feeding device comprises storage battery switching means for repeatedly performing storage battery switching to switch the storage battery in the discharge state to the chargeable state and at the same time to switch the storage battery in the chargeable state to the discharge state. Since charge and discharge can be performed simultaneously, it is possible to achieve a conveying machine (e.g., fully battery-powered RTG) in which the storage batteries cover the entire operation energy (power) required by the load of the conveying machine and which can therefore be operated solely by the storage batteries.

In addition, large reduction in size of the storage battery power feeding means is possible. This is because in the storage battery power feeding means, the storage battery in the chargeable state only needs supply of energy which is the average value of the operation energy (power) required by the loads of the

conveying machine with a loss of the storage battery energy taken into consideration (added).

{0015}

The power feeding device according to the second aspect is characterized in that, in the power feeding device according to the first aspect, the storage battery switching means is configured to perform the storage battery switching either when a residual capacity of the storage battery in the discharge state reaches or falls below a threshold, or at a regular time interval, the residual capacity being detected by a residual capacity detector. Thus, the storage battery switching can be performed at an appropriate timing in a simple manner.

{0016}

The power feeding device according to the third aspect is characterized in that, in the power feeding device according to the second aspect, the threshold of the residual capacity of the storage battery corresponds to a residual capacity with which power large enough for the conveying machine to complete one work unit is feedable. Thus, the storage battery switching can be performed whenever the residual capacity of the storage battery in the discharge state reaches or falls below the residual capacity with which power large enough for the conveying machine to complete one work unit is feedable.

{0017}

The power feeding device according to the fourth aspect is characterized in that, in the power feeding device according to any one of the first to third aspects, the storage battery power feeding means is any one of a noncontact-type power feeding system, contact-type ground power feeding equipment, and power generating equipment which is installed on the conveying machine. Thus, large reduction in size of the noncontact-type power feeding system, the contact-type ground power feeding equipment, or the power generating equipment is possible. Thereby, it is possible to achieve a conveying machine (e.g., fully battery-powered RTG) which can be operated solely by the storage batteries. In particular, a noncontact-type ground feeding type fully battery-powered RTG, which is considered to have the highest future potential, can be achieved using a noncontact-type power feeding system for which a large capacity is difficult to achieve.

{0018}

The rubber tired gantry crane according to the fifth aspect includes, as its loads, a drive electric motor to drive a tire, a hoist electric motor to hoist

and lower a conveying target, and a transverse movement electric motor to transversely move a trolley. The rubber tired gantry crane is characterized by comprising the power feeding device according to any one of the first to fourth aspects and being configured to supply power to the loads from the storage battery in the discharge state in the power feeding device. Thus, large reduction in size of the storage battery power feeding means (a noncontact-type power feeding system, contact-type ground power feeding equipment, power generating equipment, or the like) is possible. Thereby, it is possible to achieve a fully battery-powered RTG which can be operated solely by the storage batteries.

{Brief Description of Drawings}

{0019}

{Fig. 1} Fig. 1 is a view showing a configuration example of a general container yard to which a rubber tired gantry crane according to an embodiment of the present invention is applied.

{Fig. 2} Fig. 2 is an enlarged perspective view of the rubber tired gantry crane according to the embodiment of the present invention.

{Fig. 3} Fig. 3 is a diagram showing a configuration of and charge and discharge states in a power feeding device of the rubber tired gantry crane according to the embodiment of the present invention.

{Fig. 4} Fig. 4 is a diagram showing the configuration of and charge and discharge states in the power feeding device of the rubber tired gantry crane according to the embodiment of the present invention.

{Fig. 5} Fig. 5 is a diagram showing a different configuration of and charge and discharge states in the power feeding device of the rubber tired gantry crane according to the embodiment of the present invention.

{Fig. 6} Fig. 6 is a diagram showing the different configuration of and charge and discharge states in the power feeding device of the rubber tired gantry crane according to the embodiment of the present invention.

{Fig. 7} Fig. 7 is a diagram showing a configuration of and charge and discharge states in a power feeding device of a rubber tired gantry crane according to a reference example.

{Fig. 8} Fig. 8 is a diagram showing the configuration of and charge and discharge states in the power feeding device of the rubber tired gantry crane according to the reference example.

{Fig. 9} Fig. 9 is a chart showing how energy is consumed and generated during

container handling by the rubber tired gantry crane of the embodiment.

