(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 799 622 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.11.2014 Bulletin 2014/45

(51) Int Cl.:
***E02D 27/50** (2006.01)*

(21) Application number: **14166787.3**

(22) Date of filing: **01.05.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **02.05.2013 NL 2010754**

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(54) **High-voltage electricity tower provided with a foundation**

(57) The invention relates to a high-voltage electricity tower provided with a foundation. It comprises: two tower piles configured to carry high-voltage lines; a ground foundation; a tower foundation placed underneath each respective tower pile in order to support said tower pile. Each tower pile rests on a tower foundation and each tower foundation is placed on the ground foundation in such a manner that, on the one hand, the ground foundation connects the tower foundations to one another and, on the other hand, forces exerted by said lines carried by the tower piles are transmitted to the ground via the tower piles, the tower foundations and the ground foundation. The ground foundation comprises a beam pattern which extends in the horizontal plane. The beam pattern comprises a main beam. Said main beam extends, on the one hand, at right angles to the longitudinal direction of the tower piles and, on the other hand, at right angles to the extending direction of the lines carried by the tower piles.

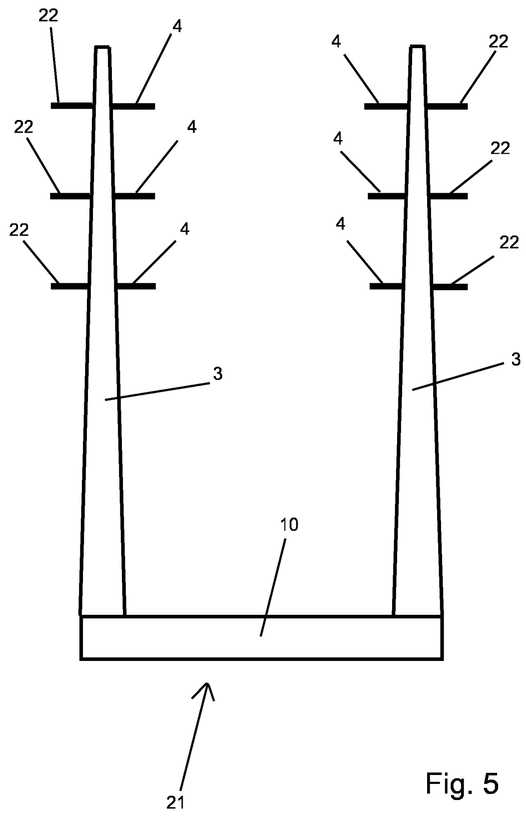

Fig. 5

EP 2 799 622 A1

Description

[0001] The invention relates to a high-voltage electricity tower provided with a foundation.

[0002] High-voltage electricity towers, also referred to as high-voltage pylons, are used to carry high-voltage lines - hereafter referred to as 'lines' for short - such as high-voltage cables through which electricity is transported from a first location to a second location at high voltage.

[0003] Depending on the position in a row of high-voltage electricity towers placed one behind the other, the following distinction can be made between high-voltage electricity towers:

- angle towers: the row of successive high-voltage electricity towers has a bend at the location of an angle tower, that is to say the lines on one side of the tower and the lines on the other side of the tower are at an angle with respect to each other;
- suspension towers: the row of successive high-voltage electricity towers continues in a straight line at the location of the suspension tower, that is to say the lines on one side of the tower and the lines on the other side of the tower extend in the same direction; and
- dead-end towers: these are situated at the beginning and end of a row of successive high-voltage electricity towers, that is to say the lines on one side of the tower run to a subsequent tower and the lines on the other side of the tower do not run to another tower, but into the ground in order to continue underground or to an installation such as a distribution station or otherwise.

[0004] In the Netherlands, most high-voltage electricity towers are conventionally configured as lattice towers. These lattice towers are composed of a very large number (tens or hundreds of) metal angle profiles, also referred to as lattices. These angle profiles are attached to each other by means of bolts. The bottom part of the lattice tower has four legs which support the lattice tower on driven piles. The legs may be short, but may also be very tall, so that agricultural vehicles can pass under them. On top of this bottom part, the so-called tower is placed, which is usually of a tapering design, at least in the Netherlands. Arms, also referred to as crossbars, are fitted to the tower, which arms project on either side of the tower and carry the lines.

[0005] In addition to lattice towers, there are also tube towers, also called duct towers. The construction of tube towers is in the shape of a pile, and they are referred to in the remainder of this application as a tower pile. This tower pile is provided with arms from which the lines are suspended. The tower pile is usually configured as a metal structure which often, but not always, tapers. A recent further development of the tube tower is the so-called Wintrack tower. One single Wintrack tower consists of two tower piles which, viewed in a direction at right angles to the longitudinal direction of the lines, are arranged next to each other at a distance of approximately 6-20 metres apart, such as a distance of 7.5-16.5 metres apart.

[0006] The present invention relates to tube towers and in particular to tube towers comprising two juxtaposed tower piles per tower.

[0007] High-voltage electricity masts are provided with a foundation in the ground. In this case, the high-voltage electricity tower has to be able to transmit the forces exerted, inter alia, by the supported lines to the ground. A good foundation or anchoring in the ground is therefore necessary.

[0008] With regard to tube towers, it is known to first excavate a pit in the ground and to place the concrete foundation of the tube tower therein. This pit, also known as a construction pit or excavation, has to be sufficiently large to accommodate the concrete foundation. It is known to configure the foundation as a concrete slab which may, in turn, be provided with a further foundation in the form of piles. With masts comprising two tower piles per mast, such as the Wintrack tower, each tower pile is provided with a separate foundation in the form of a concrete slab, which may, for example, be rectangular or circular and have a diameter of 7.5 m to 12 m and which may optionally be provided with a further foundation in the form of piles in order to absorb the forces which are exerted on the foundation by the tower pile. With angle masts, the tower piles may be too close together to allow for a separate foundation slab for each tower pile and it is known to make use of a single rectangular concrete foundation slab which may optionally be provided with a further foundation in the form of piles. Thus, a common foundation consisting of a rectangular concrete slab of approximately 17 m x 11 m is known, comprising two tower foundations - also known as a filling in the field - at a mutual centre-to-centre distance of 9 m.

[0009] A problem in constructing a high-voltage electricity tower and not least a foundation therefor is that this requires large amounts of time, work and material and is therefore a costly project. Depending on the soil conditions, further problems may be encountered, for example regarding groundwater and so-called aquifers.

[0010] In certain situations, depending on the groundwater level, the pit may fill with groundwater during excavation, as a result of which the placement of the foundation slab may be rendered more difficult. This is a significant risk, in particular in regions where the groundwater rises to high levels. Continuous dewatering is required in those cases in order to prevent this.

