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(54) ASSEMBLY AND METHOD FOR DRIVING ONE OR MORE SHEET PILES INTO OR OUT OF THE GROUND

(57) An assembly for driving one or more sheet piles into or out of the ground, in particular for assembling or disassembling a sheet pile wall of interconnected sheet piles, comprises a sonic vibration apparatus with a housing and a vibration generator inside the housing that connects to a vibrator axis that has a longitudinal direction and that extends partly outside the housing with a gripping and/or clamping portion for gripping an upper portion of a sheet pile, the vibration generator being designed to introduce vibrations at sonic frequencies in the longitudinal direction into a sheet pile via the vibrator axis and gripping and/or clamping portion, and a positioning device for positioning the sonic vibration apparatus relative to the sheet pile and having it move up or down in the longitudinal direction together with the sheet pile during its driving into or out of the ground. The vibrating mechanism of the sonic vibration apparatus comprises at least one pair of rotatable eccentric masses and a motor for driving the eccentric masses in counter rotation such that the vibrations at sonic frequencies in the longitudinal direction are introduced into the vibrator axis during said driving of the sheet pile into or out of the ground.

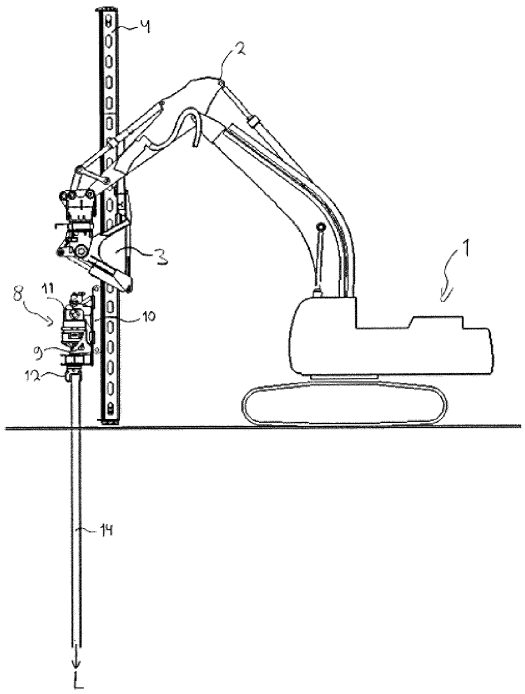

FIG. 1

EP 3 181 762 A1

Description

[0001] The invention relates to an assembly and method for driving one or more sheet piles into or out of the ground by making use of sonic vibrations.

[0002] Sheet piles normally are formed by profiled sheets with interlockable male and female side edges that can be slid into each other in a longitudinal direction of the sheet piles such that can form a substantially closed sheet pile wall. Thus a continuous barrier can be formed in the ground that for example can be used as retaining barrier wall. All kinds of shapes of sheet piles are known to be used for this, like Z-shaped, U-shaped, pan-shaped or flat sheet piles. The sheet piles in particular can be made out of steel. Other metals or materials like wood or plastic are also possible. Vibratory hammers are frequently used to install the sheet piles. If the ground however is too hard or dense, an impact hammer can be used to perform or complete the installation. At certain sites where vibrations, shocks or noise are a concern for damaging the surroundings, the sheets can also be hydraulically pushed into the ground.

[0003] It is also known to use a so-called high frequency resonator driver for installing sheet piles into the ground. This resonator driver gets freely movably hung to a hoisting crane or the like and comprises a hydraulic piston-cylinder system inside an external casing which during driving gets operated such that the piston starts to move up and down at high frequencies. For this a sophisticated switching control mechanism is used which is able to change a feeding of highly pressurized hydraulic fluid to respective opposing sides of the piston at said high frequencies. Owing to this the piston starts to move up and down at those high frequencies, causing the external casing to get subjected to high vibrational forces. For this known resonator driver, frequencies are used of between 3.600-10.000 VPM, that is to say also in a sonic frequency range.

[0004] A disadvantage of this known resonator driver is that its switching control mechanism is rather expensive and complex in order to be able to sonically switch the feeding of the hydraulic fluid to the opposing sides of the piston. Also the pressure with which the hydraulic fluid needs to get fed to the piston-cylinder system needs to be quite high in order to obtain sufficiently forceful vibrations for a sheet pile to get driven into the ground. In particular at sonic vibration frequencies a high risk occurs that sealings of the resonator driver may get damaged, because of which the highly pressurized hydraulic fluid may start to leak out. This may immediately form an important safety risk for people in the environment. Another disadvantage is that because of the external casing also getting subjected to the high vibration frequencies, the resonator driver needs to be hung in its entirety to the hoisting crane by means of a flexible tension organ like a cable, belt or strap. Thus it can freely swing relative to the hoisting crane without leading the high frequency vibrations into the hoisting crane. This freely swingable connection between the resonator driver and the hoisting crane however makes it impossible to add sideways directed steering forces onto a sheet pile during its driving into the ground.

[0005] The present invention aims to overcome one or more of those disadvantages at least partly or to provide a usable alternative. In particular the invention aims to provide a user-friendly assembly and method for driving sheet piles into and out of the ground in a quick and reliable manner.

[0006] This aim is achieved by an assembly for driving one or more sheet piles into or out of the ground, in particular for forming or removing a sheet pile wall of interconnected sheet piles, according to claim 1. The assembly comprises a sonic vibration apparatus with a housing and a vibration generator placed inside the housing that connects to a vibrator axis that has a longitudinal direction and that extends partly outside the housing with a gripping and/or clamping portion for gripping an upper portion of a sheet pile. With this the longitudinal direction of the vibrator axis preferably is positionable substantially in line with a longitudinal direction of a sheet pile. The vibration generator is designed to introduce vibrations at sonic frequencies in the longitudinal direction into a sheet pile via the vibrator axis and gripping and/or clamping portion. A suitable control unit can be provided by means of which the frequencies can be varied. The assembly further comprises a positioning device for positioning the sonic vibration apparatus relative to the sheet pile. In particular the positioning device is designed to position the sonic vibration apparatus with at least part of its weight on top of a sheet pile while having it grip the upper portion thereof with its gripping and/or clamping portion. More in particular the positioning device is designed to have the sonic vibration apparatus move up or down in the longitudinal direction together with the sheet pile. The vibrating mechanism of the sonic vibration apparatus is of the type that comprises at least one pair of eccentric masses and a motor for driving those eccentric masses in counter rotation at the aimed sonic frequencies in such a way that vibrations at those sonic frequencies are introduced into the vibrator axis in the longitudinal direction during inserting the sheet pile into the ground or during pulling the sheet pile out of the ground again.

