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(72) Inventor: **Gøttrup Christensen, Lars**  
**7182 Bredsten (DK)**

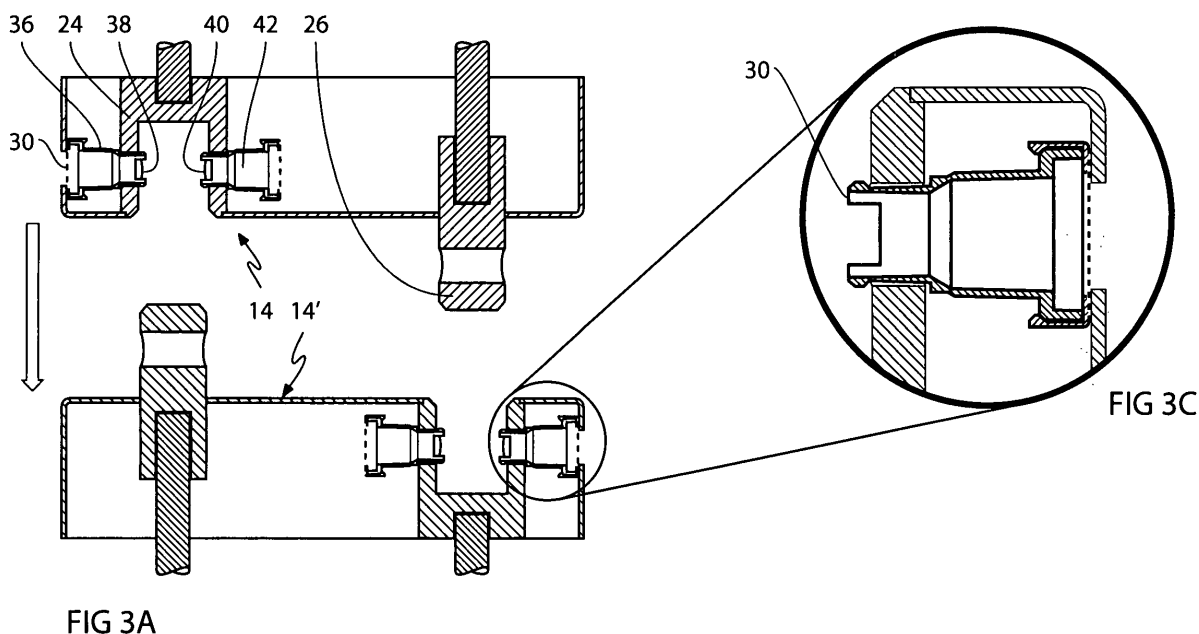
(74) Representative: **Nielsen, Henrik Sten et al**  
**Budde Schou A/S**  
**Vester Søgade 10**  
**1601 Copenhagen V (DK)**

(71) Applicant: **Centrum Pæle A/S**  
**7100 Vejle (DK)**

(54) **Pile extension**

(57) Method and system for joining two concrete piles together at their opposing ends by providing a pair of opposing coupling devices at the opposing ends. Each coupling device comprises a flat base plate defining a rear surface juxtaposed the pile, an opposite front surface and a periphery substantially concurrent with the end pe-

riphery of the pile, at least one reinforcement bar protruding into the pile from the rear surface and integrally cast into the pile, and a support flange extending from the periphery of the base plate, perpendicular to the rear surface and towards the pile. The support flange defines an aperture at a specific distance from the front surface.



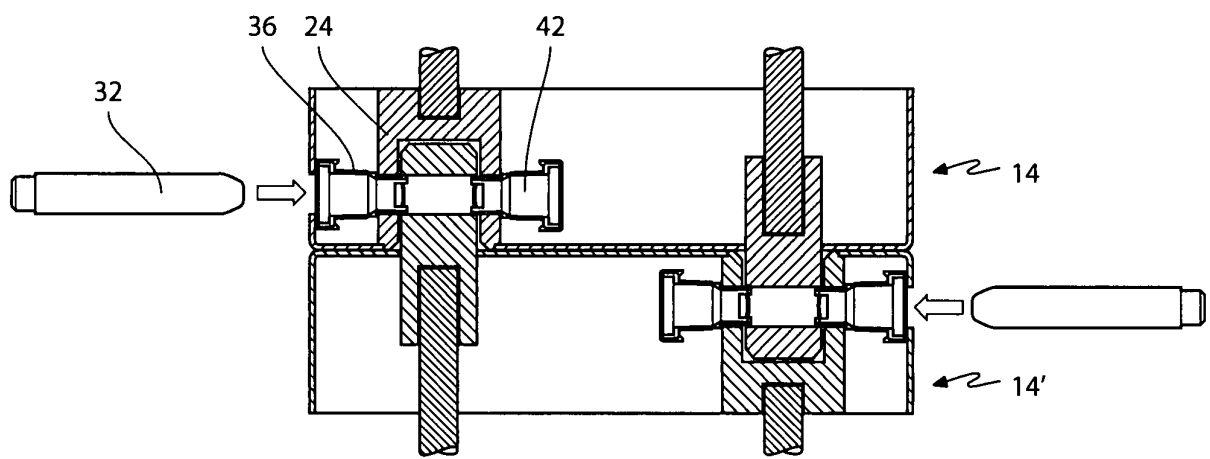


FIG 3B

## Description

**[0001]** Concrete piles are typically used for deep piling foundations, which are used when the upper soil layers are not suitable for accommodating a shallow foundation. Piles are often preferred over shallow foundations when the bearing capacity of the ground is weak in relation to the construction, which the foundation should support. By using a piling foundation the load from the construction may be transferred from the weak upper layers of the soil to stronger layers, which are typically found deeper in the ground. The piles are driven into the ground by using a pile driver or hammer or the like. The piles penetrate the soft upper soil layers and embed in the lower, more rigid lower soil layers. The piles are intended for embedment deep into the ground for providing a stable foundation for various structures such as buildings, bridges and similar constructions. The concrete piles are typically reinforced concrete piles, which are cast in standardized lengths. For reaching further into the ground than the standardized lengths the piles are fixated together end to end for achieving a total length greater than the standardized lengths. For fixating the two opposing ends of the concrete piles a coupling device is used. The coupling device is typically integrated into the end of the concrete pile when the concrete pile is being cast.

