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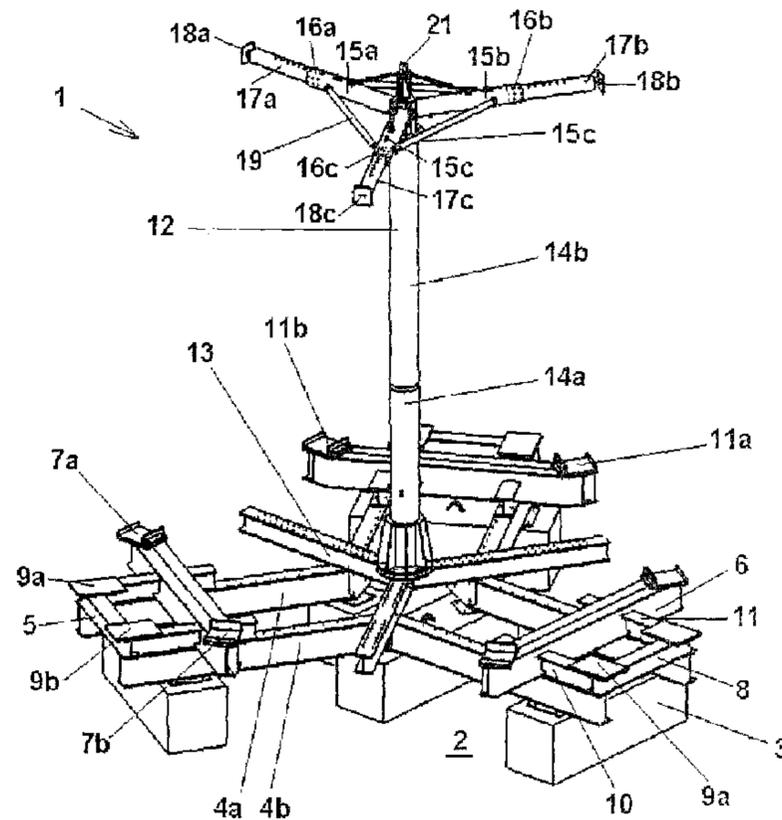
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(54) Titre : ENSEMBLE DE MONTAGE ET PROCEDE POUR ERIGER EN SECTIONS UNE TOUR ANNULAIRE POUR DES GENERATEURS EOLIENS OU HELIOSTATIQUES DANS UNE INSTALLATION DE PARC EOLIEN

(54) Title: MOUNTING ASSEMBLY AND METHOD TO ERECT IN SECTIONS AN ANNULAR TOWER FOR WIND OR HELIOSTATIC POWER GENERATORS IN AN ENERGY FARM



(57) Abrégé/Abstract:

A process for assembling an annular pre-stressed concrete tower using tower sections assembled from concrete tower segments through the use of a mounting assembly comprising a base (4) supporting three slippable supports (5) including a transverse girder (6) for supporting a first segment, and a transverse girder (8) for supporting a second segment; a retractable central column (12), having disposed at the top end of the column (12) (c) a plurality of upper retractable arms of top support (15a, 15b and 15c), the slippable supports (5), retractable central column (12), and the upper retractable arms of top support (15a, 15b and 15c) providing a tilt movement in the concrete tower segments to allow the assembling and horizontal pre-stressing of a concrete tower section, and mounting the tower sections by the use of a lifting harness which engages the hook of a crane.

ABSTRACT

A process for assembling an annular pre-stressed concrete tower using tower sections assembled from concrete tower segments through the use of a mounting assembly comprising a base (4) supporting three slippable supports (5) including a transverse girder (6) for supporting a first segment, and a transverse girder (8) for supporting a second segment; a retractable central column (12), having disposed at the top end of the column (12) (c) a plurality of upper retractable arms of top support (15a, 15b and 15c), the slippable supports (5), retractable central column (12), and the upper retractable arms of top support (15a, 15b and 15c) providing a tilt movement in the concrete tower segments to allow the assembling and horizontal pre-stressing of a concrete tower section, and mounting the tower sections by the use of a lifting harness which engages the hook of a crane.

MOUNTING ASSEMBLY AND METHOD TO ERECT IN SECTIONS
AN ANNULAR TOWER FOR WIND OR HELIOSTATIC POWER
GENERATORS IN AN ENERGY FARM

Field of the invention

This invention refers to a mounting assembly and method for assembling at floor level segmented sections of an annular pre-stressed concrete tower, particularly a mounting assembly to form tower sections from concrete tower segments to erect an annular tower for wind or heliostatic power generators and its method of erection.

Description of the related art

International patent application WO-2003069099 (& US-7,160, 085 and EP-1 474 579) assigned to MECAL describe a hybrid tower for wind power generators, which includes: (a) a lower part of an annular sectioned (tower divided in sections) and segmented (sections divided in segments) made of pre-stressed concrete and (b) an upper one consisting of a metallic tubular body connected to a power generator.

US Patent US 7,765,766 describes a pre-stressed concrete annular tower and erecting method which uses a perforated assembly base. The concrete tower segments include a lower protruding metallic bars which are introduced in the perforated assembly base so the concrete tower segments form a tower section which is in turn horizontally pre-stressed; and the

concrete tower segments also include upper perforations so corresponding lower protruding metallic bars of superjacent segments can be introduced in.

