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(71) Applicant: **VOLVO CONSTRUCTION EQUIPMENT AB** [SE/SE]; 63185 Eskilstuna (SE).

(72) Inventor: **WILGUCKI, Marek**; Partyzantów 127/11, 51-672 Wrocław (PL).

(74) Agent: **PRINZ & PARTNER MBB PATENT- UND RECHTSANWÄLTE**; Rundfunkplatz 2, 80335 München (DE).

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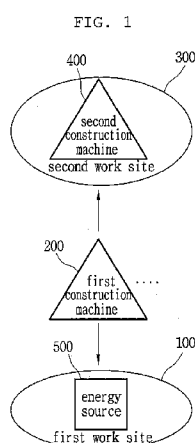
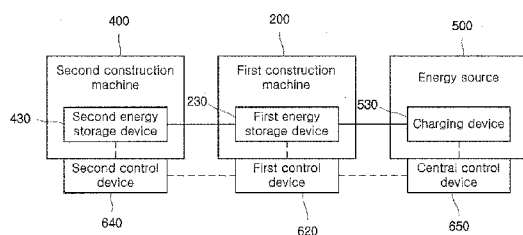


FIG. 2



(57) Abstract: The energy sharing system includes an energy source (500), a first construction machine (200) configured to carry out first mechanical work and repeatedly travel back and forth between a first work site (100) and a second work site (300) for carrying out the first mechanical work, and an energy recipient (400). The energy source provides first electrical energy to the first construction machine (200) at the first work site (100), and the first construction machine (200) provides second electrical energy to the energy recipient (400) at the second work site (300). The energy recipient includes a second construction machine (400) configured to carry out second mechanical work at the second work site (300). The energy sharing system further includes a control device (620+640+650), the control device configured to control the provision of the first electrical energy to the first construction machine (200) and the provision of the second electrical energy to the second construction machine (400). The control device includes a central control device (650) configured to control the energy source, a first control device (620) configured to control the first construction machine (200), and a second control device (640) configured to control the second construction machine (400). The central control device, the first control device and the second control device communicate and cooperate to control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine.

ENERGY SHARING SYSTEM AND METHOD

BACKGROUND

Field

[0001] The present disclosure relates to an energy sharing system and
5 method. More particularly, the present disclosure relates to a system and
method for sharing electrical energy among construction machines.

Description of Related Art

[0002] Construction machines store electrical energy therein as well as
consume stored electrical energy as it is or convert stored electrical energy into
10 mechanical energy, light energy, or the like and then consume the converted
energy. Recently, electrical construction machines as well as hybrid electrical
construction machines have been introduced onto the market, and the market
share thereof is expected to increase. Therefore, interest in technology allowing
a greater amount of electrical energy to be stored in construction machines is
15 increasing. Existing construction machines have batteries to store electrical
energy therein. However, conventional batteries are relatively expensive and
must be significantly large in order to store a large amount of energy due to the
low energy density thereof. In addition, according to conventional charging
technologies, significant amounts of time are required to charge batteries,
20 whereby the working efficiencies of construction machines may be lowered.
Furthermore, batteries are inevitably and frequently deep-discharged, so that the
lifespans thereof may be reduced due to deep-discharges.

SUMMARY

[0003] Various aspects of the present disclosure are intended to prevent the
25 battery of a construction machine from being deep-discharged by frequently
charging the battery, while minimizing the stopping of operations, of the
construction machine. Also intended is to improve the working efficiency of a

construction machine by charging the battery of the construction machine during operations to minimize the amount of time required for separately charging the battery. Also intended is to allow the battery of a construction machine to be frequently charged, so that a smaller, relatively inexpensive battery can be used.

5 [0004] According to an aspect, an energy sharing system may include: an energy source; a first construction machine configured to carry out first mechanical work and repeatedly travel back and forth between a first work site and a second work site for carrying out the first mechanical work; and an energy recipient. The energy source provides first electrical energy to the first
10 construction machine at the first work site, and the first construction machine provides second electrical energy to the energy recipient at the second work site.

[0005] The energy recipient may include a second construction machine configured to carry out second mechanical work at the second work site.

[0006] The first mechanical work may include carrying an object resulting
15 from the second mechanical work from the second work site to the first work site.

[0007] The second construction machine may include an excavator, the second mechanical work including excavating earth, and the object including the earth excavated by the second construction machine, and the first construction machine may include a dump truck, the first mechanical work including loading
20 the earth onto the dump truck at the second work site, carrying the earth from the second work site to the first work site, and unloading the earth from the dump truck at the first work site.

[0008] The first mechanical work may include carrying an object required for the second construction machine carrying out the second mechanical work from
25 the first work site to the second work site.

[0009] The energy sharing system may further include a control device, the control device configured to control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine.

30 [0010] The control device may include a central control device installed in the energy source and configured to control the energy source, a first control

device installed in the first construction machine and configured to control the first construction machine, and a second control device installed in the second construction machine and configured to control the second construction machine, and the central control device, the first control device and the second control
5 device may communicate and cooperate to control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine.

[0011] The control device may gather first data on the first construction machine and second data on the second construction machine and control the
10 provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine based on the first data and the second data.

[0012] The first data may include at least one of a first level of electrical energy remaining in the first construction machine, a first count of how many
15 times the first construction machine has been electrically deep-discharged, first machine information on the first construction machine, first work information on the first mechanical work, and a first position of the first construction machine, and the second data may include at least one of a second level of electrical energy remaining in the second construction machine, a second count of how
20 many times the second construction machine has been electrically deep-discharged, second machine information on the second construction machine, and second work information on the second mechanical work.

[0013] The first data may include the first position of the first construction machine, and when the first construction machine approaches the first work site,
25 the control device may control the energy source to prepare for the provision of the first electrical energy to the first construction machine and inform the first construction machine that the energy source is ready to supply the first electrical energy to the first construction machine.

[0014] The first data may include the first position of the first construction machine, and when the first construction machine approaches the second work
30 site, the control device may control the second construction machine to prepare for the provision of the second electrical energy to the second construction

machine and inform the first construction machine that the second construction machine is ready to receive the second electrical energy.

[0015] The first data may include the first level of electrical energy remaining in the first construction machine, the second data may include the second level of electrical energy remaining in the second construction machine, and the control device may determine an amount of the first electrical energy to be provided to the first construction machine and an amount of the second electrical energy to be provided to the second construction machine, based on at least one of the first level of electrical energy and the second level of electrical energy.

[0016] The control device may control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine such that the first construction machine avoids being deep-discharged below a predetermined level and the second construction machine avoids being deep-discharged below a predetermined level.

[0017] The control device may control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine such that the first construction machine is allowed to complete travel from the second work site to the first work site after providing the second electrical energy to the second construction machine.

[0018] The first construction machine may include at least one first construction machine; and the control device may calculate a period of time between an upcoming or current provision of the second electrical energy and the following provision of the second electrical energy, based on a travel schedule of the at least one first construction machine, and output a notice, when a maximum amount of the second electrical energy to allow the first construction machine to complete the travel from the second work site to the first work site is insufficient to allow the second construction machine to carry out the second mechanical work for the period of time, the notice notifying the insufficiency.

[0019] The first construction machine may include at least one first construction machine, and the control device may calculate a period of time between an upcoming or current provision of the second electrical energy and the following provision of the second electrical energy, based on a travel schedule of the at least one first construction machine, and output a notice, when an amount of the second electrical energy which the first construction machine provides to the second construction machine while carrying out the first mechanical work at the second work site is insufficient to allow the second construction machine to carry out the second mechanical work for the period of time, the notice notifying the insufficiency.

[0020] According to another aspect, an energy sharing method may include: a) determining whether a predetermined condition for recharging a first construction machine is satisfied, and whether a predetermined condition for recharging an energy recipient is satisfied, the first construction machine configured to carry out a first mechanical work and repeatedly travel back and forth between a first work site and a second work site for carrying out the first mechanical work, and b) controlling an energy source to provide a first electrical energy to the first construction machine at the first work site and controlling the first construction machine to provide a second electrical energy to the energy recipient at the second work site according to the determination.