**[0002]** Such a pile foundation as described above may e.g. be used in soil layers at or near bodies of water such as near lakes or near the ocean. It is thus contemplated that the piles, which are embedded into the ground, may be subjected to a large amount of water. The water may penetrate the pile, in particular at locations where the piles have been joined. Such water penetrating the joints between the piles may cause rust and may eventually cause the pile to break, which will reduce the stability of the overlying construction. The penetrating water may also freeze at a later time when subjected to lower temperatures and cause damage to the pile. There is consequently a need for technologies for avoiding water penetration into the joints between two opposing piles.

**[0003]** In the state of the art the two opposing piles are typically coupled by applying a coupling device having a flat metal plate at the end of the opposing piles. The opposing coupling devices typically comprise reciprocal coupling elements, which may interact to provide a rigid fixation between the two opposing piles. The fixation must be rigid enough for sustaining the very large forces applied to the coupling device during piling, i.e. the fixation must endure repeated hammering without breaking. One example of such a coupling device may be found in the European patent application EP 1 127 195, in which a coupling device comprises a pair of loopholes which are fixated to a pair of opposing loopholes of an opposing coupling device by a pin. A further example can be found in the European patent application EP 0 891 454, in which a coupling device having a male coupling element comprising a protruding cylinder snap-fit interlocks with an opposing coupling device having a female coupling ele-

ment having a receiving cavity. In currently used coupling devices the opposing male and female coupling elements are joined and locked in position by a locking pin. For avoiding water penetration during use and concrete penetration during casting into the coupling device the locking pin has to be completely encapsulated inside a square metal box. The metal box should be sealed in relation to the pile for avoiding any concrete entering the locking pin duct and may thus only be accessible from the outside. A square female coupling element has the drawback of requiring a large amount of machining compared to a round coupling element. Thus, square female coupling elements will be significantly more expensive and less suitable for the present purpose.

**[0004]** It is therefore an object of the present invention to provide a system and method for joining two concrete piles together at their respective opposing ends by providing a coupling device. The coupling device should comprise coupling elements of substantially only round shape.

**[0005]** The above need and object together with numerous other needs and objects, which will be evident from the below detailed description, are according to a first aspect of the present invention obtained by a method for joining two concrete piles together at their respective opposing ends by providing a pair of opposing coupling devices at the opposing ends, each of the coupling devices comprising:

a flat base plate defining a rear surface juxtaposed the pile, an opposite front surface and a periphery substantially concurrent with the end periphery of the pile,  
at least one reinforcement bar protruding into the pile from the rear surface and integrally cast into the pile, and  
a support flange extending from the periphery of the base plate, perpendicular to the rear surface and towards the pile, the support flange defining an aperture at a specific distance from the front surface, the aperture having a specific diameter,

at least one of the pair of coupling devices comprising:

a female coupling element defining a receptor cavity in the front surface and a protrusion from the rear surface adjacent to the aperture, the receptor cavity defining a tubular cylinder defining a first hole opposite the aperture and a second hole opposite the first hole, both holes having a specific diameter and defining a passage through the receptor cavity, the passage being located in registration with the aperture, a tube of flexible material defining an inner diameter corresponding to a specific diameter and connected fluid-tight between the first hole and the aperture, a hollow plug of flexible material defining an open end and an opposite closed end, the open end being connected fluid-tight to the second hole, and

at least the other one of the pair of coupling devices comprising:

a male coupling element protruding outwardly from the front surface and defining an outer shape fitting into the tubular cylinder of the receptor cavity of the opposing coupling device, the outer shape defining a cylindrical duct of a specific diameter located a specific distance from the front surface and extending through the male coupling element for allowing the duct to be positioned in registration with the aperture of the opposing coupling device, concurrent to the passage, and

the pair of coupling devices comprising:

a locking pin defining a radial dimension of a specific diameter and an axial dimension matching the distance between the aperture and the closed end of the hollow plug,

the method further comprising performing the steps of:

juxtaposing the front surfaces of the pair of coupling devices so that the peripheries are concurrent and the male coupling element is received within the receptor cavity, thereby forming a channel defined by the aperture, the first hole, the cylindrical duct, the second hole and the hollow plug, and inserting the locking pin into the channel.

**[0006]** The concrete piles should be prefabricated concrete piles such as reinforced concrete piles which are provided in lengths between approx. 4 m and approx. 20 m. The piles are driven into the ground by a pile driver comprising a hammer or the like. An example of a suitable pile driver may be found in the European patent applications 0 392 311 and 0 984 105. The pile driver forces the pile into the ground by the use of a repeated hammering action. When the first pile has been driven into the ground, a further pile may be positioned on top of the first pile, thereby enabling the total pile length to extend deeper into the ground. Often more than two piles must be joined together for reaching to a suitable depth into the ground. Sometimes, the piles must be driven more than 50 m into the ground, such as 80 m into the ground, and since a single pile typically cannot be longer than about 20 m, several piles must be connected and driven into the ground. Piles longer than 20 m would require unsuitably large pile drivers and would additionally cause logistic problems, since they would require special carriers for being transported to the installation site.

**[0007]** For permitting the piles to be connected together, a coupling device is provided at each end of the opposing pile. The coupling device is cast into the pile already during manufacture of the pile itself. The piles are factory-cast and subsequently delivered to the installation site. The coupling device comprises the flat base

plate for defining a substantially flat and stable front surface being the contact area between the two opposing piles. In this way the weight resting on the pile will be distributed over the complete surface of the base plate.

5 The reinforcement bar extending from the rear surface of the base plate and the support flange prevent any substantial movement of the base plate, both during and after installation. The periphery of the base plate should be substantially concurrent with the end periphery of the pile  
10 for allowing a stable and secure foundation and proper weight distribution. The opposing base plates should be aligned to transfer the weight of the overlying structures downwardly. Any misalignment may increase the risk of installation failure or a later foundation failure, which may  
15 in the worst case cause the overlying structure to collapse.