Such perforated assembly bases do not provide a safety support for assembling the concrete tower segments. In addition, incorporating protruding metallic bars increases the cost of the concrete towers. In order to assemble every section it is necessary to provide perforated assembly base with the diameter of the section to be assembled.

The construction of pre-stressed concrete use pre-stress tendons generally constituted of cables or rods of high resistance steel, to provide a compression load that reinforces the concrete structure.

The methods for assembling of the prior art have as main drawback the provision of a safety structure for assembling. It is necessary to say that segments of 12 meters height and of several tons of weight can be easily mounted at to floor level; nevertheless, the mounting operation at 30 meters height it is difficult under a windy environment it is risky. The sections must be mounted with the needed precision. Insofar as the prior art does not provide a process for assembling that can be conducted in a safety way and with the suitable precision. In addition, often, the unions must be cemented, which increases the complexity of the construction. In addition, the concrete tower segments are made using different molds and the segments could probably not coincide.

International patent application WO/2010/067166 of the same inventors of the present application describes a process to mount in sections an annular concrete tower. That process requires a mounting assembly unit for every section of the tower of a certain diameter. In addition, the mounting assembly and the concrete section are both hoisted together to erect the tower, so the

time lapse in which the concrete section is mounted to erect the tower cannot take advantage to assemble new sections.

The mounting assembly of the invention and the method for assembling can also raise towers for heliostatics applications, and for the erection of any class of annular tower, post or chimney. The mounting assembly and the method of assembly of the present invention provide a better functionality when compared with the assembly methods of the prior art.

SUMMARY OF THE INVENTION

It is therefore, an object of the present invention to provide one mounting assembly for concrete tower segments to form sections of an annular tower of pre-stressed concrete for wind or heliostatic power generators.

Another object of the invention is to provide a method for assembling at floor level, concrete section from concrete tower segments of an annular tapered pre-stressed concrete tower of pre-stressed concrete for wind or heliostatic power generators with the use of a mounting assembly, where the mounting assembly is adjustable to the different dimensions of the sections to be assemble and each segment conforming a section of the tower is placed in the exact required position and tilt.

To solve these previous objects, the present invention provides a process for assembling in sections an annular pre-stressed concrete tower comprising:

1. providing a tower foundation and a plurality of concrete tower segments;
2. providing a mounting assembly for assembling the sections of the tower at floor level, the mounting assembly comprising:
 - a. a mounting base comprising three pairs of radially extended double parallel arms;
 - b. a slippable support at a distal point from a center of the base that slips on the pair of double parallel arms and comprises a first transverse girder for supporting a first concrete tower segment a second transverse girder for supporting a second concrete tower segment parallel to the first transverse girder, and two parallel radial girders both joined to the first and second transverse girders; and
 - c. a central column with a column base that relies on the mounting base, said central column comprising a telescopic body consisting of a body and an extension, said central column having a top end at which are disposed a plurality of upper retractable arms each formed by a respective top support body and top support extension;
3. assembling at least one pre-stressed concrete tower section by:
 - a. placing the plurality of concrete tower segments on the slippable support;
 - b. tilting the concrete tower segments on the upper retractable arms; and
 - c. vertically pre-stressing the assembled concrete tower segments;

4. for a first assembled pre-stressed concrete tower section:
 - a. attaching a lifting harness to the pre-stressed concrete tower section;
 - b. hoisting the pre-stressed concrete tower section by means of a crane connected to the lifting harness; and
 - c. mounting the pre-stressed concrete tower section on the foundation;
5. for each subsequent superjacent assembled pre-stressed concrete tower section, using the mounting assembly:
 - a. attaching a lifting harness to the pre-stressed concrete tower section;
 - b. hoisting and mounting the pre-stressed concrete tower section according to the same routine for mounting the first assembled pre-stressed concrete tower section of the tower; and
6. mounting a ring adapter, a flange for connecting a nacelle or wind generator or heliostatic generator in the top part of the annular pre-stressed concrete tower.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood from the following detailed description referred to the drawings which are not limitative of the present invention, and where:

Figure 1 shows a mounting assembly, for assembling at floor level sections of a pre-stressed concrete tower from concrete tower segments.

Figure 2 depicts a mounting assembly arranged to assemble sections of a tower, including flat and curved segments of concrete.

Figure 3 shows a assembled section of a tower which includes a lifting harness.

Figure 4 shows an annular pre-stressed concrete tower showing the horizontal and vertical pre-stressing tendons.

DETAILED DESCRIPTION OF THE INVENTION

According to the present invention, a section of the annular tapered tower includes at least three concrete tower segments that once assembled are hoisted and mounted in the tower. The sections are mounted in a well know form, for example through the use of a fastening hoop (21) and a lifting harness (22), with a crane. Then, mounting assembly (1) is used again for assembling the following adjacent section of the tower.

Preferably, the tower includes three curved segments, all of the same dimensions, separated by three flat trapezoidal segments with variable dimensions, so the diameter of the sections depends on the sizes of the flat trapezoidal segments. The section is then composed by six segments of

concrete.