{Fig. 10} Fig. 10 is a diagram showing a configuration of and charge and discharge states in a power feeding device of a conventional rubber tired gantry crane.

{Fig. 11} Fig. 11 is a diagram showing the configuration of and charge and discharge states in the power feeding device of the conventional rubber tired gantry crane.

{Description of Embodiments}

{0020}

Embodiments of the present invention will be described below in detail based on the drawings.

{0021}

First, a configuration of a general container yard to which a rubber tired gantry crane according to an embodiment of the present invention is applied will be described based on Fig. 1.

As shown in Fig. 1, a container ship 12 is moored at a quay of a port container terminal 11. Containers 13 loaded on the container ship 12 are unloaded by gantry cranes (hereinafter, also referred to as GCs) 14 provided at the quay, and then loaded on automated guided vehicles (hereinafter, also referred to as AGVs) running automatically in a container yard 15. The containers 13 loaded on the AGVs 16 are transferred by the AGVs 16 to corresponding container storage sections 17 in the container yard 15.

Rubber tired gantry cranes (RTG) 18 of this embodiment are placed in each container storage section 17 in the container yard 15. By cargo handling operation of the RTGs 18, the containers 13 transferred by the AGVs 16 are placed at desired positions in the container storage sections 17.

{0022}

Meanwhile, in a case of loading containers 13 on the container ship 12, the containers 13 placed in the container storage sections 17 are loaded on the AGVs 16 by cargo handling operation of the RTGs 18. The containers 13 loaded on the AGVs 16 are transferred to the GCs 14 by the AGVs 16 and loaded on the container ship 12 by cargo handling operation of the GCs 14.

{0023}

An outline of the RTG 18 will be described next based on Fig. 2.

As shown in Fig. 2, the RTG 18 includes a gate-shaped gantry 21 formed by

integrally connecting horizontally-extended two beams 21A to four legs 21B provided at both sides of the beams 21A. A trolley 22 is provided over the beams 21A, and dollies 23A, 23B, 23C, and 23D are attached to lower end portions of the legs 21B, respectively. The dollies 23A, 23B, 23C, and 23D are equipped with paired tires 24A, 24B, 24C, and 24D and drive electric motors 25A, 25B, 25C, and 25D, respectively.

{0024}

Thus, the RTG 18 can move along a power feeding cable 26 laid on the container storage section 17 in the container yard 15 (i.e., along the longitudinal direction of the container storage section 17 as indicated by an arrow A) upon application of rotational drive to the tires 24A to 24D from the drive electric motors 25A to 25D. Note that, although not illustrated, the RTG 18 can turn the dollies 23A to 23D (the tires 24A to 24D) horizontally by 90 degrees. By this 90-degree turn, the RTG 18 can be moved in a direction orthogonal to the power feeding cable 26 as indicated by an arrow B and therefore displaced to another container storage section 17.

{0025}

Meanwhile, the trolley 22 is equipped with a hoist 27, a hoist electric motor 28, and a transverse movement electric motor 29. Multiple wire ropes 30 are attached to the hoist 27. A spreader 31 to lift a container 13 is attached to lower end portions of the wire ropes 30. Hence, normal or reverse rotation of the hoist 27 through application of rotational drive to the hoist electric motor 28 causes the hoist 27 to wind or unwind the wire ropes 30 and thereby hoist or lower the container 13 together with the spreader 31.

Moreover, upon application of rotational drive to drive wheels (unillustrated) of the trolley 22 from the transverse movement electric motor 29, the trolley 22 moves transversely, i.e., along rails (unillustrated) of the beams 21A in the longitudinal direction of the beams 21A as indicated by an arrow C.

{0026}

A power feeding device 32 is installed on a support 21C of the gantry 21. Power is supplied from the power feeding device 32 to loads such as the electric motors 25A to 25D, 28, and 29 of the RTG 18.

{0027}

A configuration and so forth of the power feeding device 32 will be described next based on Figs. 3 and 4.

As shown in Figs. 3 and 4, the power feeding cable 26 as a primary coil is

connected to a power system (unillustrated) via a charging board 41, a ground transformer 42, and a ground high voltage board 43. Meanwhile, a noncontact-type power receiving unit 44 including a secondary coil is provided to the RTG 18. This power receiving unit 44 is disposed in such a manner as to be near the power feeding cable 26 when the RTG 18 moves along the power feeding cable 26 as indicated by the arrow A.