[0007] Thus the invention advantageously provides an assembly with which a sheet pile can be quickly and reliably driven into or out of the ground. It has appeared that by making use of eccentric masses for obtaining the aimed sonic vibration frequencies some important advantages can be achieved. First of all the assembly has appeared to make less noise, which is important when the sheet piles need to be handled near places where people live or work. Secondly, working with eccentric masses rotating a sonic frequencies has appeared much safer than working with a hydraulically operated piston-cylinder system reciprocating at sonic frequencies. The problem with dangerous leakages of hydraulic fluids can no longer occur. Instead it now suffices to provide a rel-

ative simple motor for driving the eccentric masses at high speeds in counter rotation. No sonic speed switching of hydraulic channels needs to take place, whereas furthermore the speed of the motor for driving the eccentric masses in counter rotation can more easily and quickly be regulated wit superb response times. Thirdly, the construction with eccentric masses rotating a sonic frequencies has appeared much simpler and cheaper to build than the piston-cylinder system that needs to reciprocate at sonic frequencies. No vulnerable or complex sonic speed switching control mechanism is necessary. All in all this makes the assembly much more reliable. Fourthly, it now has appeared possible to largely isolate the housing from the generated sonic vibration frequencies. This offers the advantage that the housing now can be firmly gripped and/or manipulated in various directions by the positioning device without the positioning device itself having to withstand the vibrations.

[0008] The introduced sonic vibration preferably lies controllable by an operator in between 6,000-10,000 VPM. An operator then is able to each time choose a most optimum frequency in dependence of a progress he detects of the driving of the sheet pile into or out of the ground. If for example the resistance of the ground locally gets too high or the moving speed of the sheet pile temporarily get too low, or the required power starts to get too high, then the operator may increase the sonic vibration frequency, whereas he can lower it again as soon as an obstructions that may be present in the ground is passed by the sheet pile and the speed gets sufficiently high again.

[0009] In a preferred embodiment the positioning device may comprise a base, in particular a wheeled base, on which a guiding beam is mounted along which the sonic vibration apparatus is movably guided up and down in the longitudinal direction by means of a carriage that is fixedly connected to the housing of the sonic vibration apparatus. Thus the sonic vibration apparatus is able to smoothly follow the movement of the sheet pile into or out of the ground while at a same time helping to keep the sheet pile properly directed in an aimed direction. The carriage can be slidably guided over the guiding beam in the longitudinal direction without play or flexibility in transverse directions that are perpendicular to the longitudinal direction. The housing advantageously is provided with isolation means for substantially isolating the sonic vibrations coming from the counter rotating eccentric masses inside the vibration generator relative to the housing. The vibrations are suitably dampened inside the apparatus such that they only get to occur in the vibration generator and outgoing vibrator axis and not in the housing or carriage. Owing to this the guiding of the carriage along the beam is also substantially isolated for the sonic vibrations. This substantially vibration free slidable guidance of the carriage along the guiding beam, advantageously makes it possible to have transverse directed steering forces exerted onto the carriage of the sonic vibration apparatus during its driving into and out of the ground. Thus a direction with which the sheet pile is inserted or pulled can easily and quickly be adjusted by means of a corresponding manipulation of the guiding beam.

[0010] In another preferred embodiment a drive unit can be provided for actively moving the carriage together with the sonic vibration apparatus up or down in the longitudinal direction along the guiding beam. This makes it possible to not only have the sonic vibration apparatus introduce vibrations at the sonic frequencies into the sheet pile, but to at a same time have it exert an additional pushing or pulling force, also referred to as pull up or pull down, onto the sheet pile in the longitudinal direction. Because of this the force in the outgoing axis can be enlarged to thus obtain a faster progress in penetration speed during driving of the sheet pile into the ground, or in upwards movement during removing of the sheet pile out of the ground.

[0011] The guiding beam can be made adjustable in position relative to the base, in particular by means of having the guiding beam connected to an operable articulated arm that is provided on the base. For this also a suitable drive unit, like hydraulics, can be provided. The guiding beam can then quickly and easily be placed in a vertical or any desired slanted position that corresponds to an aimed insertion or removal direction for the sheet pile.

[0012] In a further embodiment a connection organ is provided between the base and the guiding beam which is displaceable in the longitudinal direction along the guiding beam. This makes it possible to adjust a height position of the guiding beam in dependence on a length of the sheet pile and/or a specific location where it needs to be handled.

[0013] In an advantageous variant vibration dampers are provided that lie in a radial or sideways direction against a circumferential wall part of the vibrator axis for damping transverse movements of the vibrator axis relative to the carriage. Possibly occurring radial or sideways directed forces can thus be countered.

[0014] The vibration dampers for example may comprise rubber blocks that are positioned between a circumferential wall of the vibrator axis and the carriage or housing. The provision of such sideways active dampers is particularly important because it helps to prevent the vibration generator to get damaged during operation. Preferably those vibration dampers are positioned between a part of the vibrator axis that lies outside the housing, in particular around or close to the gripping and/or clamping portion, more in particular inside an arch-shaped part of the carriage that lies interspaced around the outgoing vibrator axis part.

[0015] In a further variant a damping piston is connected to the vibrator axis, which piston is reciprocatingly movable in the longitudinal direction inside a cylinder part that is connected to the carriage or housing. The piston in particular is provided as a collar around the vibrator axis such that the damping thereof gets performed sym-

metrically around the longitudinal axis. The purpose of the damping piston is to dampen end phases of the vibration forces. This also helps to prevent the vibration generator to get damaged during operation. This can easily be done by equipping leakage holes in the damping piston or to provide a leakage channel in between the respective cylinder parts at the opposing sides of the piston. Via those leakage holes or channels air can slowly move from one side of the piston towards the other side. A compressor can be provided for feeding the cylinder space with air during this use.