The tower includes pre-stressing tendons for the vertical and horizontal pre-stressing of the tower. The horizontal pre-stressing has for object joining adjacent segments to conform an annular section of the tower. The tower in addition includes tendons of vertical pre-stressing, to keep joined concrete sections and to the foundation, which render a structure having properties of a monolithic one. The tower includes a foundation having means to anchor the pre-stressing tendons, the vertical pre-stressing tendons runs along the length of the tower, a plurality of tendons run along the whole length of the tower whereas other vertical pre-stressing tendons only runs between intermediate sections of the tower and the foundation.

The mounting assembly (1) and method to assemble at floor level sections of an annular pre-stressed concrete tower for wind or heliostatic power generators, is described:

Figure 1 depicts a mounting assembly (1) for use with sections of a pre-stressed concrete tower at floor level. The mounting assembly (1) is placed on a leveled platform (2) and includes a support (3) that includes a base (4) consisting of three pair of double parallel arms (4a and 4b) that each extend radially. Each of the double parallel arms has in its part more distant to the center, a slippable support (5) for the first segments and the second segments.

The slippable support (5) is a rectangular frame that includes a first transverse girder (6) for support of the first segments, a second transverse girder (8) for support of the second segments, both transverse girders being parallel and opposite, and being joined by two radial girders opposite (10,11) that complete the frame.

The first transverse girder (6) includes first receptacles (7a and 7b) to receive the base of a first segment of concrete. Likewise, the second transverse girder (8) includes second receptacles (9a, 9b) to receive the base of a second segment of concrete.

It is preferred that the first segments correspond to the trapezoidal flat segments, while the second segments correspond to the circular segments.

The separation of the radial girders corresponds to the separation of the pair of double parallel arms 4a, 4b so the frame formed by the girder 6, 8, 10 and 11 that form the slippable support (5) runs in the radial direction on the double parallel arms to approach or to move away from the center of the column. The slippable support (5) allows that the mounting assembly (1) of the present invention could be used for assembling sections of tower of different diameters. When the slippable support (5) moves away from the center it is possible to assemble a section of bigger diameter. When the slippable support (5) approaches the center of the mounting assembly (1) it can be used to assemble tower sections of a smaller diameter.

The first transverse girder (6) has dimensions longer than the second transverse girder (8), so that tangentially extends beyond distance between the double parallel arms (4a, 4b), having besides a higher height providing an upper level to the first trapezoidal flat segments regarding the second segments. This height allows step (44), which is suitable for preventing the horizontal displacement of a tower sections regarding a subjacent or superjacent one.

In the embodiment showed in the Figures, the position and dimensions of

the first transverse girder 6 for first segments does not change regarding the position and dimensions of the second transverse girder 8 for second segments, due to the fact that according to the preferred embodiment the circular segments always have the same width. On the other hand, the radial displacement of the slippable support (5) allows the placement of the flat trapezoidal concrete tower segments of different width.

In the case that the concrete tower sections are tapered, it is necessary to provide slippable supports (5) for the adjustment of all concrete tower segments, for example to form concrete sections of different diameters with frustoconical annular sections.

The slippable support (5), on the double parallel arms (4a, 4b) are driven through mechanical, pneumatic or hydraulic means (not illustrated) which are well-known in the art. Likewise, the slippable supports (5) include means to keep its position, these means include bolts that mate in perforations on the double parallel arms (4a, 4b), or other mechanical, pneumatic or hydraulic means well-known in the art.

The mounting assembly (1) of the present invention also includes a central column (12), having a column base (13) that relies on the base (4) of the mounting assembly (1). The column (12) has a telescopic body consisting of a body (14a) and of an extension (14b) that extends in the longitudinal direction. With the above mentioned arrangement the column can assume diverse heights considered to be suitable for assembling a section of the tower of a certain height.

At the top end of the column (12) are arranged a plurality of top support arms, which are depicted in the figures as three retractable arms (15a, 15b and 15c). The arms also are telescopic and there are each formed by a body

(16a, 16b and 16c) that lodge a respective extension (17a, 17b and 17c) that extend in radial direction to support the first concrete tower segments at a certain height. Likewise, the retractable arms include means to retain a certain position, such as bolts that mate in perforations in the body or the extension of the arms, or other mechanical, pneumatic or hydraulic means well-known in the art.

The arms 15a, 15b and 15c optionally include vertical supports 18a, 18b and 18c providing a surface where the flat face of a flat trapezoidal segment relies. The vertical supports (18a, 18b and 18c) can include means to provisionally join the arms to the concrete tower segments, for example insertions including screws and nuts, in order to prevent the trapezoidal concrete tower segments from collapsing out of the center of the mounting assembly and causing damage to working personnel, the mounting assembly or the concrete tower segments.

In addition, the support arms (15a, 15b, 15c) optionally include reinforcements of arms (19) that consist of bars joined at each end of respective arms to reinforce the above mentioned arms and to prevent the retractable arms (15a, 15b, 15c) from being deformed by the force exerted by the weight of the concrete tower segments.