**[0008]** The female coupling element comprises a receptor cavity, which is adapted to receive the male coupling element comprising a cylindrical protrusion. The female coupling element should accommodate the male coupling element of the opposing coupling device. When the lower pile has been driven into the ground, the upper pile is positioned on top of the lower pile so that the male coupling element of one of the coupling devices is accommodated inside the cavity of the female coupling element of the other coupling device, or vice versa. The coupling elements constitutes round cylinders, which are simple to manufacture compared to manufacturing square-shaped structures as in the prior art technology described above. The female and male coupling elements should be positioned on the flat base plate in a symmetrical pattern for allowing the opposing base plates to be juxtaposed without any overlapping or misalignment. The coupling elements should be placed a  
25 certain distance from the periphery of the base plate and should consequently not have any contact with the periphery of the base plate. The support flange extends from the periphery of the base plate rearwards, encapsulating the end part of the pile similar to a sleeve. The female coupling element constitutes a cavity into the front surface of the base plate. The cavity is as well cast into the pile. The cavity constitutes a rounded cylinder having a length approximately corresponding to the extension of the support flange. The aperture in the support flange and the passage defined by the first hole and the second hole of the female coupling element should be centrally located in registration at about half the distance between the rear surface of the base plate and the end of the support flange and preferably perpendicular to the direction of the pile. The male coupling element should have an outer shape fitting into the receptor cavity of the female coupling element. By fitting is meant that substantially no sideward movement should be possible when the female coupling element and the male coupling element are  
30 joined and a well-defined position is achieved. The male coupling element comprises a cylindrical duct at a distance from the front surface of the flat base plate corresponding to the distance between the front surface of the  
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flat base plate and the first and second holes of the female coupling element. In this way, when the coupling devices are juxtaposed and the male coupling element is accommodated inside the receptor cavity of the female coupling element, the duct of the male coupling element is positioned in registration with the aperture and the first and second holes. In this way, the coupling devices are assembled.

**[0009]** For avoiding any concrete blocking the space between the aperture and the first hole and for avoiding any concrete entering the receptor cavity or escaping through the first aperture when the pile is being cast, a tube is attached fluid-tight between the aperture and the first hole and a hollow plug is attached fluid-tight to the second hole, respectively. The tube and a hollow plug should be made of flexible material, providing a smooth and fluid-tight connection between the aperture and the hollow plug. Consequently, water from the outside cannot penetrate the end part of the pile and concrete cannot penetrate the receptor cavity of the female coupling element. Water penetrating the end part of the pile may cause corrosion as well as frost damages if the penetrating water freezes. Concrete entering the receptor cavity will render the coupling element useless, since the female coupling element will not be able to accommodate the male coupling element.

**[0010]** The channel resulting from assembling the coupling devices is typically filled with grease such as consistent grease or the like. The grease will simplify the insertion of the locking pin as well as prevent any water from entering the coupling device through the aperture. The locking pin should fit inside the channel for preventing the assembled opposing coupling devices from disassembling. One locking pin should be inserted in each male-female assembled pair of coupling elements. All parts of the coupling device, except the tube and the hollow plug, should be made of rigid material capable of withstanding the forces subjected to the pile from the overlying structures. The locking pin is preferably hammered into the aperture so that it is suitably fixated by the friction inside the channel. The outwardly end of the locking pin preferably forms an even surface with the support flange for avoiding any damage on the contact pin due to friction with the ground when the pile is being driven into the ground.

**[0011]** In a further embodiment according to the first aspect, the base plate, reinforcement bar, support flange, female coupling element and male coupling element are made of iron or an iron alloy such as steel. The coupling device except the tubular and hollow bodies is preferably made of iron or an iron alloy such as steel due to the great rigidity needed for supporting the foundation.

**[0012]** In a further embodiment according to the first aspect, the flexible material of the tube and the hollow plug constitutes a polymeric material such as plastic. The tube and the hollow plug are preferably made of a plastic material, since plastic materials are durable and flexible for allowing a fluid-tight connection.

**[0013]** In a further embodiment according to the first aspect, the locking pin and the hollow plug comprise locking elements for snap-fit interlocking with each other. The hollow plug may comprise locking elements so that when the locking pin is inserted in the channel and the tip of the locking pin enters the hollow plug, the hollow plug snaps around the tip for preventing the locking pin from leaving the channel. In this way it may be ensured that the locking pin does not fall out of the channel, e.g. during hammering.

**[0014]** In a further embodiment according to the first aspect, the tube and the hollow plug extend partially into the receptor cavity for snap-fit interlocking with the duct of the opposing coupling device. The tube and the hollow plug may extend partially into the receptor cavity at the first and second hole, respectively, for snap-fitting and locking with the male coupling element of the opposing coupling device. In this way, a smooth transition between the first and second coupling device is achieved, thereby simplifying the insertion of the locking pin. In addition, the gap - if any - between the first and male coupling element, viz. between the first hole and the duct, is sealed, preventing any liquid or fluid between the first and male coupling elements.

**[0015]** In a further embodiment according to the first aspect, the base plate defines an area of about 30 x 30 cm and the pile has a length of about 4-20 m. The typical size of a coupling device used for construction purposes is about 30 cm x 30 cm, i.e. a square shape. The typical length of a pile is about 4 to 20 m. Longer piles are not feasible due to limitations in the height of the pile driver and due to logistic limitations.

**[0016]** In a further embodiment according to the first aspect, each of the opposing coupling elements comprises the female coupling element, the tube, the hollow plug, the locking pin and the male coupling element. The above embodiment provides more flexibility since the risk of accidentally orienting the piles falsely is eliminated, because the same type of coupling element is used for both sides of each pile. More coupling elements provide additional stability.

**[0017]** In a further embodiment according to the first aspect, for each of the coupling devices, the cylindrical duct of the male coupling device is extending perpendicular to the passage of the female coupling device or, alternatively, the cylindrical duct of the male coupling device is extending in parallel to the passage of the female coupling device. Typically, a square coupling device is used having a square base plate. Consequently, the support flange comprises four side surfaces. For maximum flexibility and stability, the duct of the male coupling element is perpendicular to the channel of the female coupling element of the same coupling device so that the opposing coupling device should be turned 90 degrees for being juxtaposed the first coupling device. In this way, the locking pins of the opposing coupling device are perpendicular to the locking pins of the first coupling device. This way, two different orientations are possible. Alter-

natively, the coupling devices are arranged so that all contact pins have the same orientation. In this way, only one orientation is possible.

**[0018]** In a further embodiment according to the first aspect, each of the coupling devices comprises a plurality of female coupling elements and a plurality of male coupling elements, such as two female coupling elements and two male coupling elements for each coupling device. In particular, the coupling device comprises two coupling elements of the first type and two corresponding coupling elements of the second type. The first and male coupling elements should be distributed on the base plate in a symmetrical pattern, e.g. have the same distance from the central point of the coupling device to the respective peripheries of the base plates. By having at least four coupling elements per coupling device, excellent stability is achieved for ensuring a perfect alignment of the opposing base plates.