[0016] The gripping and/or clamping portion of the vibrator axis may comprise a mounting flange to which a gripper or clamp can get releasably mounted, in particular a hydraulically operable gripper or clamp. This makes it possible to, depending on a type of sheet pile that neds to be handled, mount correspondingly shaped or dimensioned types of grippers or clamps to the vibrator axis.

[0017] The vibrator axis can be guided translatable back and forth in the longitudinal direction inside the housing by means of suitable slide bearings such that it is able to perform its sonic back and forth vibrational movements in this longitudinal direction without taking along the housing or inducing too large vibration forces therein. The guiding inside those bearings can be such that the vibrator axis also has freedom to rotate relative to the housing. As shall be clear the vibrator axis however does not get actively driven in a drilling rotation though during the driving of the sheet pile. If desired means can be provided between the vibrator axis and the housing or carriage to fully prevent a rotation around the longitudinal axis between them. This makes it possible to not only exert sideways directed steering forces onto the sheet pile via the positioning means, but also to have a rotational force exerted onto the sheet pile by means of the positioning device.

[0018] It is possible to have two or more sonic vibration apparatus connected to each other in series in a common carriage together with synchronisation means of their motors for rotating their pairs of eccentric masses. It is also possible to equip the vibration operator of one same sonic vibration apparatus with multiple pairs of counter rotating eccentric masses in order to multiply the vibration forces.

[0019] Further preferred embodiments are stated in the dependent subclaims.

[0020] The invention also relates to a method according to claims 11-14, and to a use according to claim 15.

[0021] The invention shall be explained in more detail below with reference to the accompanying drawings, in which:

- Fig. 1 shows a schematic view of an assembly according to the invention during a driving of a sheet pile into or out of the ground;
- Fig. 2 shows a perspective view of the sonic vibration apparatus of fig. 1;
- Fig. 3 is a view according to fig. 2 with a gripper of the vibrator axis being removed as well as a guiding skid of the carriage being removed;
- Fig. 4 is a top view of fig. 3;
- Fig. 5 is a partially opened perspective view of the vibration generator inside the apparatus of fig. 1;
- Fig. 6 is a sectional view along a part of the vibrator axis at a location of a vibration damper; and
- Fig. 7 is a view according to fig. 3 with two sonic vibration apparatus in series.

[0022] In fig. 1 a caterpillar loader crane, also known as a knuckle-boom crane or articulating crane, is indicated with the reference numeral 1. The crane 1 comprises a hydraulically powered operable articulated arm 2. At a free outer end of the arm 2 a connection organ 3 is provided to which an elongate guiding beam 4 is connected. By means of hydraulics it is possible to manoeuvre the articulated arm 2 and thus also the beam 4 in desired angular positions and/or heights. In fig. 1 the guiding beam 4 is manoeuvred such that it extends with its longitudinal direction vertical and slightly interspaced with its lower end above the ground. It is noted that the connection organ 3 can be connected to the beam 4 at various height positions along its length in order to adjust the interspacing relative to the ground if desired.

[0023] A sonic vibration apparatus 8 is movably guided along the beam 4. For this a carriage 9 is provided that at its outer side comprises a guiding skid 10 and that is fixedly connected to an outer housing 11 of the sonic vibration apparatus 8. This sonic vibration apparatus 8 together with the carriage 9 and skid 10 are shown in more detail in fig. 2. The guiding skid 10 is constructed such that it is able to slidingly grip into or around complementary guiding parts of the beam 4.

[0024] At its lower side the apparatus 8 is provided with a gripper 12 with which it rests upon and grips an upper portion of a sheet pile 14 in such a way that it is able to introduce sonic vibrations into the sheet pile 14 in a longitudinal direction L thereof.

[0025] Inside the housing 11 the apparatus 8 for this comprises a vibration generator 20 (see fig. 5). The vibration generator 20 here comprises an oval-shaped massive block 20' with two eccentric masses 21 that are rotatable inside cylindrical openings 22 provided therein. The vibration generator 20 connects to a vibrator axis 23 that extends in the same longitudinal direction L. Each eccentric mass 21 here is formed by a cylindrical roller that is rotatably mounted to a crankshaft (not shown) that has its axis of rotation lying in a centre of its corresponding opening 22. The axis of rotation of the roller itself around the crankshaft then lies such that the roller gets to run along the inner circumferential wall of its corresponding opening 22 when the crankshaft is driven in rotation. For this the rollers are dimensioned with smaller radii than the openings 22. A forced feeding of lubricant like oil can take place towards the eccentric masses 21 and openings 22.

[0026] The eccentric masses 21 are drivable in counter

rotation by means of a common hydro motor 24. With this the eccentric masses 21 are positioned such relative to each other that each time they reach top and bottom parts of the openings 22 simultaneously, whereas they reach opposite side parts there between also simultaneously. This results in the eccentric masses 21 together getting to exert doubled forces in the longitudinal direction L, without exerting forces in a direction perpendicular thereto. By having the hydro motor 24 rotating at sonic rotational speed, vibrations at sonic frequencies in the longitudinal direction thus can get introduced into the block 20' and via this block 20' into the vibrator axis 23. A sonic frequency of the introduced vibrations thus can get to lie in between 6,000-10,000 VPM. Preferably those sonic frequencies then can be controlled by adjusting the speed of the hydro motor 24 and thus tuned to a natural frequency of the sheet pile 14 such that resonance can take place by having the back and forth pushing and pulling movements of the vibration generator 20 and vibrator axis 23 coinciding with stress waves that start to run up and down through the sheet pile 14 because of this.

[0027] The vibrator axis 23 is guided through suitable slide bearings 30-32 that are fixedly connected to the housing 11. Between the bearings 30 and 31 a piston collar 35 is fixedly connected to the vibrator axis 23, such that it gets to move back and forth together therewith in the longitudinal direction at the induced sonic frequencies. This piston collar 35 is placed inside a cylinder part 36 that is connected to the housing 11. Inside the collar 35 small vent openings are provided (not shown) for letting air gradually flow from one cylinder side of the piston collar 35 to the other. A compressor can be provided for feeding air to the cylinder 36, such that it is always sufficiently filled with air. Thus an air spring is formed that suitably dampens vibrations towards the housing 11 at end phases of each back and forth movement of the vibrator axis 23.

