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

(11) EP 2 557 232 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
15.10.2014 Bulletin 2014/42

(21) Application number: **12170306.0**

(22) Date of filing: **31.05.2012**

(51) Int Cl.:
E02D 3/026 *(2006.01)* ***E02D 7/02*** *(2006.01)*
E02D 7/08 *(2006.01)* ***E02D 7/14*** *(2006.01)*
E02D 7/18 *(2006.01)* ***E02D 13/04*** *(2006.01)*
E02D 27/42 *(2006.01)*

(54) **A pile driving assembly**

Pfahlrammanordnung

Ensemble de commande d'empilage

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

(43) Date of publication of application:
13.02.2013 Bulletin 2013/07

(73) Proprietor: **Per Aarsleff A/S**
8361 Hasselager (DK)

(72) Inventors:
- **Andersen, Claus Jørgen**
  8370 Hadsten (DK)
- **Møller, Hans Erik**
  8930 Randers SØ (DK)

(74) Representative: **Budde Schou A/S**
Hausergade 3
1128 Copenhagen K (DK)

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EP 2 557 232 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to a pile driving assembly, a method of driving a pile into the ground and a gripping mechanism for temporarily holding a pile.

Background of the invention

[0002] Piles are typically embedded into the ground to form a deep foundation for overlying structures. The piles are typically made of concrete, steel or a combination thereof. In order to drive the piles into the ground, a so called pile driving rig is used. One example of a pile driving rig is found in the European patent application EP 0 392 309 filed by the applicant company. Such pile driving rigs typically comprise a vehicle with a power supply and a mast which is used for hoisting the pile and which form a slide guide for a hammer. The hammer is repeatedly dropped onto the pile in order to cause the pile to enter the ground. This arrangement is typically used for smaller piles having a length of up to around 6 meters.

[0003] Larger piles, so called monopoles, may have a length exceeding 6 meters, such as 14m, and a diameter exceeding 1m, such as 2m. Monopoles may be used for e.g. supporting land based or off shore wind power plants, electricity poles etc. When driving such large piles into the ground, the mast would have to be very large and therefore typically no mast is used and instead a separate pile driving mechanism, such as a hammer mechanism or a vibrator, is applied onto the top surface of the pile once the pile has been positioned in the vertical orientation at the proper location. However, as no mast is used, it may be difficult to align the pile correctly once the pile driving mechanism has been installed on top of the pile. Further, when the hammering action is initiated and the pile is caused to enter the ground, the pile may be misaligned due to obstructions in the earth. The pile may therefore be caused to enter the ground in a skewed orientation. Such skewed piles will form an inferior foundation. It is therefore an object of the present invention to provide technologies for aligning the pile while the pile is entering the ground.

[0004] The installation of piles underwater has been intensively studied in the prior art. WO 2011/073778 describes a device for subsea handling of guide posts which holds the lower end section of one or more guide posts. US 4,172,681 discloses a sheet pile guide which has a holder having a friction reducing unit for bearing against a pile member. US 2011/0299938 discloses a method and a system for installing foundation element in an underwater ground formation. The system comprises a gripper for holding the foundation element. The gripper is mounted on a surface vessel. EP 0 398 833 relates to a device for handling sheet piles on the ground. The device is mounted at the end of an arm of a hydraulic shovel. Such hydraulic shovels are typically very stable in the longitudinal direction, i.e. in the direction of the arm, however, very unstable in the transversal direction, e.g. typically hydraulic shovels may tip over when exposed to transversal forces. It is therefore a need for technologies which may handle land based piles.

[0005] It is a feature according to the present invention that the pile driving assembly may be exposed to forces in all horizontal directions.

[0006] It is an advantage according to the present invention that the pile driving assembly is adjustable and may adapt to several different pile sizes and ground properties.

Summary of the invention

[0007] The above object, the above need, the above feature and the above advantage together with numerous other objects, advantages, features and needs, which will be evident from the below detailed description of the present invention, are according to a first aspect of the present invention obtained by a pile driving assembly comprising:

a pile defining a top surface, a bottom surface and a cylindrical surface extending between the top surface and the bottom surface, and
a pile driving mechanism, such as a hammer mechanism or a vibrator, for applying a force onto the top surface in a direction from the top surface towards the bottom surface for causing the pile to enter into the ground,

the pile driving assembly further comprises a holding mechanism for temporarily holding the pile, the holding mechanism comprising:

a vehicle comprising a housing including a motor, the housing comprising tracks or wheels powered by the motor, the vehicle further comprising a movable arm extending from the housing and being powered by the motor,
a gripping mechanism extending from the arm opposite the housing, the gripping mechanism comprising a frame, the frame comprising a plurality of inwardly oriented guides, the frame defining an open state in which the cylindrical surface of the pile may be received within the frame and a closed state in which the cylindrical surface of the pile may be slidably enclosed between the inwardly oriented guides of the frame,

a first supporting leg extending between the gripping mechanism and a first ground plate, and
a second supporting leg extending between the gripping mechanism and a second ground plate,

the vehicle, the first ground plate and the second ground plate together define a triangular area.

[0008] The pile is made of a rigid material and typically comprises a metal pipe, a concrete pile or a combination of metal and concrete. Typically steel is used. The pile typically has a circular cylindrical surface, but in principle the piles may have any shape such as square, elliptical, H, L, T, or I-beam shaped. The top surface is typically flat in order to receive the blows of the pile driving mechanism. The bottom is typically also flat.

[0009] The pile driving mechanism should be securely mounted on the top surface of the pile. The pile driving mechanism is for most soil types, typically a hammer mechanism, however, in some cases, especially in sandy soil, a vibrator may be used. The pile driving mechanism typically comprise a large weight, such as 12 tons, which may be lifted by hydraulic power to a specific height and thereafter dropped against the top surface of the pile in order to apply a force onto the top surface upon impacting the top surface. The force is transmitted through the pile and causes the pile to enter the ground. The above procedure is repeated until the pile is embedded in the ground.

[0010] The holding mechanism is typically a separate entity not connected to the pile driving mechanism. The vehicle is typically an excavator but may be any kind of heavy duty vehicle such as a forklift, tractor, crane, bulldozer or backhoe which has a housing exhibiting a large mass of several tons. It may also be a dedicated vehicle for the specific purpose of holding the pile. The vehicle may be track driven or wheel driven in order for the holding mechanism to approach the pile. The housing may include a cabin for the operator. The motor included in the housing is typically a diesel engine which is capable of generating hydraulic power for the arm. The arm typically has at least two joints or degrees of freedom in order to be able to move the gripping mechanism in a flexible way in relation to the housing.

[0011] The gripping mechanism typically forms an extension of the arm. The frame typically defines a hollow space for accommodating the pile. The pile is accommodated between guides, which are distributed along the frame and define an inner periphery. When in the open state, the frame should exhibit an opening which allows the pile to be introduced or received into the hollow space of the frame. The frame may e.g. constitute two opposing jaws or alternatively a U shaped part and a beam which bridge the opening of the U shaped part. When the frame is closed, it will typically completely surround the pile or alternatively leave a very small gap in the frame provided the pile cannot fall out of the frame. When the frame is closed, the pile should not be fixated to the frame, i.e. the inner periphery defined by the guides should be slightly larger than the outer periphery of the pile in order to allow the pile to move in the vertical direction during the hammering. It is contemplated that some of the guides may contact the cylindrical surface of the pile as long as the vertical movement of the pile is unrestricted, i.e. the guides should allow the pile to slide along the frame. The guides should however restrict the movement of the pile in any of the directions on the horizontal plane in order for the pile to remain aligned.

[0012] The pile is positioned at the intended location in a vertical orientation by means of a crane. The position is maintained by the holding mechanism when the pile is released from the crane and the crane may thus be used to lift the pile driving mechanism. When the pile driving mechanism is acting on the pile, the holding mechanism ensures that the pile enters the ground in a vertical direction and not in a slightly skewed direction. The weight of the vehicle provides via the arm support of the pile in the direction of the arm, both in a direction towards and in a direction away from the vehicle. However, the vehicle cannot support the pile in any substantial degree in the transversal direction, i.e. perpendicular to the arm. For this reason, the first and second support leg extends from the gripping mechanism to the ground and thereby contributes to the support of the pile in the transversal direction.

[0013] The vehicle, the first ground plate and the second ground plate together define a triangular area, i.e. form a tripod support. It is to be understood that the vehicle, i.e. the track or wheels of the vehicle, the first ground plate and the second ground plate establish the corner points of the triangle. The arm should apply a downward pressure onto the first ground plate and the second ground plate via the gripping mechanism and the support legs, thereby transferring some of the weight of the vehicle to the ground plates. In this way the gripping mechanism is supported in all horizontal directions, as well as in the downwardly oriented vertical direction. During the hammering action, the gripping mechanism will have a fixed position and the guides will align the pile thereby preventing a skewed direction of the pile. Typically, therefore, the pile must only be aligned once and thereafter, the alignment is maintained by the holding mechanism. In some cases the hammering action may be interrupted and a more precise alignment may be made. When the pile has been embedded to a substantial level, a misalignment is unlikely and the holding mechanism may be removed before the pile is finally embedded in the ground.

[0014] According to a further embodiment of the first aspect, the inwardly oriented guides define an inner periphery of the frame and the position of the plurality of inwardly oriented guides may be varied in order to adjust the inner periphery of the frame. The guides may preferably be adjustable in order to be able to use the holding mechanism together with piles having different circumferences. Preferably, the guides are adjusted such that a gap of at least about 10mm is given between the inner periphery of the frame defined by the guides and the outer periphery of the cylindrical surface of the pile.

[0015] According to a further embodiment of the first aspect, the inner periphery defines a diameter between 1m and 5m, preferably between 1.2m and 3m, more preferably between 1.5m and 2.5m, such as 1.7m, 2.0m and 2.1m. The holding mechanism according to the present invention is preferably used together with large land based piles such as monopoles or the like. Such piles have an outer periphery defining a diameter of more than one meter.

[0016] According to a further embodiment of the first aspect, the plurality of inwardly oriented guides comprises a number of rollers. The guides may be blocks comprising a material of low friction, however, preferably, rollers are used. The rollers ensure that the pile may be moved in the vertical direction, but ensures that the pile is guided in the horizontal directions.

[0017] According to a further embodiment of the first aspect, the number of rollers is between 3 and 10, such as between 3 and 5 and preferably 3. Preferably, three rollers are used in order to guide the pile, since three rollers provide stability in all horizontal directions. More than three rollers may be used for larger piles to provide additional stability.

[0018] According to a further embodiment of the first aspect, the first and second supporting legs each define an angle in the horizontal plane in relation to the movable arm of 60-150 degrees, preferably 75-135 degrees, more preferably 90-120 degrees. In order to establish a support in all horizontal directions and in particular the directions in the horizontal plane, which are transversal to the direction of the arm, the angles of the triangle establishing the triangular area should be about 45-90 degrees and the angle of the support legs in the horizontal plane in relation to the arm should be around 45 degrees, i.e. the first and second supporting legs should extend in a transversal direction in relation to the arm. In this way, a very stable tri-pod configuration includes the first support leg, the second support leg and the arm of the housing of the vehicle.

[0019] According to a further embodiment of the first aspect, the first and second supporting legs define between themselves an angle in the horizontal plane of 60-180 degrees, preferably 120-180 degrees, more preferably 150-180 degrees. Typically, the first and second supporting legs should extend in a transversal direction in relation to the arm and the first and second supporting legs define between themselves an angle in the horizontal plane of 180 degrees. In this way, each of the supporting legs will absorb pile forces which act in the respective horizontal transversal directions of the arm, and the arm will absorb the forces which act in both directions of the arm.