[0021] The methods and apparatuses of the present disclosure have other features and advantages that will be apparent from or that are set forth in greater detail in the accompanying drawings which are incorporated herein, and in the following Detailed Description, which together serve to explain certain principles of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. 1 schematically illustrates an energy sharing system according to a first exemplary embodiment;

[0023] FIG. 2 schematically illustrates the functional correlation between components of an energy sharing system according to a second exemplary embodiment;

[0024] FIG. 3 schematically illustrates the functional correlation between components of an energy sharing system according to a third exemplary embodiment;

5 [0025] FIG. 4 is a flowchart schematically illustrating an energy sharing method according to a fourth exemplary embodiment;

[0026] FIG. 5 is a flowchart schematically illustrating an energy sharing method according to a fifth exemplary embodiment;

[0027] FIG. 6 to FIG. 8 schematically illustrate energy sharing systems according to sixth to eighth exemplary embodiments;

10 [0028] FIG. 9 schematically illustrates a principle of microwave transmissions; and

[0029] FIG. 10 schematically illustrates a principle of resonant transmissions.

DETAILED DESCRIPTION

15 [0030] Hereinafter, reference will be made to an energy sharing system and method according to the present disclosure in detail, embodiments of which are illustrated in the accompanying drawings and described below, so that a person having ordinary skill in the art to which the present disclosure relates could easily put the present disclosure into practice.

20 [0031] Throughout this document, reference should be made to the drawings, in which the same reference numerals and symbols will be used to designate the same or like components. In the following description, detailed descriptions of known functions and components incorporated herein will be omitted in the case that the subject matter of the present disclosure is rendered
25 unclear by the inclusion thereof.

[0032] An energy sharing system according to some embodiments includes an energy source, an energy recipient, and a construction machine configured to deliver electrical energy from the energy source to the energy recipient. The energy source and the energy recipient may be mobile or stationary. The
30 construction machine carries out mechanical work and repeatedly travels back

and forth between a first work site and a second work site for carrying out the mechanical work. The energy source provides first electrical energy to the construction machine at the first work site. The construction machine provides second electrical energy to the energy recipient at the second work site.

5 [0033] FIG. 1 schematically illustrates an energy sharing system according to a first exemplary embodiment.

[0034] Referring to FIG. 1, the energy sharing system includes a first construction machine 200, a second construction machine 400, and an energy source 500.

10 [0035] The first construction machine 200 serves to perform first mechanical work. The first construction machine 200 repeatedly travels back and forth between a first work site 100 and a second work site 300. Such a round trip refers not only to a case in which the first construction machine 200 travels back and forth using the same route but also to a case in which the first construction
15 machine 200 travels from the first work site 100 to the second work site 300 using one route but travels from the second work site 300 back to the first work site 100 using a different route. In addition, a case in which the first construction machine 200 performs work other than the first mechanical work on the route is not excluded. Although the round trip may be performed along the same route every
20 time, the round trip may be performed along different routes. Here, the round trip does not exclude a case in which the first construction machine 200, after having visited the first work site 100, revisits the first work site 100 without visiting the second work site 300. Likewise, a case in which the first construction machine 200, after having visited the second work site 200, revisits the second work site
25 200 without visiting the first work site 100 is not excluded. The present disclosure simply requires the first construction machine 200 to repeatedly visit the first work site and the second work site to carry out the first mechanical work. In some embodiments, the first mechanical work may be the major job assigned to the first construction machine 200. In addition, in some embodiments, the first
30 mechanical work may be related to construction-associated work.

[0036] The second construction machine 400 carries out the second mechanical work at the second work site 300. In some embodiments, the second mechanical work may be the major job assigned to the second construction

machine 400. In addition, in some embodiments, the second mechanical work may be related to construction-associated work.

[0037] The first and second construction machines 200 and 400 may be selected from among compactors, demolition equipment, dumpers, dump trucks, excavators, loaders, material transfer vehicles, milling equipment, motor graders, pavers, pipelayers, road wideners, tack distributors, and waste handlers. For example, when the first construction machine 200 is a dump truck (including an articulated hauler) and the second construction machine 400 is an excavator, the excavator may carry out excavation as the second mechanical work at the second work site 300 and the dump truck may carry out transportation as the first mechanical work, so that earth excavated by the excavator can be transported from the second work site 300 to the first work site 100.

[0038] The first construction machine 200 is recharged with first electrical energy provided at the first work site 100. The second construction machine 400 is recharged with second electrical energy provided by the first construction machine 200 at the second work site 200. Thus, the first construction machine 200 is provided with the first electrical energy at the first work site 100, travels to the second work site 300, and supplies at least a portion of the first electrical energy to the second construction machine 400 as the second electrical energy at the second work site 300. As a key feature of the present disclosure, the travel of the first construction machine 200 from the first work site 100 to the second work site 300 is carried out as a portion of the first mechanical work. This is a unique and critical feature of the present disclosure, distinct from the conventional art in which an electrical energy charging vehicle travels to a vehicle that needs to be recharged and supplies electrical energy to the vehicle. That is, the travelling is performed for the supplying of electrical energy which is irrelevant to mechanical work.

[0039] The first work site 100 refers to a site at which the first construction machine 200 carries out (a portion of) the first mechanical work and is provided with the first electrical energy by the energy source 500. The second work site 300 refers to a site at which the second construction machine 400 carries out the second mechanical work and is provided with the second electrical energy by the

first construction machine 400. Thus, the location of the second work site 100 may vary, depending on the travel of the second construction machine 400.

[0040] The provision of the first electrical energy may be performed while the first construction machine 200 is carrying out the first mechanical work at the first work site 100. The provision of the second electrical energy may be performed while the first construction machine 200 is carrying out the first mechanical work at the second work site 300.

[0041] In addition, the provision of second electrical energy may be performed while the second construction machine 400 is carrying out the second mechanical work at the second work site 300. However, the present disclosure is not limited thereto.

[0042] The first mechanical work of the first construction machine 200 is associated with dealing with an outcome resulting from the second mechanical work of the second construction machine 400. For example, after the first construction machine 200 is loaded with the outcome resulting from the second mechanical work of the second construction machine 400 at the second work site 300, the first construction machine 200 transports the loaded outcome from the second work site 300 to the first work site 100 and then unloads (or dumps) the outcome at the first work site 100. Simultaneously with, after, and/or before unloading the outcome, the first construction machine 200 may be recharged with first electrical energy provided thereto as required. After the completion of unloading and recharging, the first construction machine 200 travels to the second work site 300 in an unloaded state. When recharging is unnecessary, the first construction machine 200 may travel to the second work site 300 without being recharged. Alternatively, the first construction machine 200 may travel from the first work site 100 to the second work site 300 with a different load carried thereon instead of traveling in the unloaded state.

[0043] For example, when the first construction machine 200 is a dump truck and the second construction machine 400 is an excavator, the dump truck may be loaded with earth excavated by the excavator at the second work site 300, travel from the second work site 300 to the first work site 100, and then unload the earth at the first work site 100. In this case, the second work site 300 includes an excavation site excavated by the second construction machine 400, a

site occupied by the second construction machine, a site occupied by the first construction machine 200, positioned to be able to carry out the first mechanical work, and a site occupied by the first construction machine 200, positioned to be able to provide electrical energy to the second construction machine 400. In addition, the first work site 100 includes a site at which the earth transported by the first construction machine 200 is dumped, a site occupied by the first construction machine 200 that is positioned to be able to carry out the first mechanical work, a site occupied by the energy source 500, and a site occupied by the first construction machine 200 that is positioned to be able to be provided with electrical energy by the energy source 500.

[0044] In another example, the first work site 100 may be a construction material warehouse, while the second work site 300 may be a construction site. In this case, the first construction machine 200 may serve to transport construction materials from the construction material warehouse to the construction site, while the second construction machine 400 may be a machine that carries out construction work using construction materials transported by the first construction machine 200.