{0028}

In other words, in Figs. 3 and 4, a noncontact-type power feeding system of ground power feeding equipment is employed as storage battery power feeding means.

In this noncontact-type power feeding system, power supplied from the power system via the ground high voltage board 43 is transformed by the ground transformer 42 from a high voltage of 6600 V to a low voltage of 440 V. The power is then changed into a high frequency wave by the charging board 41 and thereafter supplied to the power feeding cable 26. Thus, alternating current power is obtained at the power receiving unit 44 near the power feeding cable 26 due to an effect of electromagnetic induction between the power feeding cable 26 (the primary coil) and the power receiving unit 44 (the secondary coil). Being rectified by a rectifying circuit of the power receiving unit 44, this alternating current power is converted into direct current power and then outputted.

{0029}

The direct current power thus outputted from the power receiving unit 44 (power subjected to constant current and constant voltage control) is then supplied and charged to any one of two storage batteries 45 and 46 of the power feeding device 32.

{0030}

A negative terminal 45a of the storage battery 45 is grounded. A positive terminal 45b of the storage battery 45 is connected to the power receiving unit 44 via a first contact point 47a of a storage battery switching switch 47 and also to inverter units 49, 50, 51, 52, 53, and 54 via a first contact point 48a of a storage battery switching switch 48. The inverter units 49, 50, 51, 52, 53, and 54 are formed of combinations of converters 55, 56, 57, 58, 59, and 60, which perform AC/DC conversion, with inverters 61, 62, 63, 64, 65, and 66, respectively. The positive terminal 45b of the storage battery 45 is connected to the direct current (DC) side of each of the inverters 61, 62, 63, 64, 65, and 66.

{0031}

A negative terminal 46a of the storage battery 46 is grounded. A positive terminal 46b of the storage battery 46 is connected to the power receiving unit 44 via a second contact point 47b of the storage battery switching switch 47 and also to the direct current (DC) side of each of the inverters 61, 62, 63, 64, 65, and 66 of the inverter units 49, 50, 51, 52, 53, and 54 via a second contact point 48b of the storage battery switching switch 48.

{0032}

The alternating current (AC) side of the inverter 61 is connected to the alternating-current transverse movement electric motor 29 whose capacity is for example 22 kW, via an electromagnetic switch 67. The alternating current (AC) sides of the inverters 62, 63, 64, and 65 are connected to the alternating-current drive electric motors 25A, 25B, 25C, and 25D whose capacities are for example 30 kW, via electromagnetic switches 68, 69, 70, and 71, respectively. The alternating current (AC) sides of the inverters 64 and 65 are connected also to the alternating-current hoist electric motor 28 whose capacity is for example 150 kW, via electromagnetic switches 72 and 73, respectively.

Moreover, the alternating current (AC) side of the inverter 66 is connected to various auxiliaries 76, such as an air-conditioning system and an illumination which the RTG 18 is equipped with, via a reactor 74 and a transformer 75.

{0033}

In sum, the two storage batteries 45 and 46 are connected, in parallel, to the noncontact-type power feeding system (the power receiving unit 44) via the storage battery switching switch 46 (the contact points 46a and 46b), and also connected, in parallel, to the loads (the electric motors 25A to 25D, 28 and 29 and the auxiliaries 76) of the RTG 18 via the storage battery switching switch 47 (the contact points 47a and 47b).

{0034}

Meanwhile, a residual capacity detector 78 is provided to the storage battery 45. The residual capacity detector 78 detects the residual capacity of the storage battery 45 on the basis of a detection principle such for example as monitoring of a terminal voltage of the storage battery 45, and outputs the detected signal regarding the residual capacity to a control device 77. A residual capacity detector 79 is provided to the storage battery 46. The residual capacity detector 79 detects the residual capacity of the storage battery 46 on the basis of a detection

principle such for example as monitoring of a terminal voltage of the storage battery 46, and outputs the detected signal regarding the residual capacity to the control device 77. Note that the control device 77 may be dedicated for storage battery switching or for the overall control of the RTG 18.

{0035}

The control device 77 outputs storage battery switching command signals to the storage battery switching switches 47 and 48 on the basis of the residual capacities of the storage batteries 45 and 46 detected by the residual capacity detectors 78 and 79.

The storage battery switching switch 47 performs switching of the storage battery to be connected to the noncontact-type power feeding system (the power receiving unit 44) from the storage battery 45 to the storage battery 46 or from the storage battery 46 to the storage battery 45, through opening and closing operation of the first contact point 47a and the second contact point 47b based on the storage battery switching command signal from the control device 77.