[0020] According to a further embodiment of the first aspect, the first and second supporting legs each define an angle in the vertical plane in relation to each other of 45-135 degrees, preferably 55-125 degrees, more preferably 70-110 degrees, most preferably 90 degrees. The first and second supporting legs will also typically define an angle in the vertical plane between themselves, typically about 90 degrees, which will correspond to 45 degrees relative to the vertical direction. In this way a very stable tri-pod configuration will form including the first support leg, the second support leg and the arm of the housing of the vehicle.

[0021] According to a further embodiment of the first aspect, the lengths of the first and second supporting legs may be varied. The length of the first and second supporting legs may be varied by e.g. hydraulic power or alternatively manually by means of a telescopic configuration and a peg. In this way the orientation of the pile may be adjusted to compensate for loose soil or hilly terrain.

[0022] According to a further embodiment of the first aspect, the first and second supporting legs may be folded. In this way, the holding mechanism may be made compact in order to easily transporting it to and from the piling site. A bracket may be provided in the frame in order to fixate the first and second supporting legs during transport. According to a further embodiment of the first aspect, the first and second ground plate comprise spikes in order to be fixated to the ground. The spikes will be embedded into the ground and prevent any slippage of the ground plate relative to the ground. Alternatively, a separate auxiliary ground plate is used which may have the spikes.

[0023] According to a further embodiment of the first aspect, the first and second supporting legs are interconnected, preferably via a chain or wire located adjacent the first and second ground plates. In order to ensure that the first and second supporting legs define a proper angle between themselves and to lower the stress in the gripping mechanism, the lower portion of the first and second supporting legs may be interconnected by a chain or wire.

[0024] According to a further embodiment of the first aspect, the frame comprises a mechanical lock for locking the frame when the frame defines the closed state. In order to absorb the forces applied to the frame during guiding, the frame may comprise a lock in order to ensure that the pile does not escape from the frame.

[0025] The above object, the above need, the above feature and the above advantage together with numerous other objects, advantages, features and needs, which will be evident from the below detailed description of the present invention, are according to a second aspect of the present invention obtained by a method of driving a pile into the ground by providing a pile driving mechanism, such as a hammer mechanism or a vibrator, and a holding mechanism, the pile defining a top surface, a bottom surface and a cylindrical surface extending between the top surface and the bottom surface, the holding mechanism comprising:

a vehicle comprising a housing comprising a motor, the housing comprising tracks or wheels powered by the motor, the vehicle further comprising a movable arm extending from the housing and being powered by the motor,
a gripping mechanism extending from the arm opposite the housing, the gripping mechanism comprising a frame,

the frame comprising a plurality of inwardly oriented guides,
a first supporting leg extending between the gripping mechanism and a first ground plate, and
a second supporting leg extending between the gripping mechanism and a second ground plate,

the method comprising the steps of:

positioning the pile in a substantially vertical orientation,
positioning the gripping mechanism adjacent the cylindrical surface of the pile by using the tracks or wheels and the movable arm of the vehicle,
opening the frame, receiving the cylindrical surface of the pile within the frame and closing the frame about the cylindrical surface of the pile such that the plurality of inwardly oriented guides are located adjacent the cylindrical surface of the pile,
positioning the first and second ground plates on the ground such that the vehicle, the first ground plate and the second ground plate together define a triangular area,
applying, by means of the movable arm and the housing, a downwardly oriented force onto the gripping mechanism towards the first and second ground plates via the first and second support legs, respectively, and
applying, by means of said pile driving mechanism, a downwardly oriented force onto the top surface in a direction from the top surface towards the bottom surface, thereby pushing the pile into the ground while allowing the pile to be slidably guided by the plurality of inwardly oriented guides.

[0026] The pile is typically positioned in the vertical orientation by means of a large crane. Before releasing the pile from the crane, the gripping mechanism approaches the pile, the frame is opened and the pile is received within the frame via the opening in the frame. Thereafter, the frame is closed and preferably securely locked. The pile is thereby suspended in all directions along the horizontal plane but freely movable in the vertical direction. It is contemplated that some minor margin of movement may exist also along the horizontal plane, but the pile should be prevented from falling over or becoming skewed. The vehicle, the first ground plate and the second ground plate together define a triangular area in order for the holding mechanism to be able to absorb forces in all directions along the horizontal plane. The movable arm should apply a downwardly oriented force towards the first and second ground plates, preferably by means of hydraulic power, in order to ensure that the gripping mechanism maintains a stable position. Thereby, some of the weight of the vehicle is transferred to the first and second ground plates. The gripping mechanism and the guides will thereafter ensure that the pile maintains a vertical orientation during the piling. It is evident that all of the above features mentioned in relation to the assembly according to the first aspect are equally applicable to the method according to the second aspect.

[0027] The above object, the above need, the above feature and the above advantage together with numerous other objects, advantages, features and needs, which will be evident from the below detailed description of the present invention, are according to a third aspect of the present invention obtained by a gripping mechanism for temporarily holding a pile while a pile driving mechanism, such as a hammer mechanism or a vibrator, is used for causing the pile to enter into the ground, the pile defining a top surface, a bottom surface and a cylindrical surface extending between the top surface and the bottom surface, the gripping mechanism comprising a connector for being connected to a movable arm extending from a housing of a vehicle, the gripping mechanism comprising:

a frame comprising a plurality of inwardly oriented guides, the frame defining an open state in which the cylindrical surface of the pile may be received within the frame and a closed state in which the cylindrical surface of the pile may be slidably enclosed between the inwardly oriented guides of the frame,
a first supporting leg extending between the gripping mechanism and a first ground plate, and
a second supporting leg extending between the gripping mechanism and a second ground plate.

[0028] The vehicle may be an excavator or similar heavy duty vehicle. The connector may be a so called quick connector which is used for connecting shovels and similar equipment to the arm of the housing of the vehicle. It is evident that all of the above features mentioned in relation to the assembly according to the first aspect are equally applicable to the method according to the second aspect.

Brief description of the drawings

[0029]

Fig. 1 is a sequence describing the use according to the present invention of a pile driving assembly having a holding mechanism according to the present invention.

Fig. 2 is a sequence describing a detailed view of the holding mechanism according to the present invention.
Fig. 3 is a sequence describing a detailed view of the gripping mechanism according to the present invention.

Detailed description of the drawings

[0030] Fig. 1A shows a perspective view of a pile driving assembly 10 according to the present invention before piling operations have started. The pile driving assembly comprises a pile 12 constituting a monopole in the form of a steel pipe. The pile 12 comprises a circular cylindrical surface 14 interconnecting a top surface 16 and a bottom surface 18. The pile 12 is held in a vertical orientation by means of a wire 20 connected to a crane (not shown) and positioned at the intended location by lowering the pile 12 towards the ground in the direction of the arrow.

[0031] The pile driving assembly 10 further comprises a holding mechanism 22. The holding mechanism comprises a heavy duty vehicle 24, in the present case an excavator. The vehicle comprises a housing 26 including a motor, typically a diesel engine, for generating propulsion and hydraulic power. The vehicle 24 is driven by caterpillar tracks 28. The housing 26 of the vehicle 24 comprises a movable arm 30 powered by hydraulic power from the motor in the housing 24 and movable towards the pile 12. The movable arm 30 comprises a connector 32 in the form of a quick connector for securely attaching various equipments to the arm 30. The connector 32 is connected to a gripping mechanism 34. The gripping mechanism 34 extends in the outwardly direction of the arm 30 and comprises a frame 36. The frame 36 comprises a first frame part 36' which is fixedly connected to the arm 30 and a movable frame part 36" which may be swung between the present open position and a closed position, which will be shown in connection with fig 1B. The frame 36 comprises three rollers 38 which are inwardly oriented and positioned at an angle of 120 degrees relative to each other.

[0032] The gripping mechanism 34 further comprises a first support leg 40 and a second support leg 42. The first support leg 40 and the second support leg 42 are telescopic and thereby adjustable. The first support leg 40 and the second support leg 42 are terminated by a respective first ground plate 44 and a second ground plate 46. In order to achieve a stable position on loose grounds, the effective area of the first and second ground plates 44 46 may be extended by means of a respective first and second auxiliary ground plate 48 50, each having a cavity 52 52' for accommodating the respective first and second ground plate 44 46. The first and second ground plates 44 46 or alternatively the first and second auxiliary ground plate 48 50 may have downwardly oriented spikes in order to achieve a more firm position on the ground. The lower sections of the respective first support leg 40 and second support leg 42 are interconnected by means of a wire 54.

[0033] Fig. 1B shows a perspective view of a pile driving assembly 10 when the pile 12 has been positioned on the indented installation site. The pile 12 has now been placed in a vertical position on the ground and the arm 30 and gripping mechanism 34 has been moved towards the pile 12 and the pile 12 has been received within the frame 36. The frame has also been closed by interconnecting the first frame part 36' and the second frame part 36" thereby circumferentially enclosing the cylindrical surface 14 of the pile 12. The first and second support legs 40 42 may be extended in a transversal direction on the horizontal plane relative to the movable arm 30 and form a 45 degree angle relative to the vertical direction as shown in the figure. In this way, the holding mechanism 22 assumes a stable position supported on three points, namely, the vehicle 24, the first ground plate 44 and the second ground plate 46, forming the corners of a triangle, i.e. a triangular area between themselves.

[0034] The first and second support legs 40 42 are telescopic and may be adjusted according to the arrows in order to align the pile 12 in horizontal plane in the directions transversal to the movable arm 30. Further, the movable arm 30 of the vehicle 24 may be adjusted in order to align the pile 12 in the horizontal plane in the directions of the movable arm 30. In this way the pile 12 may be aligned in the vertical orientation.

[0035] Fig. 1C shows a perspective view of a pile driving assembly 10 when piling operation is about to begin. The wire 20 of the crane (not shown) has now been connected to a pile driving mechanism 56 which in the present embodiment constitutes a hammering mechanism. The pile driving mechanism 56 comprises a casing 58 and a weight 60. The casing 58 is applied on the top surface 16 of the pile 12.

[0036] Fig. 1D shows a perspective view of a pile driving assembly 10 during piling. The pile driving mechanism 56 has now started hammering action against the top surface 16 of the pile 12. The hammering action is caused by repeatedly lifting and releasing the weight 60 towards the top surface 16 of the pile 12 by means of hydraulic power. The pile 12 is thereby caused to enter the ground and will be constantly aligned between the rollers 38 of the frame 36 as the cylindrical surface 14 of the pile slides along the frame 36. The pile 12 may get slightly misaligned during the hammering action as indicated by the arrow.

[0037] Fig. 1E shows a perspective view of a pile driving assembly 10 when the pile 12 is aligned by the holding mechanism 22. Typically, any major misalignment will be prevented by the holding mechanism 24. In case of a major misalignment of the pile 12, hammering action may be temporarily interrupted and the orientation of the pile 12 may be adjusted by moving the movable arm 30 and/or adjusting the first and second support legs 40 42.

[0038] Fig. 1F shows a perspective view of a pile driving assembly 10 when the pile 12 has been partially embedded

into the ground. The pile driving mechanism 56 now approaches the gripping mechanism 34 and thus the holding mechanism 22 should be removed by opening the frame 36 and retracting the movable arm 30. The pile 12 has now reached a stable position in the ground and must and cannot be aligned any further.