[0045] In some embodiments, the first mechanical work carried out by the first construction machine 200 and the second mechanical work carried out by the second construction machine 400 may be correlated with each other. The term "correlation" used herein includes a relationship in which an object (excluding electrical energy) inevitably accompanying specific mechanical work inevitably accompanies different mechanical work. For example, earth, inevitably accompanying excavation, is inevitably accompanied in transportation work by a dump truck, while construction materials, inevitably accompanying transportation work of a material-transporting vehicle inevitably accompany construction work.

[0046] However, in alternative embodiments, the first mechanical work and the second mechanical work may not be correlated with each other. For example, the first construction machine 200 may be a material-transporting vehicle, while the second construction machine 400 may be a paver. In this case, the first construction machine may transport materials to the second work site (for example, for use by a third construction machine located at the second

work site), regardless of the second construction machine, yet provide electrical energy to the second construction machine located at the second work site.

[0047] The provision of first electrical energy may be carried out by wired or wireless transmissions. (Examples of wireless transmissions may be microwave transmissions and/or resonant transmissions). The provision of second electrical energy may be carried out by wired transmissions or by wireless transmissions (e.g. microwave transmissions or resonant transmissions). Since wired transmissions and wireless transmissions, such as microwave transmissions (see FIG. 9) or resonant transmissions (see FIG. 10), are well-known in the art, specific descriptions thereof will be omitted.

[0048] The first construction machine 200 and the second construction machine 400 may be propelled and/or operated by an one or more electric motors, using electrical energy. The first construction machine 200 and the second construction machine 400 may be an electric construction machine and/or a hybrid electric construction machine. The electric construction machine and/or the hybrid electric construction machine carries out first or second mechanical work using electrical energy, so that a large amount of electrical energy is required. However, since conventional batteries have limitations as described above, it has been difficult to increase the distribution of electric construction machines and/or hybrid electric construction machines. In this regard, the present disclosure can efficiently reduce an amount of time required for charging, thereby promoting the distribution of electric construction machines or hybrid electric construction machines.

[0049] A plurality of first construction machine 200 may be provided. The first construction machines 200 may be construction machines carrying out the same mechanical work or two or more types of construction machines. For example, one of the first construction machines may be a dump truck, while another of the first construction machines may be a material-transporting vehicle. The amount of first electrical energy and/or the amount of second electrical energy may vary, depending on the number of the first construction machines involved in the provision of the first electrical energy and/or the second electrical energy. For example, in the case that five trucks have been initially used, in the case that one of the trucks malfunctions and only four of the trucks are operated,

the amount of electrical energy reserved in the trucks may be reduced, but the amount of electrical energy with which the excavator is charged may be increased.

5 [0050] The energy source 500 can provide first electrical energy to the first construction machine 200 at the first work site 100. The energy source 500 may be stationary or mobile. For example, the energy source 500 may be a stationary station fixedly located at the first work site 100 or a mobile station movably located at the first work site 100. Furthermore, the energy source 500 may be a charging vehicle able to travel within and outside of the first work site 100.

10 [0051] FIG. 2 schematically illustrates the functional correlation between components of an energy sharing system according to a second exemplary embodiment.

[0052] Referring to FIG. 2, solid lines relate to the provision of electrical energy, and dotted lines relate to control.

15 [0053] The provision of the first electrical energy and/or the second electrical energy may be manually initiated and/or terminated. Alternatively, the provision of the first electrical energy and/or the second electrical energy may be initiated and/or terminated under the control of a control device. The energy sharing system may include the control device. The control device may include a
20 central control device 650, a first control device 620, and a second control device 640. The first control device 620 is disposed in the first construction machine 200 to control (a first energy storage device 230) of the first construction machine 200. The second control device 640 is disposed in the second construction machine 400 to control (a second energy storage device 430) of the second
25 construction machine 400. The central control device 650 is disposed in the energy source 500 to control (a charging device 530 of) the energy source 500. Here, the central control device 650, disposed in the energy source 500, is not limited to being mechanically connected to the energy source but may be, for example, electrically connected to the energy source. In addition, the control
30 device may further include a processing device communicating and cooperating with at least one of the central control device, the first control device 620, and the second control device 640. The processing device may manage the at least one of the central control device, the first control device 620, and the second control

device 640. Alternatively, instead of or in addition to the separate processing device, at least one central control device, the first control device 620, and the second control device 640 may perform a processing function to function as a processing device.

5 [0054] In an embodiment in which the energy sharing system includes a plurality of energy sources as illustrated in FIG. 6, a plurality of central control devices may be disposed in the plurality of energy sources, respectively, and a processing device may be provided to manage all the central control devices. Alternatively, instead of or in addition to the separate processing device, one of
10 the plurality of central control devices may perform a processing function to function as a processing device.

 [0055] The first control device 620 collects first data regarding the first construction machine 200. (The first data will be described later.) The first control device 620 transmits the collected first data to the processing device (the
15 central control device 650, the first control device 620, the second control device 640 or the separate processing device performing a processing function: hereinafter, the same). In this regard, the first construction machine 200, the second construction machine 400 and the energy source 500 may have wireless communications units. The processing device processes the first data, and
20 determines whether or not the first construction machine 200 is required to be recharged based on the first data. When it is determined that the first construction machine 200 is required to be recharged, the central control device 650 controls the energy source 500 to prepare to provide energy.

 [0056] The second control device 640 collects second data regarding the
25 second construction machine 400. (The second data will be described later.) The second control device 640 transmits the collected second data to the processing device. The processing device determines whether or not the second construction machine 400 is required to be recharged. When it is determined that the second construction machine 400 is required to be recharged, the first control
30 device 620 controls the first construction machine 200 to provide the second electrical energy, and the second control device 640 controls the second construction machine 400 to receive the second electrical energy. When a plurality of first construction machines 200 are provided, the processing device

determines an available construction machine among the plurality of first construction machines 200, based on the first data, and instructs (the operator of) the available first construction machines 200 to travel to and provide energy to the second construction machine 400 that is required to be recharged.

5 [0057] The first construction machine 200 may include the first energy storage device 230. The energy source 500 provides first electrical energy to the first energy storage device 230. The first energy storage device 230 stores the first electrical energy and provides at least a portion of the stored first electrical energy to the second construction machine 400. The first energy storage device
10 230 may have high capacitance. According to some embodiments, the first energy storage device 230 may be a fast chargeable device. Thus, the first energy storage device 230 may be charged rapidly. That is, the first energy storage device 230 can receive a great amount of energy per unit time. In this case, the length of time for which energy is provided from the energy source to
15 the first energy storage device 230 can be reduced, thereby improving efficiency. In the same manner, the energy source 500 may be a fast charging device.

[0058] The second construction machine 400 may include the second energy storage device 430. The first energy storage device 230 can provide second electrical energy to the second energy storage device 430.

20 [0059] The central control device 650, the first control device 620, and the second control device 640 communicate and cooperate with each other to control the provision of first electrical energy and the provision of second electrical energy. These control devices can control energy remaining in (the first energy storage device 230 of) the first construction machine 200 so as not to drop below
25 a predetermined level, at least while the first construction machine 200 is carrying out the first mechanical work. In addition, energy remaining in (the second energy storage device 430 of) the second construction machine 400 can be controlled so as not to drop below a predetermined level, at least while the second construction machine 400 is carrying out the second mechanical work.
30 For example, the predetermined level may be 40% of the level of fully-charged energy. This can prevent the lifespan of the energy storage devices 230 and 430 from being reduced by deep-discharging, thereby achieving an effect of increasing the lifespan of the energy storage devices 230 and 430. In addition,

the size of the energy storage devices 230 and 430 can be reduced, thereby reducing the price and weight of the energy storage devices 230 and 430.