The supports of the concrete tower segments, especially the receptacles 7a, 7b, and the retractable top arms as well as the possibility of extending or contracting the central column and the slippable support (5) allow that the concrete tower segments can be tilted to final position without risk of the concrete tower segments falling or collapsing out of the mounting assembly.

The mounting assembly (1) also includes a fastening hoop (21) for lifting, which is placed in the top end of the column (12). The hook of a derrick gets

hooked up in the above mentioned hoop to ship and to land the mounting assembly from a car of transport.

The mounting assembly (1) provides a structure that allows the assembling of concrete tower segments. Under the preferred embodiment of the present invention, a section of tower includes three first concrete tower segments (flat trapezoidal) and three second concrete tower segments (curved). As it will be apparent to a person skilled in the art, the segments of concrete can be in several pieces and can have the same or different form.

Figure 2 depicts the mounting assembly (1) of the invention, which in a preferred embodiment contains first flat trapezoidal concrete tower segments (40) alternated with the second curved segments (30). In a preferred embodiment, the curved concrete tower segments (30) incorporate ducts (31) to introduce cables or rods of steel of high resistance as pre-stressing tendons or strands for the vertical pre-stressing (51), and ducts (32) to introduce horizontal pre-stress tendons (52a, 52b, 52c). In the embodiment illustrated in Figure 2, the flat trapezoidal concrete tower segments (40) only incorporate ducts (42) to introduce horizontal cables of pre-stress (52a, 52b, 52c), but they do not include ducts for vertical pre-stressing tendons so that only the curved segments include the ducts for vertical pre-stressing. As it will be apparent to a person skilled in the art, it is possible to use flat trapezoidal concrete tower segments (40), which also include vertical cables of pre-stress.

Inside the horizontal ducts (32 and 42) of the respective segments of concrete flat and curved, are introduced pre-stressing tendons and, for the pre-stressing action, the first flat concrete tower segments (40) and the second curved concrete tower segments (30) remain fixed and firmly joined, forming a structure with structural properties similar to those of a monolithic structure.

In a preferred embodiment of the invention, the curved segments include protrusions (33) in the inner face of the segment, which enable the introduction and tensioning of the pre-stressing tendons. Under a preferred embodiment of the invention, there are provided three horizontal pre-stressing tendons (52a, 52b, 52c), every tendon joins three curved segments and two flat segments in the following way:

- the first tendon 52a has for object join the first curved segment, the first flat adjacent segment, the second curved segment, the second flat segment and the third curved segment. But not the third flat segment.

- the second tendon 52b has for object join the second curved segment, the second flat adjacent segment, the third curved segment, the third flat segment and the first curved segment. But not the first flat segment.

- the third tendon 52c has for object join the third curved segment, the third flat adjacent segment, the first curved segment, the first flat segment and the second curved segment. But not the second flat segment.

Each of the curved segments is joined by three pre-stressing tendons and each one of the flat segments is crossed by two pre-stressing tendons. There placed a plurality of projections (33) in the internal face of each curved segments to a predetermined height. In Figure 2 the circular segment includes six protrusions (33) with a separation of for example one meter.

The union obtained by the compression of the pre-stressing tendons prevents that the segments could move along the lateral faces combined of the curved and flat segments. So it is not need to use cemented unions to join adjacent concrete tower segments. However, as it is apparent to a person skilled in the art, shear locks and or cemented joints can be used.

Preferably there is formed a step (44) that is useful for assembling two sections of tower. Such a step (44) is provided by the difference of height in the receptacles of the first segments (flats) (7a, 7b) and the second segments (curved) (9a, 9b). As it is shown in Figure 1, the girder (6) for the first segments is higher than the girder (8) for the second segments.

In a first stage, preferably there are placed the flat trapezoidal segments (40), which are fixed firmly to the mounting assembly (1) on the first receptacles (7a and 7b) and the vertical arm supports (18a, 18b and 18c), and in a second stage there are placed the curved segments (30). The curved segments are heavier than the flat segments, so two flat segments can support the load due to the weight of an inclined curved concrete tower segment. The above mentioned disposition is illustrative but not limitative, since the flat trapezoidal segments and the curved segments can be installed in consecutive form or in alternated form, to preference of the builder.

As soon as there is assembled a section of tower and the pre-stressing tendons have been placed and tensioned, a lifting harness(22) is joint to the assembled concrete section. The lifting harness(22) includes at least two bars introduced in the ducts of vertical pre-stressing (31) and hold themselves in such ducts by means of nuts incorporated into the thread ends of the bars (23). The figure 3 shows a lifting harness assembled in an assembled concrete section.

There are assembled so many sections of tower according to the design of the tower. The first section is placed on the foundation and vertical means of pre-stressing are provided to join the first section to the foundation. Then, the second section is assembled and mounted on the first section, prestressing to the foundation is also conducted; the third and subsequent sections are assembled, mounted and pre-stressed. As the sections are mounted, vertical tendons of pre-stress are placed to join the sections with

the underlying previous sections and the foundation. If the tower includes cylindrical sections or a geometry different than the previously mounted section, it is necessary to mount an adapter to join the sections of different geometry. Finally, a flange is placed or adapted at the top of the tower and there are placed pre-stressing tendons that run along the total body of the tower, within all concrete sections. As previously mentioned, according to the preferred embodiment of the invention, the vertical pre-stressing tendons run only inside the concrete curved segments, but not inside the trapezoidal flat segments. Figure 4 illustrates the vertical and horizontal pre-stressing of an annular concrete tower.