[0039] Fig. 1G shows a perspective view of a pile driving assembly 10 when the pile 12 has been substantially embedded into the ground. The casing 58 of the pile driving mechanism 56 has now reached the ground.

[0040] Fig. 1H shows a perspective view of a pile driving assembly 10 when the pile 12 has been substantially embedded into the ground. In order to continue the piling operation, a block 62 must be placed on the top surface 16 of the pile 12.

[0041] Fig. 1I shows a perspective view of a pile driving assembly 10 when the pile 12 has been substantially embedded into the ground. The pile driving mechanism 56 is placed on top of the block 62.

[0042] Fig. 1J shows a perspective view of a pile driving assembly 10 when the pile 12 has been substantially embedded into the ground. The hammering action may now continue until the pile 12 is fully embedded into the ground.

[0043] Fig. 1J shows a perspective view of a pile driving assembly 10 when the pile 12 has been fully embedded into the ground.

[0044] Fig. 2A shows a detailed perspective view of the gripping mechanism 34. The gripping mechanism comprise the frame 36 including the first frame part 36' and the second frame part 36" as described above. The three rollers 38 are mounted in the frame facing inwardly and at about 120 degrees between them. The frame may be releasably connected to a quick connector (not shown) of an arm (not shown) of a vehicle (not shown) by means of an opposite connector 64. The first and second supporting legs 40 42 are telescopic and comprise pin holes into which a pin may be inserted in order for the user to be able to adjust and fixate the length of the first and second supporting legs 40 42.

[0045] The frame 36 comprises sleeves 68 and the rollers 38 are each fixated to a roller fixture 70 which is slidable within a dedicated sleeve 68. The roller fixtures 70 comprise pin holes 66' such that the rollers 38 may be adjusted for allowing the inner periphery of the frame 30 which is defined by the rollers 38 to be adjusted in order to accommodate piles of different circumference.

[0046] The frame optionally comprises two transport brackets 74 which are used for holding the first and second supporting legs 40 42 during transport of the gripping mechanism 34. The first and second supporting legs 40 42 are thereby folded into a respective transport bracket 74.

[0047] Fig. 2B shows a side view of the gripping mechanism 34 showing the first and second support legs 40 42 defining an angle in the vertical plane of about 90 degrees relative to each other and 45 degrees relative to the vertical direction. The angle may be adjusted by means of a hydraulic actuator 76. The first and second support legs 40 42 are foldable about respective joints 78 78'. The chain 54, which preferably is adjustable, limits the angle between the first and second support legs 40 42.

[0048] Fig. 2C shows a top view of the gripping mechanism 34 showing the first and second support legs 40 42 defining an angle in the horizontal plane of about 180 degrees relative to each other and 90 degrees relative to the direction defined by the connector 64.

[0049] Fig. 3A shows a top view of the frame 36 in the closed position, i.e. when the first frame part 36' and the second frame part 36" form an enclosed space.

[0050] Fig. 3B shows a top view of the frame 36 when the frame is about to be opened. When the frame 36 is closed, a locking mechanism 72 is securely joining the first frame part 36' and the second frame part 36". By operating a hydraulic lock actuator 80, the locking mechanism 72 may be swung outwardly as shown in the figure, thereby releasing the second frame part 36" from the first frame part 36'.

[0051] Fig. 3C shows a top view of the frame 36 when the frame is opened. The second frame part 36" thereby swings outwardly in relation to the first frame part 36' in the direction of the arrow about a joint 82 by means of a hydraulic frame opener 84. When the pile (not shown) has been received within the first frame part 36', the second frame part 36" may swing back towards the first frame part 36' and the locking mechanism may swing back towards the first frame part 36' in order to securely lock the first frame part 36' to the second frame part 36".

[0052] Although the present invention has been described above with reference to specific embodiments, it is of course to be contemplated that numerous modifications may be deduced by a skilled person in the art. Such modifications which are readily perceivable by the skilled person in the art should consequently be construed as being part of the present invention as defined in the appending claims.

List of parts with reference to the figures

10.	Pile driving assembly	48.	First auxiliary ground plate
12.	Pile	50.	Second auxiliary ground plate
14.	Cylindrical surface	52.	Cavity
16.	Top surface	54.	Chains

(continued)

18.	Bottom surface	56.	Pile driving mechanism (hammer mechanism)
20.	Wire	58.	Casing
22.	Holding mechanism	60.	Weight
24.	Heavy duty vehicle	62.	Block
26.	Housing (including motor)	64.	Opposite connector
28.	Tracks	66.	Pin hole
30.	Movable arm (hydraulic powered)	68.	Sleeve
32.	Connector	70.	Roller fixture
34.	Gripping mechanism	72.	Locking mechanism
36.	Frame	74.	Transport bracket
38.	Roller (guide)	76.	Hydraulic leg actuator
40.	First supporting leg	78.	Joint
42.	Second supporting leg	80.	Hydraulic locking actuator
44.	First ground plate	82.	Joint
46.	Second ground plate	84.	Hydraulic frame opener

Claims

1. A pile driving assembly comprising:

a pile defining a top surface, a bottom surface and a cylindrical surface extending between said top surface and said bottom surface, and
a pile driving mechanism, such as a pile driving mechanism, such as a hammer mechanism or a vibrator, for applying a force onto said top surface in a direction from said top surface towards said bottom surface for causing said pile to enter into the ground,

said pile driving assembly further comprises a holding mechanism for temporarily holding said pile, said holding mechanism comprising:

a vehicle comprising a housing including a motor, said housing comprising tracks or wheels powered by said motor, said vehicle further comprising a movable arm extending from said housing and being powered by said motor,
a gripping mechanism extending from said arm opposite said housing, said gripping mechanism comprising a frame, said frame comprising a plurality of inwardly oriented guides, said frame defining an open state in which said cylindrical surface of said pile may be received within said frame and a closed state in which said cylindrical surface of said pile may be slidably enclosed between said inwardly oriented guides of said frame,
a first supporting leg extending between said gripping mechanism and a first ground plate, and
a second supporting leg extending between said gripping mechanism and a second ground plate,
said vehicle, said first ground plate and said second ground plate together define a triangular area.

2. The pile driving assembly according to claim 1, wherein said inwardly oriented guides defining an inner periphery of said frame, the position of said plurality of inwardly oriented guides may be varied in order to adjust said inner periphery of said frame.

3. The pile driving assembly according to claim 2, wherein said inner periphery defining a diameter between 1m and 5m, preferably between 1.2m and 3m, more preferably between 1.5m and 2.5m, such as 1.7m, 2.0m and 2.1 m

4. The pile driving assembly according to any of the claims 1-3, wherein said plurality of inwardly oriented guides

comprise a number of rollers,

5. The pile driving assembly according to claim 4, wherein said number of rollers is between 3 and 10, such as between 3 and 5 and preferably 3.

6. The pile driving assembly according to any of the preceding claims, wherein said first and second supporting legs each define an angle in the horizontal plane in relation to said movable arm of 60-150 degrees, preferably 75-135 degrees, more preferably 90-120 degrees.

7. The pile driving assembly according to any of the preceding claims, wherein said first and second supporting legs define between themselves an angle in the horizontal plane of 60-180 degrees, preferably 120-180 degrees, more preferably 150-180 degrees.

8. The pile driving assembly according to any of the preceding claims, wherein said first and second supporting legs each define an angle in the vertical plane in relation to each other of 45-135 degrees, preferably 55-125 degrees, more preferably 70-110 degrees, most preferably 90 degrees.

9. The pile driving assembly according to any of the preceding claims, wherein the lengths of said first and second supporting legs may be varied.

10. The pile driving assembly according to any of the preceding claims, wherein said first and second supporting legs may be folded.

11. The pile driving assembly according to any of the preceding claims, wherein said first and second ground plate comprise spikes in order to be fixated to the ground.

12. The pile driving assembly according to any of the preceding claims, wherein said first and second supporting legs are interconnected, preferably via a chain or wire located adjacent said first and second ground plates.

13. The pile driving assembly according to any of the preceding claims, wherein said frame comprises a mechanical lock for locking said frame when said frame define said closed state.

14. A method of driving a pile into the ground by providing a pile driving mechanism, such as a pile driving mechanism, such as a hammer mechanism or a vibrator, and a holding mechanism, said pile defining a top surface, a bottom surface and a cylindrical surface extending between said top surface and said bottom surface, said holding mechanism comprising:

a vehicle comprising a housing comprising a motor, said housing comprising tracks or wheels powered by said motor, said vehicle further comprising a movable arm extending from said housing and being powered by said motor,
a gripping mechanism extending from said arm opposite said housing, said gripping mechanism comprising a frame, said frame comprising a plurality of inwardly oriented guides,
a first supporting leg extending between said gripping mechanism and a first ground plate, and
a second supporting leg extending between said gripping mechanism and a second ground plate,

said method comprising the steps of:

positioning said pile in a substantially vertical orientation,
positioning said gripping mechanism adjacent said cylindrical surface of said pile by using said tracks or wheels and said movable arm of said vehicle,
opening said frame, receiving said cylindrical surface of said pile within said frame and closing said frame about said cylindrical surface of said pile such that said plurality of inwardly oriented guides are located adjacent said cylindrical surface of said pile,
positioning said first and second ground plates on the ground such that said vehicle, said first ground plate and said second ground plate together define a triangular area,
applying, by means of said movable arm and said housing, a downwardly oriented force onto said gripping mechanism towards said first and second ground plates via said first and second support legs, respectively, and
applying, by means of said pile driving mechanism, a downwardly oriented force onto said top surface in a

direction from said top surface towards said bottom surface, thereby pushing said pile into the ground while allowing said pile to be slidably guided by said plurality of inwardly oriented guides.

15. A gripping mechanism for temporarily holding a pile while a pile driving mechanism, such as a hammer mechanism or a vibrator, is used for causing said pile to enter into the ground, said pile defining a top surface, a bottom surface and a cylindrical surface extending between said top surface and said bottom surface, said gripping mechanism comprising a connector for being connected to a movable arm extending from a housing of a vehicle, said gripping mechanism comprising:

a frame comprising a plurality of inwardly oriented guides, said frame defining an open state in which said cylindrical surface of said pile may be received within said frame and a closed state in which said cylindrical surface of said pile may be slidably enclosed between said inwardly oriented guides of said frame,
a first supporting leg extending between said gripping mechanism and a first ground plate, and
a second supporting leg extending between said gripping mechanism and a second ground plate.

Patentansprüche

1. Pfahlrammanordnung umfassend:

einen Pfahl, der eine Oberseite, eine Unterseite und eine zylindrische Fläche definiert, die sich zwischen der Oberseite und der Unterseite erstreckt, und
einen Pfahlrammechanismus, wie zum Beispiel einen Pfahlrammechanismus, wie zum Beispiel einen Hammermechanismus oder einen Vibrator, zum Ausüben einer Kraft auf die Oberseite in einer Richtung von der Oberseite zu der Unterseite hin, um zu bewirken, dass der Pfahl in den Boden eintritt,

wobei die Pfahlrammanordnung ferner einen Haltemechanismus zum temporären Halten des Pfahls umfasst, wobei der Haltemechanismus umfasst:

ein Fahrzeug umfassend ein Gehäuse, das einen Motor aufweist, wobei das Gehäuse durch den Motor betriebene Raupenketten oder Räder umfasst, wobei das Fahrzeug ferner einen beweglichen Arm umfasst, der sich von dem Gehäuse erstreckt und durch den Motor betrieben wird,
einen Greifmechanismus, der sich von dem Arm gegenüber dem Gehäuse erstreckt, wobei der Greifmechanismus einen Rahmen umfasst, welcher Rahmen eine Vielzahl von nach innen weisenden Führungen umfasst, wobei der Rahmen einen offenen Zustand definiert, in welchem die zylindrische Fläche des Pfahls innerhalb des Rahmens aufgenommen werden kann, und einen geschlossenen Zustand, in welchem die zylindrische Fläche des Pfahls zwischen den nach innen weisenden Führungen des Rahmens gleitbar eingeschlossen werden kann,
ein erstes Stützbein, das sich zwischen dem Greifmechanismus und einer ersten Bodenplatte erstreckt, und
ein zweites Stützbein, das sich zwischen dem Greifmechanismus und einer zweiten Bodenplatte erstreckt,

wobei das Fahrzeug, die erste Bodenplatte und die zweite Bodenplatte zusammen eine dreieckige Fläche definieren.