**[0019]** In a further embodiment according to the first aspect, the two respective male and female coupling elements are located in a crossover pattern, i.e. in opposite corners of the base plate in relation to each other. By a crossover pattern, an outstanding stability is achieved for forces in all possible directions.

**[0020]** In a further embodiment according to the first aspect, the male coupling element constitutes a removable part, which may be inserted into the reception cavity of the female coupling device. In this way, the coupling device may be manufactured with only female coupling elements, and some, i.e. half, of the female coupling elements may be transformed to male coupling elements by using a removable male coupling device part.

**[0021]** The above need and object together with numerous other needs and objects, which will be evident from the below detailed description, are according to a second aspect of the present invention obtained by a system comprising two concrete piles joined together at their respective opposing ends by a pair of opposing coupling devices at the opposing ends, each of the coupling devices comprising:

a flat base plate defining a rear surface juxtaposed the pile, an opposite front surface and a periphery substantially concurrent with the end periphery of the pile for juxtaposing the front surfaces of the pair of coupling devices so that the peripheries are concurrent,  
at least one reinforcement bar protruding into the pile from the rear surface and integrally cast into the pile, and  
a support flange extending from the periphery of the base plate, perpendicular to the rear surface and towards the pile, the support flange defining an aperture at a specific distance from the front surface, the aperture having a specific diameter,

at least one of the pair of coupling devices comprising:

a female coupling element defining a receptor cavity in the front surface and a protrusion from the rear surface adjacent to the aperture, the receptor cavity defining a tubular cylinder defining a first hole opposite the aperture and a second hole opposite the first hole, both holes having a specific diameter and defining a passage through the receptor cavity, the passage being located in registration with the aperture, a tube of flexible material defining an inner diameter corresponding to a specific diameter and connected fluid-tight between the first hole and the aperture, a hollow plug of flexible material defining an open end and an opposite closed end, said open end being connected fluid-tight to the second hole,

at least the other one of the pair of coupling devices comprising:

a male coupling element protruding outwardly from the front surface and defining an outer shape fitting into the tubular cylinder of the receptor cavity of the opposing coupling device, the outer shape defining a cylindrical duct of a specific diameter located a specific distance from the front surface and extending through the male coupling element for allowing the duct to be positioned in registration with the aperture of the opposing coupling device, concurrent to the passage, the male coupling element being received within the receptor cavity, thereby forming a channel defined by the aperture, the first hole, the cylindrical duct, the second hole and the hollow plug, and

the pair of coupling devices comprising:

a locking pin for being inserted into the channel, the locking pin defining a radial dimension of a specific diameter and a axial dimension matching the distance between said aperture and the closed end of the hollow plug.

**[0022]** It is evident that the system described above may be used together with the method described above.

**[0023]** The present invention will now be further described with reference to the figures, in which:

Fig. 1 is a pile system having opposing coupling devices,

Fig. 2 is a perspective view of a pair of opposing coupling devices, and

Fig. 3 is a cutout view of a pair of opposing coupling devices.

**[0024]** The figures illustrate numerous exemplary embodiments of the coupling device according to the present invention.

**[0025]** Fig. 1A shows a pile system 10 comprising a pair of opposing upper and lower piles 12, 12', each hav-

ing a respective upper and lower coupling device 14, 14'. The coupling devices 14, 14' are of a first type configuration. The upper coupling device 14 is accommodated on an upper pile 12 and the lower coupling device 14' is accommodated on a lower pile 12'. The piles constitute reinforced concrete piles of a length of about 10 m and a cross-section area of about 30 x 30 cm. The lower pile 12' has been driven into the ground by means of a hydraulic hammer. The upper and lower coupling devices 14, 14' are firmly fixated to their respective piles 12, 14 and assume opposing flat front surfaces 16, 16'. The coupling devices 14, 14' each comprises a substantially flat base plate 20 and a support flange 22 extending inwardly and constituting a sleeve covering the end part of the pile 12, 12'. The coupling devices 14, 14' further comprise a pair of female coupling elements 24 located in a cross-over configuration at opposite corners on the plate 20 as well as corresponding male coupling elements 26 located at the other opposite corners on the plate 20. The female coupling elements constitute tube-shaped receptor cavities 18 in the front surface 16. The male coupling elements constitute tubular protrusions in the front surface 16, which in shape and length fit inside the receptor cavities 18 of the female coupling element 24. The male and female coupling elements 24, 26 are positioned symmetrically on the base plate 20 having equal distance from each of the coupling elements 24, 26 to the centre of the front surface 16. The upper coupling device 14 is positioned opposite the lower coupling device 14' so that the female coupling elements 24 of the upper coupling device 14 are positioned opposite the male coupling elements of the lower coupling device 14'. Consequently, the male coupling elements of the upper coupling device 14 should be positioned opposite the female coupling elements 26 of the lower coupling device 14', and vice versa. The coupling devices 24, 26 should be positioned on the front surface 16 so that the front surfaces and the periphery of the front surfaces 16 may concur when the coupling devices 14, 14' are juxtaposed. The above-mentioned position may be referred to as the pre-assembly position of the piling system 10. It should be noted that in the present type configuration a further pre-assembly position is achieved by rotating the upper pile 12 around its axis by 180 degrees. When any of the pre-assembly positions have been achieved, the coupling devices 14, 14' may be juxtaposed. In the juxtaposed position, the front surfaces 16 and the periphery of the front surfaces 16 of the opposing coupling devices 14, 14' will concur, and the male coupling element 26 will be accommodated within the receptor cavity 18 of the female coupling element 24. The female and male coupling elements 24, 26 should have a tubular shape. The female and male coupling elements 24, 26 may therefore be manufactured by using standard machinery such as a lathe and a drill. The coupling elements may subsequently be welded to the coupling device.

**[0026]** Fig. 1B shows a pile system 10' similar to the pile system 10 of Fig. 1A, however, having a different

type configuration. The coupling device 14" of the present embodiment has the male coupling elements 26 at the two respective corners which define the same side of the base plate 20, and the two female coupling elements 24 at the corners defining the opposite side of the base plate 20. The opposite lower coupling device 14''' has corresponding female and male coupling elements 24, 26. The present type configuration enables one pre-assembly position.

