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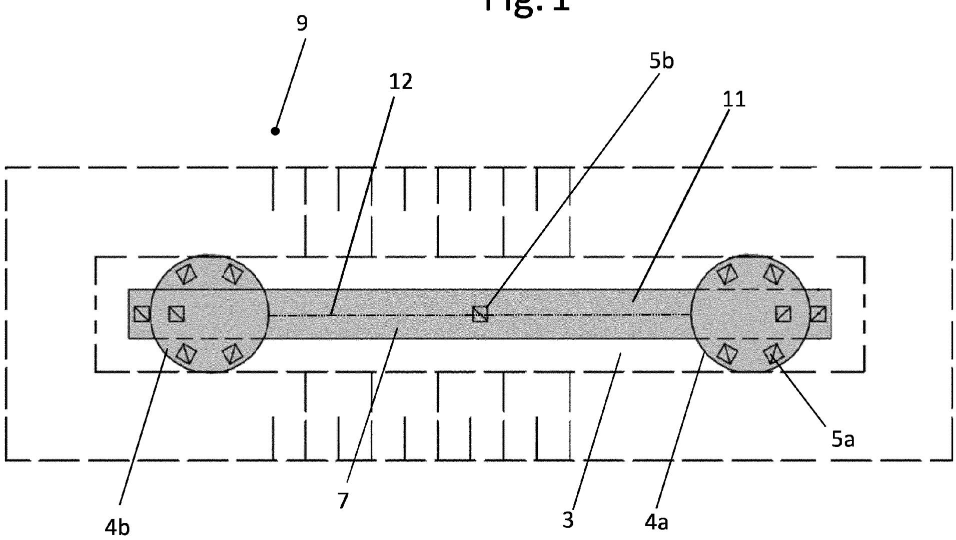
(54) **Method for providing a foundation for a high-voltage electricity tower, network of high-voltage electricity towers provided with a foundation, and high-voltage electricity tower provided with a foundation**

(57) The invention relates to a method for providing a foundation for a high-voltage electricity tower. The method comprises the steps of excavating a pit in the ground for receiving a ground foundation and forming the ground foundation in the pit. The method comprises placing two or more tower foundations on the ground foundation, in such a way that the ground foundation connects the tower foundations to one another across a distance. The method comprises placing a high-voltage tower pile on each of the tower foundations, wherein the high-voltage tower piles carry cable lines at a predetermined orientation of the cable lines with respect to the high-voltage tower piles. The ground foundation is provided with one or more beams in a beam pattern. The method comprises the step of determining the beam pattern. Determining the beam pattern is based on a distribution of forces on the ground foundation resulting from axial forces in the cable lines and the orientation of the cable lines with respect to the high-voltage tower piles.

Fig. 1



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Description

[0001] The invention relates to a method for providing a foundation for a high-voltage electricity tower, to a network of high-voltage electricity towers provided with a foundation and to a high-voltage electricity tower provided with a foundation.

[0002] High-voltage electricity towers, also referred to as high-voltage power pylons, are used to support cable lines, such as high-voltage cables through which electricity is transported from a first location to a second location at high voltage.

[0003] High-voltage electricity towers are divided into:

- Angle towers: in this case, the cable line, viewed in the horizontal plane, makes an angle. That is to say that a longitudinal direction of an incoming section of the cable line is at an angle to a longitudinal direction of an outgoing section of a cable line, with the incoming section and outgoing section belonging to the same cable line.
- Suspension towers: in this case, the direction of the incoming section of the cable line is identical to the direction of the outgoing section of the cable line.
- Dead-end towers: in this case, the direction of the incoming section of the cable line is also identical to the direction of the outgoing section of the cable line, but one of the sections of the cable line ends near the tower.

[0004] In the Netherlands, most high-voltage electricity towers are 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 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 are fitted to the tower, also referred to as crossbars, which project on either side of the tower and carry the cable 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 high-voltage tower pile. This high-voltage tower pile is provided with arms from which the cable lines are suspended. The high-voltage 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. A single Wintrack tower consists of two high-voltage tower piles which, viewed in a direction at right angles to the longitudinal direction of the cable lines, are arranged next to each other at a distance of approximately 8-20 metres apart.

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

[0007] High-voltage electricity towers 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 by the supported cable 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 foundation of the tube tower therein. This pit, also known as a construction pit and/or excavation, has to be sufficiently large to accommodate a 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 high-voltage electricity towers comprising two high-voltage tower piles per tower, such as the Wintrack tower, each high-voltage 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 (m = metre) and which may 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 high-voltage tower pile. With so-called angle towers, the high-voltage tower piles may be too close together to allow for a separate foundation slab for each high-voltage tower pile and it is known to make use of a single rectangular concrete foundation slab which may or may not 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 at a mutual centre-to-centre distance of approximately 9 m.

[0009] A problem when providing a foundation for a high-voltage electricity tower is that this is expensive and time-consuming.

[0010] In regions where groundwater rises to high levels, there is the additional problem, when providing a foundation for a high-voltage electricity tower, that the excavation has to be dewatered continuously. During excavation, the pit fills with groundwater, which makes it difficult to place the foundation slab. This is a significant risk, in particular in regions where the groundwater rises to high levels.

[0011] Not only does groundwater collect in the pit, but with clay soil there is the further problem of a significant risk of the ground bursting. In particular with clay soil, for example in low-lying polders, there is a so-called aquifer underneath a sealing layer, often a clay layer. When digging is taking place, the load on the sealing layer is reduced and the aquifer may exert an upward pressure which causes the ground to burst. As the water in the aquifer is often salty, it is highly undesirable for this water to end up in the fresh groundwater situated above it, as this has drawbacks for public health. Authorities, such as for example district water boards in the Netherlands, put stringent requirements in place to prevent such bursting. In the prior art, it is possible 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 salt water cannot be discharged everywhere, necessitating long transport lines or 'closed-circuit' dewatering.

[0012] It is an object of the present invention to provide a method for providing a foundation for high-voltage electricity towers, a network of high-voltage electricity towers provided with a foundation, and a high-voltage electricity tower provided with a foundation, in which one or more of these problems are at least partially eliminated or to at least provide a usable alternative for such a method, such a network and such a high-voltage electricity tower, respectively.

[0013] It is a particular object of the invention to provide a method and foundation for high-voltage electricity towers which makes is possible to produce the foundation of high-voltage electricity towers in a less expensive and quicker way and which can also be readily used in cases where a ground layer comprises an aquifer.

[0014] According to the invention, this object is achieved by the method for providing a foundation for high-voltage electricity towers according to claim 1.

[0015] The method comprises the step of excavating a pit in the ground for receiving a ground foundation. Excavating is also referred to as digging (out), in which case the pit is an excavation or also an open excavation. The term 'open' is intended to refer to the fact that the top of the pit is open, in such a manner that the ground foundation can be received or placed. The ground may be of any type, but is in particular clay soil with an aquifer situated underneath it.

[0016] The method furthermore comprises the step of forming the ground foundation in the pit and placing two or more tower foundations on the ground foundation, in such a way that the ground foundation connects the tower foundations to one another across a distance. The tower foundations are often placed a distance apart which is significantly smaller than the distance between two high-voltage electricity towers. The tower foundations are, for example, cylindrical, but may also be shaped differently, such as frustoconical or pyramidal, but may also be box-shaped.

[0017] The method furthermore comprises the step of placing a vertically oriented high-voltage tower pile on each of the tower foundations.

[0018] The high-voltage tower piles carry the cable lines at a predetermined orientation of a longitudinal direction of the cable lines with respect to the high-voltage tower piles. This is understood to mean that the cable lines which are carried by the high-voltage tower piles come in from a certain direction and exit in a certain direction. This results in an orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles. For example, the incoming direction is identical to the outgoing direction. This is the case with a so-called suspension tower. In another example, the incoming direction is not identical to the outgoing direction. This is the case with a so-called angle tower.

[0019] The ground foundation is provided with one or more beams in a beam pattern and the method furthermore comprises the step of determining the beam pattern. Determining the beam pattern is based on a distribution of forces on the ground foundation which results from axial forces in the cable lines and the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles. The advantage of laying a ground foundation in the form of beams in a beam pattern compared to a foundation slab is that significantly less soil has to be excavated and that the excavation is significantly less wide. This makes it possible to provide a foundation in a less expensive and quicker way. As less soil has to be excavated, the risk of the ground bursting is reduced. These advantages are made possible by the fact that the beam pattern takes into account the load or distribution of forces generated by or resulting from the cable lines.

[0020] Due to their own weight, the cable lines which are carried by the high-voltage tower piles exert an axial force. This axial force has to be transmitted to the ground via the high-voltage electricity tower, that is to say via the high-voltage tower pile, the tower foundation and the ground foundation. The way in which the axial force acts on the high-voltage tower pile depends on the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower pile. Since this orientation is known beforehand, it is therefore also possible to determine the beam pattern beforehand. Consequently, on the one hand, a reduced pit to be excavated is possible and, on the other hand, the ground foundation is sufficiently large and strong to absorb the distribution of forces resulting from the cable lines.

[0021] In an embodiment of the method for providing a foundation for a high-voltage electricity tower according to the invention, the method furthermore comprises the step of producing one or more ground foundation troughs and placing the ground foundation troughs in the pit in a pattern, wherein the pattern of the ground foundation troughs corresponds to the beam pattern. Subsequently, concrete is poured into the ground foundation troughs in order to form the ground foundation. This is particularly advantageous, as this makes it possible to place the ground foundation in situ more quickly and easily. The ground foundation troughs form a skeleton of the ground foundation, as it were. Several ground foundation troughs can form the final desired shape of the ground foundation. The ground foundation troughs may, for example, be in the form of beams and be placed in such a manner that the beam pattern is produced. In addition, due to their own weight, the ground foundation troughs provide a direct counterweight to the possible bursting of the ground. Due to the fact that the ground foundation troughs can be placed immediately after the pit has been excavated, i.e. in the wet, it is even possible to immediately fill in the ground next to the troughs. This results in a further reduction in costs and makes it possible to work more quickly.

[0022] The ground foundation troughs are preferably open at the top and comprise side walls, which define a shape of a beam, as well as a bottom. Preferably, the ground foundation troughs are made of concrete. However, they may also be made of wood and/or steel.

[0023] The ground foundation troughs may be modular and/or prefabricated.

[0024] In a particular embodiment, the bottom of the ground foundation troughs has holes for accommodating piles.

[0025] In an embodiment of the method for providing a foundation for a high-voltage electricity tower according to the invention, the step of determining the beam pattern comprises choosing a beam pattern having an I-shape, in which the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at suspension towers. In this way, a suspension tower is produced.

[0026] The term I-shape is understood to mean a single beam, preferably a slender and thin beam which has a beam width which is equal to or smaller than a largest diameter, viewed in the horizontal plane, of the tower foundation.