2. Pfahlrammanordnung nach Anspruch 1, wobei die nach innen weisenden Führungen einen Innenumfang des Rahmens definieren, die Position der Vielzahl von nach innen weisenden Führungen variiert werden kann, um den Innenumfang des Rahmens einzustellen.

3. Pfahlrammanordnung nach Anspruch 2, wobei der Innenumfang einen Durchmesser zwischen 1 mund 5m, bevorzugt zwischen 1,2m und 3m, mehr bevorzugt zwischen 1,5m und 2,5m, wie zum Beispiel 1,7m, 2,0m und 2,1m definiert.

4. Pfahlrammanordnung nach einem der Ansprüche 1-3, wobei die Vielzahl von nach innen weisenden Führungen eine Anzahl Rollen umfasst.

5. Pfahlrammanordnung nach Anspruch 4, wobei die Anzahl Rollen zwischen 3 und 10, wie zum Beispiel zwischen 3 und 5 und bevorzugt 3 beträgt.

6. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei das erste und das zweite Stützbein je

einen Winkel in der horizontalen Ebene in Bezug auf den beweglichen Arm von 60-150 Grad, bevorzugt 75-135 Grad, mehr bevorzugt 90-120 Grad definieren.

7. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei das erste und das zweite Stützbein zwischen sich einen Winkel in der horizontalen Ebene von 60-180 Grad, bevorzugt 120-180 Grad, mehr bevorzugt 150-180 Grad definieren.

8. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei das erste und das zweite Stützbein je einen Winkel in der vertikalen Ebene in Bezug aufeinander von 45-135 Grad, bevorzugt 55-125 Grad, mehr bevorzugt 70-110 Grad, am meisten bevorzugt 90 Grad definieren.

9. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei die Längen des ersten und des zweiten Stützbeins variiert werden können.

10. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei das erste und das zweite Stützbein gefaltet werden können.

11. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei die erste und die zweite Bodenplatte Stachel umfassen, um an dem Boden befestigt zu werden.

12. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei das erste und das zweite Stützbein miteinander verbunden sind, bevorzugt durch eine benachbart zu der ersten und der zweiten Bodenplatte angeordnete Kette oder einen Draht.

13. Pfahlrammanordnung nach einem der vorherstehenden Ansprüche, wobei der Rahmen ein mechanisches Schloss zum Schließen des Rahmens umfasst, wenn der Rahmen den geschlossenen Zustand definiert.

14. Verfahren zum Einrammen eines Pfahls in den Boden durch Bereitstellen eines Pfahlrammechanismus, wie zum Beispiel eines Pfahlrammechanismus, wie zum Beispiel eines Hammermechanismus oder eines Vibrators, und eines Haltemechanismus, wobei der Pfahl eine Oberseite, eine Unterseite und eine zylindrische Fläche definiert, die sich zwischen der Oberseite und der Unterseite erstreckt, wobei der Haltemechanismus umfasst:

ein Fahrzeug umfassend ein Gehäuse, das einen Motor aufweist, wobei das Gehäuse durch den Motor betriebene Raupenketten oder Räder umfasst, wobei das Fahrzeug ferner einen beweglichen Arm umfasst, der sich von dem Gehäuse erstreckt und durch den Motor betrieben wird,
einen Greifmechanismus, der sich von dem Arm gegenüber dem Gehäuse erstreckt, wobei der Greifmechanismus einen Rahmen umfasst, welcher Rahmen eine Vielzahl von nach innen weisenden Führungen umfasst,
ein erstes Stützbein, das sich zwischen dem Greifmechanismus und einer ersten Bodenplatte erstreckt, und
ein zweites Stützbein, das sich zwischen dem Greifmechanismus und einer zweiten Bodenplatte erstreckt,

wobei das Verfahren die folgenden Schritte umfasst:

Positionieren des Pfahls in einer im Wesentlichen vertikalen Orientierung,
Positionieren des Greifmechanismus benachbart zu der zylindrischen Fläche des Pfahls durch Verwendung der Raupenketten oder Räder und des beweglichen Arms des Fahrzeugs,
Öffnen des Rahmen, Aufnehmen der zylindrischen Fläche des Pfahls innerhalb des Rahmens und Schließen des Rahmens um die zylindrische Fläche des Pfahls herum derart, dass die Vielzahl von nach innen weisenden Führungen benachbart zu der zylindrischen Fläche des Pfahls angeordnet ist,
Positionieren der ersten und der zweiten Bodenplatte auf dem Boden derart, dass das Fahrzeug, die erste Bodenplatte und die zweite Bodenplatte zusammen eine dreieckige Fläche definieren,
Ausüben, durch den bewegbaren Arm und das Gehäuse, einer nach unten gerichteten Kraft auf den Greifmechanismus zu der ersten und der zweiten Bodenplatte hin über das erste bzw. das zweite Stützbein, und
Ausüben, durch die Pfahlrammanordnung, einer nach unten weisenden Kraft auf die Oberseite in einer Richtung von der Oberseite zu der Unterseite hin, wodurch der Pfahl in den Boden getrieben wird, während es dem Pfahl ermöglicht wird, durch die Vielzahl von nach innen weisenden Führungen gleitbar geführt zu werden.

15. A Greifmechanismus zum temporären Halten eines Pfahls, während ein Pfahlrammechanismus, wie zum Beispiel ein Hammermechanismus oder ein Vibrator, verwendet wird, um zu bewirken, dass der Pfahl in den Boden eintritt,

wobei der Pfahl eine Oberseite, eine Unterseite und eine zylindrische Fläche definiert, die sich zwischen der Oberseite und der Unterseite erstreckt, wobei der Greifmechanismus ein Verbindungsstück umfasst, um mit einem beweglichen Arm verbunden zu werden, der sich von einem Gehäuse eines Fahrzeugs erstreckt, wobei der Greifmechanismus umfasst:

einen Rahmen, der eine Vielzahl von nach innen weisenden Führungen umfasst, wobei der Rahmen einen offenen Zustand definiert, in welchem die zylindrische Fläche des Pfahls innerhalb des Rahmens aufgenommen werden kann, und einen geschlossenen Zustand, in welchem die zylindrische Fläche des Pfahls zwischen den nach innen weisenden Führungen des Rahmens gleitbar eingeschlossen werden kann,
ein erstes Stützbein, das sich zwischen dem Greifmechanismus und einer ersten Bodenplatte erstreckt, und
ein zweites Stützbein, das sich zwischen dem Greifmechanismus und einer zweiten Bodenplatte erstreckt.

Revendications

1. Ensemble de commande d'empilage comprenant:

un pieu définissant une surface supérieure, une surface inférieure et une surface cylindrique s'étendant entre ladite surface supérieure et ladite surface inférieure, et
un mécanisme de commande d'empilage, tel qu'un mécanisme de commande d'empilage, tel qu'un mécanisme de marteau ou un vibrateur pour l'application d'une force sur ladite surface supérieure dans une direction à partir de ladite surface supérieure vers ladite surface inférieure pour amener ledit pieu a entrer dans la terre, ledit ensemble de commande d'empilage comprend en outre un mécanisme de maintien dudit pieu temporairement, ledit mécanisme de maintien comprenant:

un véhicule comprenant un logement contenant un moteur, ledit logement comprenant des voies ou des roues actionnées par ledit moteur, ledit véhicule comprenant en outre un bras mobile qui s'étend dudit logement et qui est actionné par ledit moteur,
un mécanisme de serrage qui s'étend dudit bras opposé audit logement, ledit mécanisme de serrage comprenant un cadre, ledit cadre comprenant une pluralité de guides orientés vers l'intérieur, ledit cadre définissant un état ouvert dans lequel ladite surface cylindrique dudit pieu peut être reçu à l'intérieur dudit cadre et un état fermé, dans lequel ladite surface cylindrique dudit pieu peut être enveloppée de manière à pouvoir glisser entre lesdites guides orientées vers l'intérieur dudit cadre,
une première jambe de support qui s'étend entre ledit mécanisme de serrage et une première plaque de terre, et
une deuxième jambe de support qui s'étend entre ledit mécanisme de serrage et une deuxième plaque de terre,
ledit véhicule, ladite première plaque terre et ladite deuxième plaque de terre définissant ensemble une zone triangulaire.

2. Ensemble de commande d'empilage selon la revendication 1, dans lequel lesdites guides orientées vers l'intérieur définissent une périphérie intérieure dudit cadre, la position de ladite pluralité de guides orientées vers l'intérieur pouvant être variée de manière à ajuster ladite périphérie intérieure dudit cadre.

3. Ensemble de commande d'empilage selon la revendication 2, dans lequel ladite périphérie définit un diamètre entre 1m et 5m, de préférence entre 1,2m et 3m, plus préférablement entre 1,5m et 2,5m, tel que 1,7m, 2,0m et 2,1m.

4. Ensemble de commande d'empilage selon l'une quelconque des revendications 1 à 3, dans lequel ladite pluralité de guides orientées vers l'intérieur comprend un nombre de rouleaux.

5. Ensemble de commande d'empilage selon la revendication 4, dans lequel ledit nombre de rouleaux est entre 3 et 10, tel qu'entre 3 et 5 et de préférence 3.

6. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel lesdites première et deuxième jambes de support définissent chacune un angle dans le plan horizontal par rapport audit bras mobile de 60 à 150 degrés, de préférence de 75 à 135 degrés, plus préférablement de 90 à 120 degrés.

7. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel lesdites

première et deuxième jambes de support définissent un angle entre elles dans le plan horizontal de 60 à 180 degrés, de préférence de 120 à 180 degrés, plus préférablement de 150 à 180 degrés.

8. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel lesdites première et deuxième jambes de support définissent chacune un angle entre elles dans le plan vertical l'une par rapport à l'autre de 45 à 135 degrés, de préférence de 55 à 125 degrés, plus préférablement de 70 à 110 degrés, encore plus préférablement de 90 degrés.

9. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel les longueurs desdites première et deuxième jambes de support peuvent être variées.

10. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel lesdites première et deuxième jambes de support peuvent être pliées.

11. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel lesdites première et deuxième plaques de terre comprennent des clous de manière à ce qu'elles puissent être fixées dans la terre.

12. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel lesdites première et deuxième jambes de support sont interconnectées, de préférence par une chaîne ou un câble placé adjacent audites première et deuxième plaques de terre.

13. Ensemble de commande d'empilage selon l'une quelconque des revendications précédentes, dans lequel ledit cadre comprend un verrou mécanique pour verrouiller ledit cadre lorsque ledit cadre définit ledit état fermé.

