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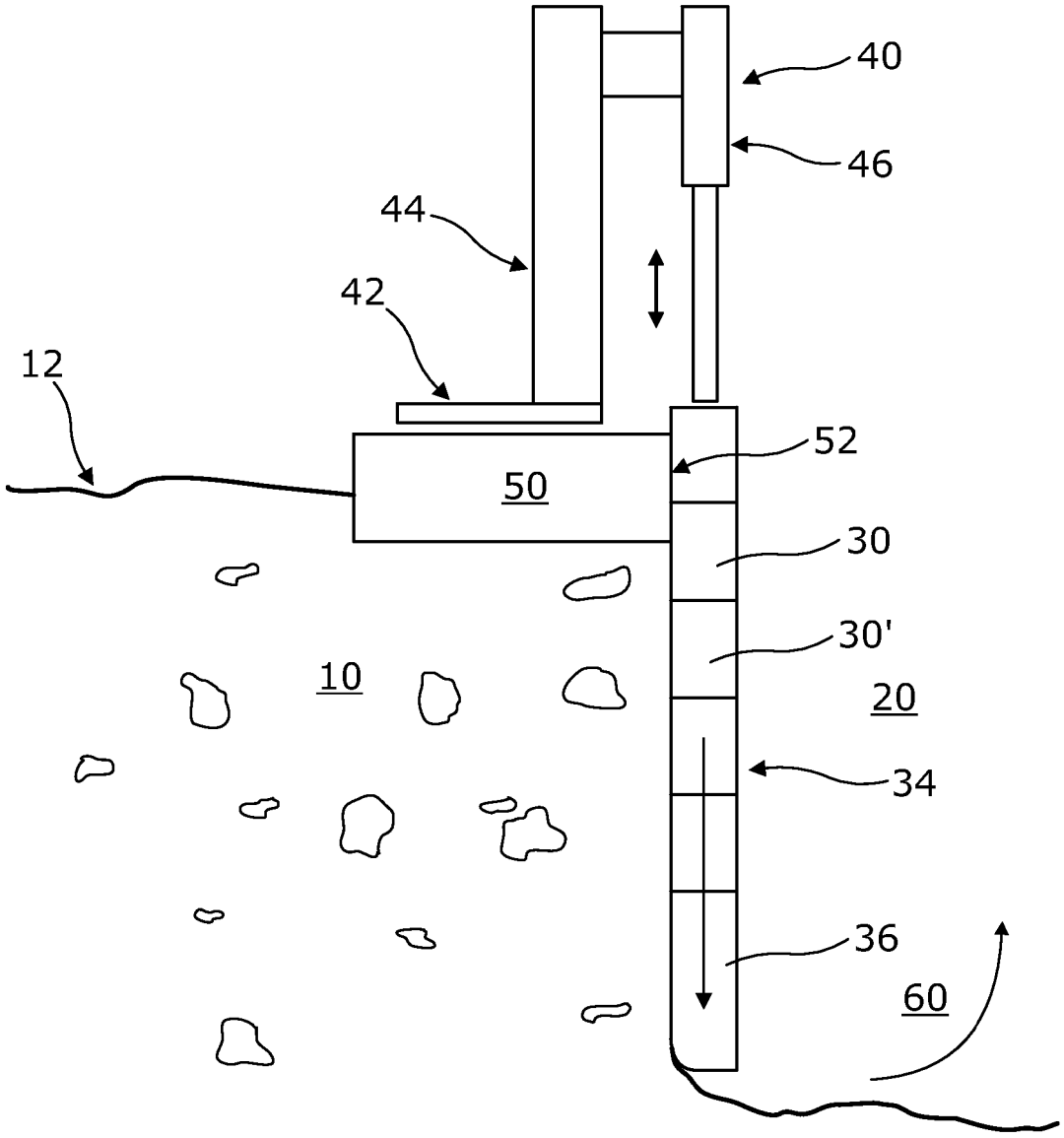