The present invention overcomes the drawbacks of the prior art, providing a mounting assembly and method for assembling concrete sections of a tower from concrete tower segments. The present invention provides a mounting assembly and method for erecting a pre-stressed concrete tower that includes:

(a) providing a mounting assembly (1) to support the concrete tower segments to assemble sections of an annular pre-stressed concrete tower.

(b) providing a flat platform or level the floor, to place the mounting assembly (1);

(c) to place the slippable supports (5) of the mounting assembly in a suitable position corresponding to the dimensions of the base of the section of tower, where the above mentioned supports (5) will support the base of every segment of concrete by means of his respective receptacles (14a, 14b, 17a, 17b);

(d) to establish the position of the column extension to a suitable height;

(e) to establish the position of the retractable arms, by means of extending the extension of arm to allow the support of the first segments of flat trapezoidal concrete tower segments, preferably on the ribs or

reinforcement ribbing arranged to the inner side of every concrete tower segment;

(f) to place the first flat trapezoidal concrete tower segments and immediately the second curved concrete tower segments that form a section of the tower, using a derrick of low or medium load capacity;

(g) to join the concrete tower segments with a plurality of horizontal pre-stressing units. Under the present invention, every pre-stressing unit including three pre-stressing tendons that hold joined three circular segments and two flat segments.

(h) to connect a lifting harness assembled and pre-stressed concrete section;

(i) to hoist the assembled section, by mean of a crane of high capacity that incorporates a hook that engages the harness of elevation.

(j) to mount the above mentioned concrete section on the foundation, and uncouple the lifting harness of the mounting assembly;

(i) to assemble the subsequent concrete sections constituting the tower, with the mounting assembly. The slippable support adjusts the diameter of the subsequent sections, which is minor that the section previously assembled to yield a tapered tower;

(j) to mount the subsequent sections of the tower through the use of the lifting harness, following the same routine for the first section of the tower; and

(k) mounting an adapter, or flange for a wind power generator or recipient heliostatic in the top part of pre-stressed concrete tower.

The method of the present invention also applies to towers of circular or polygonal cross section. In such a case the first and second segments have similar forms. Likewise, as it will be apparent to a person skilled in the art, a section of tower might be assembled from three, four, five, seven or eight

segments of concrete.

From the above description of the invention a person skilled in the art will find that the same can be modified in different ways. It is considered that such modifications do not depart from the spirit and the scope of the invention, and all these obvious modifications to a skilled in the art are included within the scope of the following claims.

CLAIMS

1. A method for sectional assembly of an annular pre-stressed concrete tower, said method comprising:
 - a. providing a tower foundation and a plurality of concrete tower segments;
 - b. providing a mounting assembly for assembling the sections of the tower at floor level, the mounting assembly comprising:
 - i. a mounting base comprising three pairs of radially extended double parallel arms;
 - ii. a slippable support at a distal point from a center of the base that slips on the pair of double parallel arms and comprises a first transverse girder (6) for supporting a first concrete tower segment a second transverse girder (8) for supporting a second concrete tower segment parallel to the first transverse girder, and two parallel radial girders both joined to the first and second transverse girders; and
 - iii. a central column with a column base that relies on the mounting base, said central column comprising a telescopic body consisting of a body and an extension, said central column having a top end at which are disposed a plurality of upper retractable arms each formed by a respective top support body and top support extension;
 - c. assembling at least one pre-stressed concrete tower section

by:

- i. placing the plurality of concrete tower segments on the slippable support;
 - ii. tilting the concrete tower segments on the upper retractable arms; and
 - iii. vertically pre-stressing the assembled concrete tower segments;
- d. for a first assembled pre-stressed concrete tower section:
- i. attaching a lifting harness to the pre-stressed concrete tower section;
 - ii. hoisting the pre-stressed concrete tower section by means of a crane connected to the lifting harness; and
 - iii. mounting the pre-stressed concrete tower section on the foundation;
- e. for each subsequent superjacent assembled pre-stressed concrete tower section, using the mounting assembly:
- i. attaching a lifting harness to the pre-stressed concrete tower section;
 - ii. hoisting and mounting the pre-stressed concrete tower section according to the same routine for mounting the first assembled pre-stressed concrete tower section of the tower; and
- f. mounting a ring adapter, a flange for connecting a nacelle or wind generator or heliostatic generator in the top part of the

annular pre-stressed concrete tower.

