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(54) TOWER CRANE

(57) A tower crane comprises a lattice tower (1) composed of sections and comprising an upper jib (2). A lower tower (1) section is attached to a base (22) comprising supports (3) with feet (4). The supports (3) comprise a hydraulic levelling unit. The upper jib (2) is mounted on a turntable (16), fixed on the upper tower (1) section. The upper jib (2) is a telescopic jib and is provided with a pair of stiffening sprits (18). The tower (1) is composed of lattice sections and is provided with a cage module (15) for lifting and installing the next sections. The lattice tower (1) is provided with a unit of lattice middle sprits (12) with lower stays (11) in the form of couplers (8). The middle sprits (12) are connected from one side to working parts of hydraulic cylinders (14) installed in the crane foot (4) supports (3) and from the other side to the eyes (9) of the middle sprits (12) of the lattice tower (1).

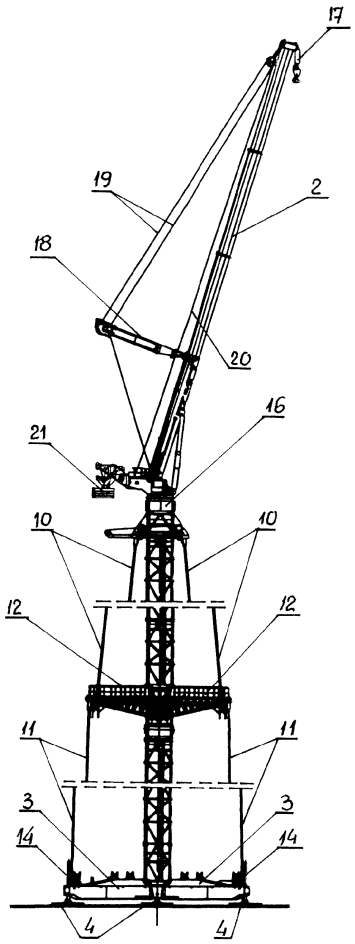

Fig. 7

EP 3 553 016 A1

Description

[0001] The present invention relates to a high lift and high lifting capacity tower crane with an upper tilting jib. The crane is intended, in particular, for the erection of wind power plants, including the lifting of a wind power generator to the working height.

[0002] Wind turbine towers are getting higher and higher, currently reaching over 145 m. The new generation turbines are designed on over 160 m high towers. This is associated with the increasing length of wind turbine blades, and with the task of using wind energy with the least possible interference. This type of winds occur higher. The increasing heights of wind turbine towers are becoming more and more demanding on lifting devices used to mount generators on said towers.

[0003] Due to the growing requirements as regards the performance of these generators, the generator weight also increases and often reaches 80 tonnes. Such requirements as regards lift and lifting capacity are increasingly difficult to be met by cranes supporting the wind power plant construction process. Crawler and mobile cranes with lattice jibs are typically used for this purpose. Uses of tower cranes for the installation of turbines are also known. In both cases, however, it is not possible to simply increase the lift due to the dead weight of the crane itself, increasing with the height. Therefore, for example, an additional bigger or smaller jib is usually mounted on the top of a tower crane, whose task, apart from lifting, is also to rotate around the vertical axis of rotation. The rotation of the jib is performed by means of a coaxial toothed wheel rim with said axis of rotation of the jib. In known solutions, both a tower crane and a jib have a lattice structure. The jib is also usually provided with a counterweight balancing the lifted weight. An operator's cab is usually located considerably high at the top of a lattice tower.

[0004] Solutions of tower cranes for this type of tasks are known. A known solution of a tower crane is disclosed in Polish patent description No. PL213684. A mobile tower crane according to this known solution comprises a telescopic tower and a jib. The tower is mounted on a semitrailer, which is provided with slots for supports. In addition, the semitrailer is provided with a system for moving and putting the tower from the horizontal transport position into the vertical working position. To the telescopic tower head stabilising stays are attached, where each stay consists of a series of hinged stiff flat bars. To each eye of the telescopic tower head, an upper fitting of the first section of the stay is permanently fixed, with the first section of the stabilising stay being a section of the wire rope. The next sections of the stays are hinged stiff flat bars. At the top of the telescopic tower, the jib is rotatably mounted in the seat. According to this known solution, the tower is a set of concentrically arranged cylinders that are hydraulically telescopically extended, where the nominal maximum tower height is reached when the cylinder with the smallest diameter is extended. Before the erection of the tower, a rotating jib, also telescopically extended, is mounted in the head seat. When the tower reaches the working height and the tower section is blocked, the stays are tightened, which stiffens the crane tower.

[0005] Another known solution is disclosed in US patent description No. US3872977. According to this known solution a collapsible crane is comprised of a mast and a jib, and is provided with a jack for raising and lowering the mast. The jib is comprised of a jib head telescopically received in a jib foot pivoted to the mast, and the jib foot is automatically extended relative to the mast by a jib tie as the mast is raised. First and second cables are attached to the jib head for extending and retracting the jib head and operably connected to a carriage which is slidably mounted within the mast. The movement of the carriage within the mast is coordinated with the raising of the mast so that the free end of the jib head initially moves along a substantially vertical trajectory, and then along a substantially horizontal trajectory during the raising of the mast from a horizontal to a vertical position and during the extension of the horizontal jib.

