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(54) **METHOD FOR MOUNTING A TOWER SUPPORT**

(57) The method is intended for support tower mounting, the upper part of which has elements of a wind-power station, antenna systems or other equipment mounting thereon. When the method is being carried out, the height at which the support tower with equipment is disposed is increased by means of the combined use of two rims, namely a main rim and an auxiliary rim, which are mutually perpendicularly arranged in such a way that said rims can turn. The support tower with the equipment is placed on top of the main rim. On the base of each rim, a lever mechanism with one long arm and two pivots is provided,

permitting a reduction in the forces required. The auxiliary rim is turned by means of a lifting end traction mechanism, and the main rim, along with the support tower, is turned using the auxiliary rim, which is used as a vertical block. As a result of the fact that each rim is able to turn smoothly in both directions, it is possible to carry out not only initial assembly, but also periodic renovation of the entire structure on the ground, in an accessible area. The method makes it possible to increase the efficiency of using equipment mounted on a support tower.

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Description

[0001] The present invention relates to the construction industry, in particular to methods for mounting long high-rise structures, and it can be used for support tower mounting, on the upper part of which an installation of wind power elements, antenna systems or other equipment is performed during the course of its assembly in horizontal position.

[0002] A method for support tower mounting, in particular for mounting a support tower with wind-power station elements installed thereon, comprising support tower assembly in horizontal position and its turning from horizontal to vertical position is known, in which the foundation of the support tower is fixed on the preprepared construction site, at the same time the support tower turning from horizontal to vertical position using heavy lifting equipment, such as mobile cranes or helicopters is performed. (Morozov E.P., Butylkin I.P., Kuptsov B.D. Installation of steel support towers using cranes and helicopters. Installation and special works in construction industry. No 6, p.34,2001).

[0003] One disadvantage of this method is that it requires the involvement of heavy duty vehicles or aerotechnics, in particular heavy-lift mobile cranes or helicopters, that increases its labor intensity.

[0004] The most technically relevant to the claimed method is the method for support tower mounting, in particular the support tower with wind-power station elements installed thereon, comprising the support tower assembly in horizontal position and its turning from horizontal to vertical position, in which the foundation of the support tower is fixed on the preprepared construction site, wherein prior to support tower assembly on the place of its horizontal placement the rail track is laid, on which a cable driven cart is mounted. The support tower is kinematically joined with the cart by means of the bar, wherein the cart is placed by the top side of the support tower. The attachment point of the bar kinematic joint to the support tower should be displaced on a distance less than the bar length to form an obtuse angle between the bar and the support tower, and the support tower turning from horizontal to vertical position is carried out by means of the bar, thereby moving the cart along the rail track towards support tower foundation using the cable drive, and securing this process from the ground using winch rope connected with the support tower top (Russian Federation Patent No.2451145, EOH12/34, EO4H12/08, 09.13.2010, pub. 05.20.2012).

[0005] The known method, as well as the previously discussed analogue, has the following main disadvantages. Upon implementation of the method, it is not uncommon that use efficiency of the equipment placed on the support tower is not high enough. This problem is primarily due to the fact that at the support tower height there are not always required conditions for efficient operation of the equipment, in particular wind-power station, antenna systems or the like installed thereon. When us-

ing the method for support tower mounting with wind-power station elements installed thereon, in many regions the average annual capacity factor of the wind-power station at the height of the tower is low that is a longstanding problem in wind-power engineering. For this reason, it is desirable to place the support tower along with wind-power station on elevation, for example, on a hill or a hillock, where the average annual wind speed is higher, the wind blows over a long time, and consequently the degree of equipment utilization is higher and duration of idle time is less. When using the method for support tower mounting, on which cellular and microwave communication antenna systems are placed, the levels of received signals at the height of support tower are not always sufficient to cover the planned area. That also requires to increasing the height of support tower and equipment placed thereon, as at high altitudes the levels of signals received by antenna systems are high. However, the required elevation is often lacking in the area of high-rise support tower. Furthermore, even if there are the necessary elevation and the support tower with equipment installed thereon, it is not always possible to perform the repair service in due time and without long-time outages including the repair requiring reconstruction, for example, eliminating the most serious damages of the support tower or equipment with large elements replacement with new ones, because of the inaccessibility of some natural elevations, especially in the autumn-winter-spring period, etc.

[0006] The present invention is aimed to resolve the technical problem of increasing the height of support tower and equipment placement and ensuring their accessibility to repair service including the possibility to perform it on the ground, in accessible area, and to perform not only initial assembly, but also the renovation of a new structure with achievement of the technical result - more efficient utilization of equipment installed on the support tower.