**[0027]** Fig. 1C shows a pile system 10" being similar to the pile system 10 of Fig. 1A, however, having a third type configuration. In the present embodiment, the upper coupling device 14<sup>IV</sup> comprises four male coupling elements 26, which are located at each of the corners of the base plate 20. The lower coupling device 14<sup>V</sup> has corresponding female coupling elements 24 for accommodating the male coupling elements 26 of the upper coupling device 14<sup>IV</sup>. The present type configuration has the drawback of needing two fundamentally different coupling devices 14<sup>IV</sup>, 14<sup>V</sup>, one having only female coupling elements 24 and one having only male coupling elements 26. Thereby the risk of an accidental incorrect pre-assembly position increases, e.g. the risk of occasionally having two opposite coupling devices of the same kind.

**[0028]** Fig. 1D shows a pile system 10''' being similar to the pile system 10" of Fig. 1C, however, having a fourth type configuration. In the present embodiment, both the upper coupling device 14<sup>VI</sup> and the lower coupling device 14<sup>VII</sup> comprise only female coupling elements 24. The male coupling elements 26' comprise loose male coupling element parts, which may be inserted into the female coupling elements 26 of one of the coupling devices, thereby transforming the female coupling elements into male coupling elements. The risk of an incorrect pre-assembly position as discussed above in relation to Fig. 1C is thus decreased.

**[0029]** Fig. 2A shows an upper coupling device 14 and lower coupling device 14' before being joined together. The lower coupling device 14' has two male coupling elements 26 located at opposing corners on the base plate 20 and protruding outwardly. At the other opposing corners of the base plate 20 two female coupling elements are located.

**[0030]** The male coupling elements 26 constitute circular cylindrical protrusions protruding outwardly in relation to the front surface of the base plate 20. The male coupling element 26 has a circular duct 28 penetrating the cylindrical surface of the male coupling element 26 at a centralized location and a certain distance of about 1 cm above the front surface. The female coupling element 24 defines a receptor cavity in the front surface, having an inner shape for fitting a male coupling element 26. The female coupling element 24 protrudes at the rear surface of the base plate 20 and defines a first and a second hole (not shown), which defines a channel intersecting the receptor cavity of the female coupling element 24 at a centralized location and about 1/2 cm from the rear surface. The female coupling element extends from

the rear surface about 2 cm, which is equal to the distance, in which the support flange 22 extends. The support flange 22 has an aperture 30, which is in registration with the first and second hole (not shown) of the female coupling element 24. The diameter of the first hole, second hole and aperture is equal to the diameter of the duct 28. A locking pin 32 is provided for each female coupling element 24. The female coupling element has a diameter matching the inside of the duct 28, and a matching length corresponding to the distance between the aperture 30 and at least through the second hole (not shown). Each of the male and female coupling elements 24, 26 has a reinforcement bar 34, extending inwardly into the pile (not shown). The reinforcement bar 34 is cast into the pile for fixating the coupling device to the pile (not shown). The support flange 22, which is filled with concrete, provides additional stability to the coupling device 14.

**[0031]** Fig. 2B shows the two opposing upper and lower coupling devices 14, 14', when they are assembled. When the coupling devices 14, 14' are assembled, the front surfaces 16 of the respective coupling devices are juxtaposed so that their respective peripheries concur and their respective male coupling elements 26 are accommodated in the receiving receptor cavities of the corresponding female coupling elements 24 of the opposite coupling device. In the assembled position, the aperture 30, the first and second holes (not shown) and the duct (not shown) are put in registration so that the locking pin 32 may be inserted in each of the apertures 30. A hammer may be used for assuring that the locking pin 32 reaches its locked position when the end of the locking pin 32 forms an even surface in relation to the support flange 22. When the locking pin 32 has reached the locking position, the coupling devices 14, 14' and their respective piles 12, 12' are joined together and fixated. Any movement of the piles 12, 12' and coupling devices 14, 14' in any direction is thereby prevented.

**[0032]** Fig. 3A shows a cut-out view of the coupling devices of Fig. 2A. A tube 36 is provided between the aperture 30 and the first hole 38. The tube 36 is made of plastic material and provides a fluid-tight connection between the aperture 30 and the receptor cavity 18 defined by the female coupling element 24. The tube has an interior passage having a dimension corresponding to the previously mentioned cylindrical duct of the male coupling element 26. The space defined inside the base plate 20 and the support flange 22 will be filled with concrete and constitute the end part of the pile. The tube 36 prevents any concrete from entering the receptor cavity 18 via the first hole 38 during casting. The tube 36 further prevents concrete from escaping through the aperture 30. The tube 36 will as well prevent water from the outside penetrating the end part of the pile. The oppositely located second hole 40 is connected to a hollow plug 42 made of plastic material and extending outwardly in relation to the female coupling element 24. The hollow plug 42 has an inner groove corresponding to the tube 36, however, is sealed at its far end for preventing any concrete from

entering the second hole 40. The groove of the hollow plug 42 has a diameter corresponding to the cylindrical duct 28 of the male coupling element and a length suitable for receiving the front end part of the locking pin (not shown).

**[0033]** Fig. 3B shows a cut-out view of the two opposing upper and lower coupling devices 14, 14' when they are assembled as shown in Fig. 2B. The male coupling elements 26 are received within the receptor cavity 18 of the female coupling elements 24, and a channel is defined from the aperture 30 via the tube 26, the first hole 38, the duct 28, the second hole 40 to the hollow plug 42. The locking pin 32 is inserted into the channel for fixating the male and female coupling elements 24, 26 in relation to each other, thereby fixating the upper and lower coupling devices 14, 14'. The channel is typically filled with grease such as consistence grease for preventing any water from entering the channel when the pile is embedded in the ground.

**[0034]** Fig. 3C shows a close-up view of the tube 46. The tube is sealed fluid-tight at the aperture 30 of the support flange 22 and at the first hole 38 of the female coupling element 24. The tube 46 comprises a locking flange 44 extending through the first hole into the receptor cavity of the female coupling element 24 for providing a sealed and smooth transition between the first hole 38 of the female coupling element 24 and the duct 28 of the male coupling element 26, when the coupling devices have been juxtaposed. The hollow plug (not shown here) is fitted with similar locking flanges 44 for providing a sealed and smooth connection between the second hole and the hollow plug.