[0028] At the free end of the vibrator axis 23 a flange 40 is provided. The gripper 12 is releasably mounted to this flange 40.

[0029] Between the mounting flange 40 and the housing 11 the carriage 9 comprises an arch-shaped part 9' that lies interspaced around a part of the vibrator axis 23 that extends outside the housing 11. Four vibration dampers 41, here formed by rubber blocks, are positioned between the arch-shaped carriage part 9' and the vibrator axis 23. Thus any transverse movements or forces that may get exerted via the sheet pile 14 onto the vibrator axis 23 get automatically countered without running the risk of those transverse movements or forces getting to damage the vibration operator 20.

[0030] The assembly of the crane 1, guiding beam 4 and sonic vibration apparatus 8 guided there along first of all can be used for driving a sheet pile 14 into the ground. For that the apparatus 8 is rested on top of the sheet pile 14 while its gripper 12 firmly grips itself around an upper portion of the sheet pile 14. Subsequently, the hydro motor 24 is switched on and driven at such speed that the sonic vibrations start to get introduced into the sheet pile 14 via the operator 20, axis 23 and gripper 12. Under the influence of the weight of the apparatus 8 and its own weight, the sheet pile 14 then shall start to penetrate into the ground in the longitudinal direction L. During this downwards movement the carriage can be given full freedom to slide downwards along the beam 4. If desired it is also possible to activate a drive unit for moving the carriage 9 together with the sonic vibration apparatus 8 down in the longitudinal direction along the guiding beam 4. Thus an additional pull down penetration force can be exerted onto the sheet pile 14. This can for example be done if the sheet pile 14 gets to run against some kind of obstacle in the ground and has difficulties in passing it, or if a higher penetration speed is desired. After the sheet pile 14 has been driven sufficiently deep into the ground, the process can be repeated for other sheet piles to get inserted into the ground adjacent the earlier inserted sheet pile(s), while having their side edges gripping slidable into each other. Together the thus inserted sheet piles then can form a substantially closed retaining sheet pile wall.

[0031] The assembly of the crane 1, guiding beam 4 and sonic vibration apparatus 8 guided there along can also be used for pulling a sheet pile 14 out of the ground. For that the apparatus 8 is again rested on top of the sheet pile 14 while its gripper 12 firmly grips itself around an upper portion of the sheet pile 14. Subsequently, the hydro motor 24 is switched on and driven at such speed that the sonic vibrations start to get introduced into the sheet pile 14 via the operator 20, axis 23 and gripper 12. By at a same time activating a drive unit for moving the carriage 9 together with the sonic vibration apparatus 8 upwards in the longitudinal direction along the guiding beam, the sheet pile 14 then can start to move upwards out of the ground again in the longitudinal direction L. Thus a sufficiently high pull up force can be exerted onto the sheet pile 14 which together with the introduced sonic vibrations make it well possible to remove sheet piles even under the hardest circumstances out of the ground again.

[0032] Fig. 7 shows a variant for doubling forces in which two vibration apparatus are connected to each other in series and have the driving of their eccentric masses synchronized. Then also they can be connected to a carriage that can get guided along the beam 4.

[0033] Besides the embodiments shown numerous variants are possible. For example it is also possible to have the sonic vibration apparatus directly connected to the outer free end of the arm. Then also it is possible to accurately manoeuvre the apparatus during the driving of the sheet pile. Also the dimensions and shapes of the various components can be changed. Furthermore the various parts can be made out of all kinds of materials. For example the sheet piles can be made out of steel or another suitable metal. They can however also be made out of a (reinforced) plastic material as long as they are strong enough to be able to deal with sonic vibrations

that get introduced therein. Although it has appeared that it is already advantageous for increasing the driving speed when the sonic vibration is introduced into the sheet pile right from the beginning, it is noticed here that in an advantageous embodiment the sonic vibration is at least introduced into the sheet pile after it has reached a depth of a few metres or when the ground conditions become stiffer or harder than clay. This is probably because from that length on, standing resonant wave patterns can more easily start to form inside the sheet pile. The first part of the penetration than can for example be performed by having the positioning device exert a sufficiently high pull down force onto the sheet pile.

[0034] Thus according to the invention an assembly is provided that is truly able to sonically vibrate sheet piles into or out of the ground in a manner that is not only quick but also safe, quiet and non-damaging for the environment.

Claims

1. Assembly for driving one or more sheet piles into or out of the ground, in particular for assembling or disassembling a sheet pile wall of interconnected sheet piles, comprising:

   - a sonic vibration apparatus with a housing and a vibration generator inside the housing that connects to a vibrator axis that has a longitudinal direction and that extends partly outside the housing with a gripping and/or clamping portion for gripping an upper portion of a sheet pile, the vibration generator being designed to introduce vibrations at sonic frequencies in the longitudinal direction into a sheet pile via the vibrator axis and gripping and/or clamping portion;
   - a positioning device for positioning the sonic vibration apparatus relative to the sheet pile and having it move up or down in the longitudinal direction together with the sheet pile during its driving into or out of the ground,

   characterized in that,
   the vibrating mechanism of the sonic vibration apparatus comprises at least one pair of rotatable eccentric masses and a motor for driving the eccentric masses in counter rotation such that the vibrations at sonic frequencies in the longitudinal direction are introduced into the vibrator axis during said driving of the sheet pile into or out of the ground.

2. Assembly according to claim 1, wherein the positioning device comprises a base, in particular a wheeled base, on which a guiding beam is mounted along which the sonic vibration apparatus is movably guided up and down in the longitudinal direction by means of a carriage that is fixedly connected to the housing of the sonic vibration apparatus.

3. Assembly according to claim 2, wherein a drive unit is provided for moving the carriage together with the sonic vibration apparatus up or down in the longitudinal direction along the guiding beam.

4. Assembly according to claim 2 or 3, wherein the guiding beam is adjustable in position relative to the base, in particular by means of a controllable articulated arm.