[0011] In regions, for example in low-lying polders, where a so-called aquifer is situated underneath a sealing layer, often a clay layer, the ground may burst. When digging is taking place, the load on the sealing layer is reduced and the pressure from the aquifer may cause the ground to burst open. The water from the aquifer may be polluted and/or salty. In order to prevent bursting, it is known to reduce the water pressure underneath the sealing layer by means of so-called vacuum-assisted dewatering. This is a costly solution, in particular since the water from the aquifer cannot be discharged everywhere, necessitating long transport lines or 'closed-circuit' dewatering.

[0012] It is an object of the present invention to provide a high-voltage electricity tower provided with a foundation and two tower piles, by means of which one or more of these problems can be overcome, at least partly, or to at least provide a usable alternative.

[0013] This object is achieved according to the invention by a high-voltage electricity tower provided with a foundation according to Claim 1.

[0014] The high-voltage electricity tower provided with a foundation according the invention comprises two tower piles, a ground foundation and a tower foundation for each tower pile on which, on the one hand, the associated tower pile rests and which, on the other hand, is placed on the foundation. Each tower pile is configured to carry high-voltage lines and the tower piles are placed in a vertical orientation at a horizontal distance apart. This horizontal distance will, considered as centre-to-centre, generally be smaller than 50 m, and in practice - as is presently envisaged - be smaller than 25 m, generally even smaller than 20 m. With the high-voltage electricity tower provided with a foundation according to the invention, each tower pile rests on a tower foundation and each tower foundation is, in turn, placed on the ground foundation in such a way that, on the one hand, the ground foundation connects the tower foundations to one another; and that, on the other hand, forces originating from the lines carried by the tower piles are transmitted to the ground via the tower piles, the tower foundations and the ground foundation.

[0015] With regard to the tower foundation, it should be noted that this may be a separate, visually visible component. However, it is also conceivable for the tower foundation not to be a separate visually visible component as - seen visually - the tower pile is fitted directly to the main beam. In this case, the bottom end, the foot, of the tower pile should be considered to be the tower foundation.

[0016] Where a foundation slab is used in the prior art, the ground foundation according to the invention comprises a beam pattern extending in the horizontal plane. According to the invention, the term 'beam pattern' is understood to mean a pattern consisting of a single beam or several beams. Thus, the beam pattern according to the invention comprises - at least - one main beam and may optionally also comprise one or more additional supporting beams.

[0017] On the one hand, the main beam extends at right angles to the longitudinal direction of the tower piles and, on the other hand, at right angles to the extending direction of the lines carried by the tower piles. In addition, both tower piles rest on the main beam via the tower foundation of the respective tower pile.

[0018] On the one hand, the beam pattern has the result that significantly less soil has to be excavated and that the excavation is much less wide and, on the other hand, that the size of the ground foundation is greatly reduced. Both factors significantly reduce costs as they lead to savings in time, material and work. As less soil has to be excavated, the risk - in those cases where there is such a risk - of the ground bursting and problems with groundwater is reduced. As is explained in the description of Figures 1 and 2 in more detail, the ground foundation with the beam pattern is also very well able to transmit forces exerted by the lines carried by the tower piles to the ground, partly as a result of the tower piles being mutually connected to each other by the beam pattern.

[0019] In addition, as the main beam connects the two tower piles to one another, the number of piles - if they are needed at all - can be reduced. This also reduces the costs due to the savings in time, material and work.

[0020] In case of a suspension mast, it is even possible, according to the invention, to use only a main beam without additional supporting beams, due to the fact that the forces acting in the longitudinal direction of the lines on one side of the suspension tower and on the other side of the suspension tower cancel each other out.

[0021] According to a further embodiment of the invention, the tower piles are provided at the ends of the main beam. Thus, one of the two tower piles is provided at either end of the main beam. In that case, the main beam does not have to project far beyond the two tower piles. In case of a lateral load by the wind, the load on the main beam exerted by the one tower pile will help to cancel out the load on the main beam exerted by the other tower pile. The own weight - gravitational forces - exerted by the tower pile situated on the wind side will also prevent the unit from being blown down. In this case, the tower piles may be at a mutual centre-to-centre distance of approximately 16 m - as is desirable for, for example, Wintrack towers - while the main beam does not have to be much longer than 20 m with tower foundations having a diameter of, for example, 4 m. With a different centre-to-centre distance and/or different diameter for the tower foundations, the main beam may have a correspondingly different length. Expressed in percentages of the length of the main beam, the tower foundation of each tower pile may have a horizontal distance to the respective end of the main beam which is at most 10%, such as at most 5%, of the length of the main beam. Expressed differently in percentages of the length of the main beam, the axis of each tower pile may, viewed in the horizontal direction, have a horizontal distance to the respective end of the main beam which is at most 20%, such as at most 15% or at most 10%, of the length of the main beam.

[0022] According to yet another embodiment, the tower piles may thus be provided on each end of the main beam. It is even possible for the tower foundations, which are usually slightly wider than the diameter of the bottom end of the tower piles, to project beyond the ends of the main beam.

[0023] According to a further embodiment of the high-voltage electricity tower according to the invention, the beam pattern furthermore comprises one or more supporting beams which form an integral part of the main beam and extend laterally in a horizontal direction from the main beam. Such supporting beams may be provided on a longitudinal side of the main beam or on both longitudinal sides of the main beam. If they are provided on both longitudinal sides of the main beam, they may be provided in a mirror-symmetrical way with respect to the main beam. Such supporting beams may be useful if the forces acting in the longitudinal direction of the lines on the one side of the high-voltage electricity tower and on the other side of the high-voltage electricity tower cancel each other out to an insufficient degree, or not at all. This is usually the case, for example, with a so-called dead-end mast. With supporting beams, the one or more supporting beams may extend at right angles to the longitudinal direction of the main beam, according to a further embodiment of the invention.

[0024] According to a further embodiment of the invention with supporting beams, the ends of the main beam may be provided with said supporting beams, in such a way that, in case additional support is required on both longitudinal sides of the main beam, the beam pattern is H-shaped or, in case additional support is required on a longitudinal side of the main beam, the beam pattern is U-shaped. With dead-end masts, this additional support is indeed required on one longitudinal side, but the practical application of required design demands teaches that additional support on both longitudinal sides is required. By providing the supporting beams at the ends of the main beam, the weight of the supporting beams and any further anchoring thereof in the ground by means of, for example, piles, can be utilized to the full.

[0025] According to a further embodiment of the high-voltage electricity tower according to the invention, each tower foundation may, viewed in the horizontal plane, project on either side of the main beam. Viewed in the horizontal plane, the tower foundation is then therefore wider than the width of the main beam. With a tower foundation having a round cross-sectional shape, viewed in the horizontal plane, this means that the largest diameter of the tower foundation is larger than the width of the main beam or other beams of the beam pattern.