[0060] As described above, the central control device 650 controls the energy source 500 based on the first data (in relation to the provision of first electrical energy). The first data may include at least one of the level of electrical energy remaining in the first construction machine, a history of deep-discharges of (the first energy storage device 230 of) the first construction machine 200 (e.g. the number of times deep discharge has occurred), machine information on the first construction machine 200, work information on the first mechanical work carried out by the first construction machine 200, and the present position (i.e. relative or absolute position) of the first construction machine 200.

[0061] As described above, the second control device 640 collects second data regarding the second construction machine 400 and may transmit the collected second data to the first construction machine 200 to share the collected second data with the first construction machine 200. The first construction machine 200 controls the first construction machine 200 based on the second data (in relation to the provision of second electrical energy). The second data may include at least one of the level of electrical energy remaining in the second construction machine, a history of deep-discharges of (the second energy storage device 430 of) the second construction machine 400 (e.g. the number of times deep discharge has occurred), machine information on the second construction machine 400, and work information on the first mechanical work carried out by the second construction machine 400. In an alternative embodiment in which the central control device 650 functions as the processing device, the second control device may transmit the second data to the central control device 650 instead of or in addition to the first control device 620.

[0062] According to some embodiments, the control device may control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine such that the first construction machine is allowed to complete travel from the second work site to the first work site after providing the second electrical energy to the second construction machine. The control device may calculate a period of time between an upcoming or current provision of the second electrical energy

and the following provision of the second electrical energy, based on a travel schedule of the first construction machine. When a plurality of first construction machines are provided, the schedule may vary depending on the number of the first construction machines, the distance between the first work site and the second work site, and the like. When a maximum amount of the second electrical energy to allow the first construction machine to complete the travel from the second work site to the first work site is insufficient to allow the second construction machine to carry out the second mechanical work for the period of time, the control device may output a notice notifying the insufficiency. When the notice is received, displacing the energy source to a position closer to the second work site or disposing an additional energy source in a position closer to the second work site may be considered. The minimum amount of electrical energy required for the first construction machine to return to the energy source may be calculated by multiplying the distance between the first work site and the second work site by the amount of electrical energy consumed for the first construction machine to travel a unit distance. Here, the maximum amount of the second electrical energy may be calculated by subtracting the minimum amount of electrical energy from the amount of electrical energy stored in the first construction machine.

[0063] According to some embodiments, when an amount of the second electrical energy which the first construction machine can provide to the second construction machine while carrying out the first mechanical work at the second work site is insufficient to allow the second construction machine to carry out the second mechanical work for the period of time, the control device may output a notice notifying the insufficiency. Upon receiving such a notice, the operator of the first construction machine may let the first construction machine remain beside the second construction machine for a required period of time without leaving the second work site after the completion of the first mechanical work of the first construction machine, so that the first construction machine can continue to provide the second electrical energy to the second construction machine.

[0064] For example, in the case that five trucks have been initially used, in the case that one of the trucks malfunctions and only four of the trucks are operated, the control device may reduce the amount of electrical energy reserved

in the trucks but increase the amount of the second electrical energy to be provided to the excavator.

[0065] FIG. 3 schematically illustrates the functional correlation between components of an energy sharing system according to a third exemplary embodiment.

[0066] Referring to FIG. 3, the first construction machine 200 and the second construction machine 400 include position sensors 240 and 440, respectively. Sensed position information is provided to the first control device 620 and the second control device 640.

[0067] FIG. 4 is a flowchart schematically illustrating an energy sharing method according to a fourth exemplary embodiment.

[0068] To recharge the first construction machine 200, it is first determined whether or not a predetermined condition required for recharging the first construction machine 200 is satisfied. When the predetermined condition is satisfied, the first construction machine 200 is charged. Afterwards, it is determined whether or not a predetermined condition required for terminating the charging operation is satisfied.

[0069] The predetermined condition required for recharging may be satisfied simply by the first construction machine 200 coming into a chargeable position. In this case, when the first construction machine 200 approaches the energy source 500 such that the first construction machine 200 can be charged, the operation of charging the first construction machine 200 may be directly initiated, regardless of the energy level of the first construction machine 200. In addition, the predetermined condition required for terminating the charging operation may be satisfied simply by the first construction machine 200 moving away from the chargeable position. In this case, when the first construction machine 200 moves to be spaced apart from the energy source 500 such that the first construction machine 200 cannot be charged, the operation of charging the first construction machine 200 may be directly terminated, regardless of the energy level of the first construction machine 200.

[0070] In the same manner, to recharge the second construction machine 400, it is first determined whether or not a predetermined condition required for

recharging the second construction machine 400 is satisfied. When the predetermined condition is satisfied, the second construction machine 400 is charged. Afterwards, it is determined whether or not a predetermined condition required for terminating the charging operation is satisfied. When the
5 predetermined condition required for terminating the charging operation is satisfied, the charging operation is terminated.

[0071] The predetermined condition required for recharging may be satisfied simply by the second construction machine 400 arriving at a chargeable position. In this case, when the first construction machine 200 approaches the second
10 construction machine 400 such that the second construction machine 400 can be charged, the operation of charging the second construction machine 400 may be directly initiated, regardless of the energy level of the second construction machine 400. In addition, the predetermined condition required for terminating the charging operation may be satisfied simply by the second construction
15 machine 400 leaving the chargeable position. In this case, when the first construction machine 200 moves to be spaced apart from the second construction machine 400 such that second construction machine 400 cannot be charged, the operation of charging the second construction machine 400 may be directly terminated, regardless of the energy level of the second construction
20 machine 400.

[0072] FIG. 5 is a flowchart schematically illustrating an energy sharing method according to a fifth exemplary embodiment.

[0073] For example, it is determined whether or not a predetermined condition required for recharging the first construction machine 200 is satisfied, e.g. whether or not the level of energy does not exceed a predetermined level,
25 e.g. based on the level of electrical energy remaining in the first construction machine 200. When the first construction machine 200, determined to satisfy the predetermined condition, approaches the first work site 100, the central control device 650 controls the energy source 500 to prepare to charge the first
30 construction machine 200. In addition, (the operator of) the first construction machine 200 is notified that the energy source is ready for the charging. When the first construction machine 200 comes into a chargeable position, the charging is initiated. When the predetermined condition required for terminating the

charging operation is satisfied (e.g. when the first mechanical work has been terminated or when the energy level of the first construction machine 200 is equal to or higher than a predetermined level), the charging operation is terminated.

[0074] In the same manner, the provision of second electrical energy can be performed as follows.

[0075] It is determined whether or not a predetermined condition for recharging the second construction machine 400 is satisfied (e.g. based on the level of electrical energy remaining in the second construction machine 400). When the predetermined condition is satisfied, (the operator of) the first construction machine 200 that is available and is approaching the second work site 300 is notified that the second construction machine 400 needs to be recharged. In addition, (the operator of) the second construction machine 400 may be notified that the first construction machine is prepared for the charging. When the second construction machine 400 is in a chargeable position (in response to the first construction machine 200 coming close thereto), the charging is initiated. When a predetermined condition required for terminating the charging operation is satisfied (e.g. when the first mechanical work has been terminated or when the energy level of the second construction machine 400 is equal to or higher than a predetermined level), the charging operation is terminated.

[0076] FIG. 6 schematically illustrates an energy sharing system according to a sixth exemplary embodiment.

[0077] Referring to FIG. 6, the first work site includes a plurality of first work sites 101 and 102. At least two of the plurality of first work sites share the energy source and/or an earth storage site with each other. The example is that a plurality of energy sources are disposed close to one large earth storage site where a plurality of dump trucks enter and exit.

[0078] The energy source includes a plurality of energy sources 501 and 502. When the energy source 500 is comprised of the plurality of energy sources, a single central control device 650 may control all the plurality of energy sources, or a plurality of central control devices 650 controlling the respective energy sources may be provided.

[0079] The central control device 650 determines whether or not it is required to recharge the first construction machine 200. When the recharging operation is required, the central control device 650 determines an available energy source, controls the available energy source to prepare to provide first electrical energy, and informs the first construction machine 200 of the preparation.