[0027] More preferably, the beam width is equal to or smaller than a smallest diameter, viewed in the horizontal plane, of the tower foundation.

[0028] The corresponding beam pattern is such that it comprises a single beam whose longitudinal direction is at right angles to the longitudinal direction of the cable lines. The advantage of such a beam pattern is that a distribution of forces resulting from and originating from cable lines which are oriented in such a way can be transmitted to the ground foundation in an optimum manner and that the ground foundation has a beam pattern which makes it possible to excavate less soil.

[0029] In this case, viewed in the horizontal plane, the cable line is at right angles to an imaginary perpendicular bisector between a first high-voltage tower pile and a second high-voltage tower pile. In particular, a suspension tower corresponds to a cable line having a longitudinal direction which is, viewed in the horizontal plane, at right angles to an imaginary perpendicular bisector between two high-voltage tower piles. This results in a first bending moment on the high-voltage tower pile about a first moment axis, in which the first moment axis is at right angles to the imaginary perpendicular bisector which extends parallel to the single beam between the two high-voltage tower piles.

[0030] In an embodiment of the method for providing a foundation for a high-voltage electricity tower according to the invention, the step of determining the beam pattern comprises choosing a beam pattern having an H-shaped pattern, in which the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at dead-end towers. In this way, a high-voltage electricity tower is produced which is a dead-end tower. In this case, viewed in the horizontal plane, a cable line ends near the high-voltage tower pile. That is to say that an incoming cable line exerts a greater axial force than a corresponding outgoing cable line.

[0031] The dead-end tower is adapted to carry such a cable line. In this case, the method preferably furthermore comprises the step of positioning the cable line on the high-voltage tower pile at such an orientation. The corresponding beam pattern is such that a first beam is fitted in a longitudinal direction at right angles to the longitudinal direction of the incoming cable lines and a second beam and third beam are fitted in a longitudinal direction parallel to the longitudinal direction of the cable lines.

[0032] The advantage of such a beam pattern is that a distribution of forces resulting from and originating from cable lines which are oriented in this way can be transmitted to the ground foundation in an optimum manner and that the ground foundation has a beam pattern which makes it possible to excavate less soil.

[0033] In particular, a dead-end tower which is configured in this way corresponds to a cable line which ends near the dead-end tower, viewed in the horizontal plane. This results in a second bending moment on the high-voltage tower pile about a second moment axis, wherein the second moment axis is parallel to an imaginary perpendicular bisector which extends parallel to the beam pattern between two high-voltage tower piles.

[0034] In an embodiment of the method for providing a foundation for a high-voltage electricity tower according to the invention, the step of determining the beam pattern comprises choosing a beam pattern having a cruciform pattern, in which the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at angle towers. In this way, a high-voltage electricity tower is produced which is an angle tower. In this case, the cable line, viewed in the horizontal plane, makes an angle. That is to say that a longitudinal direction of an incoming section of the cable line is at an angle to a longitudinal direction of an outgoing section of a cable line, with the incoming section and outgoing section belonging to the same cable line.

[0035] In this case, the angle tower is adapted to carry such a cable line. In this case, the method preferably furthermore comprises the step of positioning the cable line on the high-voltage tower pile at such an orientation.

[0036] A cruciform pattern is understood to mean that the beams form at least one cross. Preferably, the beam pattern comprises two crosses which are connected to each other by means of a leg of the two crosses, respectively.

[0037] In particular, beams have been positioned in a cruciform beam pattern underneath each separate tower foundation, wherein the intersection of the cruciform beam pattern coincides with an imaginary vertical axis of the tower foundation, or the vertical axis of the respective high-voltage tower pile. As the high-voltage electricity tower comprises two high-voltage tower piles, the respective cruciformly positioned beams are integrally connected to each other. Preferably, the legs of the beams are connected and form one integral elongate beam.

[0038] The advantage of such a beam pattern is that a distribution of forces resulting from and originating from cable lines which are oriented in this manner can be transmitted to the ground foundation in an optimum manner and that the ground foundation has a beam pattern which makes it possible to excavate less soil.

[0039] In particular, an angle tower which is configured in this way corresponds to a cable line which, viewed in the horizontal plane, makes an angle with the high-voltage tower pile. This results in a third bending moment on the high-voltage tower pile about a third moment axis and a fourth bending moment on the high-voltage tower pile about a fourth moment axis. The moment axes are at right angles to and parallel to, respectively, the imaginary perpendicular bisector which extends parallel to the beam pattern between two high-voltage tower piles.

[0040] In an embodiment according to the method for providing a foundation for a high-voltage electricity tower according to the invention, each of the beams has a beam length and beam width, viewed in a horizontal plane, in which the beam width is smaller than a largest diameter of a horizontal foundation surface of the tower foundation. This is particularly advantageous, as this minimizes an amount of soil to be excavated. Currently, large foundation slabs are used as ground foundation, but a lot of soil has to be excavated for these. Slender, thin beams in a beam pattern reduce the requirement to excavate. This is not only quicker and less expensive, but also reduces the risk of the ground bursting, as a result of which less dewatering is required.

[0041] In an embodiment according to the method for providing a foundation for a high-voltage electricity tower according to the invention, the method furthermore comprises the step of ramming one or more piles into the ground in order to support the ground foundation and placing the ground foundation on a first end of the one or more piles. The piles serve to anchor the ground foundation into the ground. The piles are, for example, made of wood, concrete and/or steel. The ground foundation rests on one or more piles.

[0042] In a further embodiment, the piles are arranged in the ground at an angle to the vertical such that a second end of the one or more piles projects beyond an outer periphery of the ground foundation, viewed in a vertical plane.

[0043] In another embodiment, the one or more piles are arranged in a centre of two tower foundations, viewed in a vertical plane.

[0044] In an embodiment according to the method for providing a foundation for a high-voltage electricity tower according to the invention, the method furthermore comprises the steps of placing high-voltage electricity towers at a mutual distance apart and mutually connecting high-voltage electricity towers by cable lines which are carried by the high-voltage electricity towers. Furthermore, the method comprises providing a foundation for each of the high-voltage electricity towers according to one of the above embodiments.

[0045] The invention furthermore relates to a network of spaced-apart high-voltage electricity towers. In particular, these are high-voltage electricity towers which have been installed according to the method of providing a foundation according to one of the above embodiments.

[0046] The network comprises at least a first high-voltage electricity tower and a second high-voltage electricity tower.

Each of the high-voltage electricity towers comprises two or more spaced-apart vertically oriented high-voltage tower piles which can carry cable lines.

[0047] Furthermore, each of the high-voltage electricity towers comprises tower foundations placed underneath the respective high-voltage tower piles in order to support the high-voltage tower piles.

[0048] The high-voltage electricity towers also comprise a ground foundation placed underneath the tower foundations in order to connect the two or more tower foundations to each other across a distance, with the tower foundations resting on the ground foundation. The first high-voltage electricity tower is connected to the second high-voltage electricity tower by means of the cable lines, a longitudinal direction of the cable lines being oriented with respect to the high-voltage tower piles of the first and the second high-voltage electricity tower.

[0049] The ground foundation of each of the high-voltage electricity towers comprises one or more beams in a beam pattern, the beam pattern being based on a distribution of forces resulting from and originating from the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles. This is advantageous because this reduces the amount of soil which has to be excavated in order to accommodate the ground foundation therein. This makes it possible to produce the foundation of the high-voltage electricity towers in a less expensive and quicker way. In addition, such high-voltage electricity towers can be installed quickly and inexpensively in a soil layer above an aquifer, as less vacuum-assisted dewatering which reduces the pressure in the aquifer is required as the ground foundation is reduced.

[0050] In an embodiment of a network according to the invention, each of the beams, viewed in the horizontal plane, has a beam length and beam width, and the beam width is smaller than a largest diameter of a horizontal foundation surface of the tower foundation. This has the advantage that the ground foundation can be reduced in size even further. In addition, it is possible to dig trenches which form the pit. Digging trenches has the advantage that undesired excavation of soil can be prevented more efficiently, or that soil situated between the trenches can be left in situ and does not have to be excavated.

[0051] In an embodiment of a network according to the invention, each of the high-voltage tower piles is tubular. In this case, a horizontal foundation surface of the tower foundation is larger than the cross-sectional surface of the high-voltage tower pile. This has the advantage that the transmission of forces from the high-voltage tower pile to the tower foundation is improved.

[0052] In an embodiment of a network according to the invention, in which the high-voltage tower piles can carry one or more cable lines, the longitudinal direction of the cable lines, viewed in the horizontal plane, is at right angles to an imaginary perpendicular bisector which extends parallel to the single beam between a first high-voltage tower pile and a second high-voltage tower pile. The ground foundation comprises a single beam having a longitudinal direction at right angles to the longitudinal direction of the cable lines. This has the advantage that a very significant reduction in the size of the ground foundation is possible with suspension towers.

[0053] According to a further embodiment, the beam pattern of the ground foundation is I-shaped. The corresponding high-voltage electricity tower is a suspension tower.

[0054] In another embodiment of a network according to the invention, in which the high-voltage tower piles can carry one or more cable lines, a separate cable line, viewed in the horizontal plane, ends near the high-voltage tower pile. The corresponding ground foundation comprises several beams. The beam pattern is such that a first beam is arranged in a longitudinal direction at right angles to the longitudinal direction of an incoming section of the cable line, and a second beam and third beam are arranged in a longitudinal direction parallel to the longitudinal direction of the cable lines. In this case, the axial forces in the incoming section of the cable line are greater than the axial forces in the outgoing section of the cable line. The reason for this is that the outgoing section of the cable line is configured to end near the high-voltage electricity tower. This has the advantage that a reduction in the size of the ground foundation is possible with dead-end towers.

[0055] According to a further embodiment, the beam pattern of the ground foundation is H-shaped in this case. The corresponding high-voltage electricity tower is a dead-end tower.

[0056] In yet another embodiment of a network according to the invention, in which the high-voltage tower piles can carry one or more cable lines, a separate cable line makes an angle, viewed in the horizontal plane. The corresponding ground foundation comprises several beams. The beam pattern is such that a first beam is arranged in a longitudinal direction at right angles to the longitudinal direction of an incoming section of the cable line. A second beam and third beam are arranged in a longitudinal direction at right angles to the longitudinal direction of the first beam. This has the advantage that a reduction in the size of the ground foundation is possible with angle towers.

[0057] According to a further embodiment, the beam pattern of the ground foundation is cruciform in this case. The corresponding high-voltage electricity tower is an angle tower.

[0058] In an embodiment, the lowest point of the ground foundations is situated at 1.5 m below a ground surface.

[0059] In an embodiment of a network according to the invention, the tower foundation has a horizontal radial periphery smaller than the respective tube diameter increased by half the respective tube diameter. In particular, the tower foundation has a horizontal radial periphery smaller than the respective tube diameter increased by 2.0 m.