[0026] According to a further embodiment of the high-voltage electricity tower according to the invention, the beam pattern may be made of steel or of reinforced concrete.

[0027] According to a further embodiment of the high-voltage electricity tower according to the invention, each tower foundation may be formed as a pouring of reinforced concrete. Optionally, bolts may also be incorporated into the tower foundation for fastening the tower pile. A tower foundation may be, for example, cylindrical, but may also have another shape, such as a frustoconical shape or a pyramid shape, but may also be box-shaped or block-shaped. It should again be noted that the tower foundation does not have to be a component which is visually distinguishable, but that the tower foundation may simply be the bottom end of a tower pile, if the tower pile is placed directly on the main beam.

[0028] According to a further embodiment, the high-voltage electricity tower according to the invention furthermore comprises said lines and these lines extend, viewed in the horizontal plane, at right angles to the longitudinal direction of the main beam, as is usually the case with suspension masts and dead-end masts.

[0029] Furthermore, according to a further embodiment of the high-voltage electricity tower according to the invention, at least a number of these lines will, in use, form a so-called circuit of at least 120 kV, such as 150 kV, and more particularly a so-called circuit of at least 300 kV, such as 380 kV. In Europe, the electricity generated in power stations is generally 3-phase electricity. The number of lines on a high-voltage electricity tower is thus always 3 or a multiple thereof (generally 6, sometimes 9 or 12). One three-phase system of three lines is referred to as a 'circuit'. Such a circuit may be regarded as a complete unit by means of which electrical power can be transported. Often, two such circuits are carried by each high-voltage electricity tower for the sake of redundancy - in order to reduce breakdowns in case of a power failure.

[0030] According to a further embodiment of the high-voltage electricity tower according to the invention, the ground foundation may furthermore comprise piles on which the beam pattern and/or the tower foundations rest. The piles serve to anchor the ground foundation in the ground. The piles may be made, for example, of wood, concrete or steel. According to a further embodiment, one or more of the piles may be arranged at an angle to the vertical. This slanting arrangement may be such that the bottom end of the respective pile, viewed in the vertical direction, is outside the contour of the beam which rests on the top end of this pile.

[0031] According to a further embodiment of the high-voltage electricity tower according to the invention, the distance between the longitudinal axes of the tower piles, viewed in the horizontal direction, may be at least 12 m, such as at least 15 m. This distance may be, for example, approximately 16 m.

[0032] Below, the invention will be explained in more detail with reference to the drawing, in which:

Fig. 1A shows a perspective view of a row of high-voltage electricity masts;

Fig. 1B diagrammatically shows the action of the forces exerted by the lines on a tower pile as a detail from Fig. 1A;

Fig. 2A diagrammatically shows a prior-art suspension mast;

Fig. 2B diagrammatically shows a first suspension tower according to the invention;

Fig. 2C diagrammatically shows a second suspension tower according to the invention;

Fig. 3 shows the suspension tower according to Fig.

2 in three views: a top view (Fig. 3A) and two side views (Figs. 3B and 3C);

Fig. 4 shows a dead-end tower according to the invention in two views: a top view (Fig. 4A) and a side view (Fig. 4B);

Fig. 5 diagrammatically shows a further high-voltage electricity tower according to the invention.

[0033] Fig. 1A shows an aboveground view of a row of five high-voltage electricity masts 1, 2 according to the invention placed in a straight line one behind the other, each comprising two tower piles 3 with a vertical longitudinal axis 20 (Fig. 1 B). The front and rear high-voltage electricity masts 2 are so-called dead-end masts and the three intermediate high-voltage electricity masts 1 are so-called suspension masts.

[0034] In Fig. 1A, the arrows X, Y and Z diagrammatically indicate an orthogonal coordinate system for the purpose of indicating directions. The X direction extends horizontally in the length direction of the row of successive high-voltage electricity masts 1, 2; the Y direction extends horizontally in the direction at right angles to the row of successive high-voltage electricity masts; and the Z direction extends vertically parallel to the longitudinal direction of the tower piles 3 of the high-voltage electricity masts 1, 2.

[0035] Each high-voltage electricity tower 1, 2 comprises two tower piles 3 which are placed, in this example, at a centre-to-centre distance of approximately 16 m (m = metre) in the Y direction. Viewed in the X direction, the distance between two successive high-voltage electricity masts 1, 2 may be several hundred metres, but it may also be much less.

[0036] In this example, each tower pile 3 has three arms 4, each of which carries a (high-voltage) line 5, 6. In addition, the tower piles are often also provided with an earth wire (not shown) and/or a service wire (not shown). In this example, each tower pile carries a so-called 380 kV circuit. It will be clear that each tower pile may also have more or fewer arms 4 situated one above the other and may also have one or more arms 4 situated one above the other on both sides, and that each tower pile may thus also carry more or fewer than three lines 5, 6. As stated above, a high-voltage electricity tower will generally carry a multiple of 3 lines. In view of redundancy, this number is at least 6 in practice (that is to say 2 circuits of 3 lines). Four circuits are also used regularly, for example two 380 kV circuits and two 150 kV circuits. Fig. 5 diagrammatically shows an example of a high-voltage electricity tower 21 comprising two tower piles which carry two 380 kV circuits and two 150 kV circuits. Each of the arms 4 situated on the inner side here carries a line of a 380 kV circuit and each of the arms 22 situated on the outer side carries a line of a 150 kV circuit.

[0037] Due to their weight, the lines 5, 6 exert the following forces on the arm 4 of the tower pile 3 in a windless situation at the suspension point 7(see Fig. 1 B):

- a downward vertical force Fv directed in the direction of the Z axis for lines 5 and 6 together; and
- a horizontal pulling force Fh5 and Fh6 directed in the direction of the X axis of line 5 and line 6, respectively.

[0038] In case there is wind, as indicated in Fig. 1A by means of the arrow 'wind', yet more forces will be added. In the first place, the wind will act in a transverse direction - that is to say in the direction of the Y axis - on the lines 5 and 6, resulting in the wind force load in the direction of the Y axis indicated by arrow Fw. The wind will also cause an increase in the pulling force exerted by lines 5 and 6 on the suspension point in the direction of the X axis. In case of wind, Fh5 and Fh6 will increase slightly.

[0039] At the mounting location where the tower pile 3 is mounted on the foundation, Fv and Fw cause a moment Mx about the horizontal X axis. Any difference in magnitude between Fh5 and Fh6 results in a moment My about the horizontal Y axis, as well as a moment Mz about the vertical Z axis, at the location where the tower pile 3 is mounted on the foundation.