5. Assembly according to one of the preceding claims 2-4, wherein a connection organ between the base and the guiding beam is displaceable along the guiding beam.

6. Assembly according to one of the preceding claims 2-5, wherein one or more vibration dampers are provided that lie against a circumferential wall part of the vibrator axis for damping transverse movements of the vibrator axis relative to the carriage.

7. Assembly according to claim 6, wherein the vibration dampers comprise rubber blocks that are positioned between a circumferential wall of the vibrator axis and the carriage or housing.

8. Assembly according to one of the preceding claims, wherein a damping piston is connected to the vibrator axis, which piston is reciprocatingly movable in the longitudinal direction inside a cylinder part that is connected to the carriage or housing.

9. Assembly according to one of the preceding claims, wherein the clamping portion of the vibrator axis may comprise a mounting flange to which a gripper or clamp is releasably mounted.

10. Assembly according to one of the preceding claims, wherein two or more sonic vibration apparatus are connected to each other in series.

11. Method for driving one or more sheet piles into or out of the ground, in particular for assembling or disassembling a sheet pile wall of interconnected sheet piles, comprising the steps of:

    - providing an assembly of a sonic vibration apparatus and a positioning device according to one of the preceding claims;
    - having the sonic vibration apparatus clamp an upper portion of a sheet pile;
    - driving the sheet pile into or out of the ground by driving the eccentric masses in counter rotation at sonic frequencies such that vibrations at sonic frequencies in the longitudinal direction are introduced into the vibrator axis during this

driving of the sheet pile into or out of the ground.

12. Method according to claim 11, wherein a frequency of the introduced vibrations is controllable in between 6,000-10,000 VPM.

13. Method according to claim 11 or 12, wherein the sonic vibration apparatus is fixedly held during the driving of the sheet pile.

14. Method according to claim 13, wherein a transverse directed steering force gets exerted onto the sonic vibration apparatus during its driving into or out of the ground.

15. Use of a sonic vibration apparatus of the type comprising at least one pair of rotatable eccentric masses and a motor for driving the eccentric masses in counter rotation, for driving a sheet pile into or out of the ground while having vibrations at sonic frequencies get introduced in the longitudinal direction into the sheet pile.