[0006] Another known solution relating to tower cranes is disclosed in British patent description No. GB 1404135. This specification discloses a telescopic tower structure extended and folded by means of a hydraulic piston and cylinder arrangement. When the tower is extended to the working height, individual extendable parts of the tower structure are locked in the working position by wedges. A crane includes a telescopic tower extended by a multi-section hydraulic cylinder fed by a working medium from the hydraulic system. A turntable on the top tower section carries an operator's cab and a telescopic jib adapted to luffing by the hydraulic system mounted on the turntable on a platform tiltable around a horizontal axis by means of hydraulic cylinders. Using the hydraulic cylinders of the hydraulic system, the tower and the jib can be collapsed onto a trailer for transport, with the tower and the jib being pivoted around bearings to lie horizontally. In use, the tower is maintained extended by working fluid pressure applied to the cylinder in excess of the pressure required to sustain the total weight of the movable tower sections and parts carried thereby, including the maximum permitted load, thus maintaining the tower in operation. Extension of the tower sections is limited by inter-engaging means with position wedging units of adjacent tower sections on adjacent sections. These means, between sections are wedges acting to give lateral stability to the tower. Safety latches may be moved into position between adjacent tower sections to prevent collapse of the tower in case of failure of the cylinder or of the fluid pressure supply.

[0007] Another British patent description of invention No. GB1374253 discloses a known solution of a mobile tower crane comprising a telescopic jib mounted on a pivot for luffing by a pair of luffing hydraulic cylinders on a slewing turntable at the top of a telescopic tower over an operator's cab. In order to fold the crane into its transport position, the retracted jib is brought to a horizontal position, with the tower retracted by a rack-and-pinion mechanism. The tower and

the jib are then swung into a vertical position, and the upper section of the jib can be slid through the base of the lower section.

[0008] In a number of cases, tower cranes with a lattice tower are used, where the tower itself is a jib. In this type of a structure, the first section of the tower is mounted on the axis of rotation, which makes it possible to operate the tower as a jib at the end of which there is a unit for hauling hoisting cables. A lattice tower is mounted on a turntable ring. However, this type of a crane also has its limitations and, for operational reasons, it must be located at a distance from the wind turbine tower, which results in additional field requirements for the construction site area. This type of known cranes also have height restrictions.

[0009] The object of the invention is to develop a crane that meets the requirements for the installation of the state-of-the-art wind turbines with a 166m high rotor axis and 180m to 200m in the future. The crane will also be used in other types of works where equipment with significant lifting capacity at high lifts is required, such as skyscrapers and power units. The aim of the invention is also to develop the structure of a lattice tower that will not require additional space at the construction site of the wind power plant and on the last section of the tower will comprise a jib with variable outreach, which will additionally make it possible to increase the maximum lift of the load, but will also make it possible to operate in the desired radius around the crane tower. At the same time, the solution of the lattice tower is to enable the efficient assembly and disassembly of the crane according to the invention, to transport it to another place for the construction of another wind power plant.

[0010] The object of the invention has been achieved by designing a hybrid design tower crane structure, as described in first claim and in subsequent claims.

[0011] According to the invention, a tower crane comprises a tower composed of sections, comprising an upper jib, where a lower tower section is attached to a base comprising supports with feet. The supports comprise a hydraulic levelling unit, and the upper jib is mounted on a turntable, fixed on an upper tower section. The upper jib is provided with a counterweight and is provided with a high-resolution closed-circuit television camera, and a cable connection with the screen in an operator's cab. The upper jib is provided with a pair of stiffening sprits. The tower is composed of lattice sections and is provided with a cage module for lifting and installing the next sections of the tower.

[0012] According to the invention, the tower crane is characterised in that the upper jib is a telescopic jib and the lattice tower is provided with at least one unit of lattice sprits with stays. The stays have the form of couplers. The stays are connected from one side to working parts of hydraulic cylinders installed in the crane foot supports and from the other side to the eyes of the sprits of the first level of the lattice tower.

[0013] In the solution according to the invention, the tower is preferably situated on the base mounted on the four supports, where the end of each support is provided with the foot mounted on a vertical extendable mandrel.

[0014] The operator's cab is preferably arranged according to the invention in a self-propelled mobile ground unit, with the operator's cab ground unit comprising a cab rotation unit in the vertical plane.

[0015] The object of the invention has been achieved by combining a lattice tower erected using the cage method from the ground level with a known telescopic jib fixed on the top section of the tower. The combination of these two solutions has made it possible to construct the lattice tower using the cage module, section by section until reaching the highest level through the last lattice section with the upper jib, being a telescopic jib, mounted on this section. Therefore, an additional lifting device is unnecessary for attaching the upper telescopic jib. In the solution according to the invention, without the use of an additional lifting device, gradually, using the cage module method, the telescopic jib mounted on the last section of the tower was raised at the top of the lattice tower. This would not be possible with the use of prior art solutions. The hybrid structure according to the invention, by adding the upper telescopic jib to the lattice tower stiffened by means of stays, has made it possible to significantly improve the operating parameters of the crane.

[0016] The object of the invention is shown in the embodiments in the accompanying drawing, in which the individual figures illustrate:

Fig. 1 - a tower crane with the stays over the entire height of the tower and with two levels of the sprits,
Fig. 2 - the tower crane, according to Fig. 1, with the stays over the entire height of the tower and with one level of the sprits,
Fig. 3 - the crane, according to Fig. 1, during the construction of the lattice tower,
Fig. 4 - the lattice tower with the stays to the first level of the sprits,
Fig. 5 - the lattice tower, according to Fig. 2,
Fig. 6 - the lattice tower, according to Fig. 1,
Fig. 7 - an enlarged view of parts of the tower crane, according to Fig. 2,
Fig. 8 - an enlarged connection zone of the lattice tower and the upper jib,
Fig. 9 - a side view of the operator's cab,
Fig. 10 - a view of a part of the support with the foot,
Fig. 11 - a top view of the construction site with the location of the crane lattice tower marked on it.