[0007] The problem can be solved using the claimed method for support tower mounting, in particular for mounting a support tower with wind-power station elements installed thereon, comprising support tower assembly in horizontal position and its turning from horizontal to vertical position, wherein, according to present invention, before the support tower mounting the main and auxiliary rims assembly is performed, each of them is shaped as a circle arc or a parabola with adjustable tension spokes. With that, a support tower is placed on top of the main rim, which is made with a large radius. At the same time, a possibility of the smooth turns of each rim in both directions is provided. The rotation axes of the two rims are chosen to be perpendicular to each other, and a hub is set at the site of their intersection, while on the base of each rim a lever mechanism with one long lever arm and two pivots suitable for reducing the required forces is formed. For example, a lever mechanism of the first class lever is provided, and the counterweights are mounted on its two short lever arms, which are con-

nected with recessions in foundation after turning of the respective rim in vertical position. At that, between the hub and the upper part of the auxiliary rim, the possibility of elevator movement is provided, and the space along the axis between the hub and the upper part of the main rim is left to be free, thereby providing the possibility of its rotation over the vertical auxiliary rim, with that, in the first instance, the rotation of the auxiliary rim from horizontal to vertical position is performed by using a lifting and traction mechanism, for example, by using double-acting jacks mounted in the recesses in foundations along this rim. Then the main rim together with the support tower is turned using the auxiliary rim provided with a direct and inverse rope drives and endowed with the fixed pulley function. For example, during assembly, the outer part of the auxiliary rim is configured providing the possibility of the rope slipping, one end of which is connected to the direct drive attached to one of foundations through the roller system in the upper part of the auxiliary rim, and a second rope end is attached to the upper part of the main rim, which is also connected to the inverse drive attached to the closest foundation of the auxiliary rim through the rope, at that, the contact and connection of the upper parts of the two rims are provided in vertical positions. With that, the renovation of the support tower and rims is performed in horizontal position after turning the rims from vertical to horizontal position by performing the operations in reverse order, at that, the main rim is turned from vertical to horizontal position by means of common use of direct and inverse rope drives.

[0008] In the claimed invention the set problem is solved by increasing the height of the support tower with equipment installed thereon by common use of the main and auxiliary rims arranged in mutually perpendicular directions being configured to provide a smooth turning of each rim in both directions. With that, the support tower with equipment is placed on top of the main rim designed for long period of carrying the loads while in operation and produced with a larger radius than that of the auxiliary rim. To facilitate the turns in both directions, a lever mechanism having one long lever arm and two pivots is already created on the basis of each rim that allows to reduce the efforts required, for example, a lever of the first class having one long and two short arms with counterweights, i.e. a modified Archimedean lever. It is possible to set for a lever a close to equilibrium regime, which reduces the efforts required in this case by adjusting the counterweights and selection the arm lengths, thereby the rim can be rotated with minimal efforts. In this regard, the auxiliary rim may have a radius substantially greater than the length of the lifting and traction equipment, because an auxiliary rim having no additional heavy elements on its upper part can be turned meshing his points near the axis of rotation, eliminating thereby the need to use long high-power lifting and traction equipment, such as double-acting jack with long solid bar comparable in length with the rim radius. The auxiliary rim is made with the possibility of elevator movement, and the space along

the axis between the hub and the upper part of the main rim is left free, thereby the main rim has the possibility of free rotation over the vertical auxiliary rim. In the first instance, the auxiliary rim is transferred in vertical position, while operation the said rim is not used as a support for carrying the vertical loads, but it is used for holding the main rim in vertical position excluding its turns due to lateral wind loads. In addition, the auxiliary rim has an additional important function - it is used as a vertical fixed pulley of a lever mechanism turning the main rim. At the same time, through the use of high fixed pulley, the main rim turns on both sides meshing the points most distant from the axis of rotation are provided, i.e. in the upper part of the rim, where the support tower with relatively heavy equipment is placed, thereby creating the necessary torque moment at minimum efforts. Thus, a lever mechanism reducing the required efforts used together with a lifting and traction mechanism provides the possibility of smooth turns of the auxiliary rim in both directions, as well as its using together with high fixed pulley provides the possibility of similar turns of the main rim along with the support tower and equipment. Implementation of the said ensemble and sequence of operations provides the possibility to increase the height of placing the support tower with equipment allowing to perform not just the primary assembly, but also the periodic renovation of the entire structure with the replacement of large components with new ones on the ground, in an accessible area, which makes it possible to solve the set problem with the achievement of technical result - to improve the utilization efficiency of the equipment installed on the support tower.

[0009] The use of the rims shaped as a circle arc with spokes is known in the art. For example, such constructions are widely used as parts of suspension bridges and other structures. However, the use of the rims in known constructions for any purpose other than their destination, particularly for increasing the height of the support tower with equipment placed thereon with ensuring its accessibility to repair service including the possibility to perform it on the ground, in accessible area, and to perform not only initial assembly, but also the periodical renovation of a new structure, would allow to resolve a problem that occurs in the implementation of the known methods for support tower mounting.