2. The method of claim 1, wherein the first transverse girder (6) includes first receptacles and the second transverse girder (8) for supporting the second segments includes second receptacles.
3. The method of claim 1, wherein the tilt movement for adjustment of the concrete tower segments is provided by the slippable support, the retractable central column and the upper retractable arms driven by mechanical, pneumatic or hydraulic means.
4. The method of claim 1, wherein the first concrete tower segments consist of flat trapezoidal concrete tower segments and the second concrete tower segments consist of curved segments.
5. The method of claim 1, wherein horizontal pre-stressing consists of a plurality of pre-stressing units arranged to different heights of the tower section, where every pre-stressing unit includes three pre-stressing strands holding three curved segments and two flat trapezoidal concrete tower segments.
6. A mounting assembly for assembling at floor level the sections of an annular pre-stressed concrete tower comprising:
 - a. a base comprising three pairs of radially extended double parallel arms;

- b. a slippable support at a distal point from a center of the base that slips on the pair of double parallel arms and comprises a first transverse girder for supporting a first concrete tower segment a second transverse girder for supporting a second concrete tower segment parallel to the first transverse girder, and two parallel radial girders both joined to the first and second transverse girders; and
 - c. a retractable central column with a column base that relies on the mounting base, said central column comprising a telescopic body consisting of a body and an extension, said central column having a top end at which are disposed a plurality of upper retractable arms each formed by a respective top support body and top support extension.
7. The mounting assembly of claim 6, wherein the first transverse girder includes first receptacles and the second transverse girder for supporting the second segments includes second receptacles.
8. The mounting assembly of claim 6, wherein a tilt movement for adjustment of the concrete tower segments is provided by the slippable support, the retractable central column and the upper retractable arms driven by mechanical, pneumatic or hydraulic means.