14. Procédé d'empilage d'un pieu dans le terre en fournissant un mécanisme de commande d'empilage, tel qu'un mécanisme de commande d'empilage, tel qu'un mécanisme de marteau ou un vibrateur, et un mécanisme de maintien, ledit pieu définissant une surface supérieure, une surface inférieure et une surface cylindrique s'étendant entre ladite surface supérieure et ladite surface inférieure, ledit mécanisme de maintien comprenant:

un véhicule comprenant un logement comprenant un moteur, ledit logement comprenant des voies ou des roues actionnées par ledit moteur, ledit véhicule comprenant en outre un bras mobile qui s'étend dudit logement et qui est actionné par ledit moteur,
un mécanisme de serrage qui s'étend dudit bras opposé audit logement, ledit mécanisme de serrage comprenant un cadre, ledit cadre comprenant une pluralité de guides orientés vers l'intérieur,
une première jambe de support qui s'étend entre ledit mécanisme de serrage et une première plaque de terre, et une deuxième jambe de support qui s'étend entre ledit mécanisme de serrage et une deuxième plaque de terre,

ledit procédé comprenant les étapes de:

positionner ledit pieu dans une orientation substantiellement verticale,
positionner ledit mécanisme de serrage adjacent à ladite surface cylindrique dudit pieu en utilisant lesdites voies ou roues et ledit bras mobile dudit véhicule,
ouvrir ledit cadre, recevoir ladite surface cylindrique dudit pieu à l'intérieur dudit cadre et fermer ledit cadre autour de ladite surface cylindrique dudit pieu de manière à ce que ladite pluralité desdites guides orientées vers l'intérieur sont placées adjacentes à ladite surface cylindrique dudit pieu,
positionner lesdites première et deuxième plaques de terre sur la terre de manière à ce que ledit véhicule, ladite première plaque de terre et ladite deuxième plaque de terre définissent ensemble une zone triangulaire,
appliquer, par moyens dudit bras mobile et dudit logement, une force orientée vers le bas sur ledit mécanisme de serrage vers lesdites première et deuxième plaques de terre par lesdites première et deuxième jambes, respectivement, et
appliquer, par moyens dudit mécanisme de commande d'empilage, une force orientée vers le bas sur ladite surface supérieure dans une direction à partir de ladite surface supérieure vers ladite surface inférieure, poussant ainsi ledit pieu dans la terre tout en permettant audit pieu d'être guider de manière glissante par ladite pluralité de guides orientées vers l'intérieur.

15. Mécanisme de serrage pour tenir temporairement un pieu lorsqu'un ensemble de commande d'empilage, tel qu'un mécanisme de marteau ou un vibrateur, est utilisé pour amener ledit pieu à entrer dans la terre, ledit pieu définissant

une surface supérieure, une surface inférieure et une surface cylindrique entre ladite surface supérieure et ladite surface inférieure, ledit mécanisme de serrage comprenant un connecteur pour être connecté à un bras mobile qui s'étend d'un logement d'un véhicule, ledit mécanisme de serrage comprenant:

un cadre comprenant une pluralité de guides orientés vers l'intérieur, ledit cadre définissant un état ouvert dans lequel ladite surface cylindrique dudit pieu peut être reçue à l'intérieur dudit cadre, et un état fermé dans lequel ladite surface cylindrique dudit pieu peut être enveloppée de manière à pouvoir glisser entre lesdites guides orientées vers l'intérieur dudit cadre,
une première jambe de support qui s'étend entre ledit mécanisme de serrage et une première plaque de terre, et
une deuxième jambe de support qui s'étend entre ledit mécanisme de serrage et une deuxième plaque de terre.

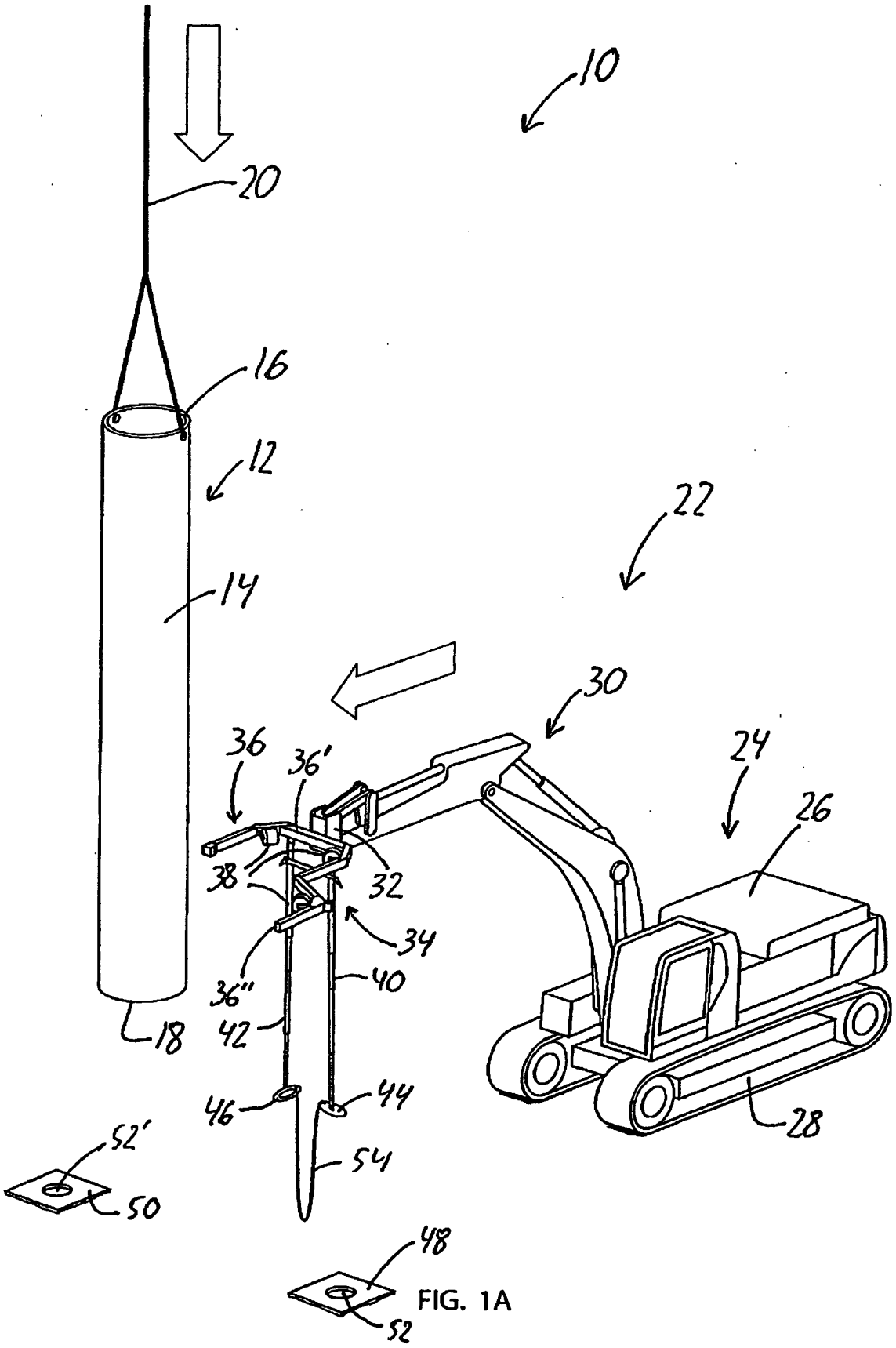
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FIG. 1A

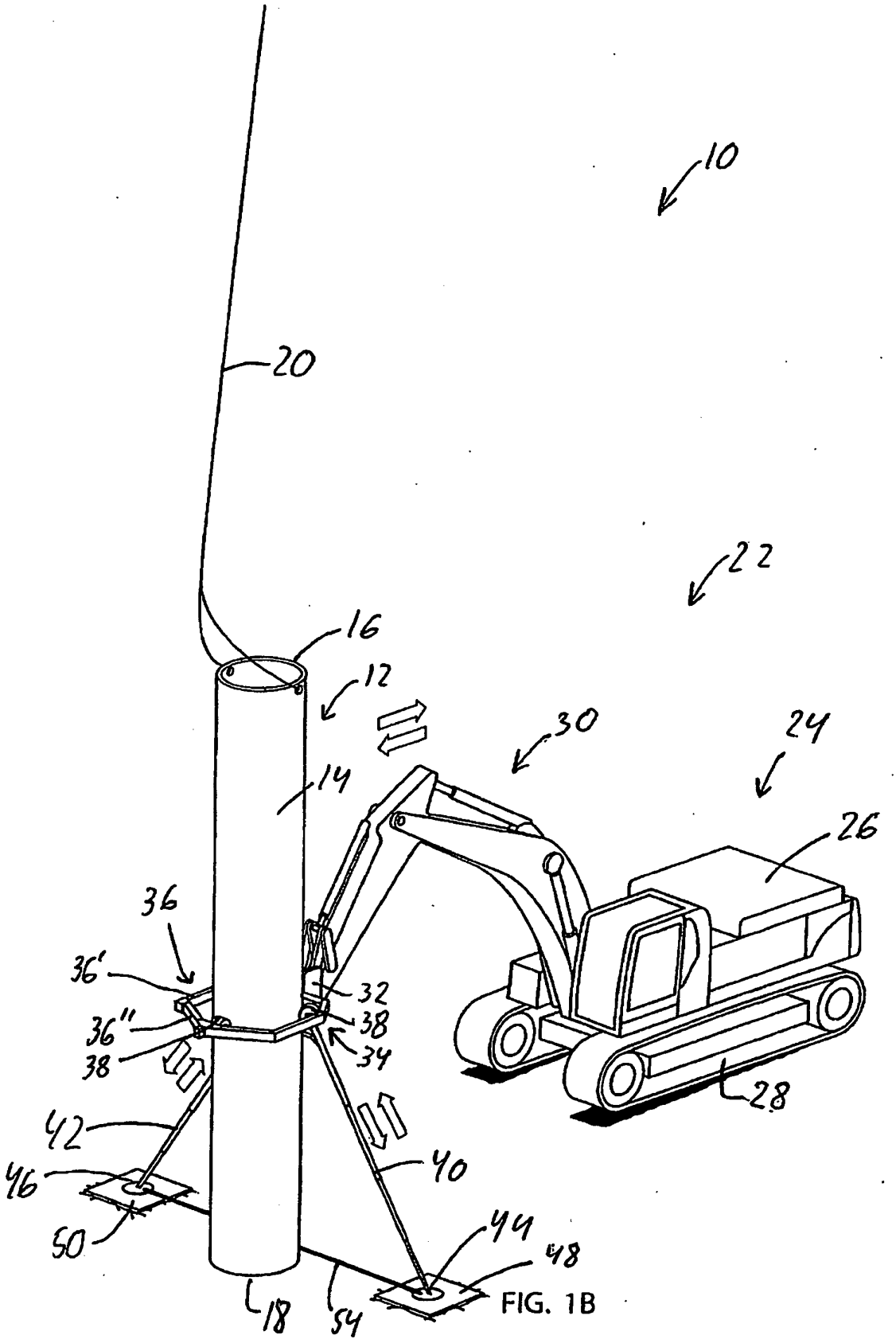
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FIG. 1B