[0017] Fig. 1 and Fig. 2 show the tower crane, according to the invention, in two embodiments. Fig. 1 shows the crane in the form of a lattice tower 1 with a telescopic jib 2 mounted at its top. The lattice tower 1 is mounted on four supports 3. An example of the arrangement of the supports 3 is shown in Fig. 11. The supports 3 are provided with feet 4 at the end based on the ground.

[0018] The foot 4 unit is shown in the embodiment in Fig. 10. The foot 4 is mounted on a mandrel 5, slidaby arranged in a sleeve 6 attached to the support 3. The mandrel 5 comprises holes 7 making it possible to select the correct height for the foot 4 support on the ground. In this embodiment, each of the four supports 3 shown in Fig. 11, comprises on its free end the foot 4 unit as shown in Fig. 10. The same Fig. 10 shows, folded next to one another, on the horizontal support 3, components of a stay in the form of couplers 8. As shown, a single coupler 8 comprises eyes 9 at its ends. The couplers 8 connected by means of the eyes 9 comprise upper stays 10 and lower stays 11 of the lattice tower 1.

[0019] In Fig. 1 and Fig. 2, the lattice tower 1 is then additionally stabilised by the lower stays 11 and the upper stays 10. The four lower stays 11 are attached to the extreme parts of the four supports 3 by means of known cylinders 14. The lower stays 11 composed of the connected said couplers 8, and the other end of the couplers 8 connected to form the lower stay 11, are attached from the other side to four middle sprits 12. A single middle sprit 12 is a known expansion lattice structure. The four middle sprits 12 in this embodiment are attached radially to the lattice tower 1 at a height of 87m, where the overall height of the lattice tower 1 in this embodiment is 131.8m. Each middle sprit 12 in this embodiment is 16m long, and the arrangement of the sprits 12 around the lattice tower 1 reflects the radial arrangement of the four supports 3 shown in Fig. 11.

[0020] The embodiment in Fig. 1 shows that to the top section of the lattice tower 1 four upper sprits 13 are attached, which, like the middle sprits 12, reflect the arrangement of the supports 3. In this embodiment, the upper sprits 13 are attached at a height of 131.8m. Between the free ends of the middle sprits 12 and the upper sprits 13, the upper stabilising stays 10 extend, the structure of which is the same as the structure of the lower stabilising stays 11. The stabilising stays 10,11 are suspended and extended during the erection of the lattice tower 1, which is performed using a known technology with the use of a cage module 15. Fig. 1 schematically shows the known cage module 15 used to erect lattice towers.

[0021] The known cage module 15 with the next section of the lattice tower 1 prepared to be incorporated into the tower 1 structure is also shown in Fig. 3 in another working stage of this cage module 15. Fig. 3 shows the crane according to the invention during the construction stage of the lattice tower 1. This Fig. shows that on the last section of the lattice tower 1, the upper jib 2 is mounted at the begging of the tower structure. The upper jib 2 is a typical telescopic jib in this embodiment. When the construction of the crane according to the invention as shown in this embodiment is finished, the highest point to be reached by a hook 17 of the upper jib 2 is at a height of 189m. However, the usable working height is 174m. The upper jib 2 is provided with known sprits 18, tightening stay ropes 19 and a hoisting rope 20. In this embodiment, two sprits 18 attached to the upper jib 2 are used. The sprits 18 are shown in Fig. 1 and Fig. 2 and also in Fig. 3, Fig. 7 and Fig. 8. The sprits 18 are attached in a known manner to the upper jib 2, in the same place and form a right angle between them in this embodiment, which is not shown in the attached drawings. The upper jib 2 is also provided with a counterweight 21.

[0022] The upper jib 2 is connected to the top section of the lattice tower 1 by means of a known turntable 16. The upper jib 2 at the working end is provided with a known closed-circuit television camera, which in this embodiment is connected via a cable connector to a known display screen in an operator's cab 23.

[0023] Fig. 2 shows the object of the invention in another embodiment. According to this solution, the lattice tower 1 is not provided with the upper sprits 13, and the upper stays 10 connect the middle sprits with the attachment zone of the turntable 16 on which the upper jib 2 is mounted. The other parts of the crane structure according to the invention are the same as in the solution shown in Fig. 1.

[0024] Fig. 4, Fig. 5 and Fig. 6 show three embodiments of the lattice tower which is the main part of the crane according to the invention. Fig. 4 shows the lattice tower 1 only with the lower stays 11 extending from the supports 3 to the middle sprits 12. Fig. 5 shows the lattice tower 1 from Fig. 2 which is provided with the lower stays 11, the middle sprits 12 and the upper stays 10 connected to the top section of the lattice tower 1. In this embodiment, the tower is not provided with the upper sprits 13. Fig. 6 shows the lattice tower 1 according to the embodiment of the crane shown in Fig. 1. In the embodiments shown in Fig. 4, Fig. 5 and Fig. 6, the height of the lattice tower from the ground level to the top is 135m, and the middle sprits 12 are situated at a height of 90m from the ground. Each support 3 is 20m long, the middle sprit 12 is 16m long, and the upper sprit 13 is 12m long.

[0025] Fig. 7 shows the main parts of the crane according to the invention shown in Fig. 2 enlarged. However, Fig. 8 illustrates the connection zone of the top section of the lattice tower 1 and the upper jib 2.