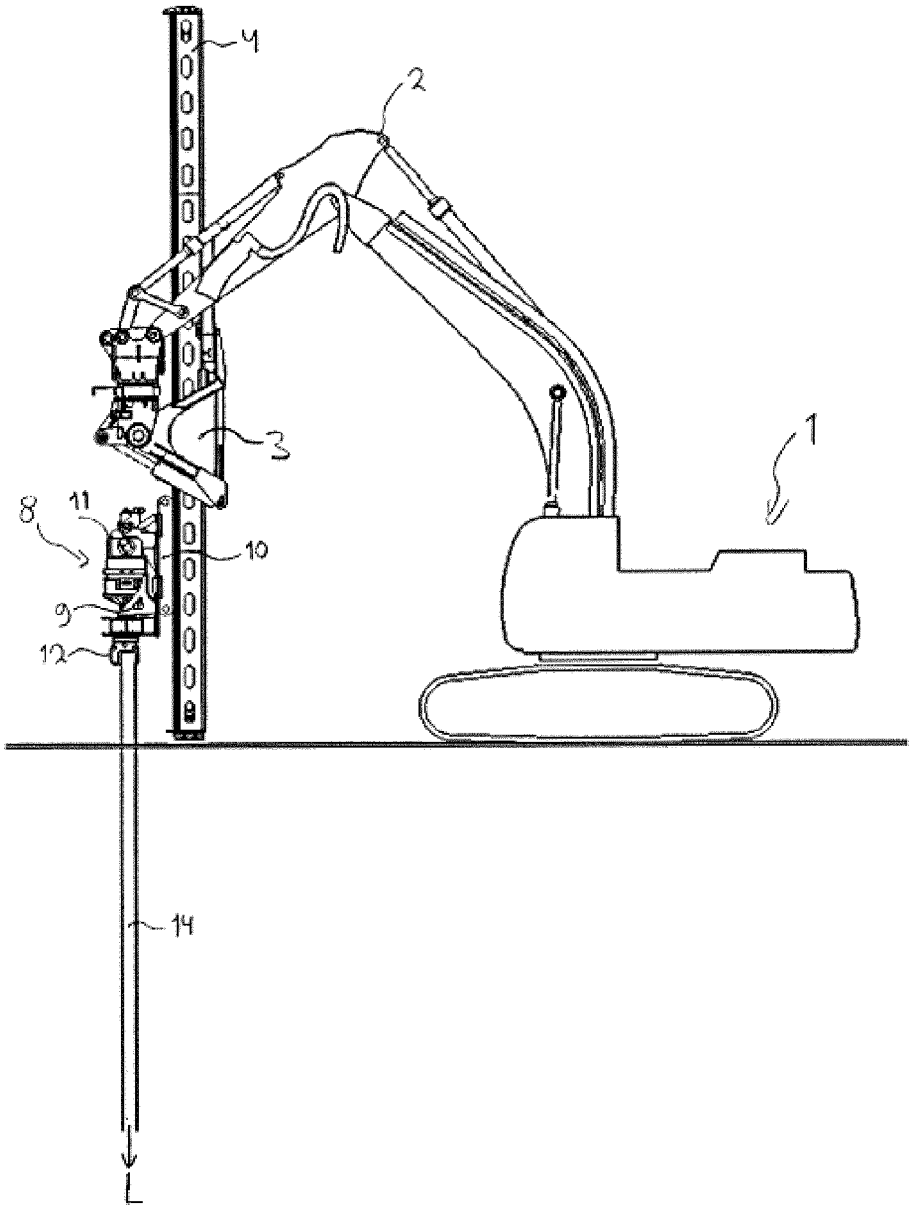

FIG. 1

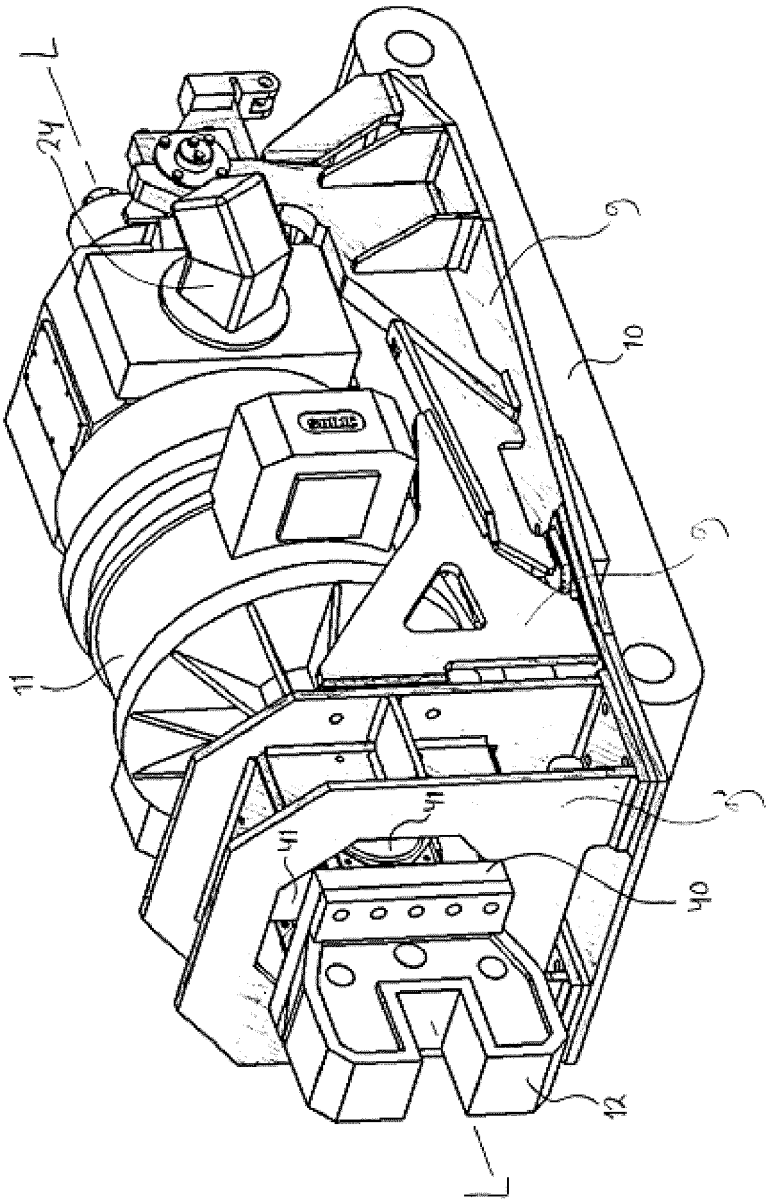

FIG. 2

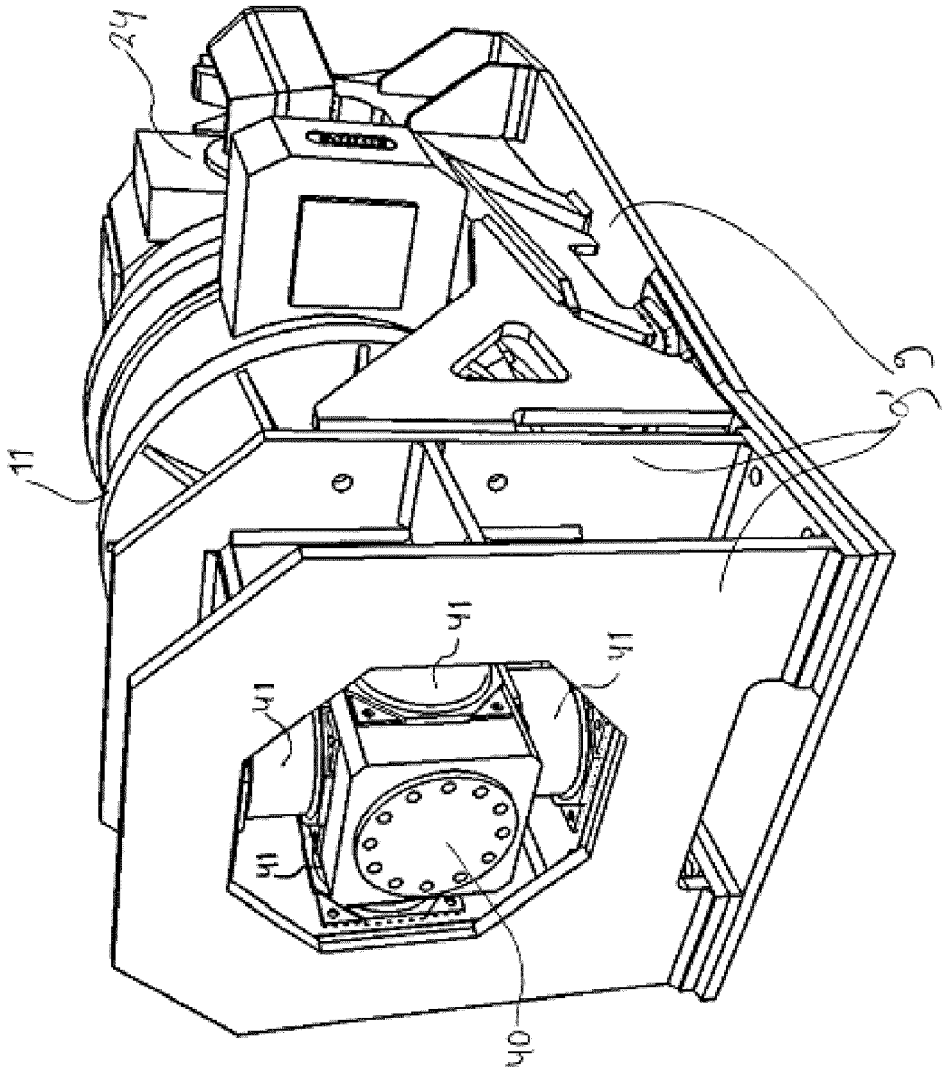

FIG. 3

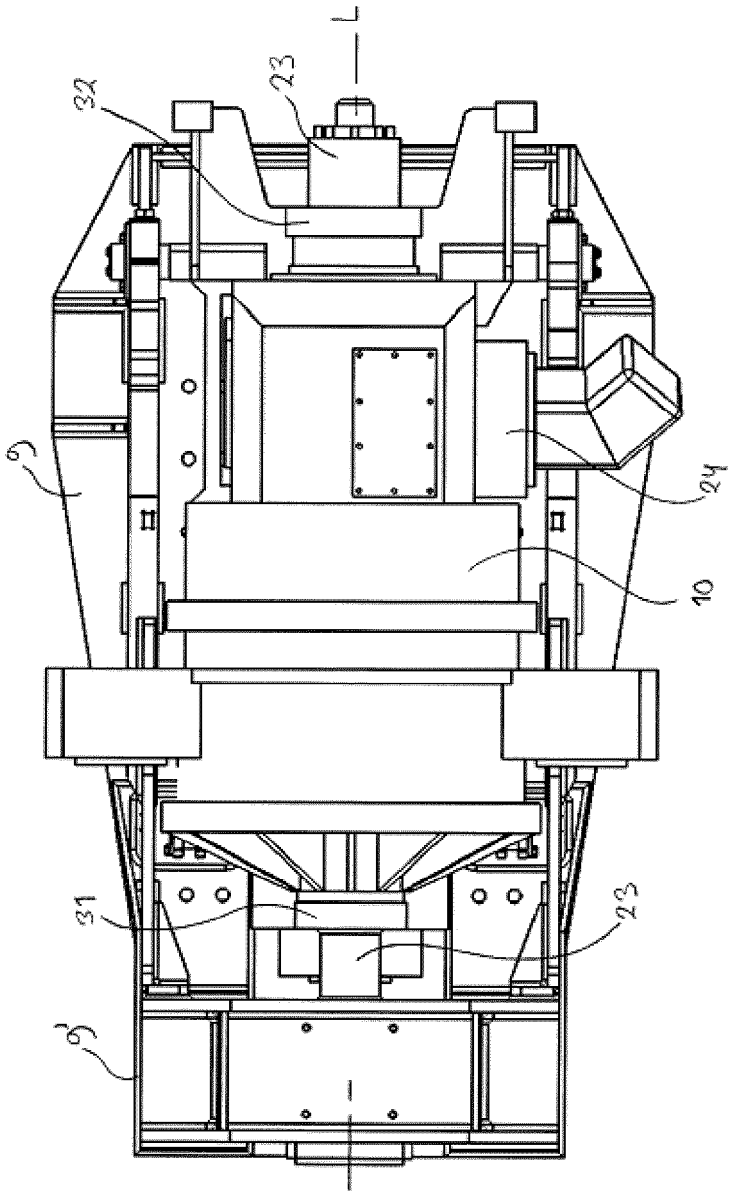

FIG. 4

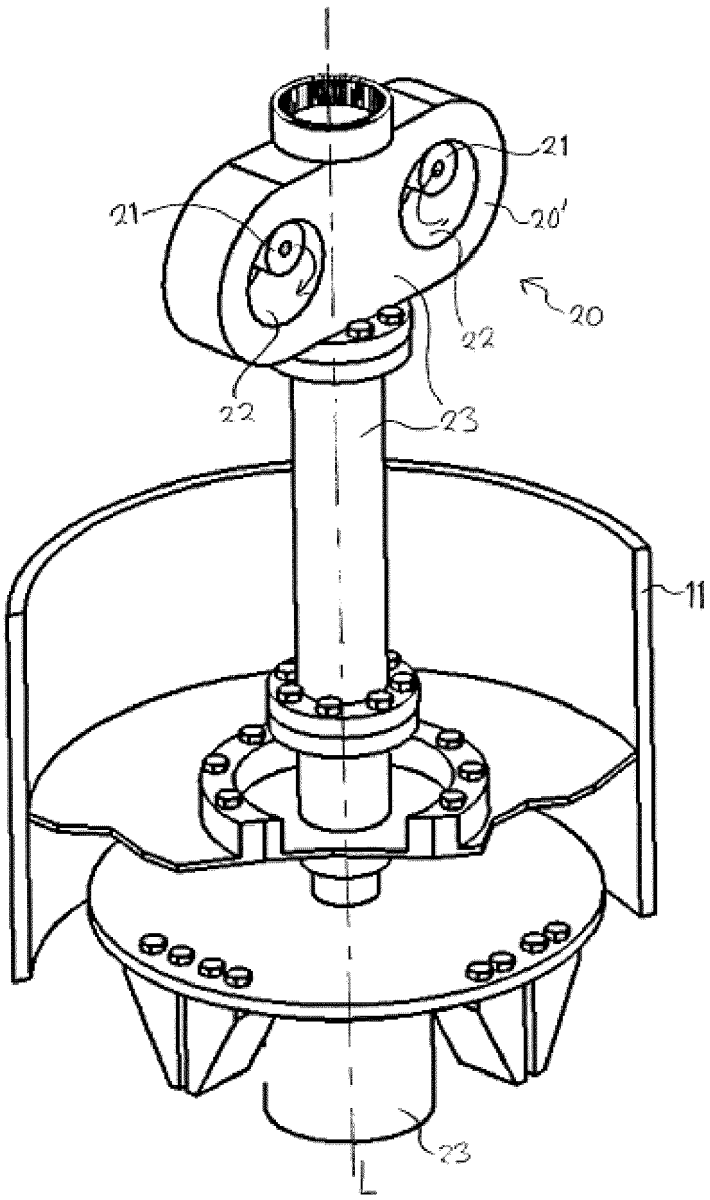

FIG. 5

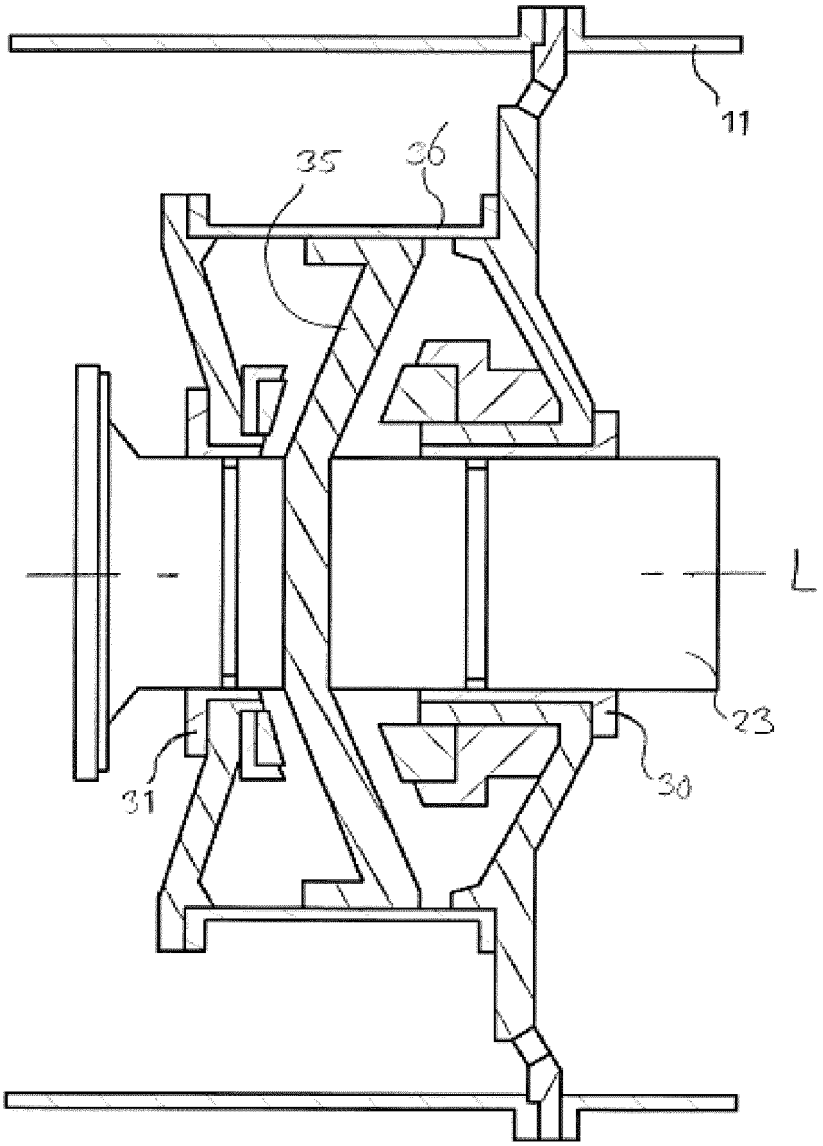