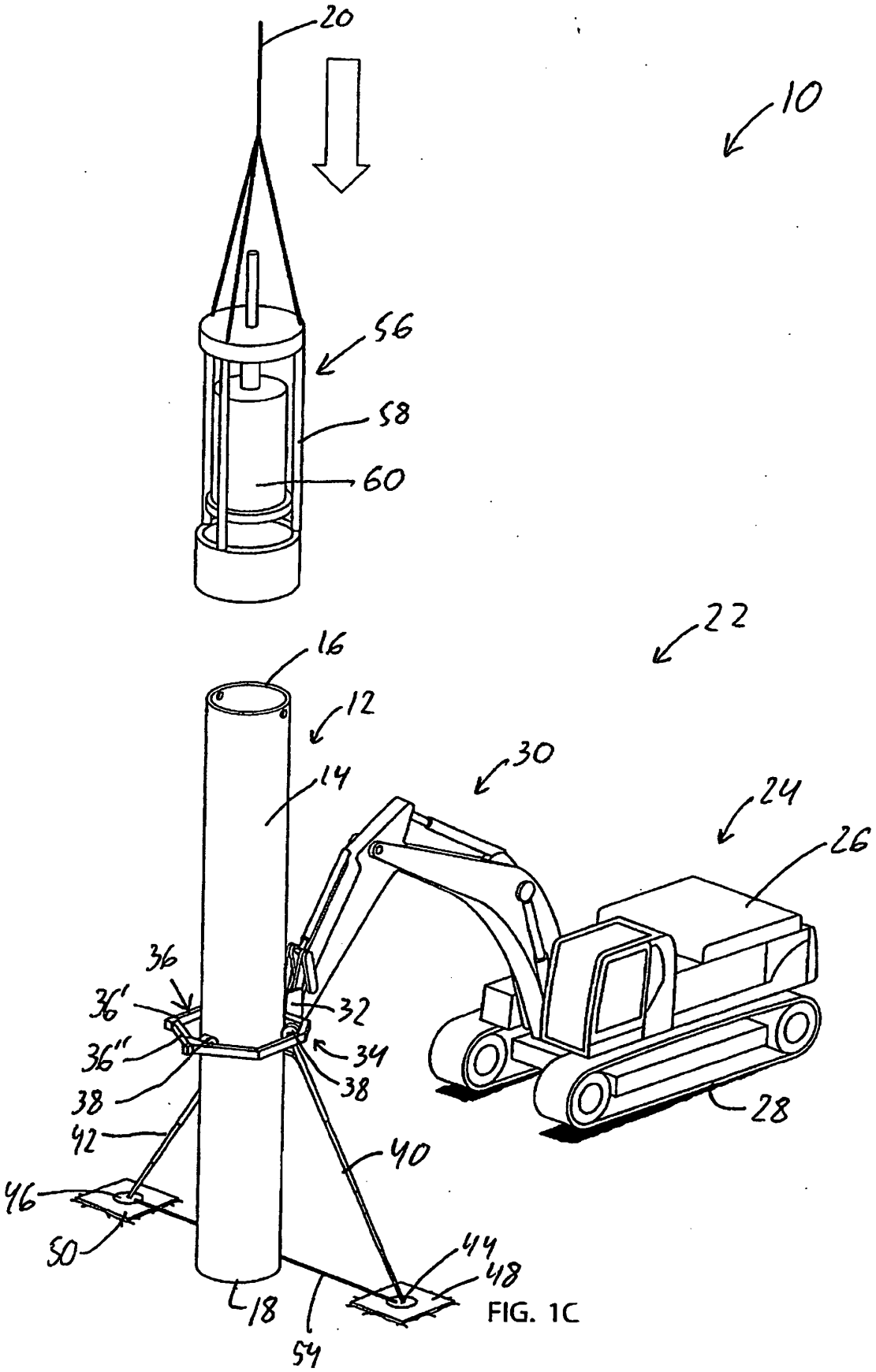
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FIG. 1C

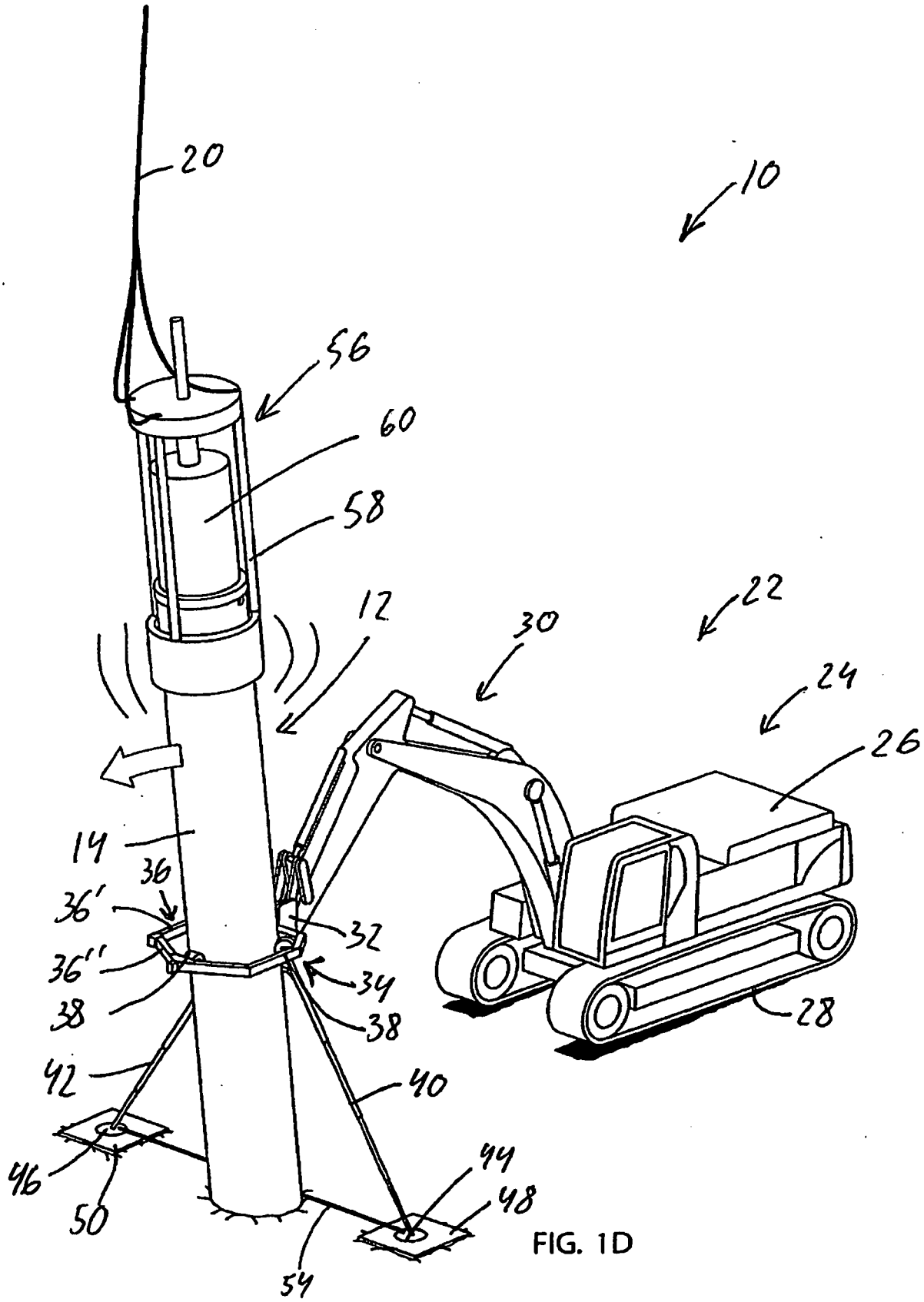
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FIG. 1D

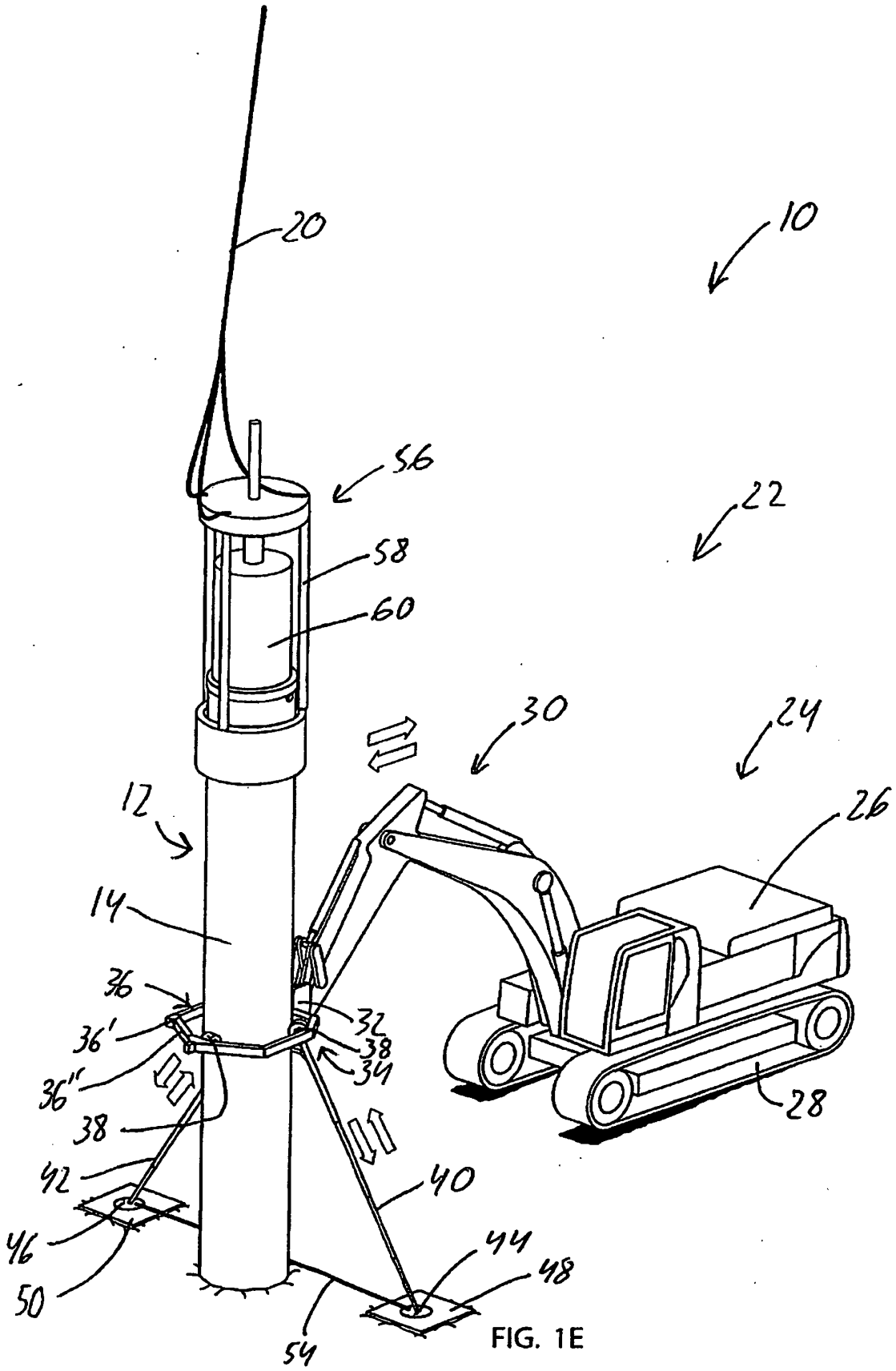
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FIG. 1E