[0060] In an embodiment of a network according to the invention, the tube diameters of the high-voltage tower piles are of equal size.

[0061] In an embodiment of a network according to the invention, each of the high-voltage electricity towers furthermore comprises one or more piles anchored in the ground in order to support the ground foundation, with the ground foundation resting on the one or more piles. In a further embodiment, the piles are arranged in the ground at an angle to the vertical such that a second end of the one or more piles projects beyond an outer periphery of the ground foundation, viewed in a vertical plane. In an alternative further embodiment, the one or more piles are arranged in a centre of two tower foundations, viewed in a vertical plane.

[0062] In an alternative further embodiment, the one or more piles are arranged in the ground at an angle to the vertical based on the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles.

[0063] The invention furthermore relates to a high-voltage electricity tower provided with a foundation according to claim 16.

[0064] Further embodiments of the invention are defined in the dependent claims.

[0065] Some embodiments of the invention will be explained in more detail by means of the attached figures, in which:

Figure 1 shows a top view of a foundation of a high-voltage electricity tower according to a first embodiment according to the invention;

Figures 2a and 2b show a front view and a side view, respectively, of a foundation of a high-voltage electricity tower according to the first embodiment according to the invention;

Figure 3 shows cable lines carried by a high-voltage electricity tower according to the first embodiment according to the invention;

Figure 4 shows a top view of a foundation of a high-voltage electricity tower according to a second embodiment according to the invention;

Figure 5 shows a side view of a foundation of a high-voltage electricity tower according to the second embodiment according to the invention;

Figure 6 shows cable lines carried by a high-voltage electricity tower according to the third embodiment according to the invention,

Figure 7 shows a top view of a foundation of a high-voltage electricity tower according to a third embodiment according to the invention;

Figure 8 shows a front view of a foundation of a high-voltage electricity tower according to the third embodiment according to the invention; and

Figure 9 shows cable lines carried by a high-voltage electricity tower according to the third embodiment according to the invention.

[0066] Figure 1 shows a ground foundation 7 with two tower foundations 4a, 4b arranged thereon according to a first embodiment. This is the result of a method for providing a foundation for a high-voltage electricity tower.

[0067] The method comprises the step of digging a pit 3 in the ground 9, as is shown more clearly in Fig. 2, which shows a front and side view. The ground foundation 7 is accommodated in the pit 3.

[0068] Digging the pit is carried out in such a way that the pit is not significantly larger than the dimensions of the ground foundation 7.

[0069] The ground foundation 7 is formed in the pit 3. This can be effected by placing the entire ground foundation 7 in the pit, but is preferably effected by first providing ground foundation troughs which are subsequently filled with concrete. These ground foundation troughs are preferably prefabricated, so that they can easily be placed in situ in the pit 3. The pattern of the ground foundation troughs corresponds to the beam pattern of the ground foundation 3. After the ground foundation troughs have been placed, they are filled with concrete in order to form the ground foundation 3.

[0070] On the ground foundation, two or more tower foundations 4a, 4b are placed. Here, a first tower foundation 4a and a second tower foundation 4b are placed on the ground foundation 3. The ground foundation 3 connects the tower foundations 4a, 4b to each other across a distance.

[0071] As is illustrated in Fig. 2, a vertically oriented high-voltage tower pile 10a, 10b is placed both on the first and the second tower foundation 4a, 4b. The high-voltage tower piles 10a, 10b carry cable lines 20a, 21 a; 20b, 21 b, as illustrated in Figure 3. The cable lines 20a, 21 a; 20b, 21 b have a predetermined orientation of a longitudinal direction of the cable lines with respect to the high-voltage tower piles 10a, 10b.

[0072] The ground foundation 3 is provided with one or more beams 11 in a beam pattern which, in the embodiment according to Figs. 1-3, consists of a single beam 11 and which, in the embodiments according to Figs. 4-9, consists of several beams. The method comprises the step of determining the beam pattern, with determining the beam pattern being based on the distribution of forces on the ground foundation 3 resulting from axial forces in the cable lines 20a, 21 a, 20b, 21 b and the orientation of the longitudinal direction of the cable lines 20a, 21 a, 20b, 21 b with respect to the high-voltage tower piles 10a, 10b.

[0073] In a first embodiment according to the invention, a so-called suspension tower is installed, that is to say the foundation for the suspension tower is placed in a construction pit 3. This is illustrated in Figures 1 and 2. The associated orientation of the cable lines 20a, 20b is illustrated in Figure 3.

[0074] The method for providing a foundation for the suspension tower comprises selecting a beam pattern having an |-shape during the step of determining the beam pattern. This is illustrated in Figure 1. The orientation of the longitudinal direction of the cable lines 20a, 20b corresponds to the orientation in the case of the suspension towers, as illustrated in Figure 3.

[0075] In Figure 3, a first cable line 20a is carried by a first high-voltage tower pile 10a and a second cable line 20b is carried by a second high-voltage tower pile 10b. Although the high-voltage tower piles 10a, 10b are not illustrated in Figure 3, the corresponding tower foundations 4a, 4b are illustrated.

[0076] With the suspension tower, viewed in the horizontal plane, the longitudinal direction of the cable lines 20a, 21 a; 20b, 21 b is situated at right angles to an imaginary perpendicular bisector 12 between the first and the second high-voltage tower piles 10a, 10b. This results in a bending moment on the first high-voltage tower pile 10a about a moment axis which is at right angles to the imaginary perpendicular bisector 12 between the first and the second high-voltage tower pile 10a, 10b. The same analogously applies to the second cable line 20a and corresponding second high-voltage tower pile 10b.

[0077] With the suspension tower, the axial forces in the cable lines 20a, 21 a; 20a, 20b are such that they do not generate a bending moment about a moment axis which is situated parallel to the imaginary perpendicular bisector 12 between the first and the second high-voltage tower pile 10a, 10b. The axial forces of an incoming section 20a, 20b and an outgoing section 21 a, 21 b of the cable lines cancel each other out.

[0078] In accordance with a beam pattern having a single beam 11, the ground foundation 7 is such that the bending moment, whose moment axis is at right angles to the imaginary perpendicular bisector 12 between the first and the second high-voltage tower pile 10a, 10b, can be absorbed by the ground foundation 7. In this case, the longitudinal direction of the single beam 11 is situated parallel to the abovementioned perpendicular bisector 12.

[0079] Figures 1, 2a, 2b and 3 show a so-called suspension tower, at least a foundation and associated orientation of cable lines are illustrated which correspond to that at a suspension tower.

[0080] In a second embodiment according to the invention, a so-called dead-end tower is installed, that is to say the foundation of the dead-end tower is placed in a construction pit 103. This is illustrated in Figures 4 and 5. The associated orientation of the cable lines 120a, 121 a, 120b, 121 b is illustrated in Figure 6. Components of the second embodiment which are similar to components in the first embodiment are denoted by the same reference numeral, but increased by 100. The advantages and description of components with the first embodiment accordingly also apply to the second embodiment.

[0081] The method for providing a foundation for the dead-end tower comprises choosing a beam pattern having an H-shaped pattern during the step of determining the beam pattern. This is illustrated in Figure 4. The orientation of the longitudinal direction of the cable lines 120a, 121 a, 120b, 121 b corresponds to the orientation of the dead-end towers, as illustrated in Figure 6.

[0082] With the dead-end tower, the cable line 120a, 121 a, 120b, 121 b ends near the dead-end tower, viewed in the horizontal plane, which results in a bending moment on the high-voltage tower pile 110a, 110b about a moment axis which runs parallel to the imaginary perpendicular bisector 112 between the two high-voltage tower piles 110a, 110b.

[0083] Figure 6 shows two cable lines, a first cable line 120a, 121 a and a second cable line 120b, 121 b which are oriented with respect to a first high-voltage tower pile 110a and a second high-voltage tower pile 110b, respectively. The respective first tower foundation 104a and second tower foundation 104b are also illustrated in Figure 6.

[0084] The first cable line 120a, 121 a consists of an incoming section 120a and an outgoing section 121 a. Axial forces in the incoming section are smaller than the axial forces in the outgoing section 121 a. The reason for this is that the incoming section 120a is smaller because it ends. A smaller incoming section 120a means less weight and thus smaller axial forces.

[0085] Therefore, the resulting bending moment in the high-voltage tower pile 110a has to be transmitted to the ground via the ground foundation 107. As a consequence thereof, an H-shaped pattern is chosen during the selection of the beam pattern, as a result of which the ground foundation 107 can absorb the bending moment.

Figures 4, 5 and 6 show a so-called dead-end tower, at least a foundation and associated orientation of cable lines are illustrated which correspond to those at a dead-end tower.

[0086] In a third embodiment according to the invention, a so-called angle tower is installed, that is to say the foundation of the angle tower is placed in a construction pit 203. This is illustrated in Figures 7 and 8. The associated orientation of the cable lines 220a, 220b is illustrated in Figure 9. Components of the third embodiment which are similar to components in the preceding embodiments are denoted by the same reference numeral, but increased by a multiple of 100, i.e. starting with 200. The advantages and description of components of the preceding embodiment accordingly also apply to the third embodiment.

[0087] In Figures 7, 8 and 9, the beam pattern is cruciform, i.e. the beams 211 a, 211 b, 211 c, viewed in a horizontal plane, have a cruciform pattern, as can be seen in Figure 7 and Figure 9. Here, the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at so-called angle towers, which carry cable lines 220a, 221 a, 220b, 221 b, as illustrated in Figure 9.

[0088] A first cable line 220a, 221 a consists of an incoming section 220a of the cable line and an outgoing section 221 a of the cable line. The incoming section 220a of the cable line makes an angle with the outgoing section 221 a of the cable line. This results in a distribution of forces on the high-voltage tower pile 210a and therefore on the ground foundation 203. The distribution of forces is absorbed by the ground foundation 203 by the beam pattern comprising the beams 211 a, 211 b, 211 c.

[0089] The above has the advantage that the beam pattern is such that the amount of soil to be excavated to produce the pit 203 is minimized, while the distribution of forces can be absorbed to a sufficient degree by the tower foundation 203.

[0090] In addition, it is possible to dig out trench-shaped pits which correspond to the beam pattern, instead of a large pit. As a result thereof, it is possible to prevent aquifers underneath a sealing soil layer from being penetrated.

[0091] Figures 7, 8 and 9 show a so-called angle tower, at least a foundation and associated orientation of cable lines are illustrated which correspond to those at an angle tower.

[0092] It is particularly advantageous for all preceding embodiments that the beam width is smaller than a largest diameter of a horizontal foundation surface of the tower foundation 4a, 4b, 104a, 104b, 204a, 204b. For each beam 11, 111 a, 111 b, 111 c, 211 a, 211 b, 211 c, the beam length and beam width are defined as lying in a horizontal plane.