1/4

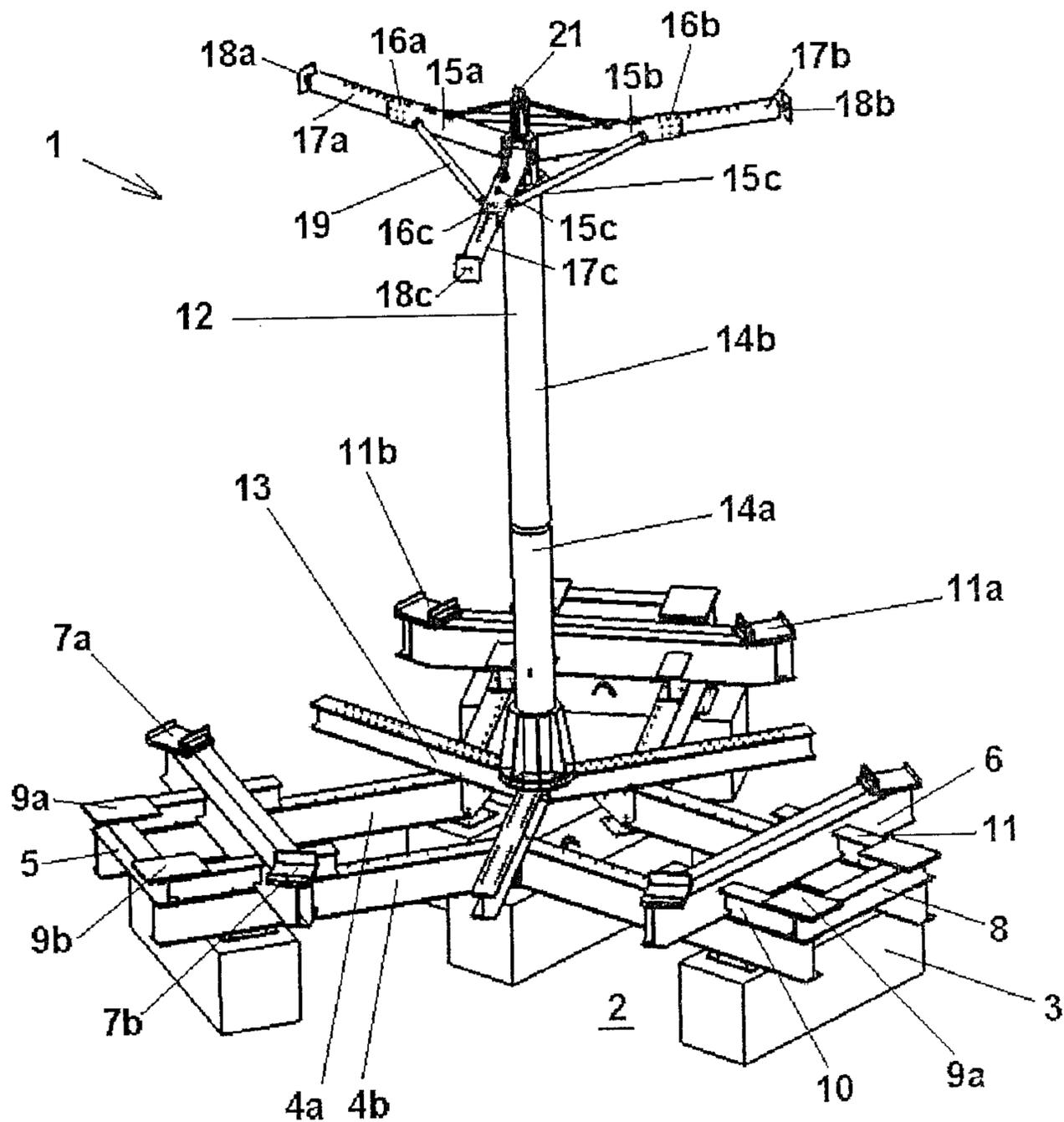


FIG. 1

2/4

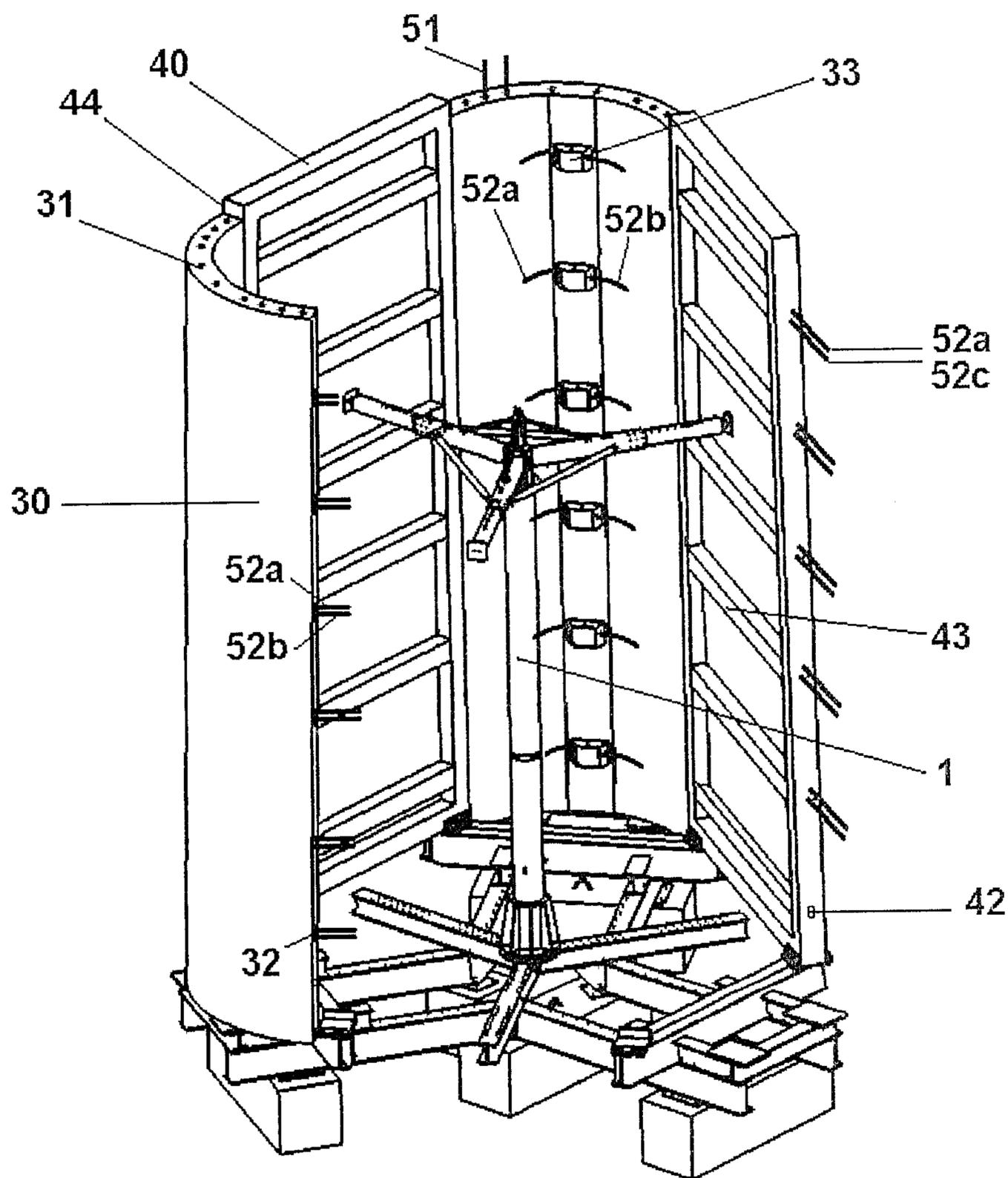


Fig. 2