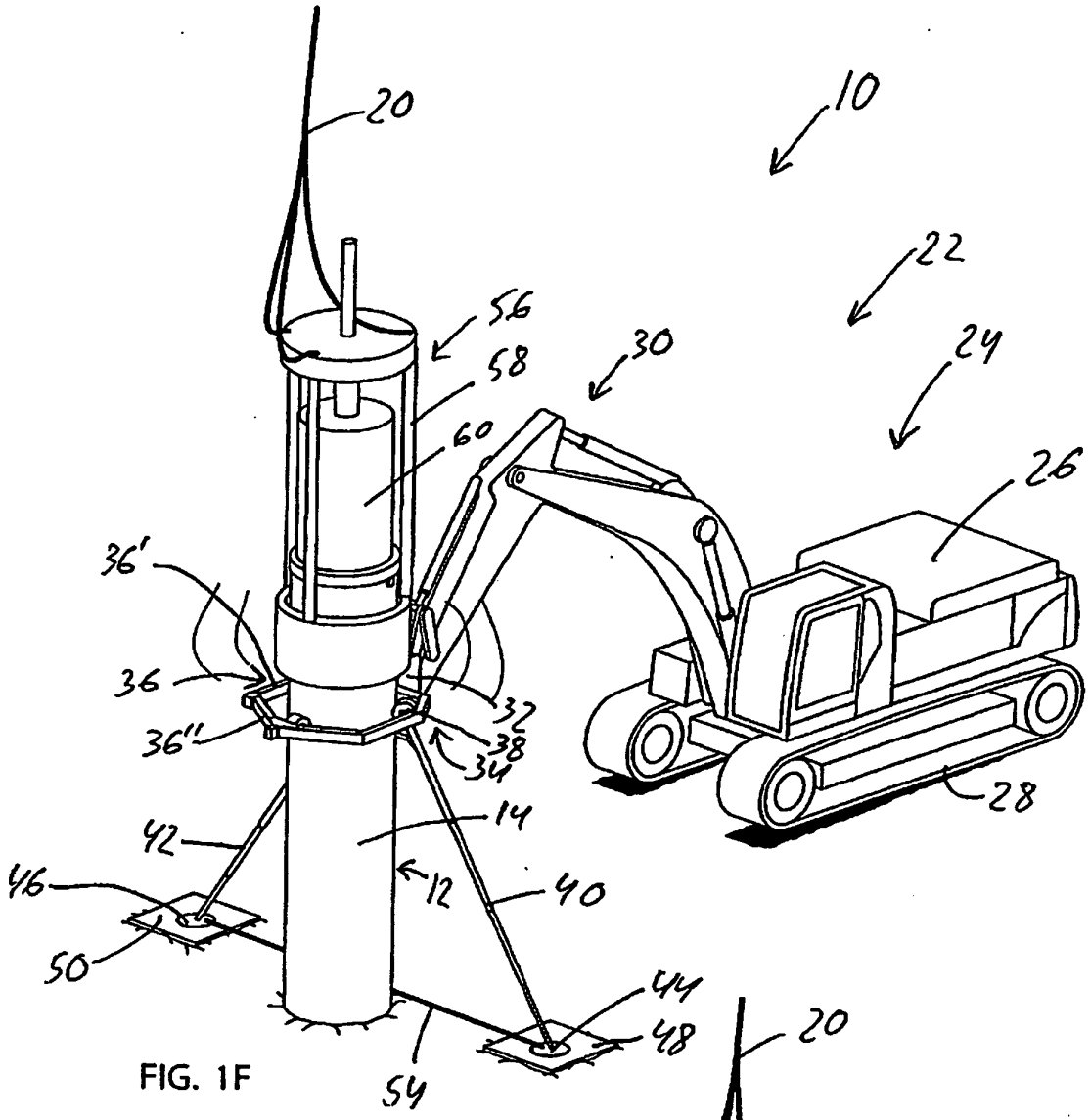
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FIG. 1F

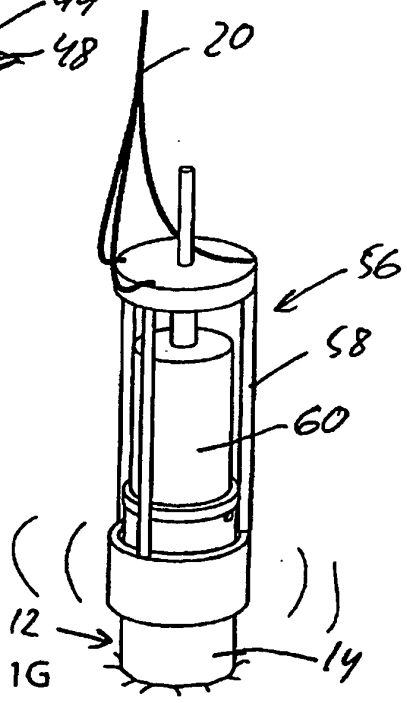
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FIG. 1G