[0040] The above-described play of forces and moments occurs at each suspension point 7 on each tower pile 3, both with prior-art high-voltage electricity masts and with high-voltage electricity masts according to the invention. All these forces acting on each suspension point 7 will continue in a similar way in the moments Mx, My and Mz. In case the tower pile carries lines on two sides, as is the case with the tower piles 3 of the suspension tower 21 from Fig. 5, the forces at the suspension points on the one side of the tower pile 3 and the forces at the suspension points on the other side of the tower pile may partly, or sometimes completely, cancel each other out. In case one side - the outer side - of the tower pile carries a 150kV circuit and the other side - the inner side - of the tower pile carries a 380 kV circuit, the lines of the 380 kV circuit are usually significantly heavier than those of the 150 kV circuit. Thus, the forces cannot be cancelled out completely.

[0041] With reference to Fig. 2, the same reference numerals are used in Fig. 2 as in Fig. 1 for items which are identical to the preceding Fig. 1.

[0042] Fig. 2A diagrammatically shows, viewed in the direction of the X axis, a prior-art suspension tower 8, in which each suspension tower is provided with a separate foundation slab 9. As a result of the wind, the tower pile 3 will exert a moment Mx (see Fig. 1A) on the foundation slab 9, resulting in the foundation slab 9 exerting the forces F1, F2 and F3, F4, respectively, on the ground. By now connecting the foundation slabs 9 to one another to form a foundation section 10, the forces F2 of the one foundation slab 9 and F3 of the other foundation slab 9 acting on the ground cancel each other out. They are now absorbed internally, inside the foundation section 10 itself, as internal bending stress. As the foundation slabs 9 are connected to form a foundation section 10, the effective length of the lever arm increases, viewed in the direction of the Y axis, and as, furthermore, the own weight of the right-hand tower pile 3 and lines carried thereby contributes to reducing F1 and F4, the forces F5 and F6 acting on the ground will be smaller than F1 and F4, respectively. This makes it possible to remove the parts 11 of the foundation section 10 which project laterally from the tower piles 3 from Fig. 2B, resulting in the foundation section illustrated in Fig. 2C.

[0043] Since, under static circumstances (that is to say no wind), with a suspension mast, the amount of line on either side of the tower pile 3 is equal, at least the weight thereof is equal, Fh5 and Fh6 - see Fig. 1B - will be approximately equal and will thus cancel each other out on balance. With a wind which is exactly at right angles to the row of high-voltage electricity masts, that is to say acts exactly in the Y direction, Fh5 and Fh6 will still cancel each other out if approximately the same length is provided on line 5 and line 6 on both sides of the tower pile 3. If the wind is at an angle, that is to say acts in the X and Y direction, no mutual cancellation will take place, but, in practice, the differences in magnitude between Fh5 and Fh6 due to the wind load have been found to be negligible with a suspension mast. This means that, in practice, the moment My (Fig. 1A) is negligible with a suspension mast, even when there is a wind. This only leaves the wind load which acts directly on the mast. This means that the foundation section 10, viewed in the direction X - at right angles to the plane of the drawing in Fig. 2 - hardly requires a lever arm, i.e. length. With a suspension mast, the foundation section 10 can thus be configured as a beam, as is illustrated in Fig. 3.

[0044] Fig. 3 diagrammatically shows a suspension tower according to the invention, Fig. 3A being a top view, looking down vertically, Fig. 3B being a side view, looking in the direction of the X axis (see Fig. 1A), and Fig. 3C being a side view, looking in the direction of the Y axis (see Fig. 1A). In Fig. 3, the same reference numerals are used as in the preceding figures for items which are identical to those in the preceding figures.

[0045] Fig. 3 shows that the beam pattern consists of a single main beam 10 and that a tower pile 3 is provided on top thereof, one at each end of the main beam, with a tower foundation 12 also being provided between the tower pile 3 and the main beam 10. The tower pile 3 may be installed on the tower foundation by means of a flange (not shown) and bolts (not shown) which have been incorporated in the concrete tower foundation, but this may also be achieved in a different way. The tower foundation may be a so-called filling of concrete provided with reinforcement and is fixedly attached to the main beam.

[0046] Figs. 3a and 3c furthermore show that the single main beam 10 has a width which is smaller than the diameter of the tower foundation 12. Furthermore, the pit 16 to be dug in the ground 15 is significantly smaller than with a foundation slab.

[0047] In order to securely anchor the foundation in the ground, piles 13 and 14 are provided in this example. The piles 13 carry the main beam and are fixedly connected to the main beam at their top end. The piles 14 carry the tower foundations 12 laterally next to the main beam and are fixedly connected by their top ends to in each case a tower foundation. The piles 13 and 14 are partly arranged at an angle to the vertical. The central pile 13 is exactly vertical.

[0048] Here, the distance Q of the tower foundations 12 to the end of the main beam 10 in this example is approximately 3% of the length L of the main beam.

[0049] Fig. 4 diagrammatically shows a dead-end tower according to the invention, Fig. 4A being a top view, looking down vertically, and Fig. 4B being a side view, looking in the direction of the Y axis (see Fig. 1A). In Fig. 4, the same reference numerals have been used as in the preceding figures for items which are identical to those in the preceding figures.

[0050] The main difference between a dead-end tower 2 and an aforementioned suspension tower 1 is that with a dead-end tower 2, the lines enter from one side (line 5) as a long line from another tower and pass to the ground or to an installation, such as a distribution station or otherwise, on the other side (line 17) as a short line. This results in the forces Fh5 and Fh17 (not shown) (comparable to Fh6 in Fig. 1 B) not being equal, leading to a moment My about the Y axis which is exerted on the foundation. In order to be able to resist this moment My, the beam pattern is provided with two supporting beams 18. Although not strictly necessary, the beam pattern is provided with in each case a supporting beam 19 on the side opposite the supporting beams 18. Per end of the main beam, the supporting beams 18, 19 together may be seen as a supporting beam. Thus, an H-shaped beam pattern is produced.

[0051] Fig. 4 shows that, in this embodiment, the tower piles are positioned at the end of the supporting beam and that the tower foundations 2 project beyond the end of the supporting beam. In this context, it should be noted that the tower piles 3 of the suspension tower from Fig. 3 can also be positioned in the same way as in Fig. 4 or, conversely, that the tower piles in Fig. 4 can be positioned in the same way as in Fig. 3.

[0052] With regard to the forces caused by the wind, it should be noted that these differ in the case of a dead-end tower 2 from those with a suspension tower 1 in so far as there will be no cancellation of forces caused by the action of the wind on line 17 and forces caused by the action of the wind on line 5 with a dead-end tower 2.