At the same time, the storage battery switching switch 48 performs switching of the storage battery to be connected to the loads (the electric motors 25A to 25D, 28, and 29 and the auxiliaries 76) of the RTG 18 from the storage battery 45 to the storage battery 46 or from the storage battery 46 to the storage battery 45, through opening and closing operation of the first contact point 48a and the second contact point 48b based on the storage battery switching command signal from the control device 77.

{0036}

The storage battery switching control by the control device 77 will be described in detail based on Figs. 3 and 4.

{0037}

Fig. 3 shows a state where the first contact point 47a of the storage battery switching switch 47 is opened and the second contact point 47b thereof is closed so that the storage battery 46 is connected to the noncontact-type power feeding system (the power receiving unit 44), whereas the first contact point 48a of the storage battery switching switch 48 is closed and the second contact point 48b thereof is opened so that the storage battery 45 is connected to the loads (the electric motors 25A to 25D, 28, and 29 and the auxiliaries 76) of the RTG 18.

During this state, the storage battery 45 is in a discharge state as indicated by an arrow D in Fig. 3, hence supplying power to the loads of the RTG 18 or being

charged with regenerated power when power is regenerated from the load such as the hoist electric motor 28. In contrast, during the state, the storage battery 46 is in a chargeable state as indicated by an arrow E in Fig. 3, hence being charged with power supplied from the noncontact-type power feeding system.

In such state, the residual capacity of the storage battery 46 increases whereas the residual capacity of the storage battery 45 decreases gradually. Then, the control device 77 outputs the storage battery switching command signals to the storage battery switching switches 47 and 48 after comparing the residual capacity of the storage battery 45 detected by the residual capacity detector 78 with a threshold and judging that the residual capacity has reached or fallen below the threshold.

{0038}

As a result, the first contact point 47a of the storage battery switching switch 47 is closed and the second contact point 47b thereof is opened, whereby the storage battery to be connected to the noncontact-type power feeding system is switched from the storage battery 46 to the storage battery 45. At the same time, the first contact point 48a of the storage battery switching switch 48 is opened and the second contact point 48b thereof is closed, whereby the storage battery to be connected to the loads of the RTG 18 is switched from the storage battery 45 to the storage battery 46.

{0039}

This switched state is shown in Fig. 4. During this state, the storage battery 46 is in the discharge state as indicated by an arrow F in Fig. 4, hence supplying power to the loads of the RTG 18 or being charged with regenerated power when power is regenerated from the load such as the hoist electric motor 28. In contrast, during this state, the storage battery 45 is in the chargeable state as indicated by an arrow G in Fig. 4, hence being charged with power supplied from the noncontact-type power feeding system.

In such state, the residual capacity of the storage battery 45 increases whereas the residual capacity of the storage battery 46 decreases gradually. Then, the control device 77 outputs the storage battery switching command signals to the storage battery switching switches 47 and 48 after comparing the residual capacity of the storage battery 46 detected by the residual capacity detector 79 with a threshold and judging that the residual capacity has reached or fallen below the threshold.

{0040}

As a result, the first contact point 47a of the storage battery switching switch 47 is opened and the second contact point 47b thereof is closed, whereby the storage battery to be connected to the noncontact-type power feeding system is switched from the storage battery 45 to the storage battery 46. At the same time, the first contact point 48a of the storage battery switching switch 48 is closed and the second contact point 48b thereof is opened, whereby the storage battery to be connected to the loads of the RTG 18 is switched from the storage battery 46 to the storage battery 45. In other words, the previous state in Fig. 3 is obtained. Here, the threshold of the residual capacity of each of the storage batteries 45 and 46 corresponds for example to a residual capacity with which power large enough for the RTG 18 to complete one work unit is feedable (one cycle of cargo handling; details will be described later).

{0041}

Afterward, the storage battery switching as above is repeated, and thus charge and discharge are always simultaneously performed.

Specifically, the storage battery switching switches 47 and 48 and the control device 77 constitute the storage battery switching means, and this storage battery switching means repeatedly performs the storage battery switching to switch the storage battery 45 (or the storage battery 46) in the discharge state to the chargeable state and at the same time to switch the storage battery 46 (or the storage battery 45) in the chargeable state to the discharge state.