**[0035]** It should be noted that in the present embodiment, the tube 36 and the hollow plug 42 may constitute effectively equivalent components, namely a pipe being open towards the receptor cavity 18 and closed off by a pierceable cap in the opposite direction. The dashed line in the figure represents a pierceable membrane, which is a part of the pierceable cap. The pierceable membrane prevents concrete from entering the channel. The pierceable membrane of the tube 36 is ruptured by driving the locking pin 32 through the aperture 30. The pierceable membrane constitutes a plastic membrane having slits, which are closed while the concrete pile 12 is cast to the coupling device 14, and the slits are separated when the locking pin is driven through the aperture 30. Alternatively, the pierceable cap may be omitted and the pipe being a part of the hollow plug 42 may be provided with a non-pierceable cap, whereas the pipe being a part of the tube 36 may be left open towards the aperture 30.

**[0036]** Although the invention has been described above with reference to a number of specific and advantageous embodiments, it is to be understood that the present invention is by no means limited to the above disclosure of the above described advantageous embodiments, as the features of the above-identified embodiments may be combined to provide additional embodiments. The additional embodiments are all construed to



be part of the present invention. Furthermore, the present invention is to be understood encompassed by any equivalent or similar structure as described above and also to be encompassed by the scope limited by the below claims defining the protective scope of the present patent application.

List of features with reference to the figures:

**[0037]**

- 10. Pile system
- 12. Concrete pile
- 14. Coupling device
- 16. Front surface
- 18. Receptor cavity
- 20. Base plate
- 22. Support flange
- 24. Female coupling element
- 26. Male coupling element
- 28. Cylindrical duct
- 30. Aperture
- 32. Locking pin
- 34. Reinforcement bar
- 36. Tube
- 38. First hole
- 40. Second hole
- 42. Hollow plug
- 44. Locking flange

**Claims**

1. A method for joining two concrete piles together at their respective opposing ends by providing a pair of opposing coupling devices at said opposing ends, each of said coupling devices comprising:

a flat base plate defining a rear surface juxtaposed said pile, an opposite front surface and a periphery substantially concurrent with the end periphery of said pile,  
at least one reinforcement bar protruding into said pile from said rear surface and integrally cast into said pile, and  
a support flange extending from said periphery of said base plate, perpendicular to said rear surface and towards said pile, said support flange defining an aperture at a specific distance from said front surface, said aperture having a specific diameter,

at least one of said pair of coupling devices comprising:

a female coupling element defining a receptor cavity in said front surface and a protrusion from said rear surface adjacent to said aperture, said

receptor cavity defining a tubular cylinder defining a first hole opposite said aperture and a second hole opposite said first hole, both holes having said specific diameter and defining a passage through said receptor cavity, said passage being located in registration with said aperture, a tube of flexible material defining an inner diameter corresponding to said specific diameter and connected fluid-tight between said first hole and said aperture,  
a hollow plug of flexible material defining an open end and an opposite closed end, said open end being connected fluid-tight to said second hole, and

at least the other one of said pair of coupling devices comprising:

a male coupling element protruding outwardly from said front surface and defining an outer shape fitting into said tubular cylinder of said receptor cavity of said opposing coupling device, said outer shape defining a cylindrical duct of said specific diameter located said specific distance from said front surface and extending through said male coupling element for allowing said duct to be positioned in registration with the aperture of the opposing coupling device, concurrent to said passage, and

said pair of coupling devices comprising:

a locking pin defining a radial dimension of said specific diameter and a axial dimension matching the distance between said aperture and said closed end of said hollow plug,

said method further comprising performing the steps of:

juxtaposing said front surfaces of said pair of coupling devices so that said peripheries are concurrent and said male coupling element is received within said receptor cavity, thereby forming a channel defined by said aperture, said first hole, said cylindrical duct, said second hole and said hollow plug, and inserting said locking pin into said channel.

2. The method according to claim 1, wherein said base plate, reinforcement bar, support flange, female coupling element and male coupling element are made of iron or an iron alloy such as steel.

3. The method according to any of the preceding claims, wherein said flexible material of said tube and said hollow plug constitute a polymeric material such as plastic.

4. The method according to any of the preceding claims, wherein said locking pin and said hollow plug comprise locking elements for snap-fit interlocking with each other. 5
5. The method according to any of the preceding claims, wherein said tube and said hollow plug extend partially into said receptor cavity for snap-fit interlocking with said duct of said opposing coupling device. 10
6. The method according to any of the preceding claims, wherein said base plate defines an area of about 30 x 30 cm and said pile has a length of about 4-20 m. 15
7. The method according to any of the preceding claims, wherein each of said opposing coupling elements comprises said female coupling element, said tube, said hollow plug, said locking pin and said male coupling element. 20
8. The method according to claim 7, wherein for each of said coupling devices, said cylindrical duct of said male coupling device is extending perpendicular to said passage of said female coupling device or, alternatively, said cylindrical duct of said male coupling device is extending in parallel to said passage of said female coupling device. 25  
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9. The method according to any of the preceding claims, wherein each of said coupling devices comprises a plurality of female coupling elements and a plurality of male coupling elements, such as two female coupling elements and two male coupling elements for each coupling device. 35
10. The method according to claim 9, wherein said two respective male and female coupling elements are located in a crossover pattern, i.e. in opposite corners of the base plate in relation to each other. 40
11. The method according to any of the preceding claims, wherein said male coupling element constitutes a removable part, which may be inserted into said reception cavity of said female coupling device. 45
12. A system comprising two concrete piles joined together at their respective opposing ends by a pair of opposing coupling devices at said opposing ends, each of said coupling devices comprising: 50

a flat base plate defining a rear surface juxtaposed said pile, an opposite front surface and a periphery substantially concurrent with the end periphery of said pile for juxtaposing said front surfaces of said pair of coupling devices so that said peripheries are concurrent, 55

at least one reinforcement bar protruding into said pile from said rear surface and integrally cast into said pile, and  
a support flange extending from said periphery of said base plate, perpendicular to said rear surface and towards said pile, said support flange defining an aperture at a specific distance from said front surface, said aperture having a specific diameter,

at least one of said pair of coupling devices comprising:

a female coupling element defining a receptor cavity in said front surface and a protrusion from said rear surface adjacent to said aperture, said receptor cavity defining a tubular cylinder defining a first hole opposite said aperture and a second hole opposite said first hole, both holes having said specific diameter and defining a passage through said receptor cavity, said passage being located in registration with said aperture, a tube of flexible material defining an inner diameter corresponding to said specific diameter and connected fluid-tight between said first hole and said aperture,  
a hollow plug of flexible material defining an open end and an opposite closed end, said open end being connected fluid-tight to said second hole,

at least the other one of said pair of coupling devices comprising:

a male coupling element protruding outwardly from said front surface and defining an outer shape fitting into said tubular cylinder of said receptor cavity of said opposing coupling device, said outer shape defining a cylindrical duct of said specific diameter located said specific distance from said front surface and extending through said male coupling element for allowing said duct to be positioned in registration with the aperture of the opposing coupling device, concurrent to said passage, said male coupling element being received within said receptor cavity, thereby forming a channel defined by said aperture, said first hole, said cylindrical duct, said second hole and said hollow plug, and

said pair of coupling devices comprising:

a locking pin for being inserted into said channel, said locking pin defining a radial dimension of said specific diameter and an axial dimension matching the distance between said aperture and said closed end of said hollow plug.