3/4

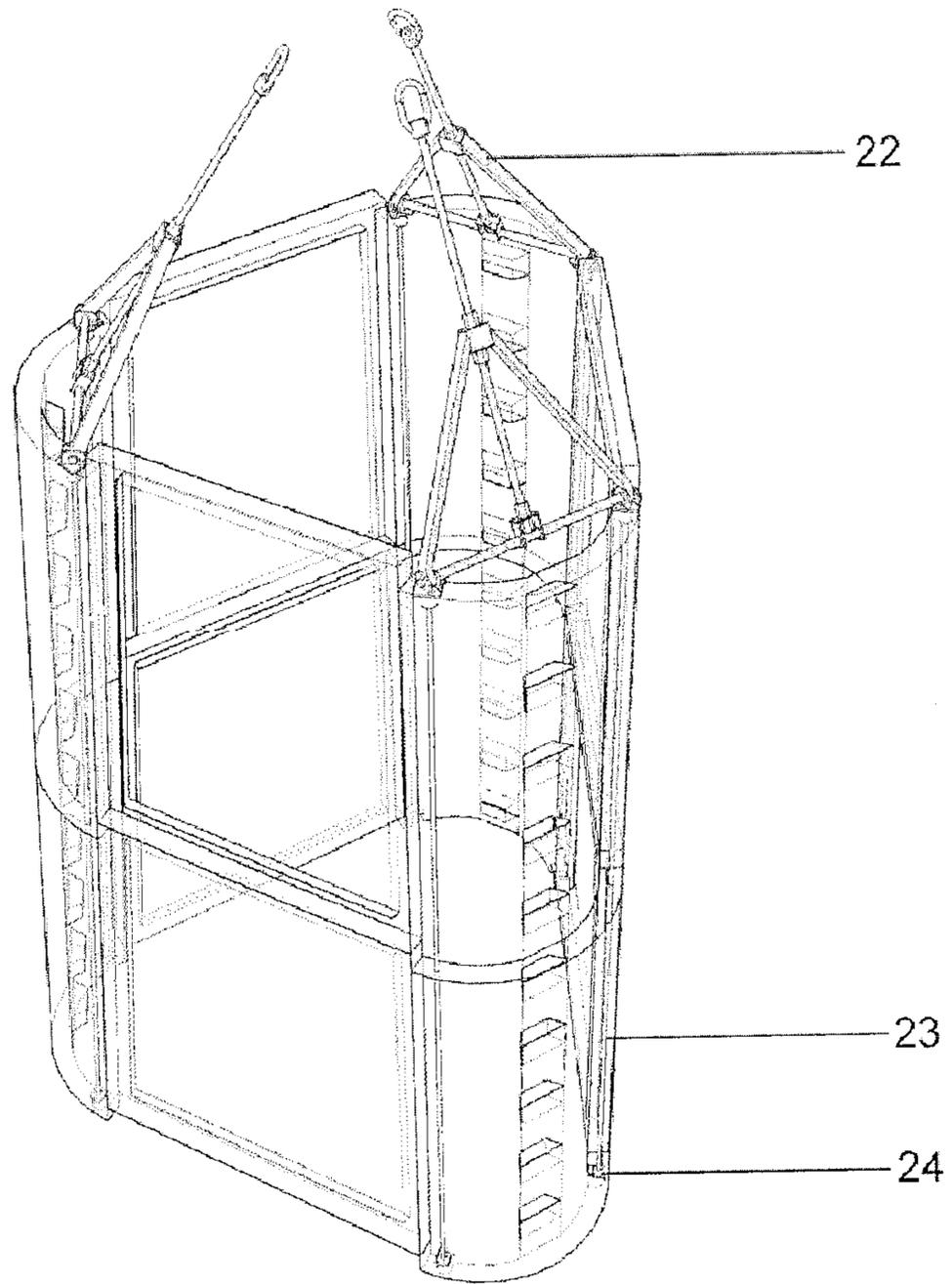


FIG. 3

4/4

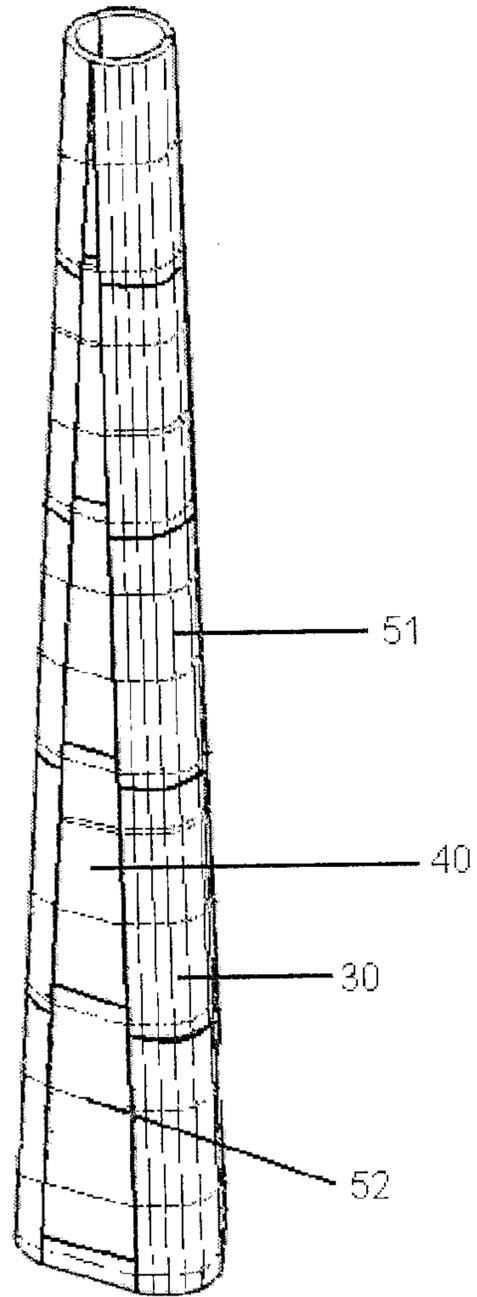


FIG. 4