[0080] When the first construction machine 200 returns from the second work site 300, the first construction machine 200 may not return to the previous first work site (e.g. 101) but may return to another work site (e.g. 102) to be provided with first electrical energy. Here, the first work site to which the first construction machine is to travel is determined by the control device. (According to embodiments, the central control device or the first control device 620 may determine a specific site among the first work sites to which the first construction machine is to travel.)

[0081] A specific first construction machine, after having visited a specific first work site, may visit another first work site without traveling to the second work site 300. For example, after an object A, loaded at the second work site 300, is unloaded from a specific first construction machine at a specific first work site, the specific first construction machine may travel to another first work site to have another object B loaded thereon before traveling to the second work site 300.

[0082] FIG. 7 schematically illustrates an energy sharing system according to a seventh exemplary embodiment.

[0083] Referring to FIG. 7, the second work site includes a plurality of second work sites 301 and 302. A plurality of second construction machines 400 may be provided. At least two of the second construction machines 400 may be the same type of construction machines carrying out the same mechanical work. The second construction machines 400 may be two or more different types of construction machines.

[0084] After the first construction machine 200 leaves the first work site 100, the first construction machine 200 may not travel to the previous second work site (e.g. 301) but may travel to another second work site (e.g. 302) to provide second

electrical energy to a second construction machine (e.g. 402) that is carrying out second mechanical work at the second work site 302. Here, the second work site to which the first construction machine is to travel is determined by the control device. (According to embodiments, the first control device 620 or the second control device 640 may determine a specific one of the second work sites to which the first construction machine is to travel.)

[0085] The first construction machine 200, after having visited a second work site (e.g. 302), may visit another second work site (e.g. 301) instead of traveling to the first work site 100. For example, after an object C, loaded at the first work site 100, is unloaded at a second work site (e.g. 301), the first construction machine 200 may travel to another second work site (e.g. 302) to have another object D loaded thereon before traveling to the first work site 100.

[0086] FIG. 8 schematically illustrates an energy sharing system according to an eighth exemplary embodiment.

[0087] Referring to FIG. 8, the energy sharing system includes a plurality of first work sites 100 (101, 102) and a plurality of second work sites 300 (301, 302) connected via an energy sharing network.

[0088] The number of the first construction machines 200, the number of the second construction machines 400, and the number of the energy source 500 may not correspond to each other. For example, five dump trucks may be provided as the first construction machines 200, two excavators may be provided as the second construction machines 400, and a single energy source 500 may be provided.

[0089] FIG. 9 and FIG. 10 schematically illustrate a principle of microwave transmissions and a principle of resonant transmissions that may be used in exemplary embodiments.

[0090] The foregoing descriptions of specific exemplary embodiments of the present disclosure have been presented with respect to the drawings. They are not intended to be exhaustive or to limit the present disclosure to the precise forms disclosed herein, and many modifications and variations are obviously possible for a person having ordinary skill in the art in light of the above teachings.

[0091] It is intended therefore that the scope of the present disclosure not be limited to the foregoing embodiments, but be defined by the Claims appended hereto and their equivalents.

[0092]

5 [0093] Description of Reference Numerals

[0094] 100, 101, 102 : first work site

[0095] 200 : first construction machine

[0096] 230 : first energy storage device

[0097] 240 : position sensor

10 [0098] 300, 301, 302 : second work site

[0099] 400, 401, 402 : second construction machine

[00100] 430 : second energy storage device

[00101] 440 : position sensor

[00102] 500, 501, 502 : : energy source

15 [00103] 530 : charging device

[00104] 620 : first control device

[00105] 640 : second control device

[00106] 650 : central control device

CLAIMS

1. An energy sharing system comprising:
an energy source;
5 a first construction machine configured to carry out first mechanical work and repeatedly travel back and forth between a first work site and a second work site for carrying out the first mechanical work; and
an energy recipient;
wherein the energy source provides first electrical energy to the first
10 construction machine at the first work site, and
the first construction machine provides second electrical energy to the energy recipient at the second work site.
2. The energy sharing system of claim 1,
wherein the energy recipient comprises a second construction machine
15 configured to carry out second mechanical work at the second work site.
3. The energy sharing system of claim 2,
wherein the provision of the first electrical energy to the first construction machine is performed while the first construction machine carries out the first mechanical work at the first work site, and
20 the provision of the second electrical energy to the second construction machine is performed while the first construction machine carries out the first mechanical work at the second work site.
4. The energy sharing system of claim 2,
wherein the first mechanical work comprises carrying an object resulting from
25 the second mechanical work from the second work site to the first work site.
5. The energy sharing system of claim 4,

wherein the second construction machine comprises an excavator, the second mechanical work comprising excavating earth, and the object comprising the earth excavated by the second construction machine, and

the first construction machine comprises a dump truck, the first mechanical
5 work comprising loading the earth onto the dump truck at the second work site, carrying the earth from the second work site to the first work site, and unloading the earth from the dump truck at the first work site.

6. The energy sharing system of claim 2, further comprising a control
device, the control device configured to control the provision of the first electrical
10 energy to the first construction machine and the provision of the second electrical energy to the second construction machine.

7. The energy sharing system of claim 6,

wherein the control device comprises a central control device installed in the
energy source and configured to control the energy source, a first control device
15 installed in the first construction machine and configured to control the first construction machine, and a second control device installed in the second construction machine and configured to control the second construction machine,
and

the central control device, the first control device and the second control
20 device communicate and cooperate to control the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine.

8. The energy sharing system of claim 6,

wherein the control device gathers first data on the first construction machine
25 and second data on the second construction machine and controls the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine based on the first data and the second data.

9. The energy sharing system of claim 8,

wherein the first data comprises at least one of a first level of electrical energy remaining in the first construction machine, a first count of how many times the first construction machine has been electrically deep-discharged, first machine information on the first construction machine, first work information on the first mechanical work, and a first position of the first construction machine, and

the second data comprises at least one of a second level of electrical energy remaining in the second construction machine, a second count of how many times the second construction machine has been electrically deep-discharged, second machine information on the second construction machine, and second work information on the second mechanical work.

10. The energy sharing system of claim 9,

wherein the first data comprises the first position of the first construction machine, and

when the first construction machine approaches the first work site, the control device controls the energy source to prepare for the provision of the first electrical energy to the first construction machine and informs the first construction machine that the energy source is ready to supply the first electrical energy to the first construction machine.

11. The energy sharing system of claim 9,

wherein the first data comprises the first position of the first construction machine, and

when the first construction machine approaches the second work site, the control device controls the second construction machine to prepare for the provision of the second electrical energy to the second construction machine and informs the first construction machine that the second construction machine is ready to receive the second electrical energy.

12. The energy sharing system of claim 9,

wherein the first data comprises the first level of electrical energy remaining in the first construction machine,

the second data comprises the second level of electrical energy remaining in the second construction machine, and

the control device determines an amount of the first electrical energy to be provided to the first construction machine and an amount of the second electrical energy to be provided to the second construction machine, based on at least one
5 of the first level of electrical energy and the second level of electrical energy.

13. The energy sharing system of claim 6,

wherein the control device controls the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine such that the first construction machine
10 avoids being deep-discharged below a predetermined level and the second construction machine avoids being deep-discharged below a predetermined level.

14. The energy sharing system of claim 6,

wherein the control device controls the provision of the first electrical energy to the first construction machine and the provision of the second electrical energy to the second construction machine such that the first construction machine is allowed to complete travel from the second work site to the first work site after providing the second electrical energy to the second construction machine.

20 15. The energy sharing system of claim 14,

wherein the first construction machine comprises at least one first construction machine; and

the control device

calculates a period of time between an upcoming or current provision of the second electrical energy and the following provision of the second electrical energy, based on a travel schedule of the at least one first construction machine, and
25

outputs a notice, when a maximum amount of the second electrical energy to allow the first construction machine to complete the travel from the second work site to the first work site is insufficient to allow the second construction machine
30

to carry out the second mechanical work for the period of time, the notice notifying the insufficiency.