[0093] For all preceding embodiments, it is also particularly advantageous that the method furthermore comprises the step of ramming one or more piles 5a, 5b, 105a, 205a into the ground in order to support the ground foundation 7, 107, 207. In this case, the ground foundation 7, 107, 207 is placed on a first end of the one or more piles 5a, 5b, 105a, 205a. In this case, the ground foundation 7, 107, 207 rests on the one or more piles 5a, 5b, 105a, 205a.

[0094] In particular, piles 5a, 105a, 205a are arranged in the ground at an angle to the vertical, such that a second end of the one or more piles 5a, 105a, 205a projects beyond an outer periphery of the ground foundation, viewed in a vertical plane. This can be seen in the front and side views of Figures 2a, 2b, 5, and 8.

[0095] Furthermore, in particular one or more piles 5b are arranged in a centre of two tower foundations, viewed in a vertical plane. This can be seen in the front and side views in Figures 2a and 2b, in which one pile 5a is arranged centrally between the first tower foundation 4a and the second tower foundation 4b of the first embodiment.

[0096] Many variants are possible in addition to the illustrated embodiments. Thus, it is for example possible to combine all embodiments with each other, depending on whether certain advantages are desired.

[0097] Thus, a method for providing a foundation for high-voltage electricity towers is obtained, in which the risk of the ground bursting is reduced, less soil has to be excavated, and in which less vacuum-assisted dewatering has to be used. These advantages are, in particular, the result of a smaller ground foundation, the smaller dimensions of which are made possible by the fact that a distribution of forces of cable lines on the high-voltage tower pile has been taken into account.

[0098] The present invention and embodiments thereof can also be expressed as indicated in the clauses below:

1] Method for providing a foundation for a high-voltage electricity tower, comprising the following steps:

- excavating a pit in the ground for receiving a ground foundation;
- forming the ground foundation in the pit;
- placing two or more tower foundations on the ground foundation, in such a way that the ground foundation connects the tower foundations to one another across a distance;
- placing a vertically oriented high-voltage tower pile on each of the tower foundations, wherein the high-voltage tower piles carry cable lines at a predetermined orientation of a longitudinal direction of the cable lines with respect to the high-voltage tower piles characterized by the fact that the ground foundation is provided with one or more beams in a beam pattern and the method furthermore comprises the step of determining the beam pattern, in which determining the beam pattern is based on a distribution of forces on the ground foundation resulting from axial forces in the cable lines and the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles.

2] Method for providing a foundation for a high-voltage electricity tower according to one of the preceding clauses, in which the method furthermore comprises the following step:

- producing one or more ground foundation troughs;
- placing the ground foundation troughs in the pit in a pattern, wherein the pattern of the ground foundation troughs corresponds to the beam pattern;
- pouring concrete into the ground foundation troughs in order to form the ground foundation.

3] Method for providing a foundation for a high-voltage electricity tower, being a suspension tower, according to one of the preceding clauses, in which the step of determining the beam pattern comprises choosing a beam pattern having a |-shape, in which the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at suspension towers.

4] Method according to the preceding clause, in which suspension towers correspond to a cable line having a longitudinal direction which is, viewed in the horizontal plane, at right angles to an imaginary perpendicular bisector between two high-voltage tower piles, resulting in a first bending moment on the high-voltage tower pile about a first moment axis, in which the first moment axis is at right angles to the imaginary perpendicular bisector between the two high-voltage tower piles.

5] Method for providing a foundation for a high-voltage electricity tower, being a dead-end tower, according to one of the preceding clauses, in which the step of determining the beam pattern comprises choosing a beam pattern having an H-shaped pattern, in which the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at dead-end towers.

6] Method according to the preceding clause, in which dead-end towers correspond to a cable line which ends near the dead-end tower, viewed in the horizontal plane, resulting in a second bending moment on the high-voltage tower pile about a second moment axis, wherein the second moment axis is parallel is to an imaginary perpendicular bisector between two high-voltage tower piles.

7] Method for providing a foundation for a high-voltage electricity tower, being an angle tower, according to one of the preceding clauses, in which the step of determining the beam pattern comprises choosing a beam pattern having a cruciform pattern, wherein the axial forces and the orientation of the longitudinal direction of the cable lines correspond to those at angle towers.

8] Method according to the preceding clause, in which angle towers correspond to a cable line which, viewed in the horizontal plane, makes an angle with respect to the high-voltage tower pile, resulting in a third bending moment on the high-voltage tower pile about a third moment axis and a fourth bending moment on the high-voltage tower pile about a fourth moment axis, in which the moment axes are at right angles to or parallel to an imaginary perpendicular bisector between two high-voltage tower piles.

9] Method according to one of the preceding clauses, in which each of the beams is provided with a beam length and beam width, viewed in a horizontal plane, the beam width being smaller than a largest diameter of a horizontal foundation surface of the tower foundation.

10] Method according to one of the preceding clauses, in which the method furthermore comprises the following step:

- ramming one or more piles into the ground in order to support the ground foundation;
- placing the ground foundation on a first end of the one or more piles, with the ground foundation resting on the one or more piles, wherein the piles are arranged in the ground at an angle to the vertical such that a second end of the one or more piles projects beyond an outer periphery of the ground foundation, viewed in a vertical plane.

11] Method according to one of the preceding clauses, in which the method furthermore comprises the following step:

- ramming one or more piles into the ground in order to support the ground foundation;
- placing the ground foundation on a first end of the one or more piles, with the ground foundation resting on the one or more piles, wherein the one or more piles are arranged in a centre of two tower foundations, viewed in a vertical plane.

12] Method for producing a network of high-voltage electricity towers, comprising the following steps:

- placing high-voltage electricity towers at a distance apart;
- connecting high-voltage electricity towers to each other by cable lines which are carried by the high-voltage electricity towers;
- providing a foundation for each of the high-voltage electricity towers according to one of the preceding clauses.

13] Network of spaced-apart high-voltage electricity towers, in particular high-voltage electricity towers provided with a foundation according to one of the preceding clauses, in which the network comprises a first high-voltage electricity tower and a second high-voltage electricity tower, in which each of the high-voltage electricity towers comprises:

- two or more spaced-apart vertically oriented high-voltage tower piles which can carry cable lines;
- tower foundations placed underneath the respective high-voltage tower piles in order to support the high-voltage tower piles,
- a ground foundation placed underneath the tower foundations in order to connect the two or more tower foundations to one another across a distance, with the tower foundations resting on the ground foundation, wherein the first high-voltage electricity tower is connected to the second high-voltage electricity tower by means of the cable lines, a longitudinal direction of the cable lines being oriented with respect to the high-voltage tower piles of the first and the second high-voltage electricity tower, characterized in that the ground foundation of each of the high-voltage electricity towers comprises one or more beams in a beam pattern, the beam pattern being based on a distribution of forces resulting from the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles.

14] Network according to one of the preceding clauses, in which each of the beams is provided with a beam length and beam width, viewed in a horizontal plane, the beam width being smaller than a largest diameter of a horizontal foundation surface of the tower foundation.

15] Network according to one of the preceding clauses, in which each of the high-voltage tower piles is tubular and has a cross-sectional surface and in which a horizontal foundation surface of the tower foundation is greater than the cross-sectional surface of the high-voltage tower pile.

16] Network according to one of the preceding clauses, in which the high-voltage tower piles can carry one or more cable lines, in which a longitudinal direction of the cable lines, viewed in the horizontal plane, is at right angles to an imaginary perpendicular bisector between a first high-voltage tower pile and a second high-voltage tower pile, in which the ground foundation comprises a single beam having a longitudinal direction at right angles to the longitudinal direction of the cable lines.

17] Network according to the preceding clause, in which the beam pattern of the ground foundation is I-shaped and the corresponding high-voltage electricity tower is a suspension tower.

18] Network according to one of the preceding clauses, in which the high-voltage tower piles can carry one or more cable lines, in which a separate cable line makes an angle, viewed in the horizontal plane, in which the ground foundation comprises several beams, in which the beam pattern is such that a first beam is arranged in a longitudinal direction at right angles to the longitudinal direction of an incoming cable line and a second beam is arranged in a longitudinal direction at right angles to the longitudinal direction of an outgoing cable line.

19] Network according to the preceding clause, in which the beam pattern of the ground foundation is cruciform and the corresponding high-voltage electricity tower is an angle tower.

20] Network according to one of the preceding clauses, in which the high-voltage tower piles can carry one or more cable lines, in which a separate cable line ends near the high-voltage tower pile, viewed in the horizontal plane, in which the ground foundation comprises several beams, in which the beam pattern is such that a first beam is arranged in a longitudinal direction at right angles to the longitudinal direction of an incoming cable line and a second beam is arranged in a longitudinal direction at right angles to the longitudinal direction of an outgoing cable line.

21] Network according to the preceding clause, in which the beam pattern of the ground foundation is H-shaped and the corresponding high-voltage electricity tower is a dead-end tower.

22] Network according to one of the preceding clauses, in which a lowest point of the ground foundations is situated at 1.5 m under a ground surface.

23] Network according to one of the preceding clauses, in which the tower foundation has a horizontal radial periphery smaller than the respective tube diameter increased by half the respective tube diameter, in particular has a horizontal radial periphery smaller than the respective tube diameter increased by 2.0 m.

24] Network according to one of the preceding clauses, in which the tube diameters of the high-voltage tower piles are of equal size.

25] Network according to one of the preceding clauses, in which each of the high-voltage electricity towers furthermore comprises:

- one or more piles anchored in the ground in order to support the ground foundation, with the ground foundation resting on the one or more piles and with the piles being arranged in the ground at an angle to the vertical such that a second end of the one or more piles projects beyond an outer periphery of the ground foundation, viewed in a vertical plane.

26] Network according to one of the preceding clauses, in which each of the high-voltage electricity towers furthermore comprises:

- one or more piles anchored in the ground in order to support the ground foundation, with the ground foundation resting on the one or more piles and with the one or more piles being arranged in a centre of two tower foundations, viewed in a vertical plane.

27] Network according to one of the preceding clauses, in which each of the high-voltage electricity towers furthermore comprises:

- one or more piles anchored in the ground in order to support the ground foundation, with the ground foundation resting on the one or more piles and with the piles being arranged in the ground at an angle to the vertical depending on the orientation of the longitudinal direction of the cable lines with respect to the high-voltage tower piles.

28] High-voltage electricity tower provided with a foundation, comprising:

- two spaced-apart vertically oriented high-voltage tower piles 10a, 10b; 110a, 110b; 210a, 210b which can carry cable lines 20a, 20b; 120a, 120b; 220a, 220b;
- two tower foundations 4a, 4b; 104a, 104b; 204a, 204b, each placed underneath said respective high-voltage tower pile 10a, 10b; 110a, 110b; 210a, 210b in order to support the high-voltage tower piles 10a, 10b; 110a, 110b; 210a, 210b,
- a ground foundation 7; 107; 207 placed underneath the tower foundations 4a, 4b; 104a, 104b; 204a, 204b, in which the ground foundation 7; 107; 207 connects the spaced-apart tower foundations 4a, 4b; 104a, 104b; 204a, 204b to one another, in which the tower foundations 4a, 4b; 104a, 104b; 204a, 204b rest on the ground foundation 7; 107; 207, characterized in that the ground foundation 7; 107; 207 comprises one or more beams 11; 111a, 111b, 111c; 211a, 211b, 211c in a beam pattern.