13. The system according to claim 12, further comprising any of the features of claims 1-11.

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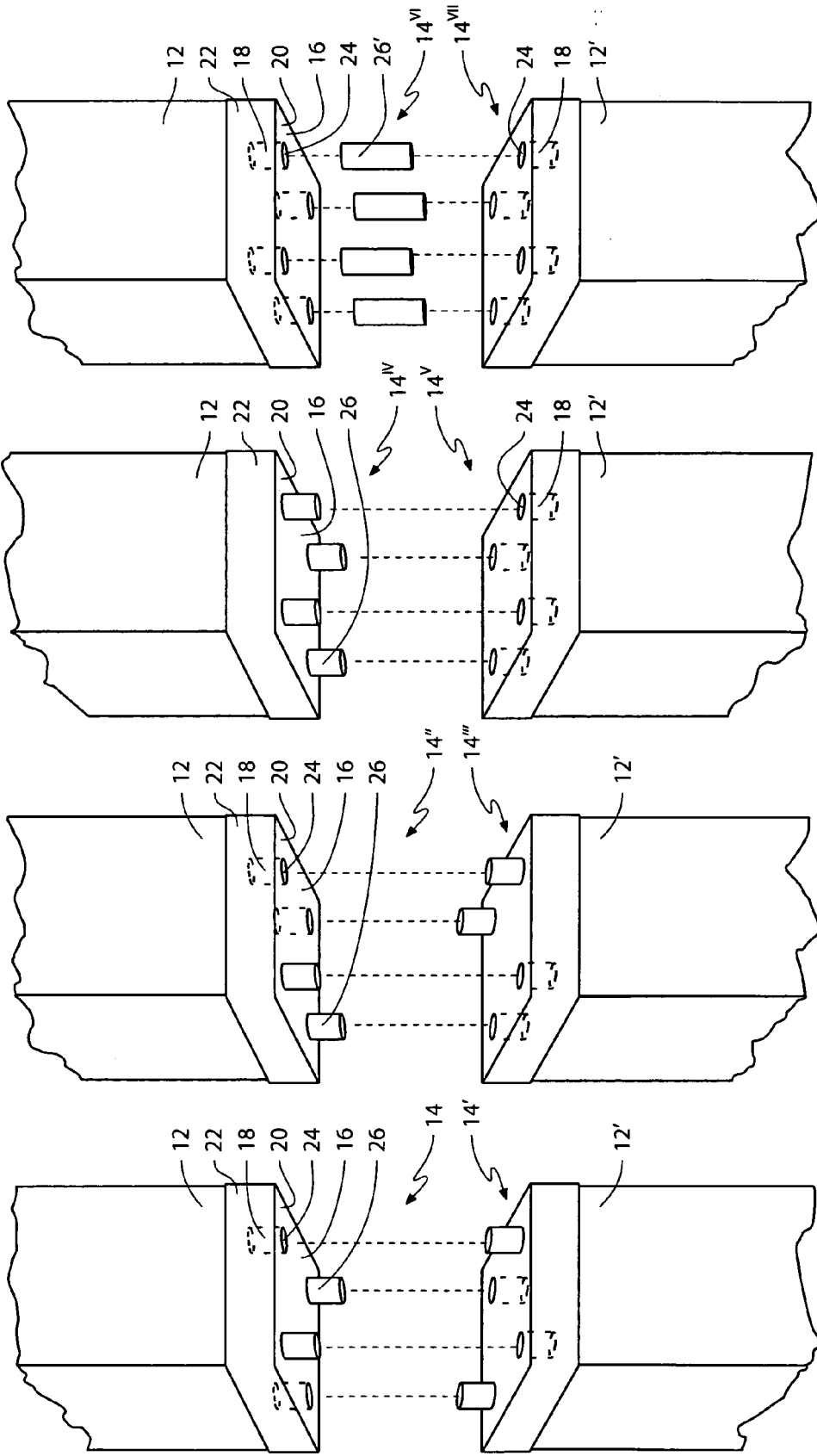
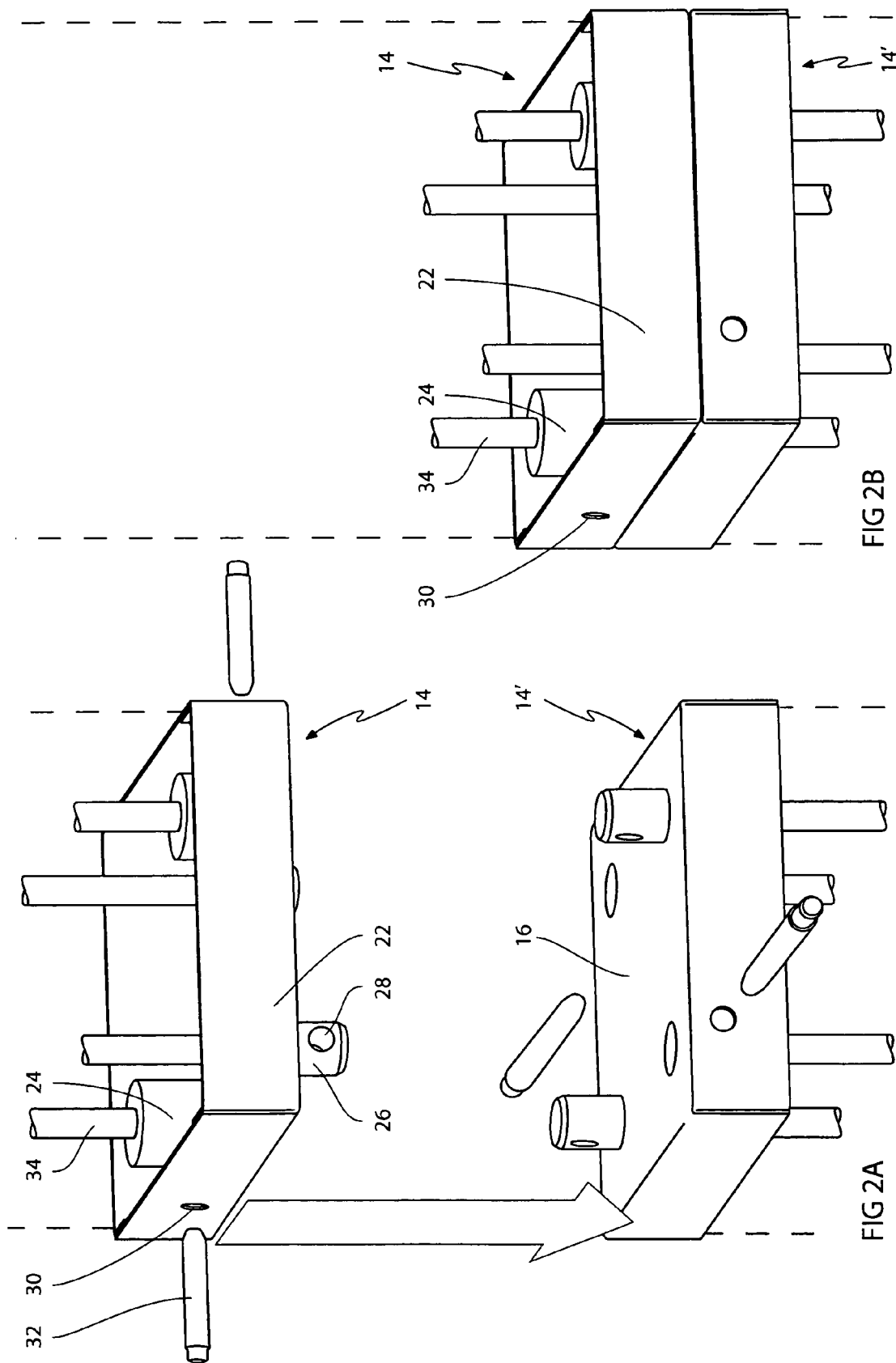