Incidentally, such storage battery switching is also referred to as bank switching as it switches the storage battery 45 (or the storage battery 46) charged (accumulated) with power to the storage battery 46 (or the storage battery 45) whose residual capacity is decreased due to discharge.

{0042}

The above description has been given based on the case where storage battery switching is performed based on the detected signal regarding the residual capacity. However, the present invention is not necessarily limited to this case. For example, the storage battery switching command signals may be outputted at a regular time interval from the control device 77 to the storage battery switching switches 47 and 48. Then, the open/close states of the first contact point 47a and the second contact point 47b of the storage battery switching switch 47 as well as those of the first contact point 48a and the second contact point 48b of the storage battery

switching switch 48 may be switched based on the storage battery switching command signals. In this way, the storage battery to be connected to the noncontact-type power feeding system (i.e., the storage battery in the chargeable state) may be switched at the regular time interval from the storage battery 45 (or the storage battery 46) to the storage battery 46 (or the storage battery 45), and the storage battery to be connected to the loads of the RTG 18 (i.e., the storage battery in the discharge state) may be switched at the regular time interval from the storage battery 46 (or the storage battery 45) to the storage battery 45 (or the storage battery 46).

{0043}

Moreover, the noncontact-type power feeding system is not limited to one that produces an electromagnetic induction effect through an air gap. A power feeding system in which transformer coupling is achieved via interposition of an iron core, a microwave power transmission type power feeding system, or the like may be used as appropriate.

Also, the storage battery power feeding means is not necessarily limited to a noncontact-type power feeding system. Although not illustrated, contact-type ground power feeding equipment (e.g., a pantograph-type) may be used as the storage battery power feeding means. Even in this case, the bank switching scheme between the storage batteries 45 and 46 remains the same as that in the case of using the noncontact-type power feeding system.

{0044}

Further, as shown in Figs. 5 and 6, power generating equipment 91 may be installed on the RTG 18 (i.e., a hybrid RTG may be provided) and used as the storage battery power feeding means. The power generating equipment 91 includes an engine such as a diesel engine and a generator that generates power through application of rotational drive to the engine. Power generated by the power generating equipment 91 is subjected to AC/DC conversion by a converter 92. Then, the direct current power outputted from the converter 92 (power subjected to constant current and constant voltage control) is supplied and charged to any one of the two storage batteries 45 and 46 of the power feeding device 32. Even in this case, the bank switching scheme between the storage batteries 45 and 46 remains the same as that in the case of using the noncontact-type power feeding system.

{0045}

Fig. 5 shows a state where the first contact point 47a of the storage battery

switching switch 47 is opened and the second contact point 47b thereof is closed so that the storage battery 46 is connected to the power generating equipment 91, whereas the first contact point 48a of the storage battery switching switch 48 is closed and the second contact point 48b thereof is opened so that the storage battery 45 is connected to the loads of the RTG 18. During this state, the storage battery 45 is in the discharge state as indicated by an arrow L in Fig. 5, hence supplying power to the loads of the RTG 18 or being charged with regenerated power when power is regenerated from the load such as the hoist electric motor 28. In contrast, during the state, the storage battery 46 is in the chargeable state as indicated by an arrow M in Fig. 5, hence being charged with power supplied from the power generating equipment 91.

Fig. 6 shows a state where the first contact point 47a of the storage battery switching switch 47 is closed and the second contact point 47b thereof is opened so that the storage battery 45 is connected to the power generating equipment 91, whereas the first contact point 48a of the storage battery switching switch 48 is opened and the second contact point 48b thereof is closed so that the storage battery 46 is connected to the loads of the RTG 18. During this state, the storage battery 46 is in the discharge state as indicated by an arrow N in Fig. 6, hence supplying power to the loads of the RTG 18 or being charged with regenerated power when power is regenerated from the load such as the hoist electric motor 28. In contrast, during the state, the storage battery 45 is in the chargeable state as indicated by an arrow O in Fig. 6, hence being charged with power supplied from the power generating equipment 91.