29] High-voltage electricity tower according to clause 28, in which the beam pattern comprises a first beam 11; 111a; 211a which connects the two tower foundations 4a, 4b; 104a, 104b, 204a, 204b to one another.

30] High-voltage electricity tower according to clause 29, in which the beam pattern comprises a second beam 111b; 211b which intersects with the first beam 111a; 211a in a direction at right angles to the longitudinal direction of the first beam 111a; 211a, and comprises a third beam 111c; 211c which intersects with the first beam 111a; 211a in a direction at right angles to the longitudinal direction of the first beam 111a; 211a, and in which the one tower foundation is placed at the intersection of the first beam 111a; 211a and the second beam 111b; 211b and the other tower foundation is placed at the intersection of the first beam 111a; 211a and the third beam 111c; 211c.

31] High-voltage electricity tower according to clause 30, in which the first beam 211a, the second beam 211b and the third beam 211c together form a beam pattern comprising two crosses.

32] High-voltage electricity tower according to clause 30, in which the first beam 111a, the second beam 111b and the third beam 111c together form an H-shaped beam pattern.

33] High-voltage electricity tower according to clause 29, in which the beam pattern consists of said single first beam 11.

34] High-voltage electricity tower according to one of clauses 28-33, in which each of the beams 11; 111a, 111b, 111c; 211a, 211b, 211c of the beam pattern has a beam length and a beam width, and in which the beam width, viewed in the horizontal plane, is smaller than a largest diameter of the tower foundation 4a, 4b; 104a, 104b; 204a, 204b.

Claims

1. Method for providing a foundation for a high-voltage electricity tower comprising two or more high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b), comprising the following steps:

    • excavating a pit (3; 103; 203) in the ground (9; 109; 209) for receiving a ground foundation (7; 107; 207);
    • forming the ground foundation (7; 107; 207) in the pit (3; 103; 203);
    • placing two or more tower foundations (4a, 4b; 104a, 104b; 204a, 204b) on the ground foundation (7; 107; 207), in such a way that the ground foundation (7; 107; 207) connects the tower foundations (4a, 4b; 104a, 104b; 204a, 204b) to one another across a distance;
    • placing a vertically oriented high-voltage tower pile (10a, 10b; 110a, 110b; 210a, 210b) on each of the tower foundations (4a, 4b; 104a, 104b; 204a, 204b), wherein the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) carry cable lines (20a, 20b; 120a, 120b; 220a, 220b) at a predetermined orientation of a longitudinal direction of the cable lines (20a, 20b, 21a, 21b; 120a, 120b, 121a, 121b; 220a, 220b, 221a, 221 b) with respect to the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) **characterized in that** the ground foundation (7; 107; 207) is provided with one or more beams (11, 111a, 111b, 111c, 211a, 211b, 211c) in a beam pattern and the method furthermore comprises the step of determining the beam pattern, in which the beam pattern is determined based on a distribution of forces on the ground foundation (7; 107; 207) originating from the cable lines (20a, 20b; 120a, 120b; 220a, 220b) or resulting from axial forces in the cable lines (20a, 20b, 21a, 21b; 120a, 120b, 121a, 12b; 220a, 220b, 221a, 221b) and the orientation of the longitudinal direction of the cable lines (20a, 20b, 21a, 21b; 120a, 120b, 121a, 121b; 220a, 220b, 221a, 221b) with respect to the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b).

2. Method for providing a foundation for a high-voltage electricity tower according to claim 1, in which the method furthermore comprises the following step:

    • producing one or more ground foundation troughs;
    • placing the ground foundation troughs in the pit (3; 103; 203) in a pattern, wherein the pattern of the ground foundation troughs corresponds to the beam pattern;
    • pouring concrete into the ground foundation troughs in order to form the ground foundation (7; 107; 207).

3. Method for providing a foundation for a high-voltage electricity tower according to one of claims 1-2, in which the step of determining the beam pattern comprises choosing a beam pattern having a |-shape, in which the axial forces and the orientation of the longitudinal direction of the cable lines (20a, 20b, 21 a, 21 b) correspond to those at suspension towers.

4. Method for providing a foundation for a high-voltage electricity tower according to one of claims 1-2, in which the high-voltage electricity tower to be provided with a foundation is a dead-end tower comprising two spaced-apart high-voltage tower piles (110a, 110b), in which the step of determining the beam pattern comprises choosing a beam pattern having an H-shaped pattern, in which the axial forces and the orientation of the longitudinal direction of the cable lines (120a, 120b, 121 a, 121 b) correspond to those at dead-end towers.

5. Method for providing a foundation for a high-voltage electricity tower, according to one of the preceding claims, in which the high-voltage electricity tower to be provided with a foundation is an angle tower comprising two spaced-apart high-voltage tower piles (210a, 210b), in which the step of determining the beam pattern comprises choosing a beam pattern with two crosses, the beams (211a, 211b, 211c) of which are integrally connected to each other, in which the axial forces and the orientation of the longitudinal direction of the cable lines (220a, 220b, 221a, 221b) correspond to those at angle towers.

6. Method according to one of the preceding claims, in which, viewed in a horizontal plane, each of the beams (11; 111a, 111b, 111c, 211a, 211b, 211c) has a beam length and beam width, the beam width being smaller than a largest diameter of a horizontal foundation surface of the tower foundation (4a, 4b; 104a, 104b; 204a, 204b).

7. Method according to one of the preceding claims, in which the method furthermore comprises the following step:

    • ramming one or more piles into the ground (9; 109; 209) in order to support the ground foundation (7; 107; 207);
    • placing the ground foundation (7; 107; 207) on a first end of the one or more piles, with the ground foundation (7; 107; 207) resting on the one or more piles,

in which:

- the piles are arranged in the ground (9; 109; 209) at an angle to the vertical such that a second end of the one or more piles projects beyond an outer periphery of the ground foundation (7; 107; 207), viewed in a vertical plane;
and/or
- the one or more piles are arranged in the centre of two tower foundations (4a, 4b; 104a, 104b; 204a, 204b), viewed in a vertical plane.

8. Network of spaced-apart high-voltage electricity towers provided with a foundation, in particular high-voltage electricity towers provided with a foundation according to one of the preceding claims,
in which the network comprises a first high-voltage electricity tower and a second high-voltage electricity tower,
in which each of the high-voltage electricity towers comprises:

- two or more spaced-apart vertically oriented high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) which can carry cable lines (20a, 20b, 21a, 21b; 120a, 120b, 121a, 121b; 220a, 220b, 221a, 221b);
- tower foundations (4a, 4b; 104a, 104b; 204a, 204b) placed underneath the respective high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) in order to support the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b),
- a ground foundation (7; 107; 207) placed underneath the tower foundations (4a, 4b; 104a, 104b; 204a, 204b) in order to connect the two or more tower foundations (4a, 4b; 104a, 104b; 204a, 204b) to one another across a distance, in which the tower foundations (4a, 4b; 104a, 104b; 204a, 204b) rest on the ground foundation (7; 107; 207),

in which the first high-voltage electricity tower is connected to the second high-voltage electricity tower by means of the cable lines (20a, 20b; 120a, 120b; 220a, 220b),
in which a longitudinal direction of the cable lines (20a, 20b, 21a, 21b; 120a, 120b, 121a, 121b; 220a, 220b, 221a, 221b) is oriented with respect to the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) of the first and the second high-voltage electricity tower, **characterized in that** the ground foundation (7; 107; 207) of each of the high-voltage electricity towers comprises one or more beams (11; 111a, 111b, 111c, 211a, 211b, 211c) in a beam pattern, in which the beam pattern is based on a distribution of forces resulting from the orientation of the longitudinal direction of the cable lines (20a, 20b, 21a, 21b; 120a, 120b, 121a, 121b; 220a, 220b, 221a, 221b) with respect to the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b).

9. Network according to claim 8, in which, viewed in a horizontal plane, each of the beams (11; 111 a, 111 b, 111 c, 211 a, 211 b, 211 c) has a beam length and beam width, and in which the beam width is smaller than a largest diameter of a horizontal foundation surface of the tower foundation (4a, 4b; 104a, 104b; 204a, 204b).

10. Network according to one of the preceding claims 8-9, in which each high-voltage electricity tower contains two of said high-voltage tower piles (10a, 10b) which carry one or more cable lines (20a, 20b, 21a, 21b), in which, viewed in the horizontal plane, a longitudinal direction of the cable lines (20a, 20b, 21a, 21b) is at right angles to an imaginary perpendicular bisector (12) on and between a first high-voltage tower pile and a second high-voltage tower pile, in which, with said high-voltage electricity tower, the beam pattern contains a single beam (11) having a longitudinal direction at right angles to the longitudinal directions of the cable lines (20a, 20b, 21a, 21b), in which the two high-voltage tower piles (10a, 10b) of said high-voltage electricity tower are supported on the single beam (211) by means of said two tower foundations (4a, 4b).

11. Network according to one of the preceding claims 8-9, in which each high-voltage electricity tower contains two of said high-voltage tower piles (110a, 110b) which carry one or more cable lines (120a, 120b, 121a, 121b), in which, viewed in the horizontal plane, a separate cable line (120a, 120b, 121 a, 121 b) ends near said high-voltage electricity tower, in which the beam pattern of the ground foundation (107) of said high-voltage electricity tower is an H-shaped pattern comprising a first (111 a), a second (111 b) and a third (111 c) beam, with the first beam (111 a) extending between the second beam (111 b) and third beam (111c).

12. Network according to one of the preceding claims 8-9, in which each high-voltage electricity tower contains two of said high-voltage tower piles (210a, 210b) which carry one or more cable lines (220a, 220b; 221 a, 221 b), in which, with said high-voltage electricity tower and viewed in the horizontal plane, a separate cable line (220a, 221 a) has an incoming section (220a) which makes an angle with an outgoing section (221 b) of said separate cable line (220a, 221 a), in which the beam pattern of the ground foundation (207) of said high-voltage electricity tower is a cruciform pattern of a first (211 a), a second (211 b) and a third (211 c) beam (211 a, 211 b, 211 c), said beam pattern being such that the second beam (211 b) is arranged in a longitudinal direction at right angles to the longitudinal direction of the first beam (211a) and the third beam (211c) is arranged in a longitudinal direction at right angles to the longitudinal direction of the first beam (211 a).