[0026] The mobile operator's cab 23 is located at the ground level and it is shown in the embodiment in Fig. 9. A known display screen of the operator's cab 23 is connected by means of a known cable connector, not shown in the attached drawing, to a known closed-circuit television camera at the working end of the upper jib 2. The cab is mounted on tracks 24 driven by a combustion drive unit 25. The cab 23 is provided with a transmission cable mast 26 and a rotation unit 27 in the form of a cylinder lifting the front of the cab 23 up to allow the operator to observe the upper parts of the crane tower 1 together with the jib 2.

[0027] When the lattice tower 1 is placed on a known base 22 with the supports 3 and with the feet 4, the stabilising stays 10,11 are tightened using the cylinders 14.

[0028] Fig. 11 shows a top view of the arrangement of the supports 3 with the feet 4 of the tower 1 on the ground and an example of the location of the operator's cab 23. A dashed line indicates, for example, the working range of the crane according to the invention. This figure also shows a circular outline of the structure being erected, which - in this embodiment - is a wind power plant.

Table 1.

No.	Crane parts	Estimated weight (t)	Estimated dimensions (m)
1.	Telescopic jib with the machine room	90	Max. working length 55
2.	Telescopic jib counterweight	60	3 x 2.5 x 2.0
3.	Single section of the lattice tower	15.5	7.8 x 3.3 x 3.3
4.	Single middle sprit of the lattice tower	2.75	6.4 x 3.3 x 2.5
5.	Single upper sprit of the lattice tower	2.75	4.3 x 3.3 x 2.0
6.	Single support of the lattice tower	20.5	8.5 x 3.3 x 2.2

[0029] Table 1 above contains the basic parameters related to the weight and dimensions of the main components of the tower crane according to the invention in the embodiment shown in Fig. 1.

List of designations in the figures

[0030]

1. Lattice tower.
2. Upper jib.
3. Support.
4. Foot.
5. Foot mandrel.
6. Sleeve.
7. Hole.
8. Coupler.
9. Eye.
10. Upper stabilising stay.
11. Lower stabilising stay.
12. Middle sprit.
13. Upper sprit.
14. Cylinder.
15. Cage module.
16. Turntable.
17. Hook.
18. Upper jib sprit.
19. Tightening stay rope.
20. Hoisting rope.
21. Counterweight.
22. Base.
23. Operator's cab.
24. Track.
25. Combustion drive unit.
26. Cable mast.
27. Operator's cab rotation unit.

Claims

1. A tower crane comprising a lattice tower (1) composed of sections and comprising an upper jib (2) mounted at the top of the tower, where a lower tower (1) section is attached to a base (22) comprising supports (3) with feet (4), with the supports (3) comprising a known hydraulic levelling unit, and the upper jib (2) being mounted on a turntable (16), fixed on the upper tower (1) section, with the upper jib (2) being provided with a counterweight and being provided with a high-resolution closed-circuit television camera, and a cable connection with the monitor screen in an operator's cab (23), and said upper jib (2) being provided with a pair of stiffening sprits (18), where the tower (1) is composed of lattice sections and is provided with a cage module (15) for lifting and installing the next sections of the tower (1), **wherein** the upper jib (2) is a telescopic jib and the lattice tower (1) is provided with at least one unit of lattice middle sprits (12) with lower stays (11) in the form of couplers (8), with the middle sprits (12) being connected from one side to working parts of hydraulic cylinders (14) installed in the crane foot (4) supports (3) and from the other side to the eyes (9) of the middle sprits (12) of the lattice tower (1).

2. The tower crane, as set forth in claim 1, **wherein** the lattice tower (1) is situated on the base (22) mounted on the four supports (3), where the end of each support (3) is provided with the foot (4) mounted on a vertical mandrel (5) slidably arranged in a sleeve (6).

3. The tower crane, as set forth in claim 1 or 2, **wherein** the operator's cab (23) is arranged in a mobile ground unit with its own combustion drive unit (25), with the operator's cab (23) comprising a cab (23) rotation unit (27) in the vertical plane.

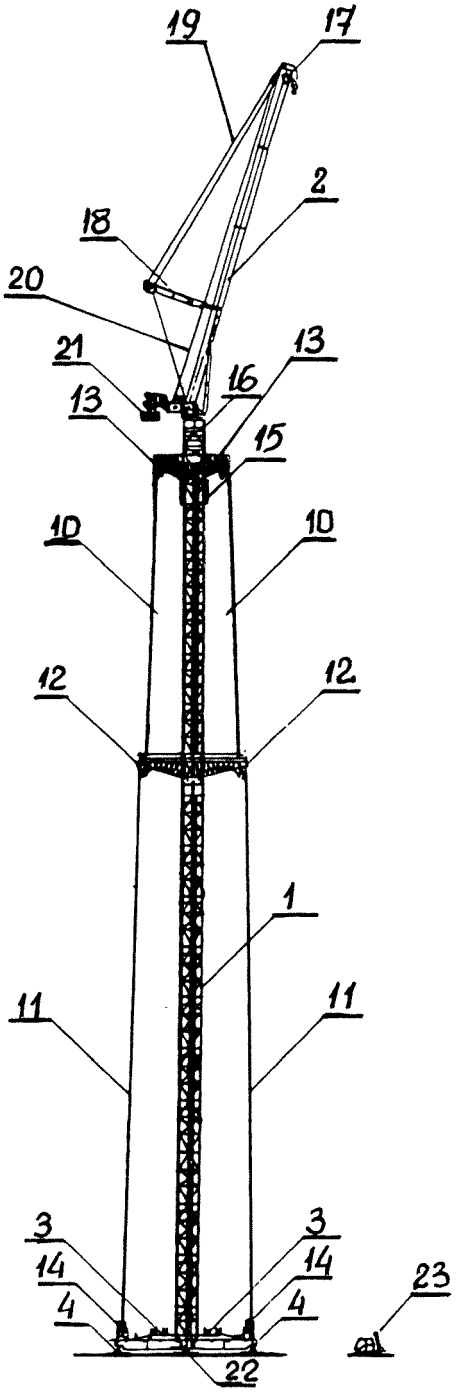
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Fig. 1