List of reference numerals

[0053]

1	suspension mast
2	dead-end mast
3	tower pile
4	(carrying) arm
5	(high-voltage) line
6	(high-voltage) line
7	suspension point

8 prior-art suspension mast
9 prior-art foundation slab
10 main beam
11 projecting part of main beam
12 tower foundation
13 foundation pile
14 foundation pile
15 ground
16 pit/excavation
17 (high-voltage) line
18 supporting beam
19 supporting beam
20 longitudinal axis of tower pile
21 high-voltage electricity mast
22 arm for 150 kV line

wind wind direction

X X axis
Y Y axis
Z Z axis
Mx moment about X axis
My moment about Y axis
Mz moment about Z axis
Fw wind load exerted by lines at suspension point on tower pile in the Y axis direction
Fv vertical force exerted by lines at suspension point on tower pile in the Z axis direction
Fh5 horizontal force exerted by line 5 on the suspension point in the X axis direction
Fh6 horizontal force exerted by line 6 on the suspension point in the X axis direction

Claims

1. High-voltage electricity tower (1, 2) provided with a foundation, comprising:

- two tower piles (3) configured to carry high-voltage lines (5, 6, 17), in which the tower piles (3) are placed a distance apart and are oriented vertically;
- a ground foundation (10, 13, 14, 18, 19);
- a tower foundation (12) placed underneath each respective tower pile (3) in order to support said tower pile (3);

in which, on the one hand, each tower pile (3) rests on a tower foundation (12) and, on the other hand, each tower foundation (12) is placed on the ground foundation (10, 13, 14, 18, 19) in such a manner that:

- the ground foundation (10, 13, 14, 18, 19) connects the tower foundations (12) to one another; and
- forces exerted by said lines (5, 6, 17) carried by the tower piles (3) are transmitted to the ground (15) via the tower piles (3), the tower foundations (12) and the ground foundation (10, 13, 14, 18, 19);

characterized
in that the ground foundation (10, 13, 14, 18, 19) comprises a beam pattern (10, 18, 19) which extends in the horizontal plane;
in that the beam pattern comprises a main beam (10);
in that said main beam (10) extends, on the one hand, transverse to the longitudinal direction of the tower piles (3) and, on the other hand, transverse to the extending direction of the lines (5, 6, 17) carried by the tower piles (3); and
in that both tower piles (3) rest on the main beam via said tower foundation (12).

2. High-voltage electricity tower (1, 2) according to claim 1, in which one said tower pile (3) is provided at each end of the main beam (10).

3. High-voltage electricity tower (1, 2) according to one of the preceding claims, in which one said tower pile (3) is provided on each end of the main beam (10).

4. High-voltage electricity tower (1) according to one of the preceding claims, in which the beam pattern consists of one single said main beam (10).

5. High-voltage electricity tower (2) according to one of claims 1-3, in which the beam pattern furthermore comprises one or more supporting beams (18, 19) which form an integral part of the main beam (10) and extend laterally in a horizontal direction from the main beam (10).

6. High-voltage electricity tower (2) according to claim 5, in which the one or more supporting beams (18, 19) extend transverse to the longitudinal direction of the main beam (10).

7. High-voltage electricity tower (2) according to one of claims 5-6, in which the ends of the main beam (10) are provided with said supporting beams (18, 19) in such a way that the beam pattern is H-shaped.

8. High-voltage electricity tower (2) according to one of claims 5-6, in which the ends of the main beam (10) are provided with said supporting beams (18) in such a way that the beam pattern is U-shaped.

9. High-voltage electricity tower (1, 2) according to one of the preceding claims, in which, viewed in the horizontal direction, the tower foundation (9) of each tower pile (3) has a horizontal distance (Q) to the respective end of the main beam (10) which is at most 10%, such as at most 5%, of the length (L) of the main beam (10).

10. High-voltage electricity tower (1, 2) according to one of the preceding claims, in which, viewed in the horizontal direction, the longitudinal axis (20) of each tower pile (3) has a horizontal distance to the respective end of the main beam (10) which is at most 20%, such as at most 15% or at most 10%, of the length of the main beam (10).

11. High-voltage electricity tower (1, 2) according to one of the preceding claims, in which, viewed in the horizontal plane, each tower foundation (12) projects on either side of the main beam (10).

12. High-voltage electricity tower (1, 2) according to one of the preceding claims,
in which the beam pattern (10, 18, 19) is made of concrete provided with reinforcement;
and/or
in which each tower foundation (12) is a filling of concrete provided with reinforcement.

13. High-voltage electricity tower (1, 2) according to one of the preceding claims,
in which the high-voltage electricity tower (1, 2) furthermore comprises said lines (5, 6, 17);
in which, viewed in the horizontal plane, said lines (5, 6, 17) extend at right angles to the longitudinal direction of the main beam (10);
and/or
in which at least a number of said lines (5, 6, 17), in use, form a circuit of at least 120 kV, such as 150 kV, and more particularly form a circuit of at least 300 kV, such as 380 kV.

14. High-voltage electricity tower (1, 2) according to one of the preceding claims, in which the ground foundation (10, 13, 14, 18, 19) furthermore comprises piles (13, 14) on which the beam pattern (10, 18, 19) and/or the tower foundations (12) rest.

15. High-voltage electricity tower (1, 2) according to one of the preceding claims, in which, viewed in the horizontal direction, the distance between the longitudinal axes (20) of the tower piles is at least 12 m, such as at least 15 m.