13. Network according to claim 11 or 12, in which the tower foundations (104a, 104b; 204a, 204b) of the high-voltage tower piles (110a, 110b; 210a, 210b) of said high-voltage electricity tower are placed at the intersection of the second beam (111b; 111b) and the first beam (111a, 211a) and at the intersection of the third beam (111c; 111c) and the first beam (111a, 211a).

14. Network according to one of the preceding claims 8-13,
in which

- a lowest point of the ground foundations (7; 107; 207) is situated at 1.5 m below a ground surface;
and/or
- the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) are tubular and have a cross-sectional surface, and in which a horizontal foundation surface of the tower foundation (4a, 4b; 104a, 104b; 204a, 204b) is greater than the cross-sectional surface of the high-voltage tower pile (10a, 10b; 110a, 110b; 210a, 210b);
and/or
- the tower foundation (4a, 4b; 104a, 104b; 204a, 204b) has a horizontal radial periphery smaller than the respective tube diameter increased by half the respective tube diameter, in particular a horizontal radial periphery smaller than the respective tube diameter increased by 2.0 m;
and/or
- the tube diameters of the high-voltage tower piles are of equal size.

15. Network according to one of the preceding claims 8-14, in which each of the high-voltage electricity towers furthermore comprises one or more piles anchored in the ground (9; 109; 209) in order to support the ground foundation (7; 107; 207), with the ground foundation (7; 107; 207) resting on the one or more piles, and
in which

- the piles are arranged in the ground (9; 109; 209) at an angle to the vertical such that a second end of the one or more piles projects beyond an outer periphery of the ground foundation (7; 107; 207), viewed in a vertical plane;
and/or
- in which the one or more piles are arranged in a centre of two tower foundations (4a, 4b; 104a, 104b; 204a, 204b), viewed in a vertical plane;
and/or
- in which the piles are arranged in the ground (9; 109; 209) at an angle to the vertical based on the orientation of the longitudinal direction of the cable lines (20a, 20b, 21 a, 21b; 120a, 120b, 121a, 121b; 220a, 220b, 221 a, 221 b) with respect to the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b).

16. High-voltage electricity tower provided with a foundation, comprising:

- two spaced-apart vertically oriented high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b) which can carry cable lines (20a, 20b; 120a, 120b; 220a, 220b);
- two tower foundations (4a, 4b; 104a, 104b; 204a, 204b), each placed underneath said respective high-voltage tower pile (10a, 10b; 110a, 110b; 210a, 210b) in order to support the high-voltage tower piles (10a, 10b; 110a, 110b; 210a, 210b),
- a ground foundation (7; 107; 207) placed underneath the tower foundations (4a, 4b; 104a, 104b; 204a, 204b), in which the ground foundation (7; 107; 207) connects the spaced-apart tower foundations (4a, 4b; 104a, 104b; 204a, 204b) to one another, in which the tower foundations (4a, 4b; 104a, 104b; 204a, 204b) rest on the ground foundation (7; 107; 207), **characterized in that** the ground foundation (7; 107; 207) comprises one or more beams (11; 111 a, 111b, 111 c; 211 a, 211 b, 211 c) in a beam pattern.

17. High-voltage electricity tower according to claim 16, in which the beam pattern comprises a first beam (11; 111 a; 211 a) which connects the two tower foundations (4a, 4b; 104a, 104b, 204a, 204b) to one another; in which the beam pattern comprises a second beam (111b; 211b) which intersects with the first beam (111 a; 211 a) in a direction at right angles to the longitudinal direction of the first beam (111a; 211a), and comprises a third beam (111c; 211c) which intersects with the first beam (111 a; 211 a) in a direction at right angles to the longitudinal direction of the first beam (111 a; 211 a), and in which the one tower foundation is placed at the intersection of the first beam (111 a; 211 a) and the second beam (111b; 211b) and the other tower foundation is placed at the intersection of the first beam (111a; 211a) and the third beam (111c; 211c).