{0046}

As described above, the power feeding device 32 of this embodiment is characterized as follows. Specifically, the power feeding device 32 is a power feeding device which includes two storage batteries 45 and 46 and supplies power to loads of an RTG 18 from any one of the two storage batteries 45 and 46 (the storage battery 45 (or the storage battery 46)). The other storage battery 46 (or the storage battery 45) is connected to storage battery power feeding means (the noncontact-type power feeding system, contact-type ground power feeding equipment, or power generating equipment 91) and hence put in a chargeable state where the storage battery 46 is charged with power supplied from the storage battery power feeding means. The power feeding device simultaneously allows discharge of the storage battery 45 (or the storage battery 46) in the discharge state and charge

of the storage battery 46 (or the storage battery 45) in the chargeable state. In addition, the power feeding device includes storage battery switching means (the storage battery switching switches 47 and 48 and the control device 77) for repeatedly performing storage battery switching to switch the storage battery 45 (or the storage battery 46) in the discharge state to the chargeable state and at the same time to switch the storage battery 46 (or the storage battery 45) in the chargeable state to the discharge state. Since charge and discharge can be performed simultaneously, it is possible to achieve a fully battery-powered RTG in which the storage batteries cover the entire operation energy (power) required by the loads of the RTG 18 and which can therefore be operated solely by the storage batteries.

In addition, large reduction in size of the storage battery power feeding means (the noncontact-type power feeding system, contact-type ground power feeding equipment, or power generating equipment 91) is possible. This is because in the storage battery power feeding means (the noncontact-type power feeding system, contact-type ground power feeding equipment, or power generating equipment 91), the storage battery in the chargeable state only needs supply of energy which is the average value of the operation energy (power) required by loads of the RTG 18 with a loss of the storage battery energy taken into consideration (added). In particular, a noncontact ground power feeding type fully battery-powered RTG 18, which is considered to have the highest future potential, can be achieved using a noncontact-type power feeding system for which a large capacity is difficult to achieve.

{0047}

Moreover, the power feeding device 32 of this embodiment is characterized in that the storage battery switching means is configured to perform the storage battery switching either when the residual capacity of the storage battery 45 (or the storage battery 46) in the discharge state, which is detected by the residual capacity detector 78 (or the residual capacity detector 79), reaches or falls below a threshold, or at a regular time interval. Thus, the storage battery switching can be performed at an appropriate timing in a simple manner.

{0048}

Furthermore, the power feeding device 32 of this embodiment is characterized in that the threshold of the residual capacity of each of the storage batteries 45 and 46 corresponds to a residual capacity with which power large enough for

the RTG 18 to complete one work unit is feedable. Thus, the storage battery switching can be performed whenever the residual capacity of the storage battery 45 (or the storage battery 46) in the discharge state reaches or falls below the residual capacity with which power large enough for the RTG 18 to complete one work unit is feedable.

{0049}

Now, advantageous effects of the present invention will be described in further detail based on Figs. 7 to 9.

When a circuit configuration of a hybrid RTG as a conventional technique is applied as is, the circuit includes a single storage battery 81 as shown in a reference example in Figs. 7 and 8. For this reason, charge and discharge cannot be performed simultaneously with the storage battery 81.

Specifically, as indicated by arrows H and I in Fig. 7, ground power feeding equipment (noncontact-type power feeding system) needs to cover load operation energy while it is charging the storage battery 81. In addition, as indicated by arrows J and K in Fig. 8, during discharge of the storage battery 81, the energy from the ground power feeding equipment (noncontact-type power feeding system) is fed to nowhere or applied as load operation energy. Supply of the energy from the ground power feeding equipment (noncontact-type power feeding system) hence fluctuates depending on the statuses of the loads and the state of the storage battery 81.

For this reason, ground power feeding equipment (noncontact-type power feeding system) with a large capacity to guarantee a peak power is needed, and as such is greatly hindering practical application thereof.

In contrast, as described above, the power feeding device 32 of this embodiment includes two storage batteries 45 and 46 and supplies power to loads of an RTG 18 from any one of the two storage batteries 45 and 46 (the storage battery 45 (or the storage battery 46)). The other storage battery 46 (or the storage battery 45) is connected to storage battery power feeding means (the noncontact-type power feeding system, contact-type ground power feeding equipment, or power generating equipment 91) and hence put in a chargeable state where the storage battery 46 (or the storage battery 45) is charged with power supplied from the storage battery power feeding means. The power feeding device 32 is configured to simultaneously allow discharge of the storage battery 45 (or the storage battery 46) in the discharge state and charge of the storage battery 46 (or the storage

battery 45) in the chargeable state. In addition, the power feeding device 32 is configured to repeatedly perform storage battery switching to switch the storage battery 45 (or the storage battery 46) in the discharge state to the chargeable state and at the same time to switch the storage battery 46 (or the storage battery 45) in the chargeable state to the discharge state. Thus, large reduction in size of a noncontact-type power feeding system is possible, whereby ground power feeding using a noncontact-type power feeding system can be achieved.