FIG. 6

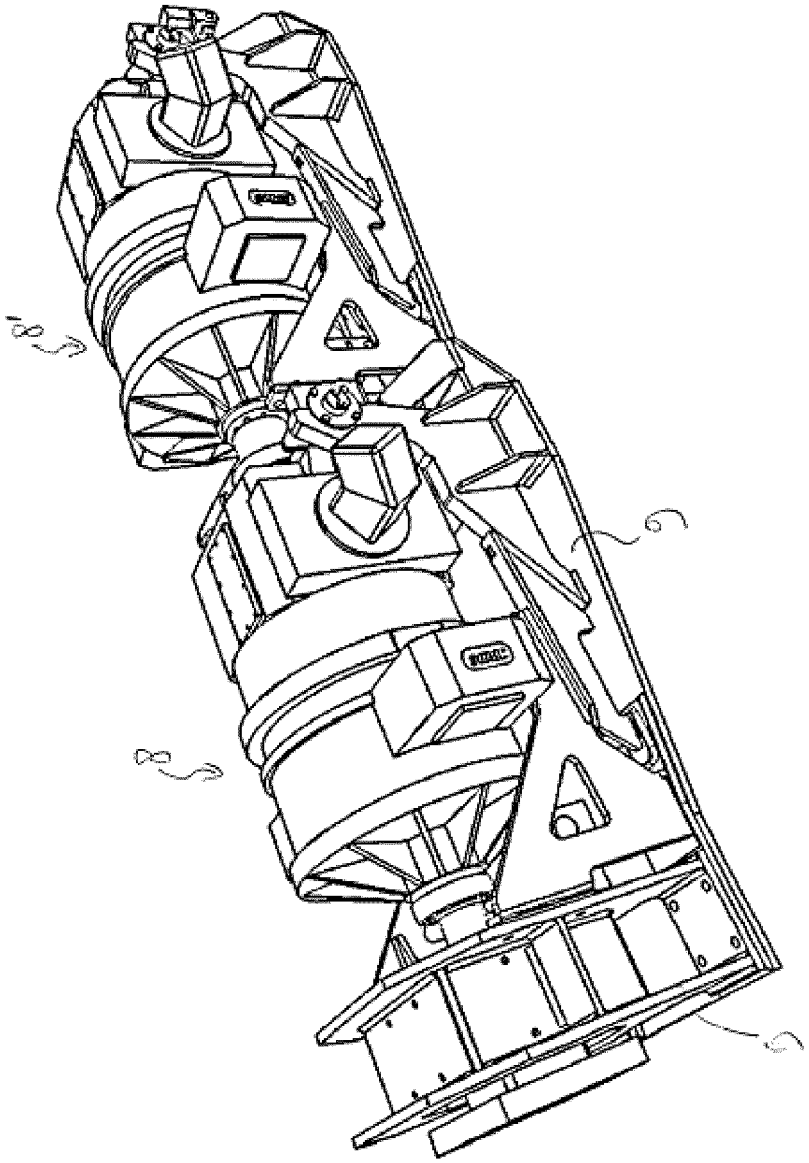

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 2869

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 116 164 A1 (TUNKERS JOSEF GERHARD) 22 August 1984 (1984-08-22) * abstract * * page 14, lines 1-32 * * page 17, lines 5-27; figures 1-4 * -----	1-15	INV. E02D7/18 E02D11/00
			TECHNICAL FIELDS SEARCHED (IPC) E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 February 2017	Koulo, G

CATEGORY OF CITED DOCUMENTS

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