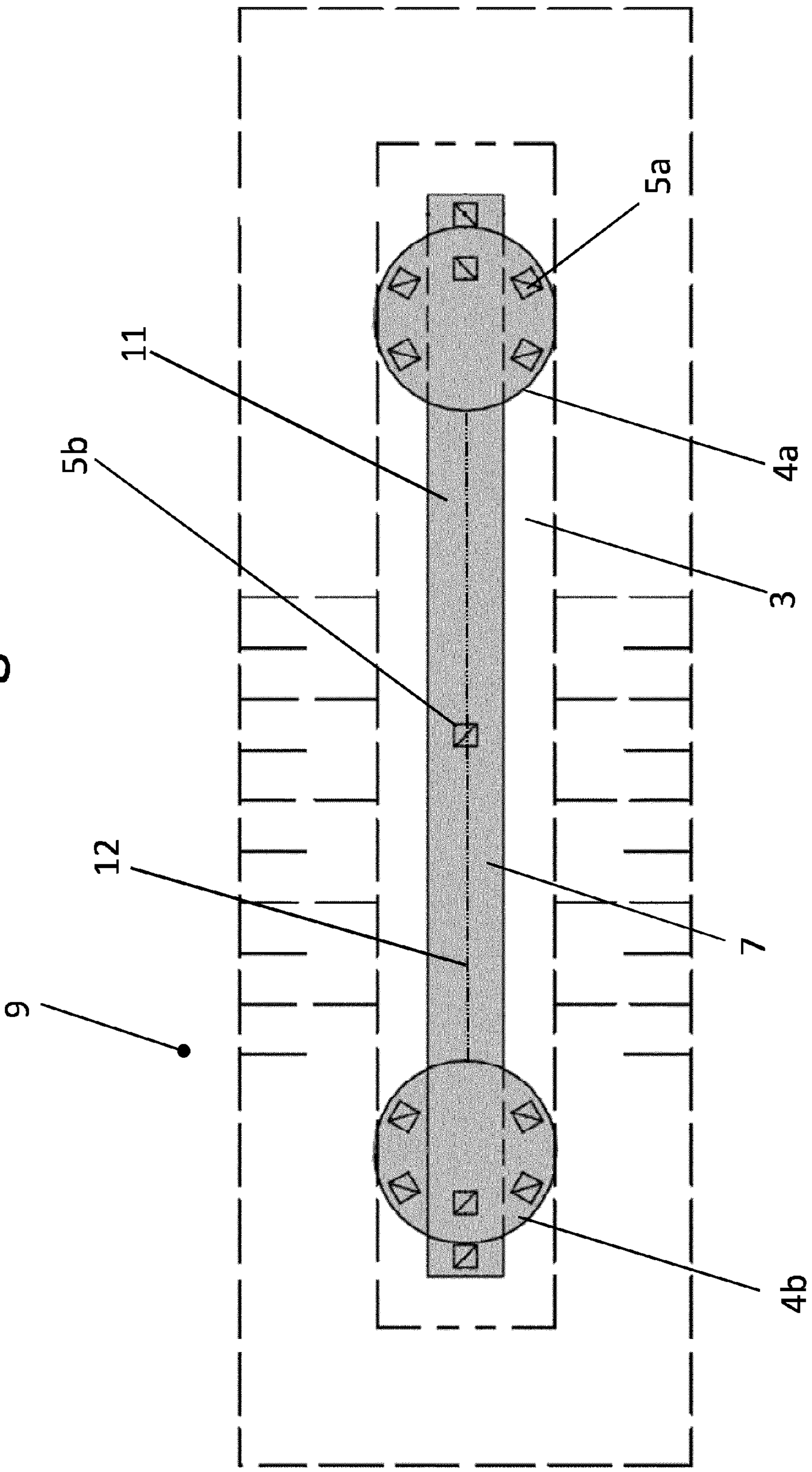


Fig. 1

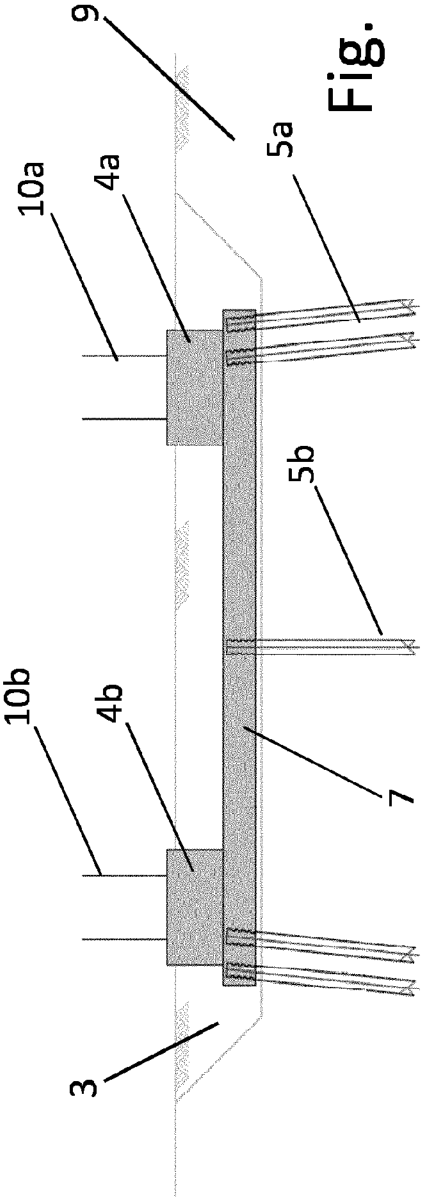


Fig. 2a

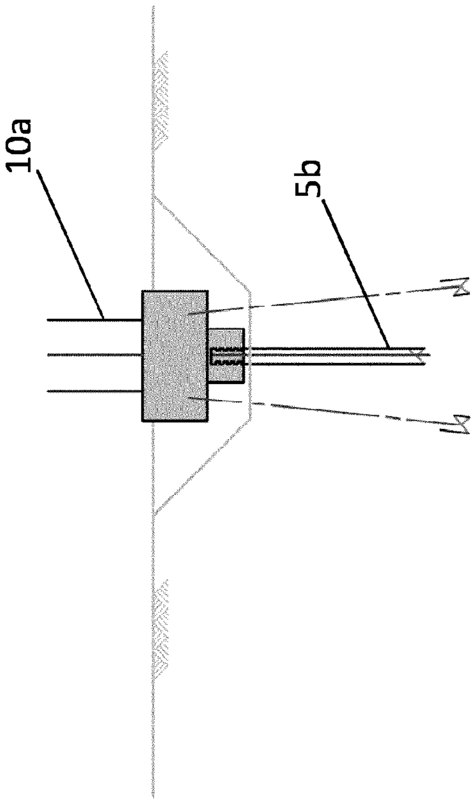


Fig. 2b

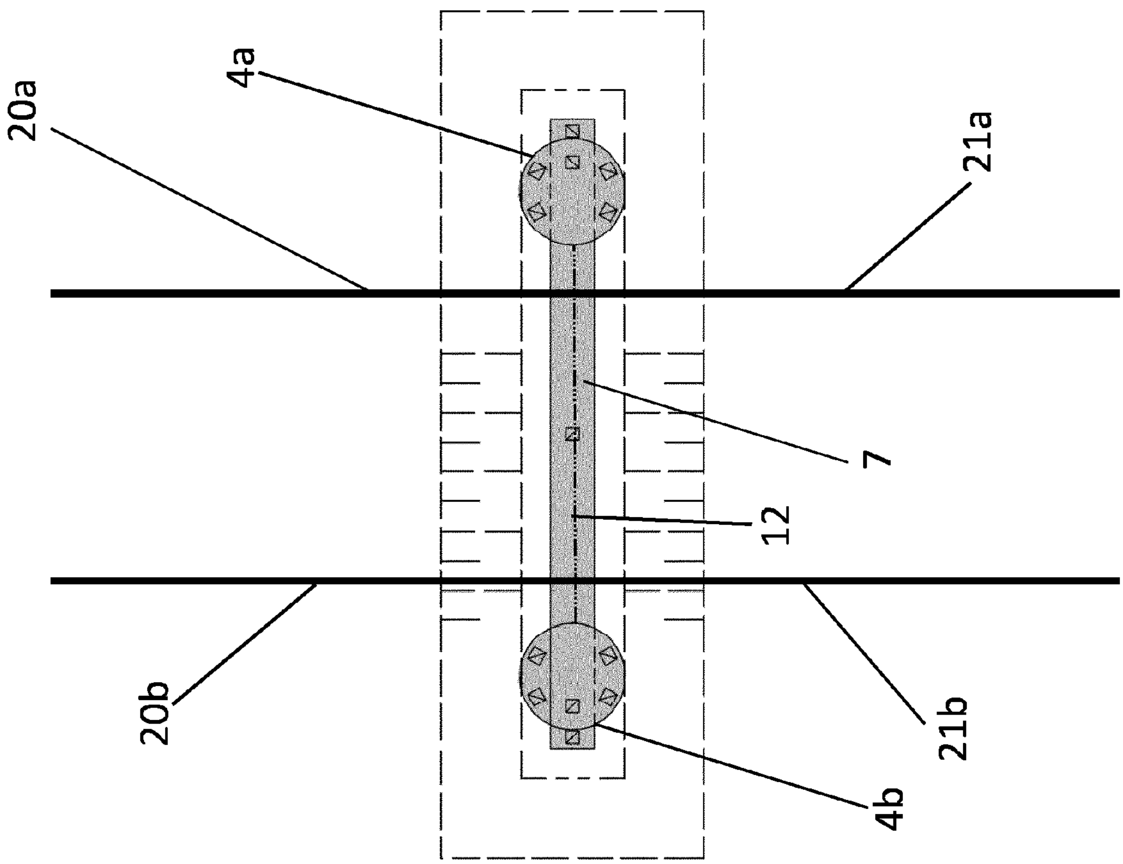


Fig. 3

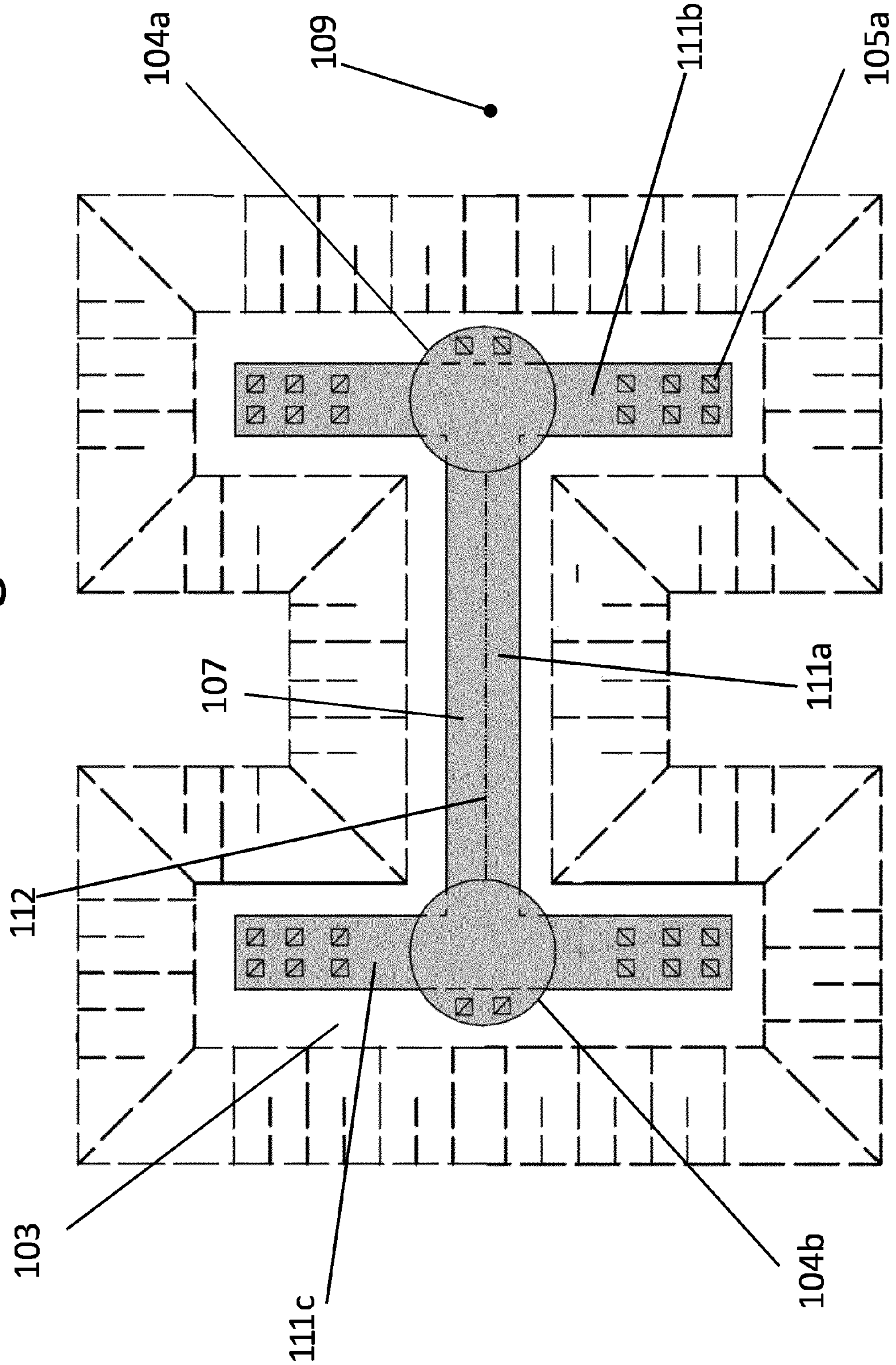
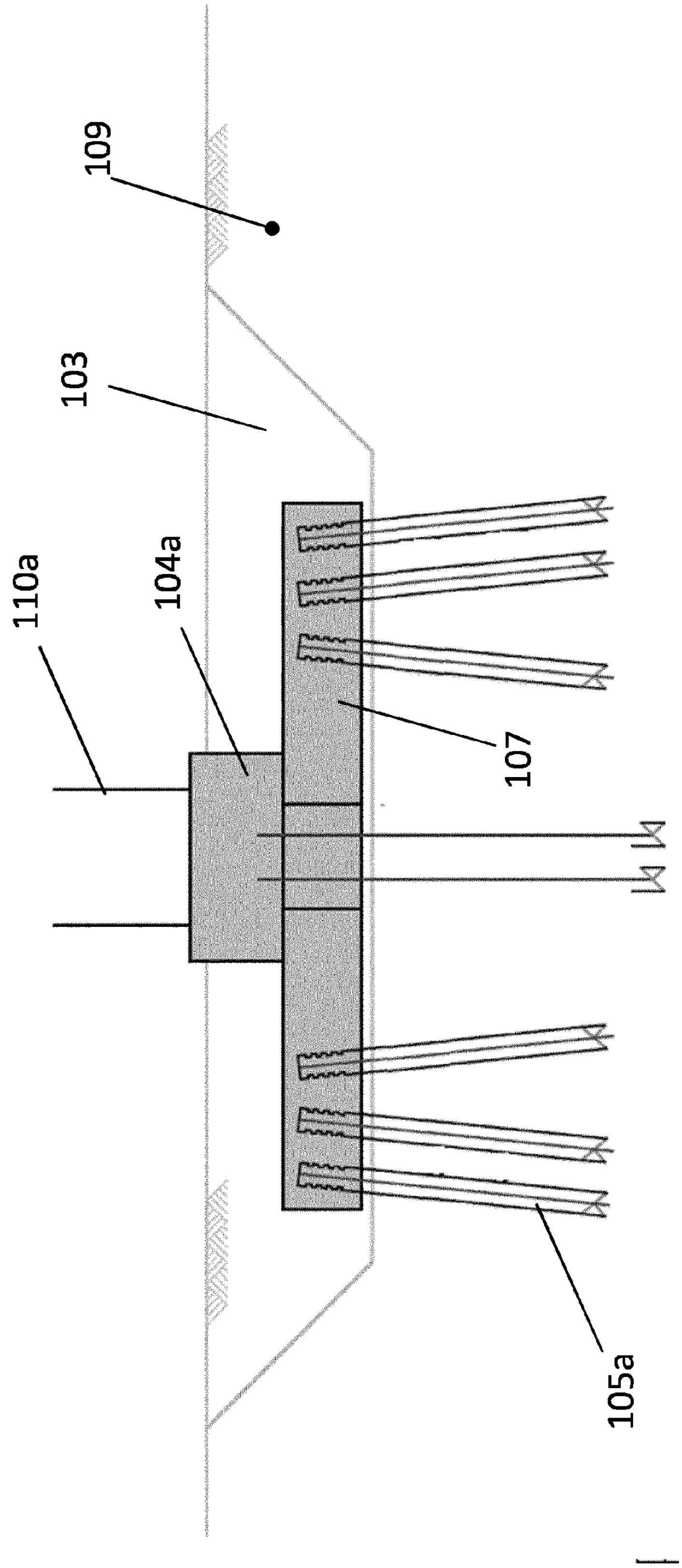