{0050}

Fig. 9 shows how the energy is consumed (indicated by power on the positive side in Fig. 9) and generated (indicated by power on the negative side in Fig. 9) during container handling operation by the RTG 18. In Fig. 9, a portion a represents energy consumption when the spreader 31 is hoisted by the hoist electric motor 28 in a steady state immediately before the spreader 31 is lowered. A portion b represents energy generation (regenerated power) when the spreader 31 is lowered by the hoist electric motor 28. A portion c represents energy consumption when a container 13 is hoisted by the hoist electric motor 28. A portion d represents energy consumption when the trolley 22 is moved transversely by the transverse electric motor 29. A portion e represents energy consumption (regenerated power) when the container 13 is lowered by the hoist electric motor 28. A portion f represents energy consumption when the spreader 31 is hoisted by the hoist electric motor 28. A portion g represents energy consumption when the RTG 18 is moved by the drive electric motors 25A to 25D. A section from the portion a to the portion g corresponds to one cycle (one work unit) of container handling.

{0051}

As shown in Fig. 9, the consumption of energy required by the loads reaches or exceeds 300 kW at maximum. It can be seen, however, that the energy consumption is only about 30 kW when averaged in terms of the one cycle of container handling. Even when an energy loss of each of the storage batteries 45 and 46 is considered in the energy (30 kW) necessary for hoisting and lowering the container as well as the transverse movement of the trolley 22 and the movement of the RTG 18 which occur in a steady cycle, steady energy supply of approximately 45 kW should presumably balance the supply and demand of energy. Accordingly, the storage batteries 45 and 46 do need to discharge peak power over 300 kW but only temporarily and only need to discharge power of approximately 30 kW on average.

{0052}

In sum, the power feeding device 32 of this embodiment is capable of sufficiently covering the operation energy as long as it is storage battery power feeding means (the noncontact-type power feeding system, contact-type ground power feeding equipment, or power generating equipment 91) capable of steadily supplying power (approximately 45 kW) which is the average (approximately 30 kW) of the energy consumed by the loads with energy losses of the storage batteries 45 and 46 taken in consideration (i.e., storage battery power feeding means capable of charging the storage batteries 45 and 46 with steady low power).

This, as a result, makes it possible to achieve a fully battery-powered RTG 18 even in a case of a noncontact-type power feeding system whose practical application has currently been considered difficult from the viewpoints of the feeding capacity and equipment cost. This noncontact ground power feeding type fully battery-powered RTG 18 is considered to have the highest future potential in terms of implementation. However, the implementation is not limited to this of course. An ultimate hybrid RTG 18 on which small power generating equipment 91 is installed or a ground power feeding type electric RTG 18 with a small capacity can be also implemented.

{0053}

Note that the above description has been given based on the case of using two storage batteries 45 and 46; however, the present invention is not limited to this, and three or more storage batteries may be used. Even when three or more storage batteries are used, the power feeding device uses at least one of the multiple (three or more) storage batteries to supply power to the loads of the RTG. The other storage batteries are connected to the storage battery power feeding means and hence put in the chargeable state where the storage batteries are charged with power supplied from the storage battery power feeding means. The power feeding device simultaneously allows discharge of the storage battery in the discharge state and charge of the storage batteries in the chargeable state. In addition, the power feeding device includes storage battery switching means which repeatedly perform storage battery switching to switch the storage battery in the discharge state to the chargeable state and at the same time to switch the storage battery in the chargeable state to the discharge state.

{0054}

Moreover, in the above description, when the ground power feeding equipment (noncontact-type power feeding system) is to feed power, the power feeding cable

is laid along the entire container storage section 17 on which the RTG 18 moves. However, the present invention is not limited to this. A certain number of points to charge the ground power feeding equipment (noncontact-type power feeding system) may be provided to the container storage section 17, the certain number corresponding to the number of cargo handling points (e.g., 10 charging points for 100 cargo handling points).

Furthermore, the power feeding device of the present invention is useful when applied to RTGs. However, the power feeding device of the present invention is also applicable to conveying machines other than RTGs (e.g., an AGV that moves in a predetermined area).