16. The energy sharing system of claim 6,

wherein the first construction machine comprises at least one first
5 construction machine, and

the control device

calculates a period of time between an upcoming or current provision of the second electrical energy and the following provision of the second electrical energy, based on a travel schedule of the at least one first construction machine,
10 and

outputs a notice, when an amount of the second electrical energy which the first construction machine provides to the second construction machine while carrying out the first mechanical work at the second work site is insufficient to allow the second construction machine to carry out the second mechanical work
15 for the period of time, the notice notifying the insufficiency.

FIG. 1

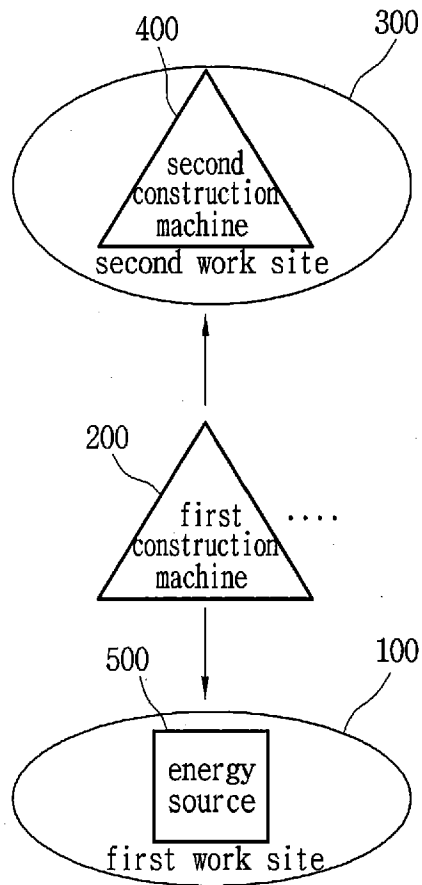


FIG. 2

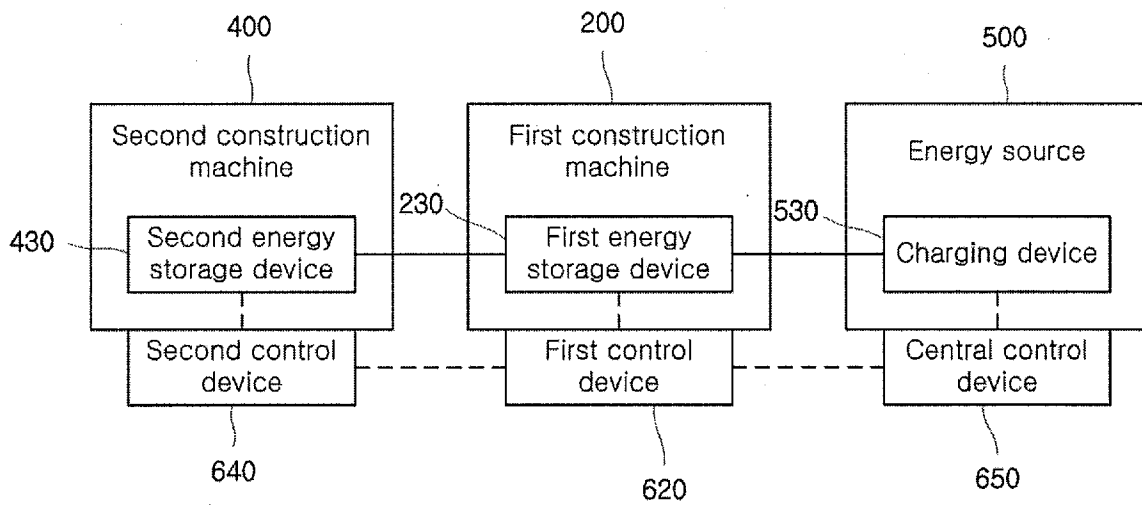


FIG. 3

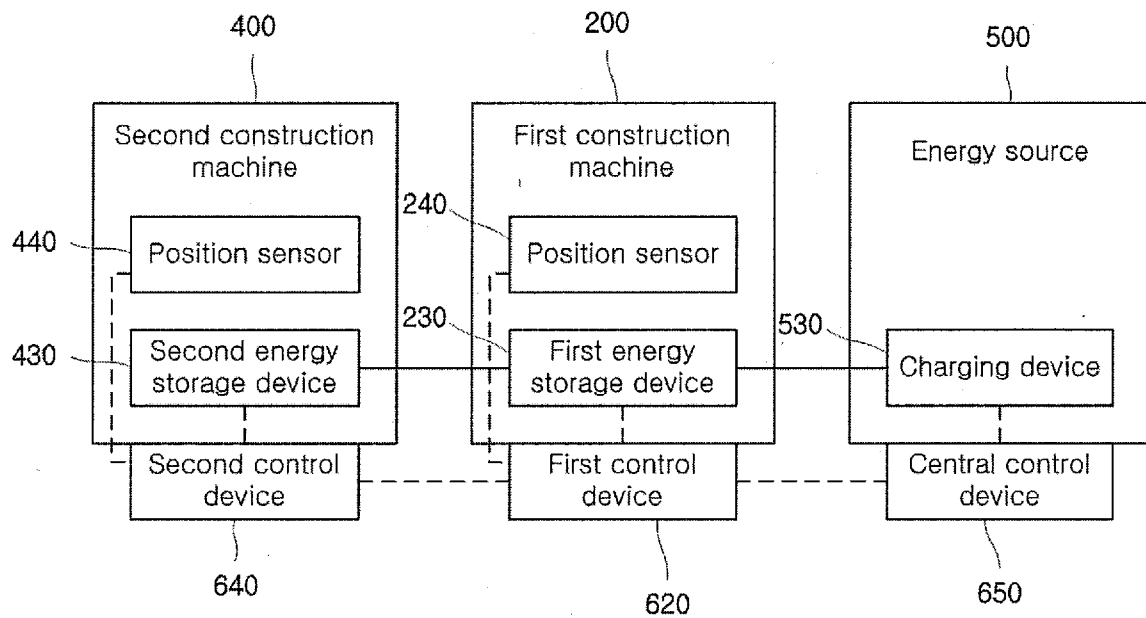


FIG. 4

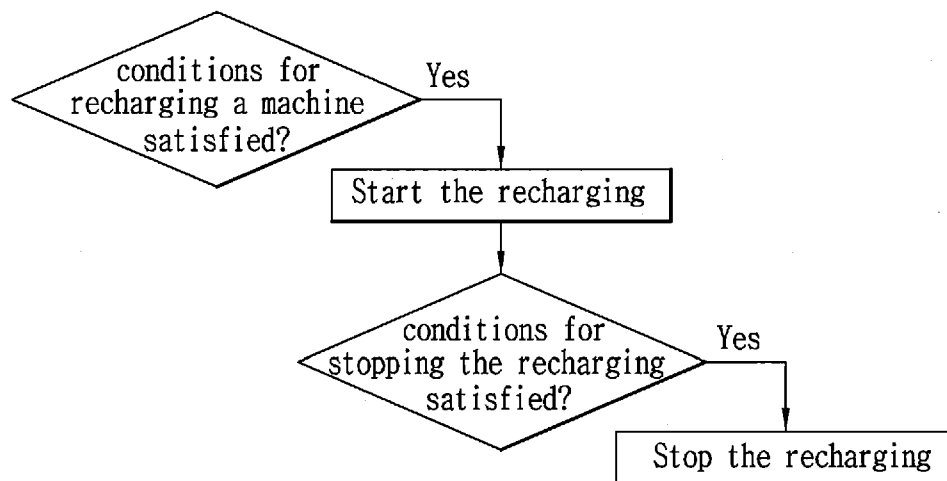


FIG. 5

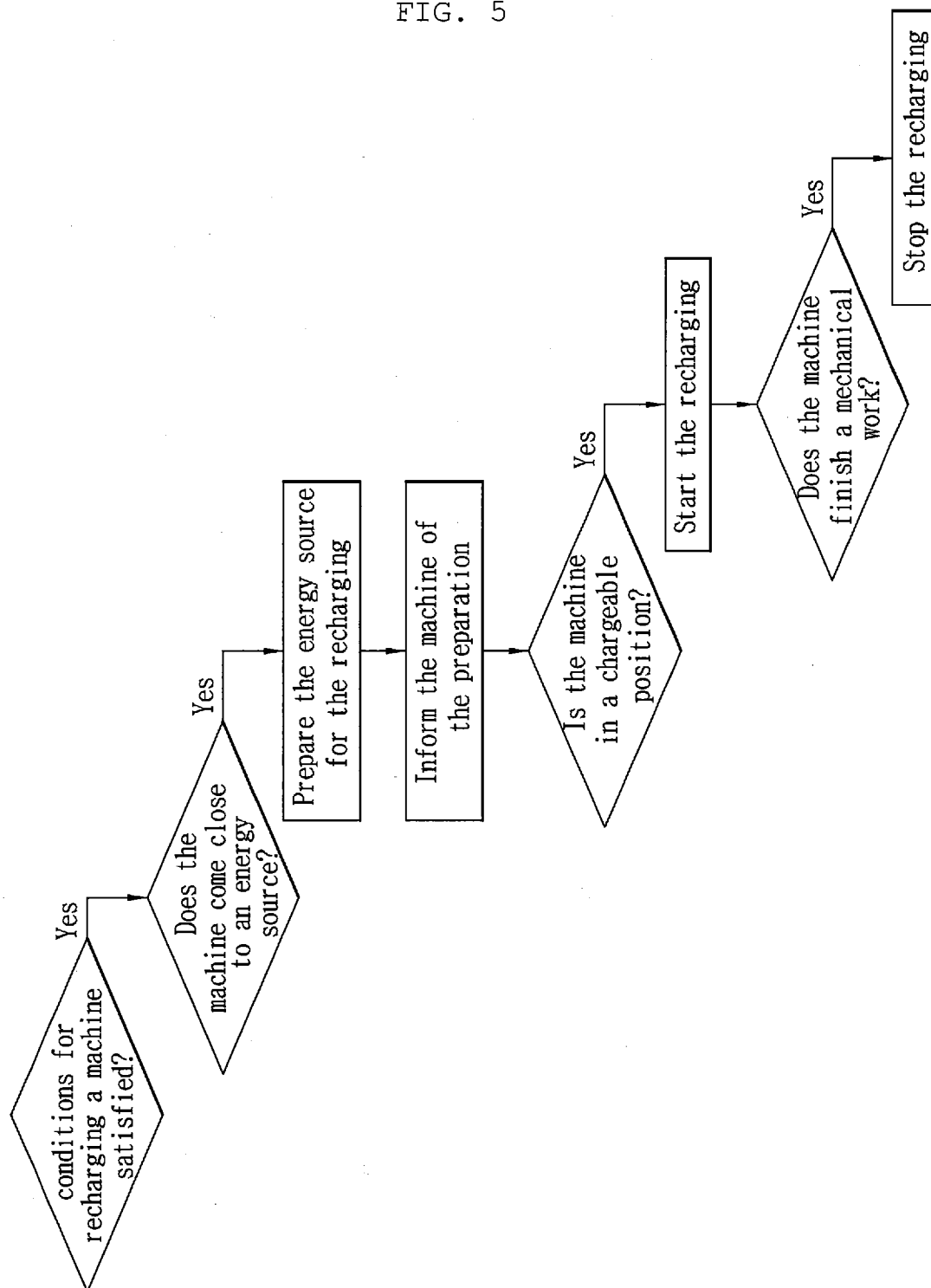


FIG. 6

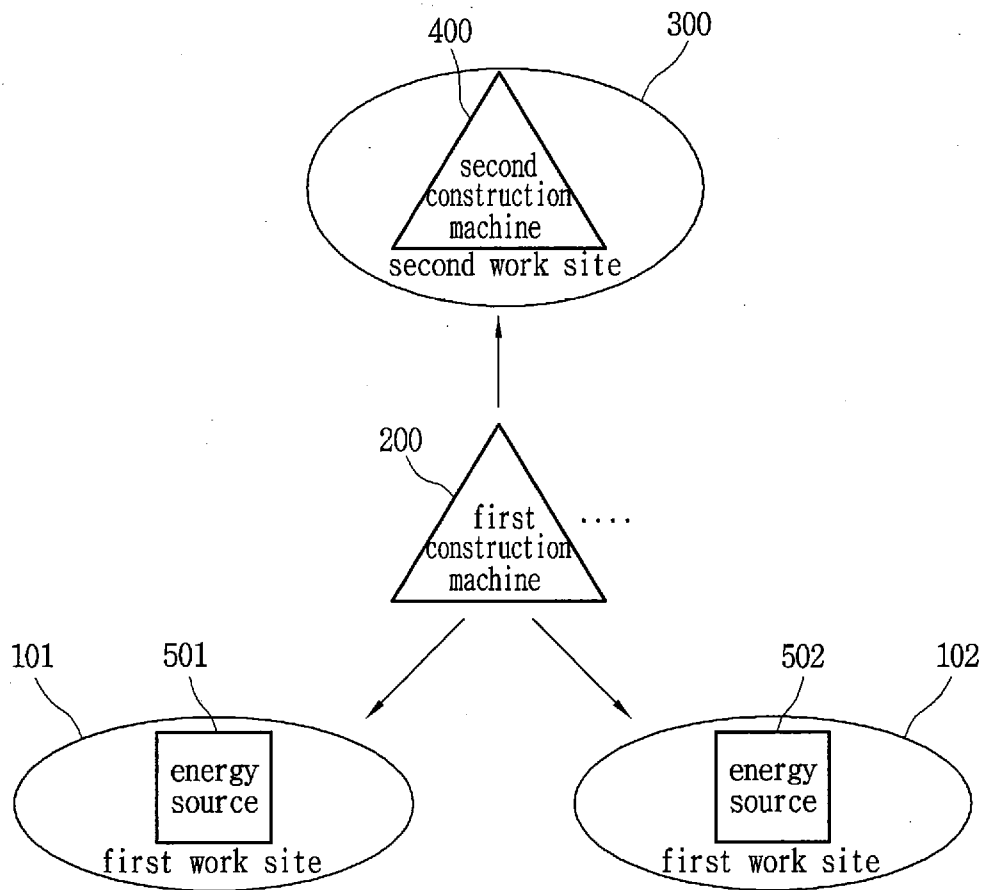


FIG. 7

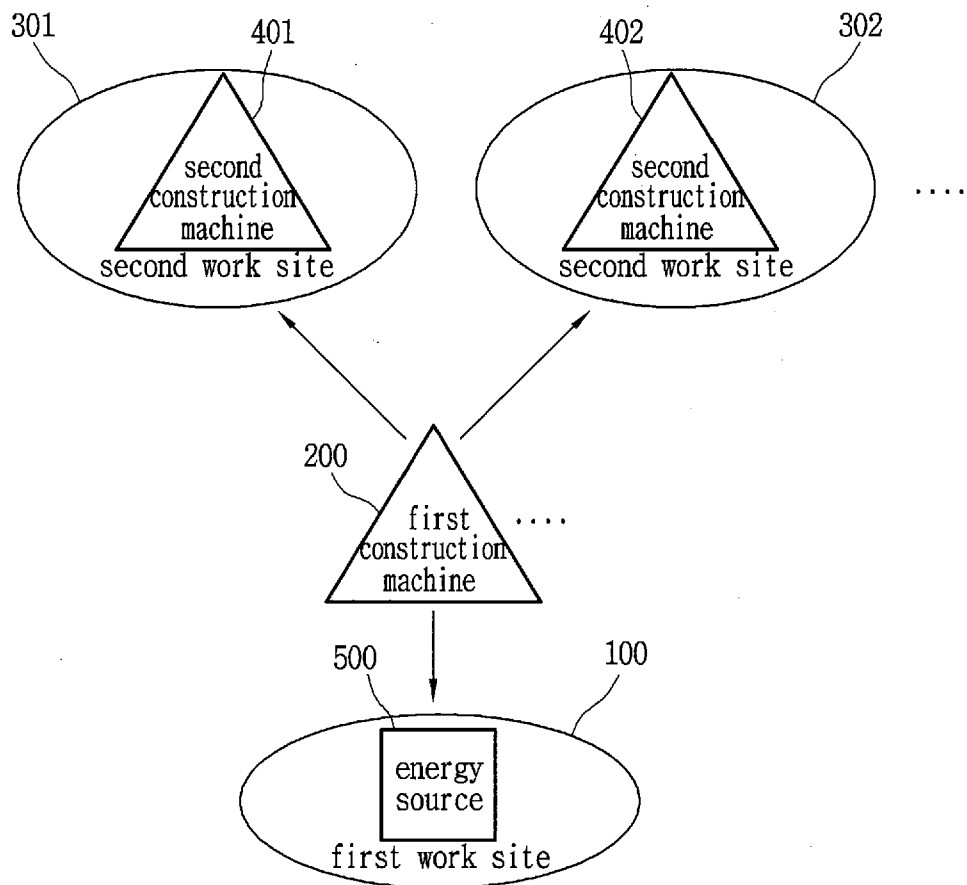


FIG. 8

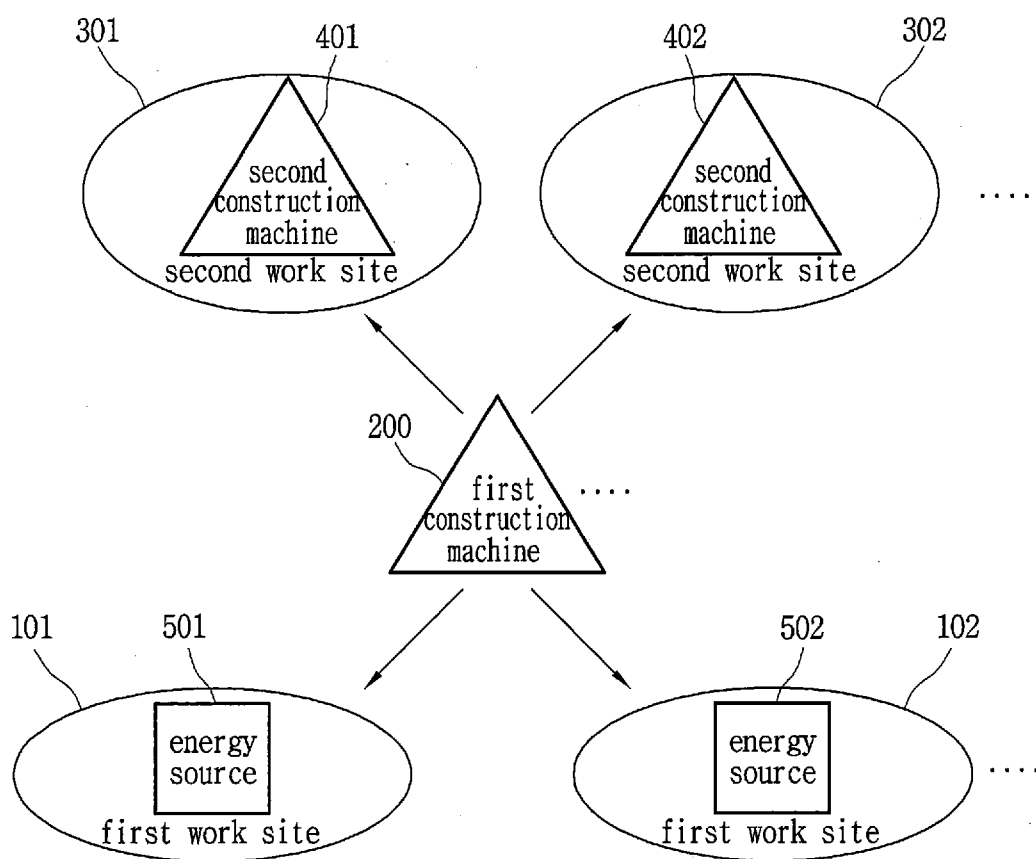


FIG. 9

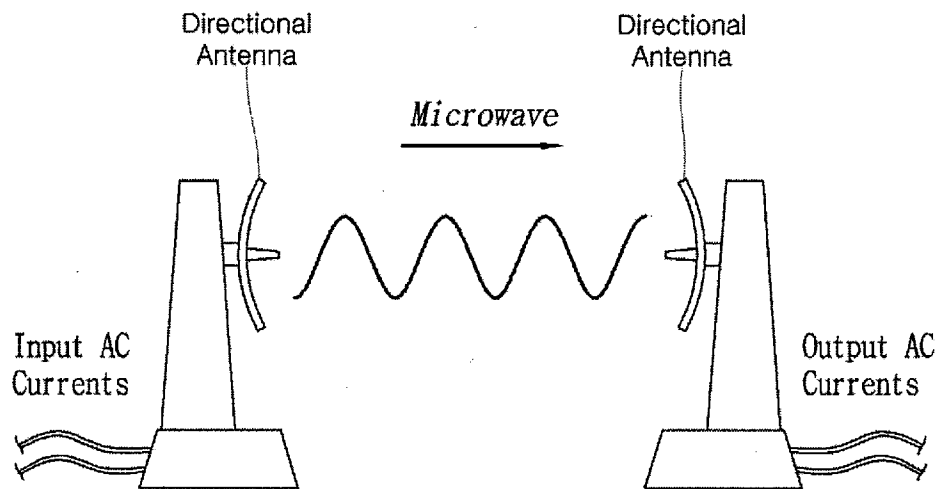
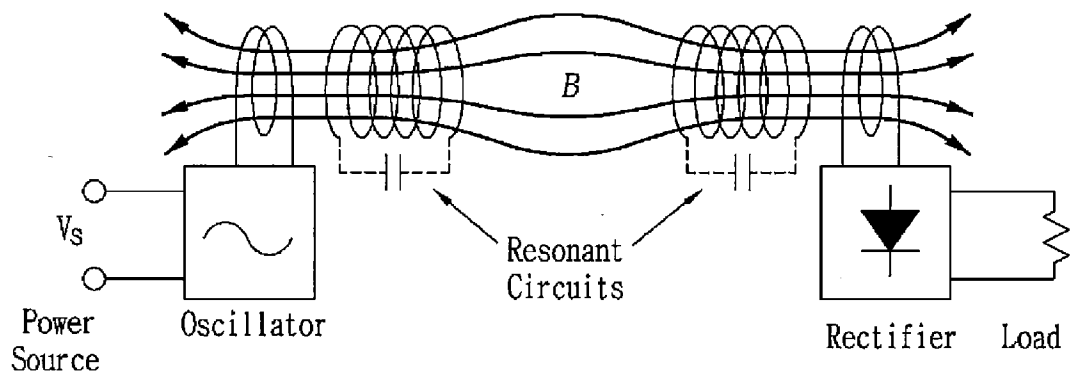


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/056320

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02F9/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	JP 2010 142050 A (HITACHI CONSTRUCTION MACHINERY) 24 June 2010 (2010-06-24)	1-8,14
Y	paragraphs [0016] - [0026]; figure 1 and 2	9-13,15,16
Y	----- JP 2016 084633 A (HITACHI CONSTRUCTION MACHINERY) 19 May 2016 (2016-05-19) paragraph [0044] paragraph [0045] paragraph [0055] paragraph [0058] - paragraph [0060] paragraphs [0068] - [0075]; figure 1	9-11,15,16
Y	----- JP 2008 069517 A (HITACHI CONSTRUCTION MACHINERY) 27 March 2008 (2008-03-27) paragraph [0048] - paragraph [0061]; figures 1, 2 ----- -/--	9,12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

8 December 2017

Date of mailing of the international search report

19/12/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Bultot, Coralie

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/056320

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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