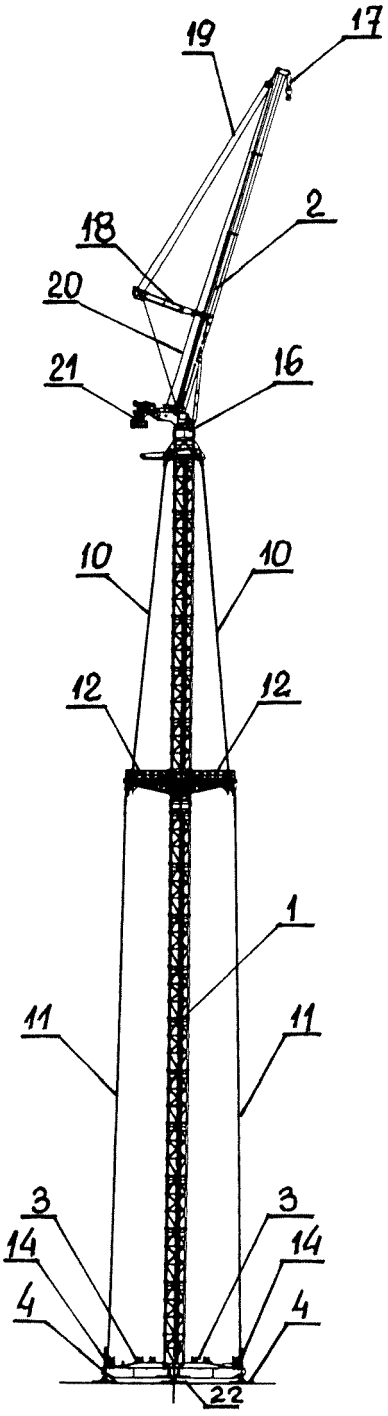
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Fig. 2