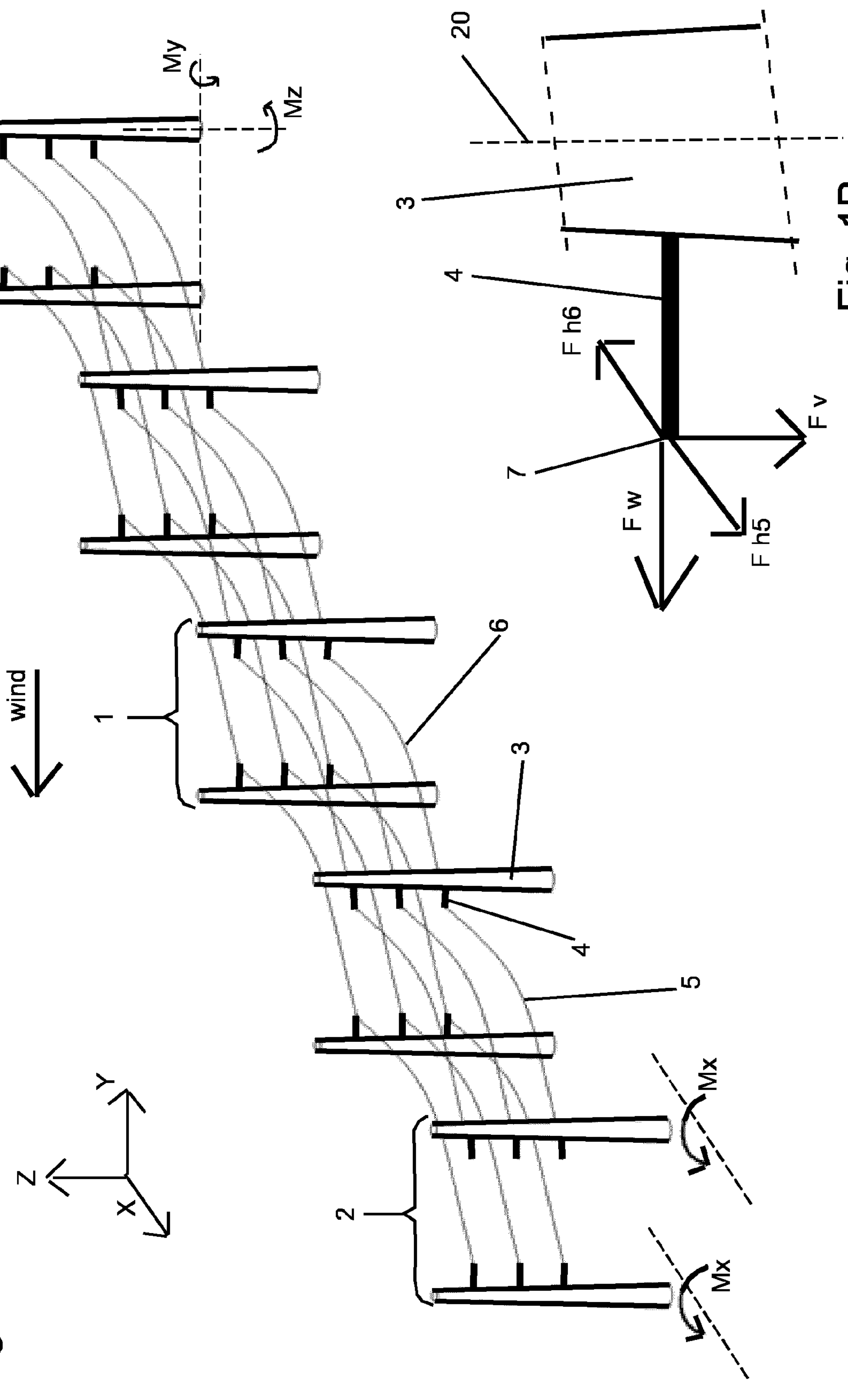

Fig. 1A

Fig. 1B

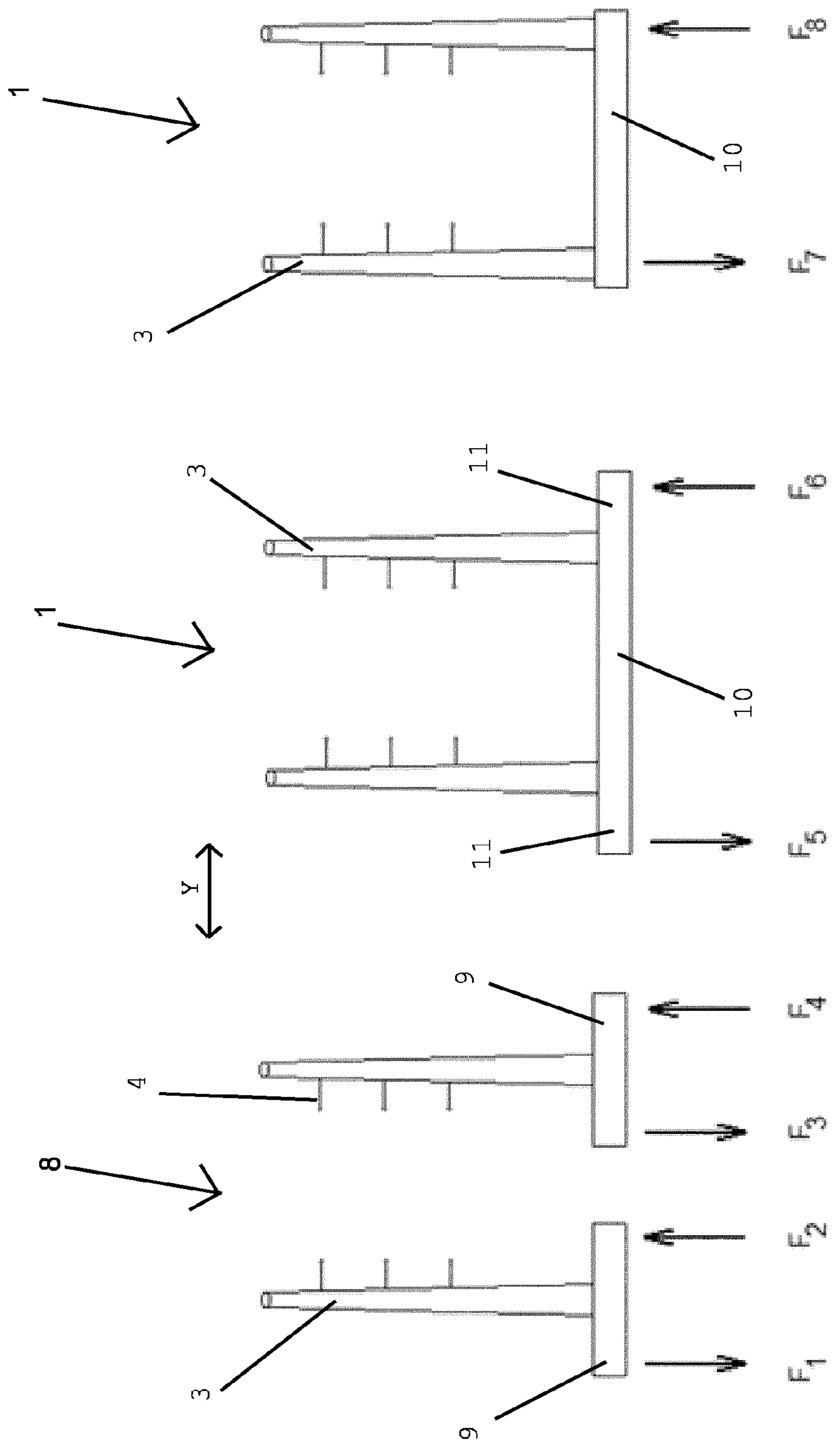

Fig. 2C

Fig. 2B

Fig. 2A (prior art)