{Industrial Applicability}

{0055}

The present invention relates to a power feeding device and a rubber tired gantry crane including the power feeding device. In particular, the present invention is useful when applied to a case where a noncontact ground power feeding type fully battery-powered RTG using a noncontact-type power feeding system is to be achieved, and other cases.

{Reference Signs List}

{0056}

- 11 CONTAINER TERMINAL
- 12 CONTAINER SHIP
- 13 CONTAINER
- 14 GANTRY CRANE (GC)
- 15 CONTAINER YARD
- 16 AUTOMATED GUIDED VEHICLE (AGV)
- 17 CONTAINER STORAGE SECTION
- 18 RUBBER TIRED GANTRY CRANE (RTG)
- 21 GANTRY
- 21A BEAM
- 21B LEG
- 21C SUPPORT
- 22 TROLLEY
- 23A, 23B, 23C, 23D DOLLY
- 24A, 24B, 24C, 24D TIRE
- 25A, 25B, 25C, 25D DRIVE ELECTRIC MOTOR

26 POWER FEEDING CABLE
 27 HOIST
 28 HOIST ELECTRIC MOTOR
 29 TRANSVERSE MOVEMENT ELECTRIC MOTOR
 30 WIRE ROPE
 31 SPREADER
 32 POWER FEEDING DEVICE
 41 CHARGING BOARD
 42 GROUND TRANSFORMER
 43 GROUND HIGH VOLTAGE BOARD
 44 POWER RECEIVING UNIT
 45, 46 STORAGE BATTERY
 47 STORAGE BATTERY SWITCHING SWITCH
 47a FIRST CONTACT POINT
 48b SECOND CONTACT POINT
 48 STORAGE BATTERY SWITCHING SWITCH
 48a FIRST CONTACT POINT
 48b SECOND CONTACT POINT
 49, 50, 51, 52, 53, 54 INVERTER UNIT
 55, 56, 57, 58, 59, 60 CONVERTER
 61, 62, 63, 64, 65, 66 INVERTER
 67, 68, 69, 70, 71, 72, 73 ELECTROMAGNETIC SWITCH
 74 REACTOR
 75 TRANSFORMER
 76 AUXILIARY
 77 CONTROL DEVICE
 81 STORAGE BATTERY
 91 POWER GENERATING EQUIPMENT
 92 CONVERTER

{Claims}

{Claim 1}

A power feeding device which is installed on a conveying machine, includes a plurality of storage batteries , and supplies power to a load of the conveying machine from at least one of the plurality of storage batteries, the power feeding device characterized in that

the other storage battery is connected to storage battery power feeding means and thus put in a chargeable state of being charged with power supplied from the storage battery power feeding means , and the power feeding device simultaneously allows discharge of the storage battery in the discharge state and charge of the storage battery in the chargeable state,

the power feeding device characterized by comprising storage battery switching means for repeatedly performing storage battery switching to switch the storage battery in the discharge state to the chargeable state and at the same time to switch the storage battery in the chargeable state to the discharge state.

{Claim 2}

The power feeding device according to claim 1, characterized in that the storage battery switching means is configured to perform the storage battery switching either at a regular time interval, or at timing when a residual capacity of the storage battery in the discharge state reaches or falls below a threshold, the residual capacity being detected by a residual capacity detector.

{Claim 3}

The power feeding device according to claim 2, characterized in that the threshold of the residual capacity of the storage battery corresponds to a residual capacity with which power large enough for the conveying machine to complete one work unit is feedable.

{Claim 4}

The power feeding device according to any one of claims 1 to 3, characterized in that the storage battery power feeding means is any one of a noncontact-type power feeding system, contact-type ground power feeding equipment, and power generating equipment which is installed on the conveying machine.

{Claim 5}

A rubber tired gantry crane including, as its own loads, a drive electric motor to drive a tire, a hoist electric motor to hoist and lower a conveying target, and a transverse movement electric motor to transversely move a trolley, the rubber tired gantry crane characterized by comprising the power feeding device according to any one of claims 1 to 3, the rubber tired gantry crane being configured to supply power to the loads from the storage battery in the discharge state.

{Claim 6}

A rubber tired gantry crane including, as its own loads, a drive electric motor to drive a tire, a hoist electric motor to hoist and lower a conveying target, and a transverse movement electric motor to transversely move a trolley, the rubber tired gantry crane characterized by comprising the power feeding device according to claim 4, the rubber tired gantry crane being configured to supply power to the loads from the storage battery in the discharge state.