[0010] Fig.1 shows a device for performing the claimed method, wherein the main rim is shown at the moment of turning the support tower from horizontal to vertical position after the assembly is completed.

[0011] Method for support tower mounting is implemented as following. Before the support tower mounting the main 1 and auxiliary 2 rims are mounted, each of which is shaped as a circle arc or a parabola with adjustable tension spokes 3. Support tower 4 with the equipment 5 is placed on the upper part of the main rim 1, which is made with a large radius. At the same time a possibility of the smooth turns of each rim in both directions is provided. The rotation axes of the two rims are

chosen to be perpendicular to each other, and hub 6 is set at the site of their intersection. On the base of each rim a lever mechanism with one long lever arm and two pivots suitable for reducing the required force is created, this is a modified Archimedean lever, which can be made on the base of the working principle of one of the known levers of the first, second or third class. In operation using the auxiliary rim 2, the main rim 1 is held in vertical position without the possibility to turn under the effect of wind shear loading.

[0012] First, the auxiliary rim 2 is turned from horizontal to vertical position by means of the lifting and traction mechanism, then the main rim 1 along with the support tower 4 and equipment 5 are turned by means of the auxiliary rim 2, which plays a role of a fixed pulley. For example, during the process of mounting the outer part of auxiliary rim 2 is configured to allow a slip of the rope 7, one end of which is connected through a roller system to direct drive 8 attached to one of foundations, and the second end of the rope is attached to the upper part of the main rim 1. The upper part of the main rim 1 via a rope 9 is also connected to reverse drive 10 attached to the foundation nearest to auxiliary rim 2. Between hub 6 and the upper part of auxiliary rim 2 the possibility of elevator 11 movement is provided, and the space along the axis between hub 6 and the upper part of the main rim 1 is left to be free, whereby the main rim 1 has the possibility of freely rotating in both directions over the vertical auxiliary rim 2. A part of large dimension elements of the support tower 4 and equipment 5 is mounted by preparing recesses in the foundation or by partially turning the main rim 1 and lifting slightly its upper part. The rims and spokes, as well as the support tower elements, may be made of steel, reinforced concrete, duralumin, composite materials or other materials with high strength.

[0013] Fig.2 shows the main and auxiliary rims during the assembly process, where, for clarity, a simplified top view at the initial stage of the assembly process for rims 1, 2 and high support tower 4 with equipment 5 is shown.

[0014] Fig.3 shows the auxiliary rim in the assembly process, where in order to avoid cluttering up the schemes in the other figures, the examples of lever mechanism implementation for reducing the efforts required, as well as the lifting and traction mechanism, are shown separately. At the two short arms of the lever mechanism shaped as a lever of the first class with two hinge support points 12 the counterweights 13 are installed, which are connected with foundations in the recesses 14 after actuation of vertical position of the rim. With that, the auxiliary rim 1 is rotated by means of a lifting and traction mechanism, for example, by using the double-acting jack 15 mounted in recesses 16 along the rim.

[0015] When the fully assembled rims 1 and 2 have been raised to vertical position, a contact and connection of their upper parts 5 are provided. The perpendicular arrangement of the two rims allows using of the high support tower of almost any kind including a mast with inclined guy wire, and with that, the renovation of rims 1,

2 and support tower 4 with equipment 5 is carried out on the ground, in horizontal position, by performing the reverse sequence of operations used in the process of their rotation from horizontal to vertical positions. The main rim 1 together with the support tower 4 and equipment 5 is turned back from vertical to horizontal position by common use of the reverse rope drive 10 and direct rope drive 8.

[0016] The claimed invention allows solving the problem of increasing the height at which the support tower with equipment is disposed. This problem is a long-standing one in wind-power engineering, because usually there is no required natural elevation in the location area of the support tower with elements of wind-power station installed thereon that hinders the development of wind energetics as a whole. In addition, by providing a smooth turns of each of the rims in both directions, an opportunity to implement not only a primary assembly, but also a periodic renovation of the entire construction on the ground, in an accessible area, is created.