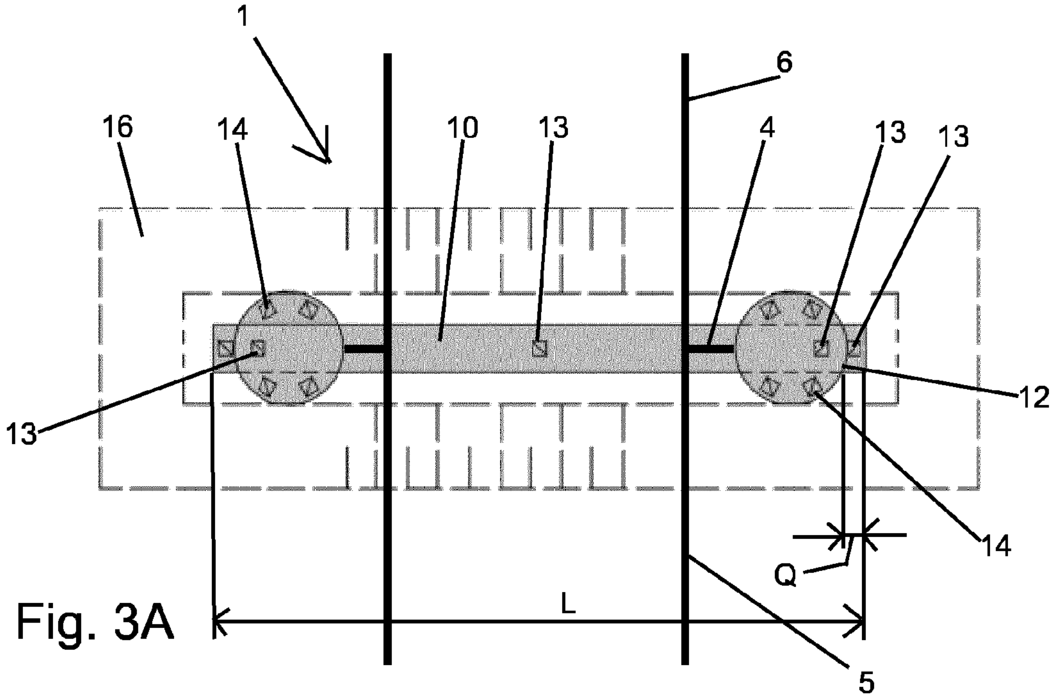

Fig. 3A

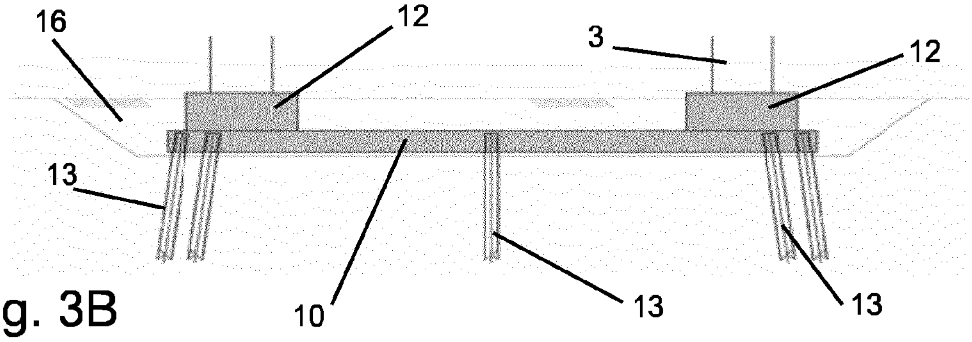

Fig. 3B

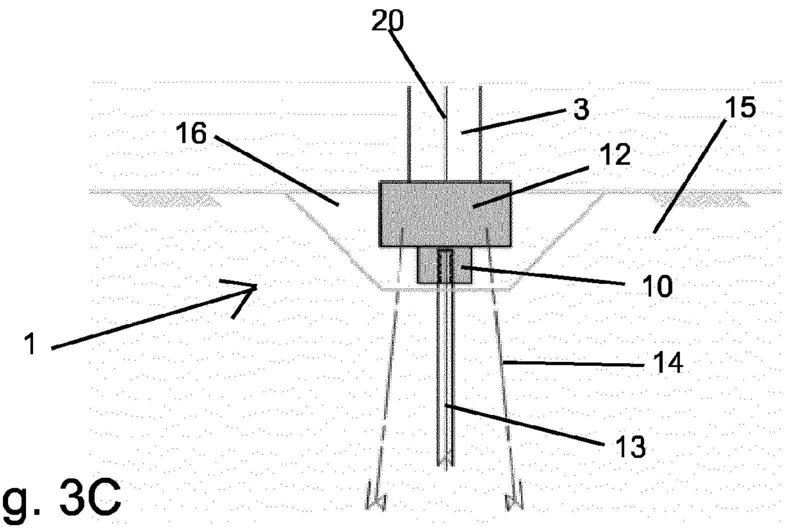

Fig. 3C

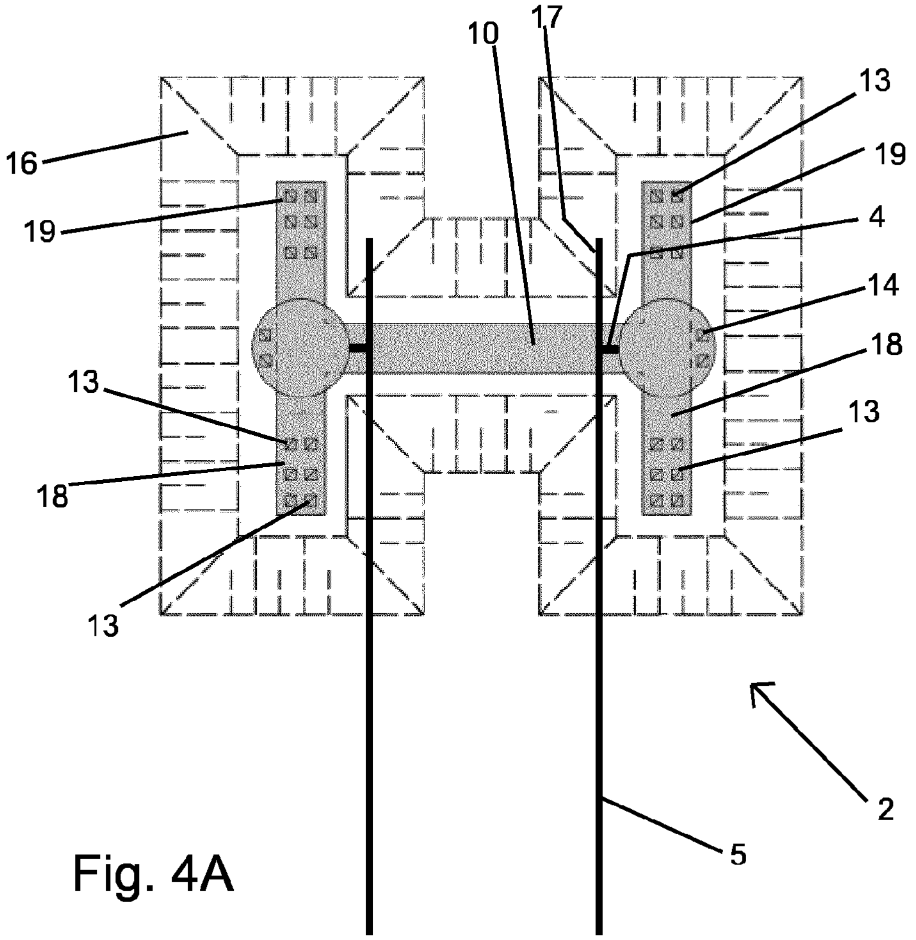
10
17
13
16
19
19
4
14
18
13
13
18
13
2
5