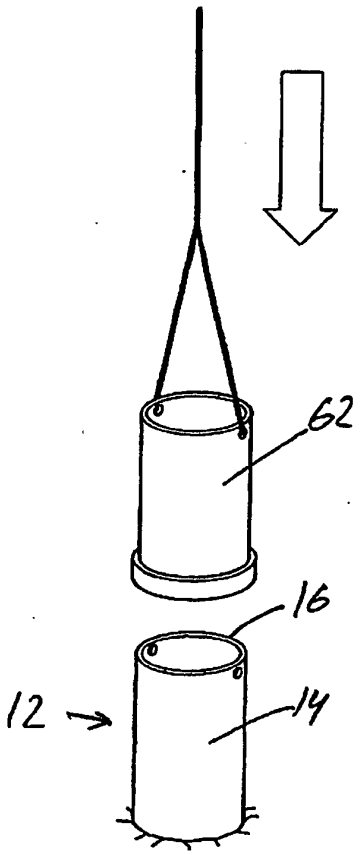


FIG. 1H

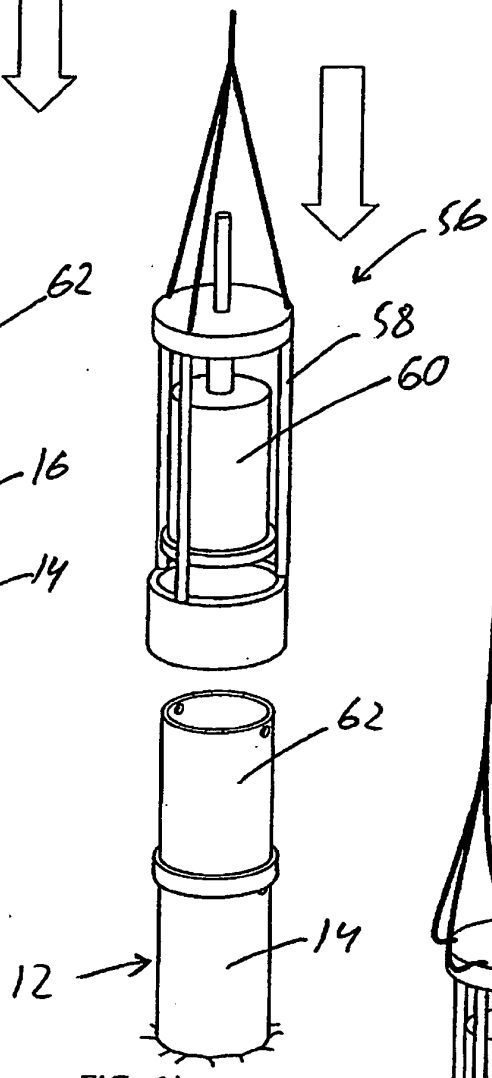


FIG. 1I

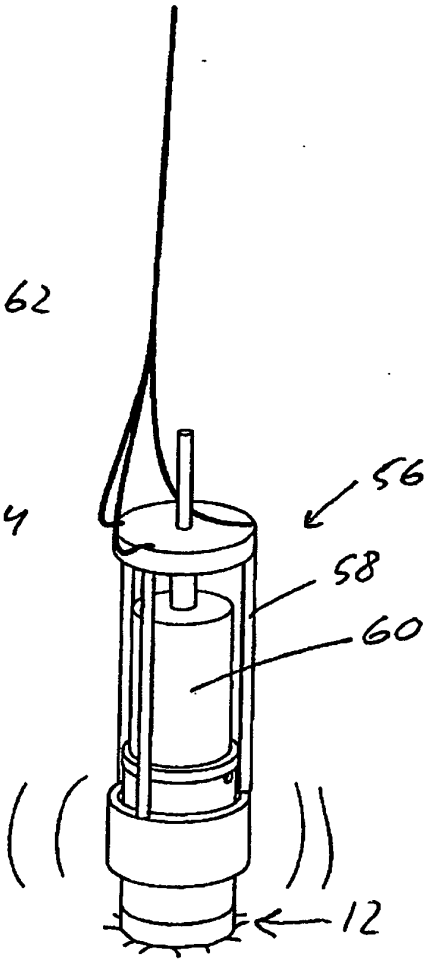


FIG. 1J

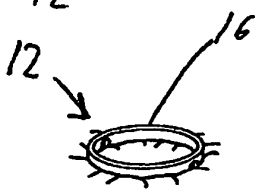


FIG. 1K

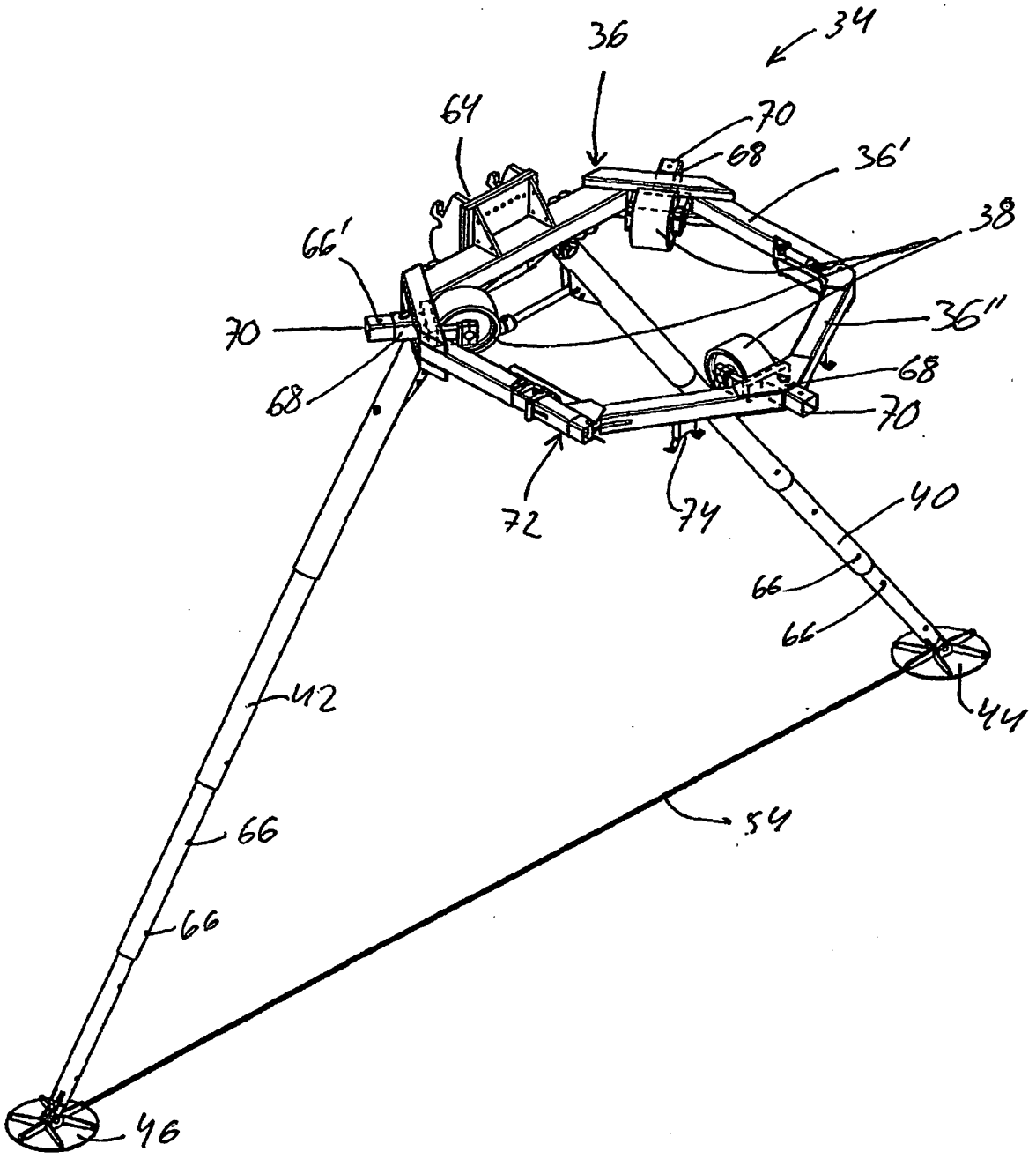
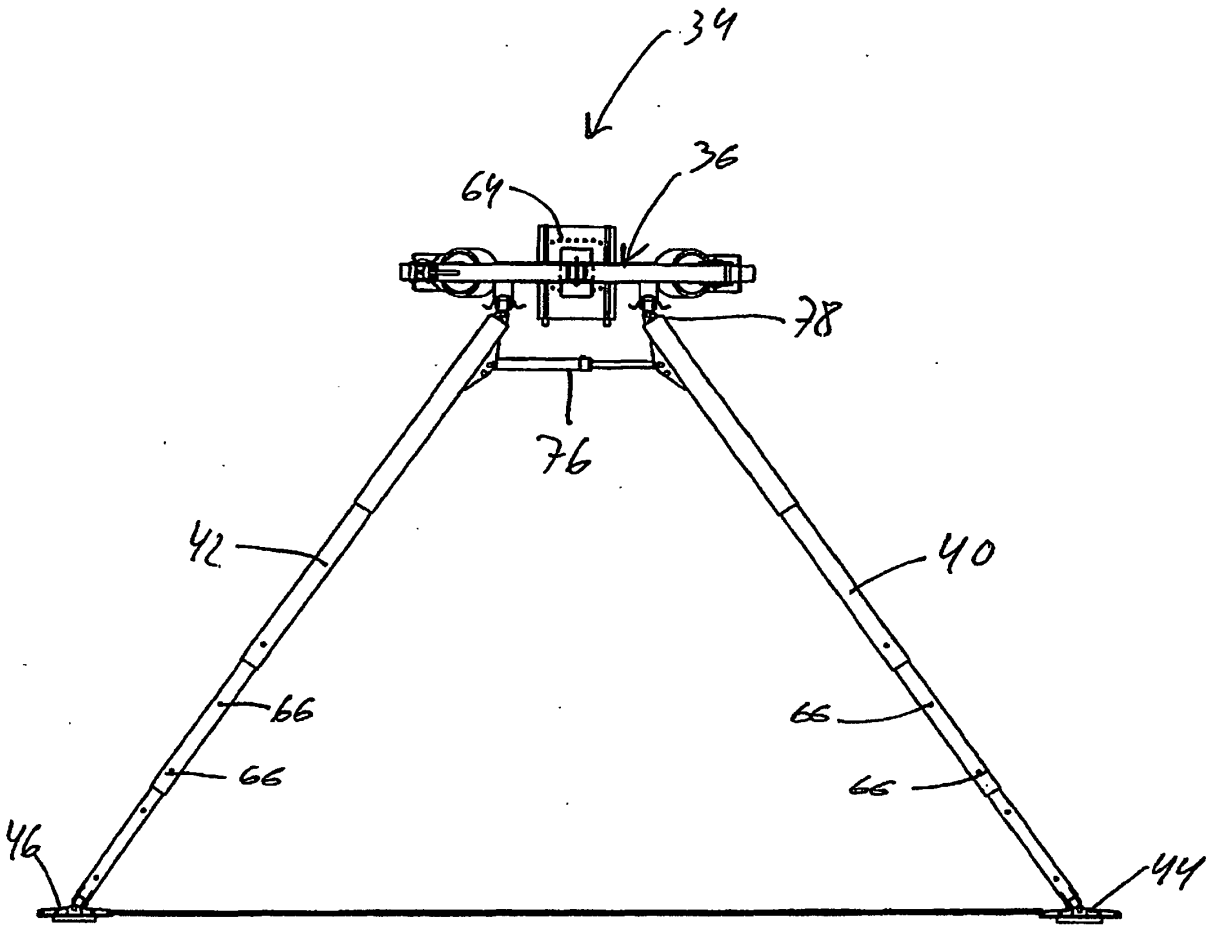


FIG. 2A


34
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36
78
76
42
40
66
66
66
66
46
44

FIG. 2B

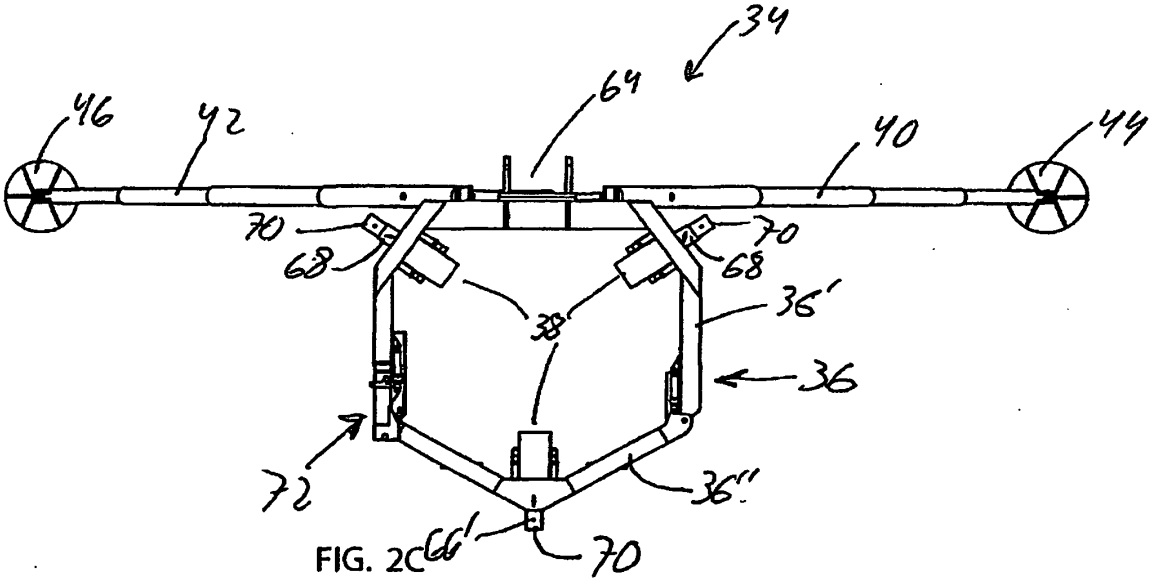
34
64
46
42
40
44
70
70
68
68
38
36'
36
72
36''
66'
70

FIG. 2C

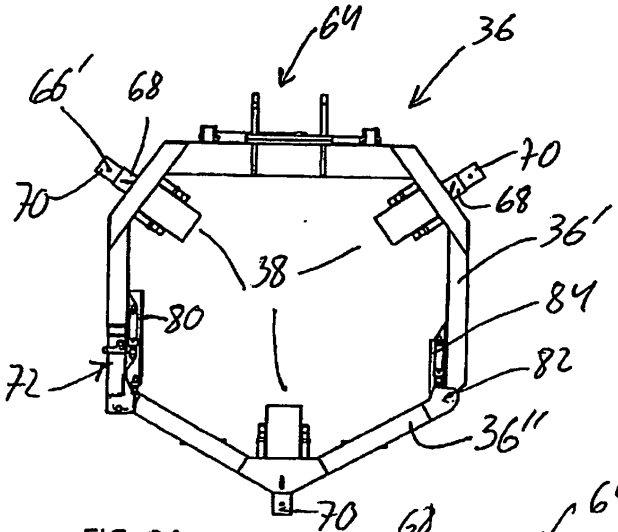

FIG. 3A

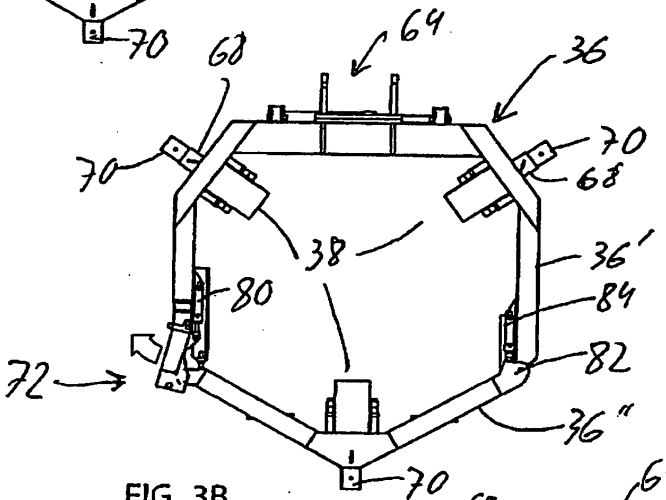

FIG. 3B

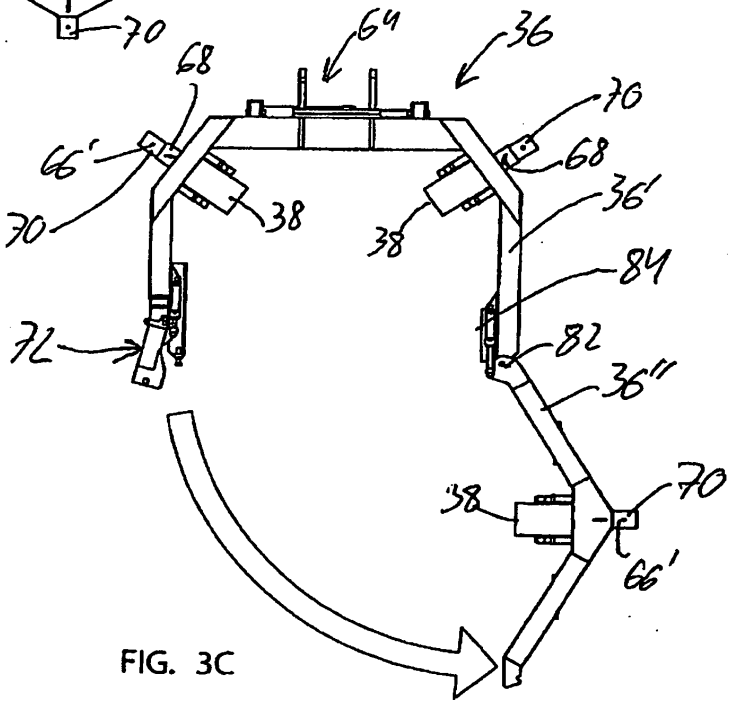

FIG. 3C

REFERENCES CITED IN THE DESCRIPTION

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