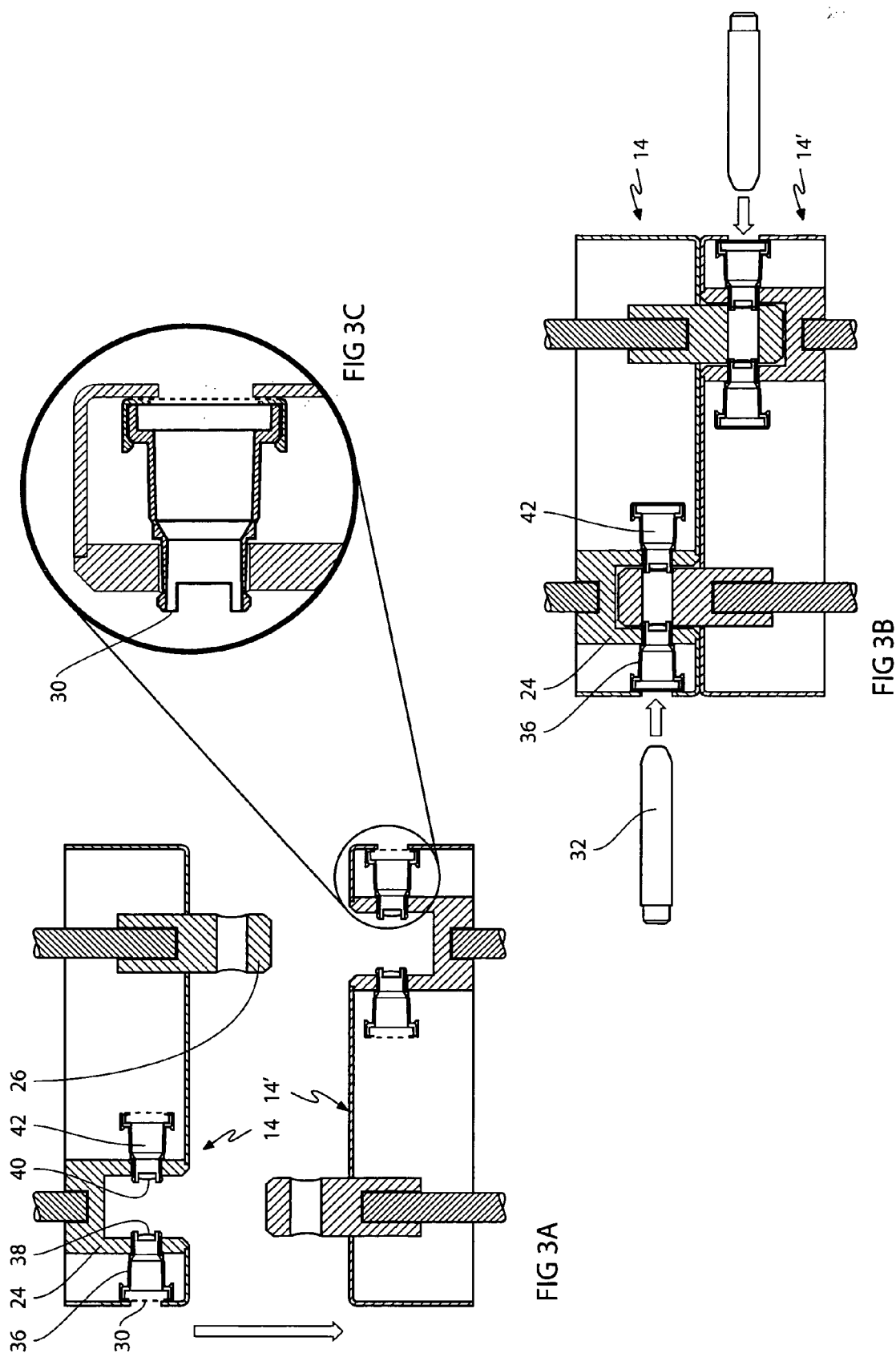
FIG 1D

FIG 1C

FIG 1B

FIG 1A







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Application Number  
EP 08 02 2355

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| CATEGORY OF CITED DOCUMENTS                                                                                                                                                                                             |                                                                                                                                            | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                         |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                            |                                                                                                                                                                                                                                                                              |                                         |

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