Fig.4

Fig. 5



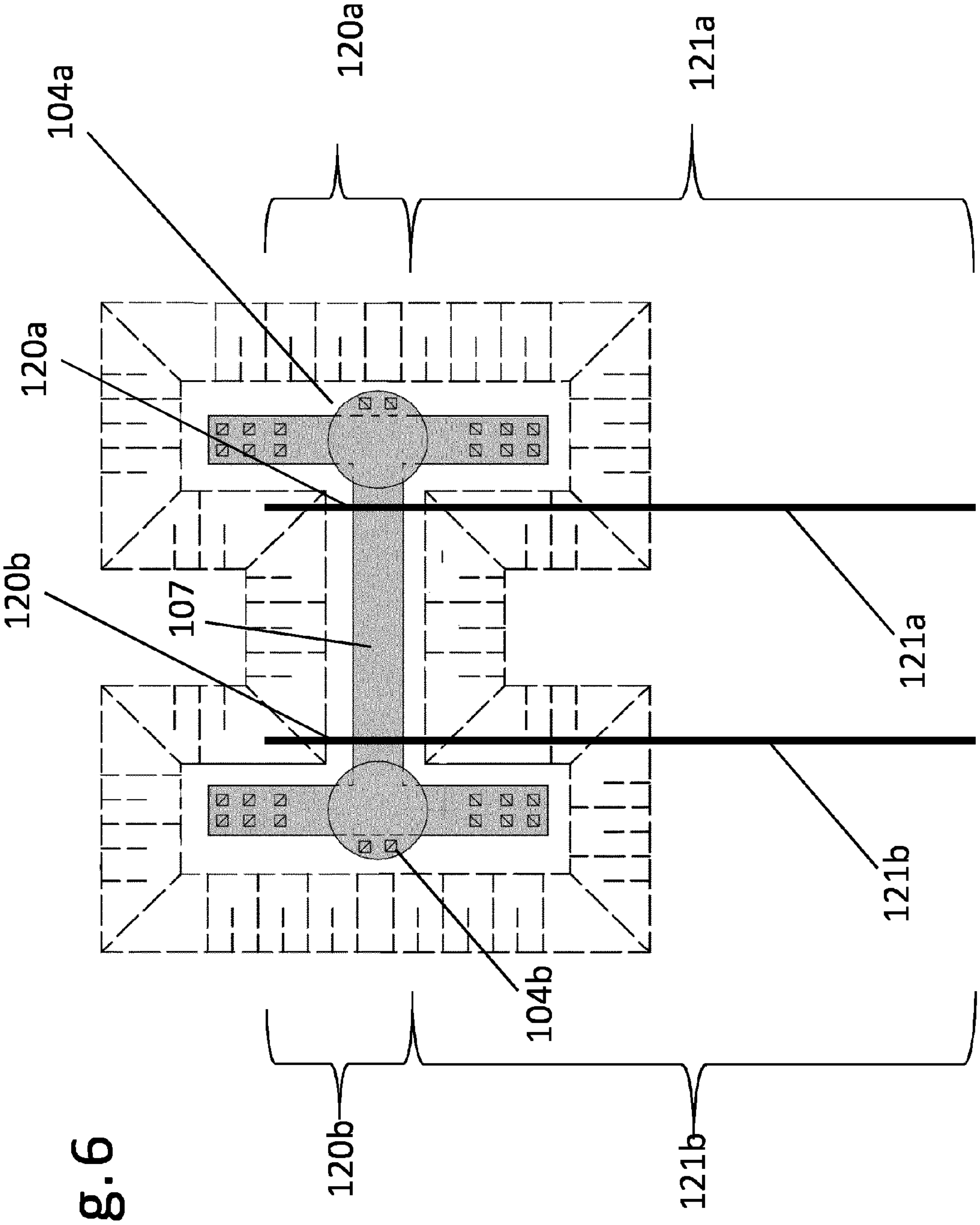


Fig.6

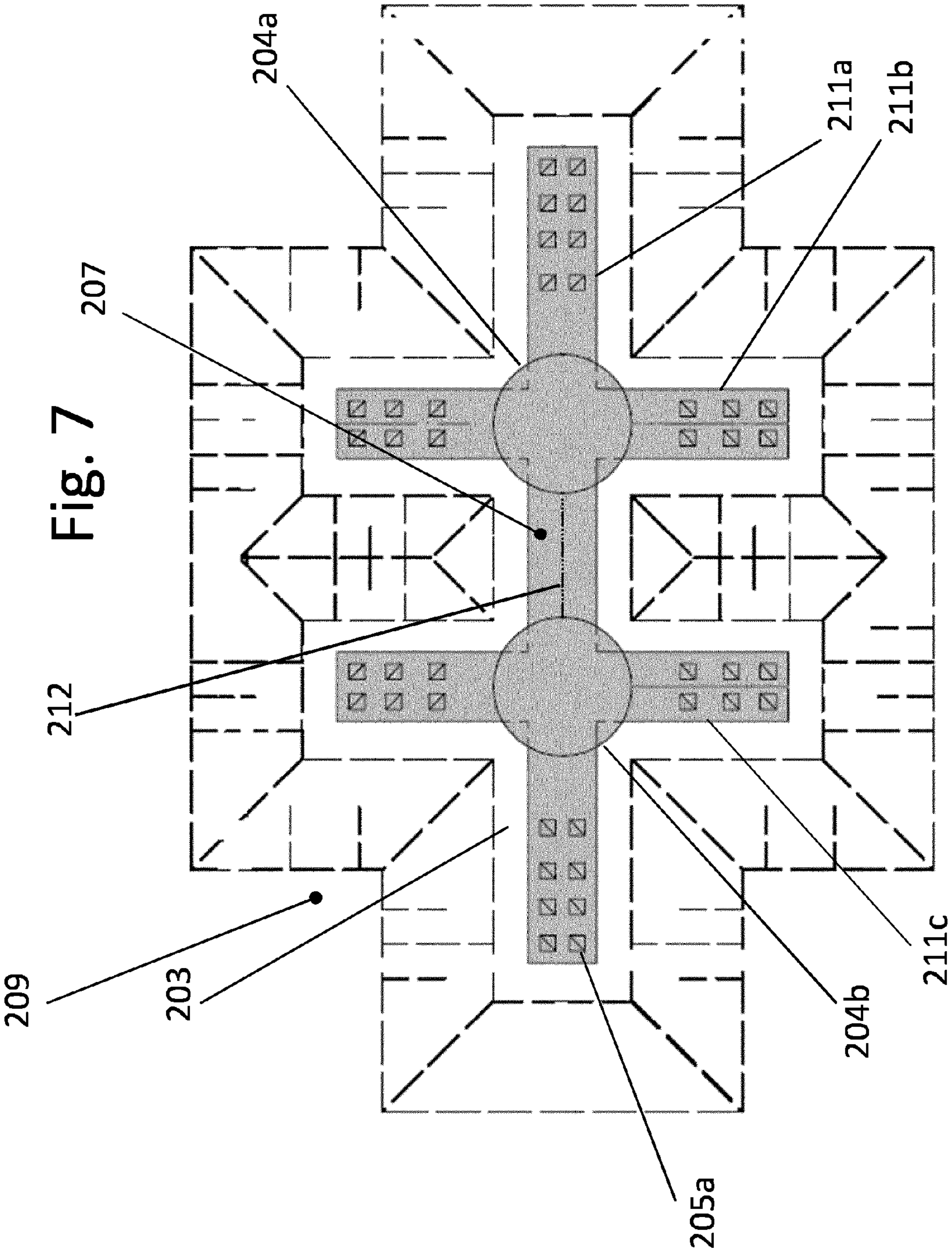


Fig. 7

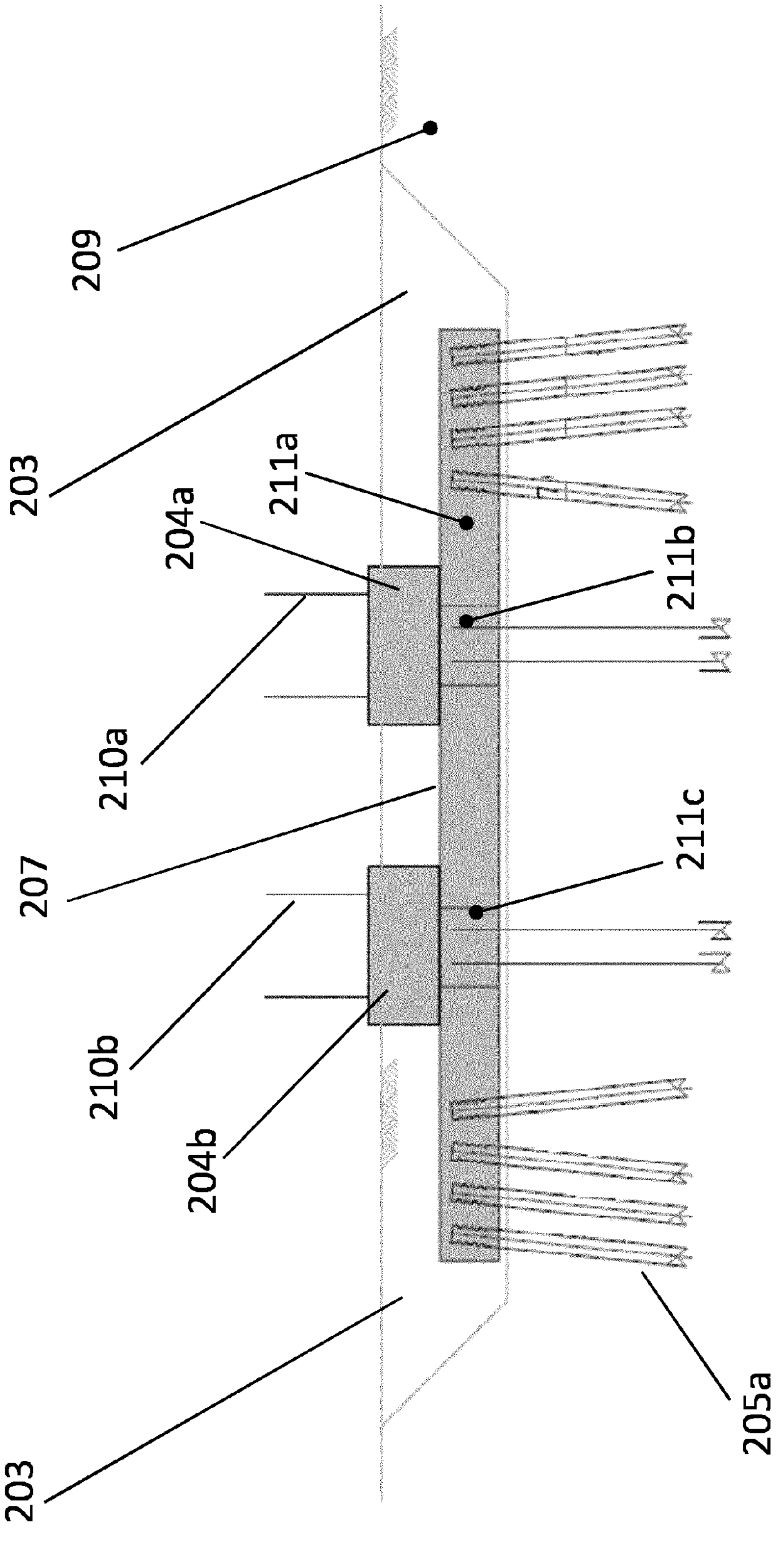


Fig. 8

Fig.9