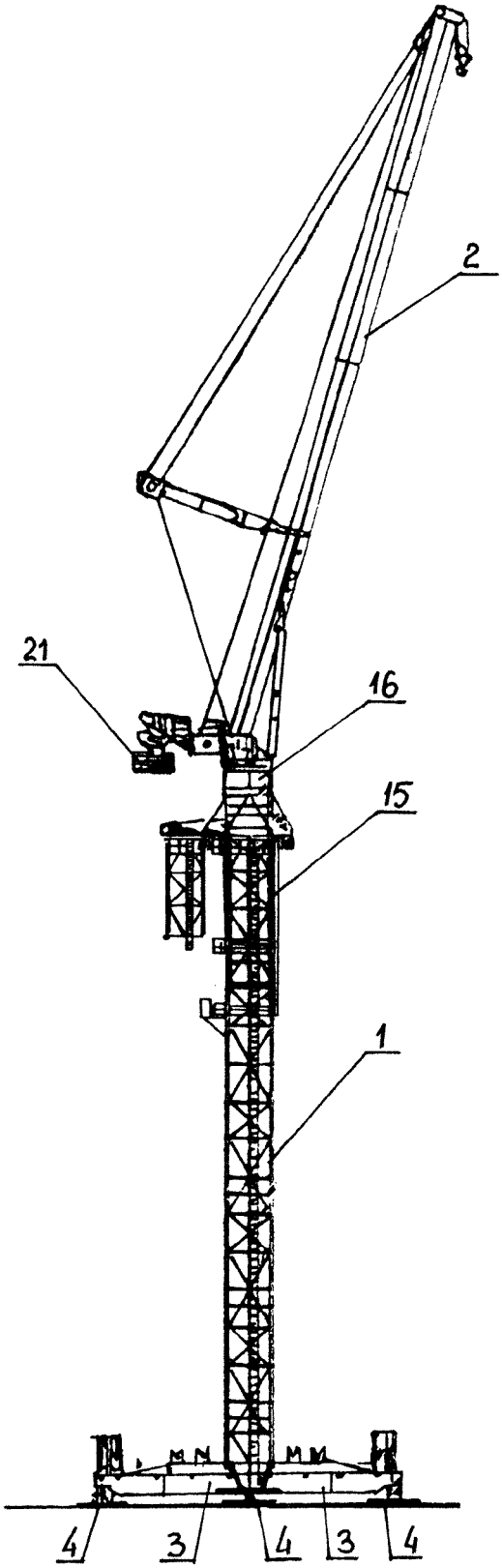

Fig. 3

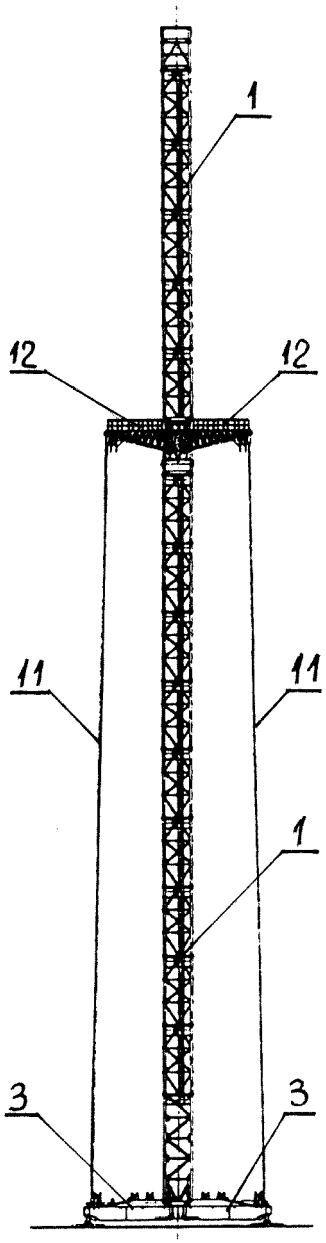

Fig. 4

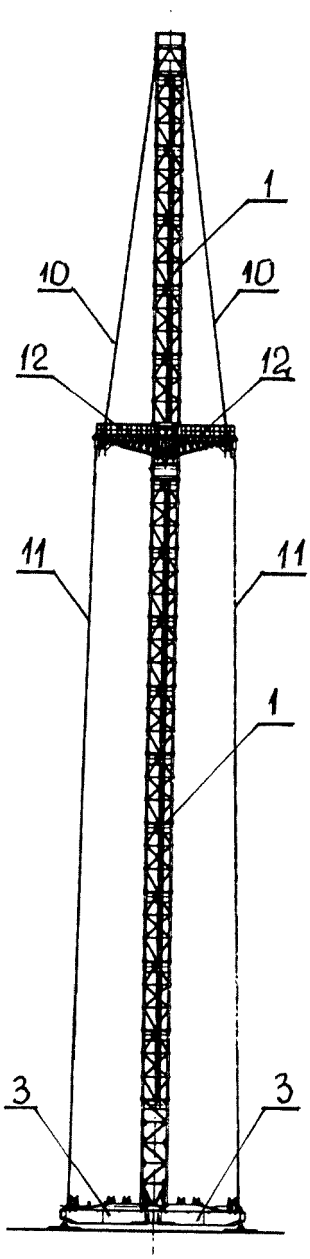

Fig. 5

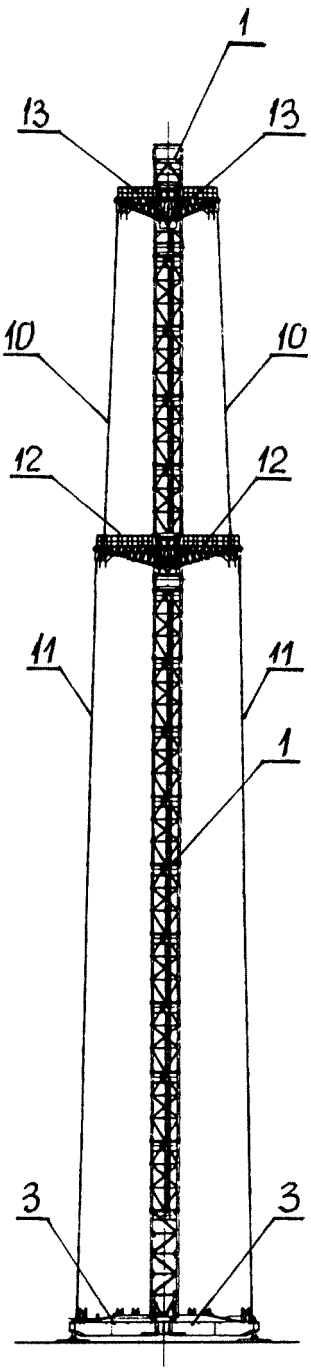

Fig. 6

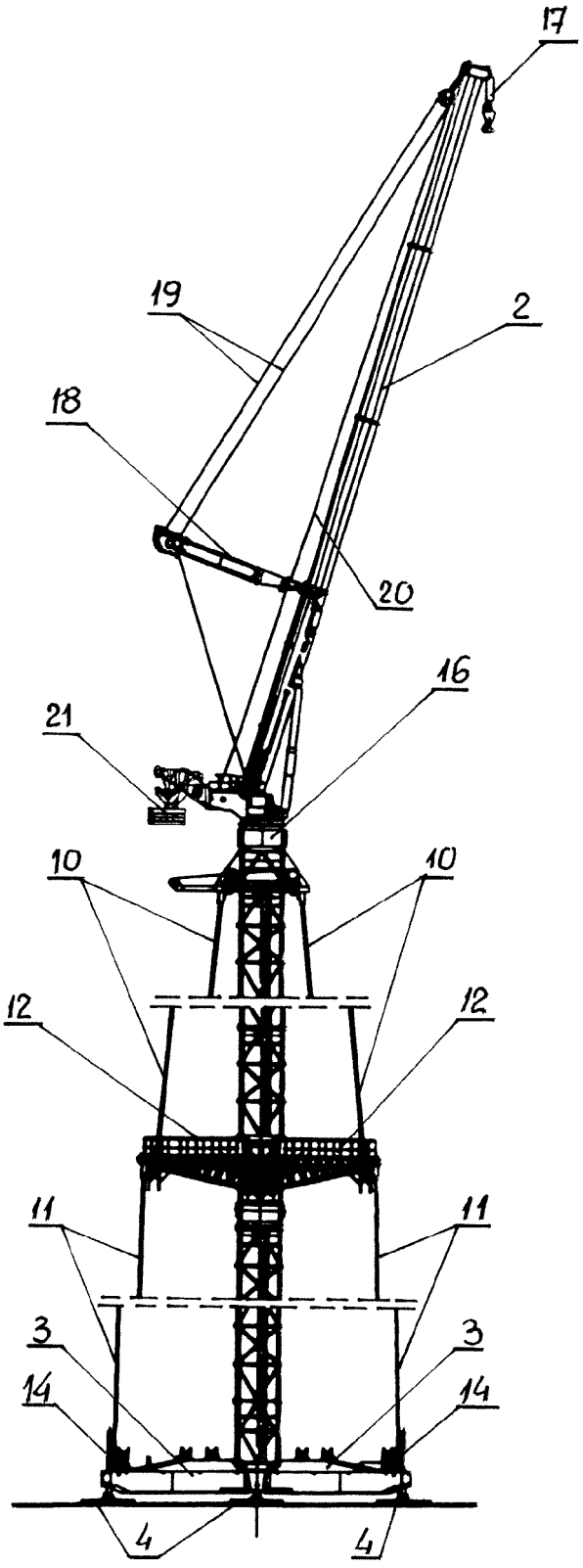

Fig. 7

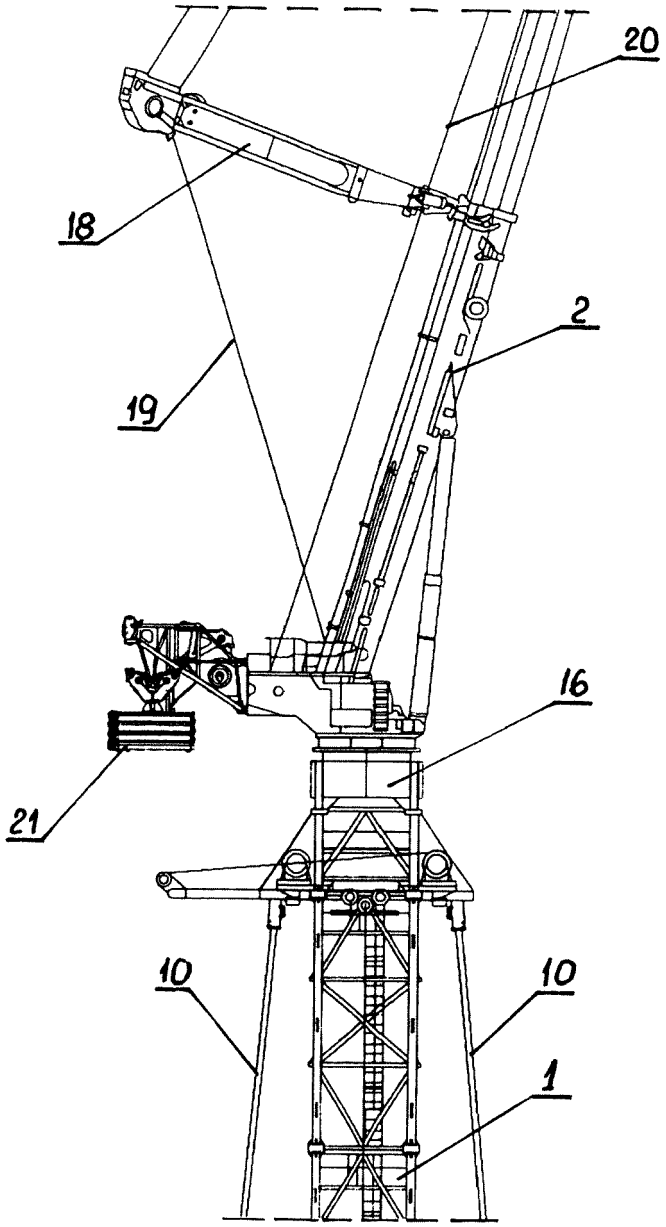

Fig. 8

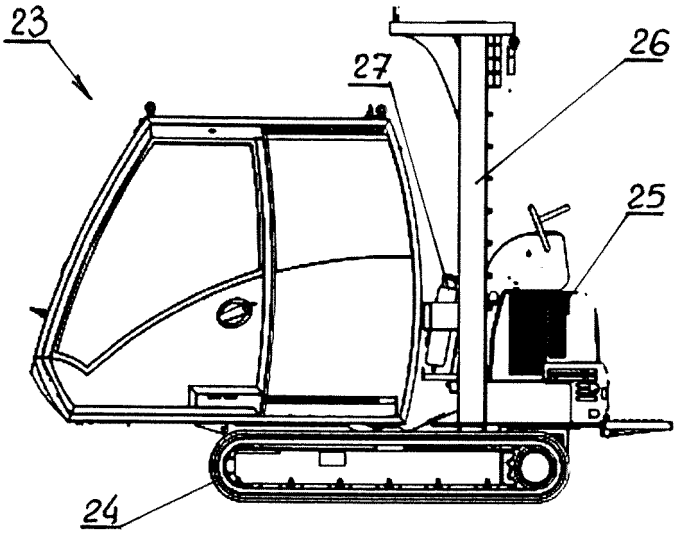

Fig. 9

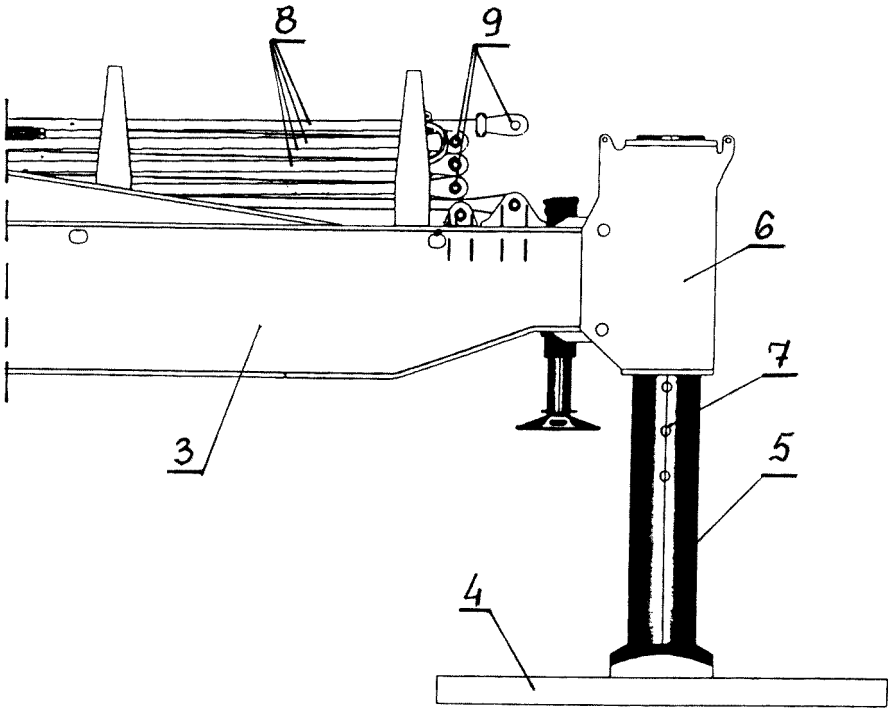

Fig. 10

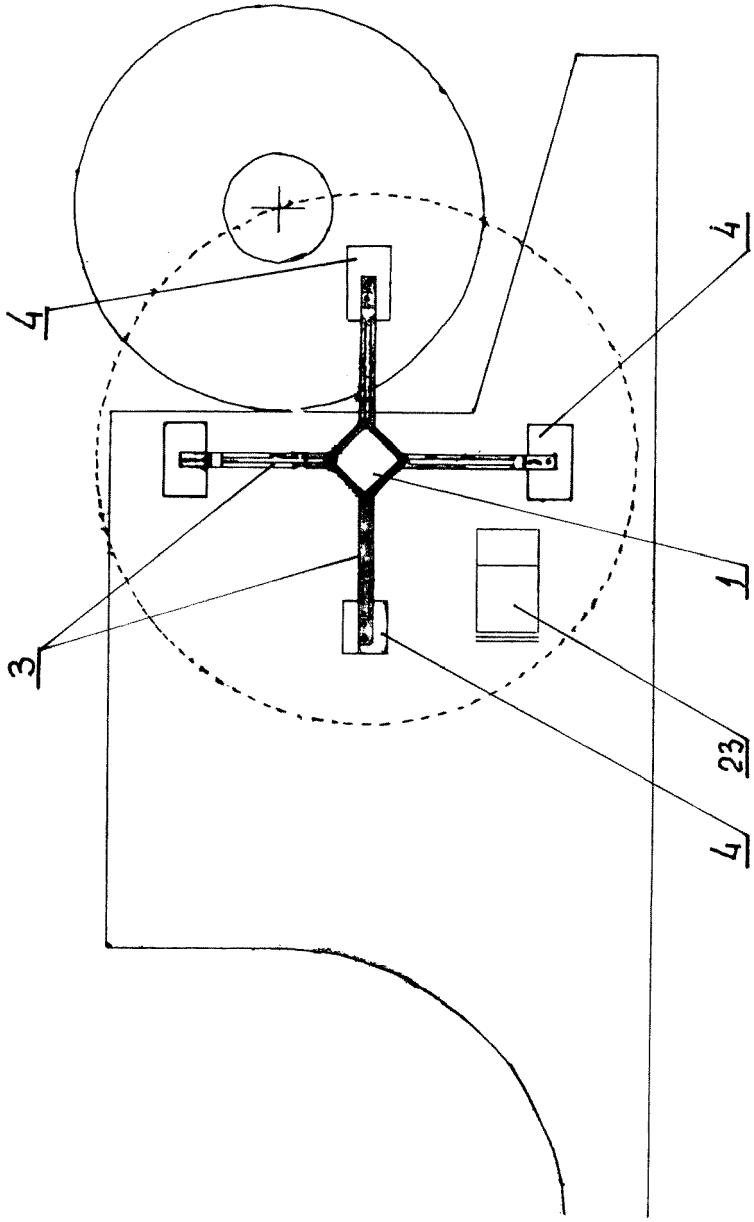

Fig. 11

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 18 46 0021

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	DE 10 2013 011489 A1 (LIEBHERR WERK EHINGEN [DE]) 15 January 2015 (2015-01-15) * paragraphs [0026], [0050], [0052], [0045]; figure 1 *	1-3	INV. B66C23/28 B66C13/46 B66C13/54 B66C23/18 B66C23/62 B66C23/82
Y	DE 10 2015 016279 A1 (LIEBHERR-WERK EHINGEN GMBH [DE]) 23 June 2016 (2016-06-23) * paragraphs [0026], [0025], [0030], [0072]; claim 7; figure 1 *	1-3	
Y	PL 213 684 B1 (VIATRON SPOLKA Z OGRANICZONA ODPOWIEDZIALNOSCIA [PL]) 30 April 2013 (2013-04-30) * figure 2 *	1-3	
Y	CN 102 826 470 A (XU JILIN) 19 December 2012 (2012-12-19) * abstract *	1-3	

TECHNICAL FIELDS SEARCHED (IPC)

B66C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	22 October 2018	Serôdio, Renato

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 46 0021

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22-10-2018

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