Fig. 4A

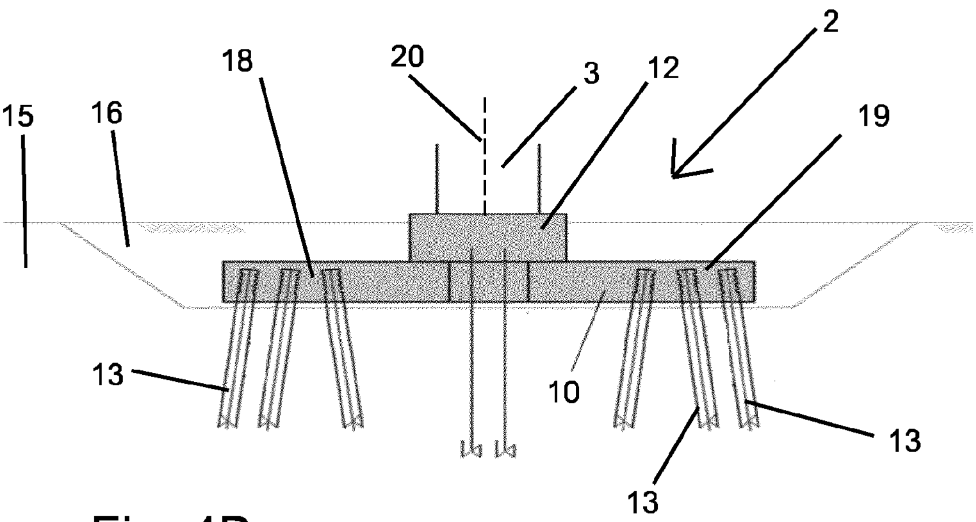
2
18
20
3
12
15
16
19
13
10
13
13
13

Fig. 4B

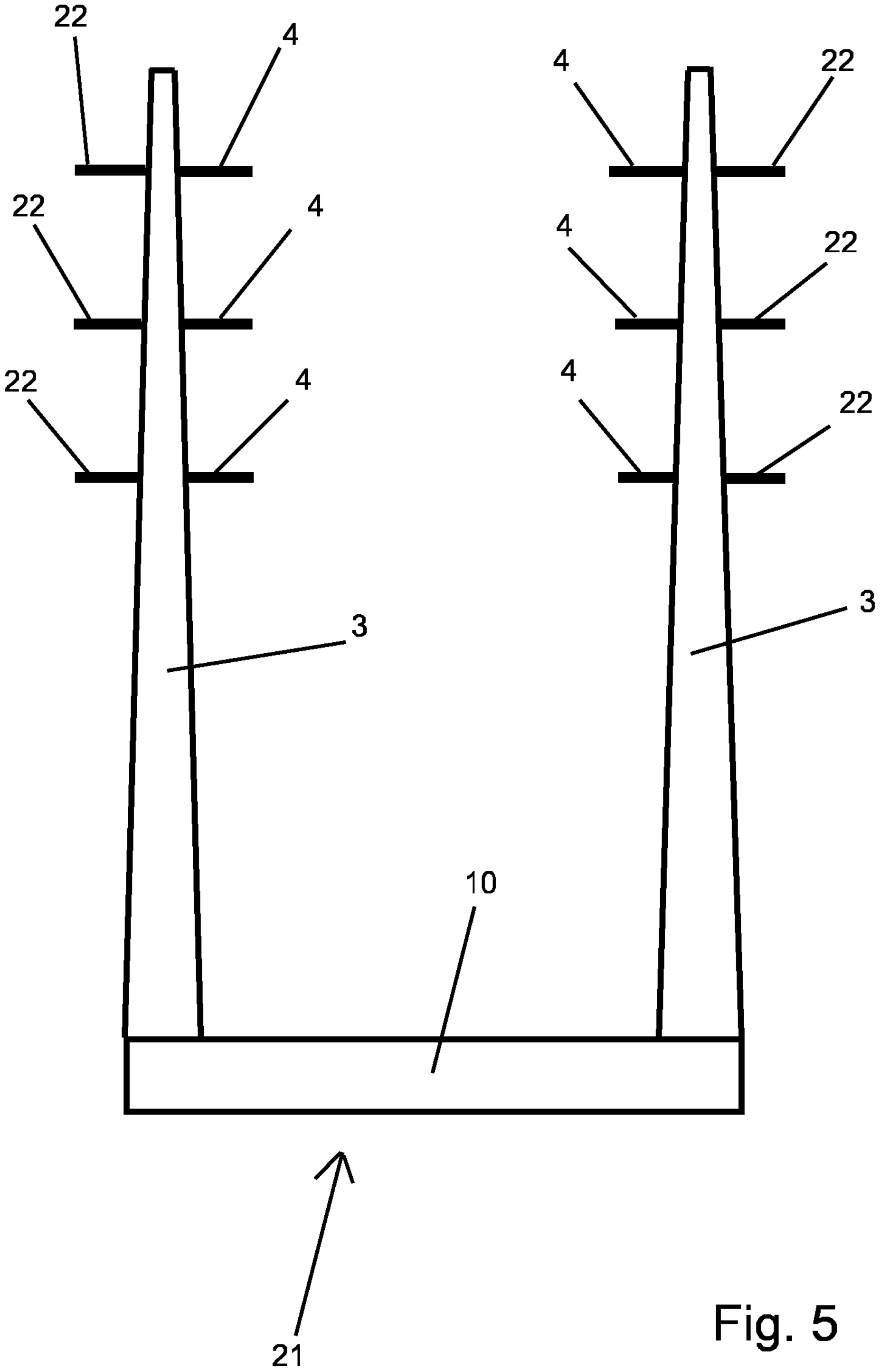

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 14 16 6787

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 253 252 A1 (KEMA NV [NL]) 30 October 2002 (2002-10-30) * the whole document * -----	1-15	INV. E02D27/50
A	DE 100 28 755 A1 (TESSAG TECH SYSTEME & SERVICES [DE]) 13 December 2001 (2001-12-13) * the whole document * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)
E02D

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	18 September 2014	Friedrich, Albert

CATEGORY OF CITED DOCUMENTS

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18-09-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1253252 A1	30-10-2002	EP 1253252 A1	30-10-2002
		NL 1017953 C2	05-11-2002
DE 10028755 A1	13-12-2001	AT 411538 B	25-02-2004
		DE 10028755 A1	13-12-2001
		FR 2810056 A1	14-12-2001

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