Claims

1. A method for support tower mounting, in particular for mounting a support tower with wind-power station elements installed thereon, comprising support tower assembly in horizontal position and its turning from horizontal to vertical position **characterized in that** before the support tower mounting the main and auxiliary rims assembly is performed, each of them is shaped as a circle arc or a parabola with adjustable tension spokes, with that, a support tower is placed on top of the main rim, which is made with a large radius, at the same time, a possibility of the smooth turns of each rim in both directions is provided; the rotation axes of the two rims are chosen to be perpendicular to each other, and a hub is set at the site of their intersection, while on the base of each rim a lever mechanism with one long lever arm and two pivots suitable for reducing the required forces is formed, for example, a lever mechanism of the first class lever is provided, and the counterweights are mounted on its two short lever arms, which are connected with recessions in foundation after turning of the respective rim in vertical position; wherein, between the hub and the upper part of the auxiliary rim, the possibility of elevator movement is provided, and the space along the axis between the hub and the upper part of the main rim is left to be free, thereby providing the possibility of its rotation over the vertical auxiliary rim, with that, in the first instance, the rotation of the auxiliary rim from horizontal to vertical position is performed by using a lifting and traction mechanism, for example, by using double-acting jacks mounted in the recesses in foundations along this rim; then the main rim together with the support tower is turned using the auxiliary rim provided with

a direct and inverse rope drives and endowed with the fixed pulley function, for example, during assembly, the outer part of the auxiliary rim is configured providing the possibility of the rope slipping, one end of which is connected to the direct drive attached to one of foundations through the roller system in the upper part of the auxiliary rim, and a second rope end is attached to the upper part of the main rim, which is also connected to the inverse drive attached to the closest foundation of the auxiliary rim through the rope, wherein, the contact and connection of the upper parts of the two rims are provided in vertical positions; with that, the renovation of the support tower and rims is performed in horizontal positions after turning the rims from vertical to horizontal position by performing the operations in reverse order, at that, the main rim is turned from vertical to horizontal position by means of the common use of direct and inverse rope drives.

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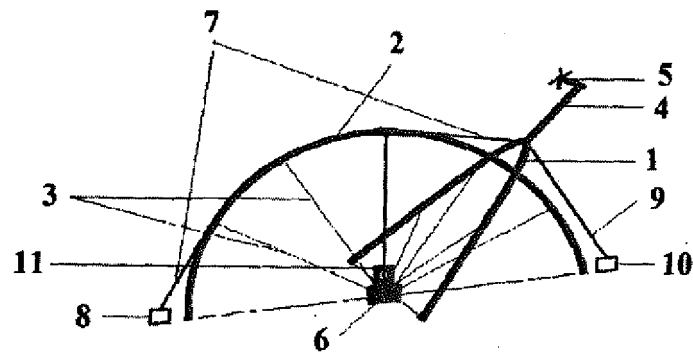


Fig. 1

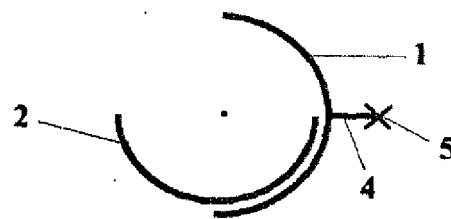


Fig. 2

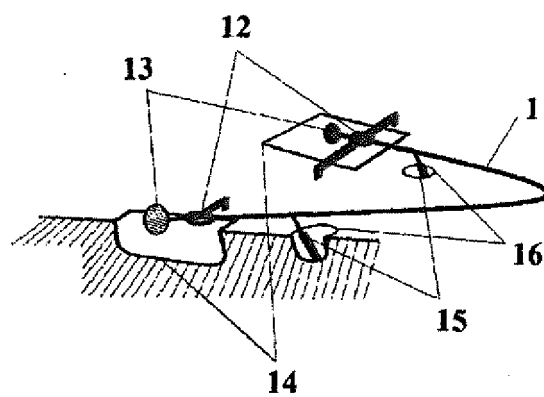


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KZ 2015/000019

A. CLASSIFICATION OF SUBJECT MATTER

E04H 12/34 (2006.01)

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)

E04H 12/00-12/34

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008/099129 A2 (BONTE-CAZAL JEAN-CHRISTOPHE et al.) 21.08.2008	1
A	RU 2451145 C1 (OBSCHESTVO S OGRANICHENNOI OTVETSTVENNOSTIU "STROITELNO-MONTAZHNAIA KOMPANIJA SIBIR" (OOO "SMK SIBIR")) 20.05.2012	1
A	SU 159962 A1 (SOLOVEV F. A.) 01.01.1964	1
A	DE 568462 C (SIEMENS-SCHUCKERTWERKE AKT.-GES.) 19.01.1933	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

"&" document member of the same patent family

Date of the actual completion of the international search

21 December 2015 (21.01.2016)

Date of mailing of the international search report

21 January 2016 (21.01.2016)

Name and mailing address of the ISA/

Authorized officer

Facsimile No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- RU 2451145 [0004]

Non-patent literature cited in the description

- **MOROZOV E.P. ; BUTYLKIN I.P. ; KUPTSOV B.D.**
Installation of steel support towers using cranes and helicopters. *Installation and special works in construction industry*, 2001, 34 [0002]