Figure 1

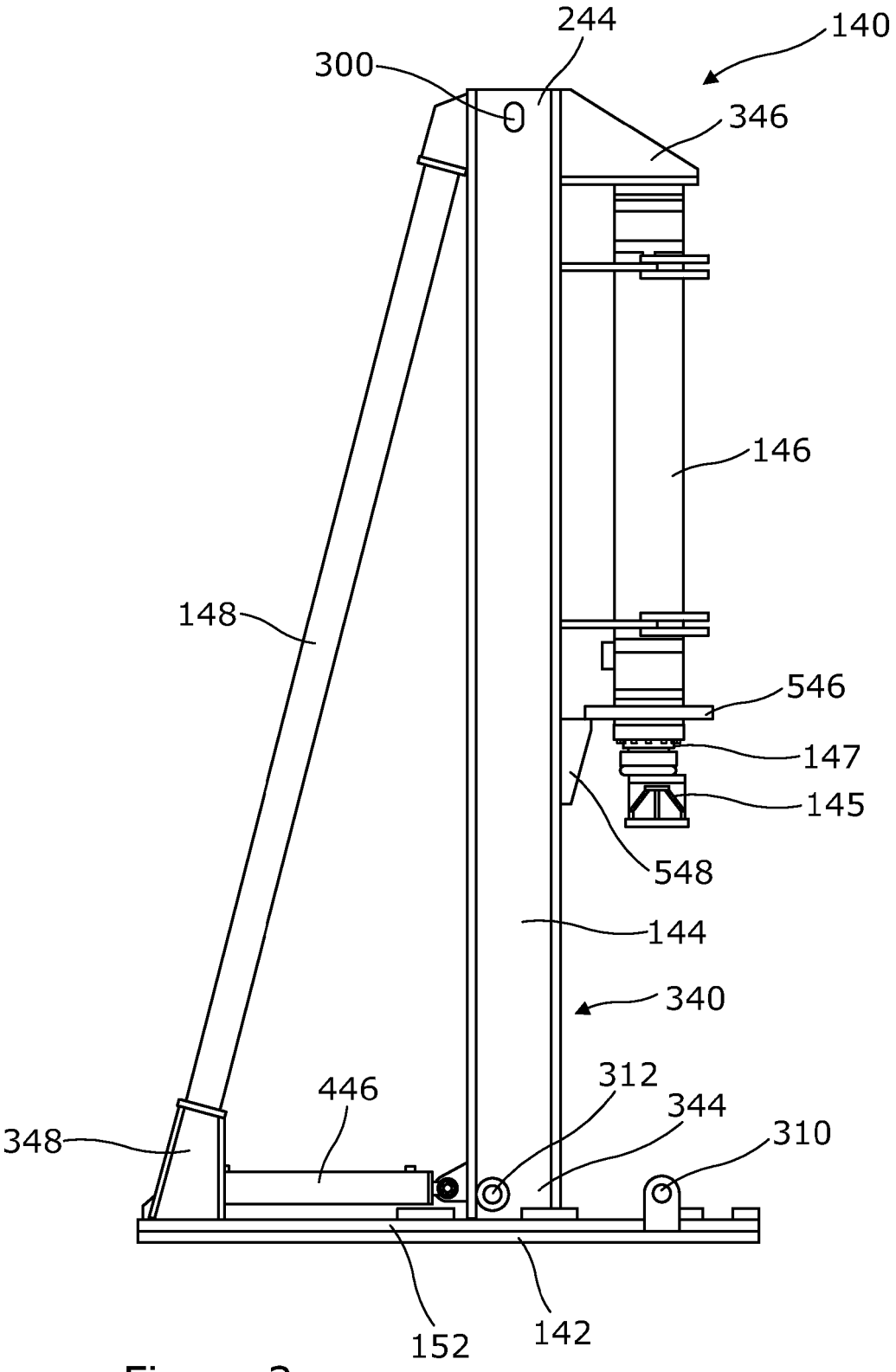

Figure 2

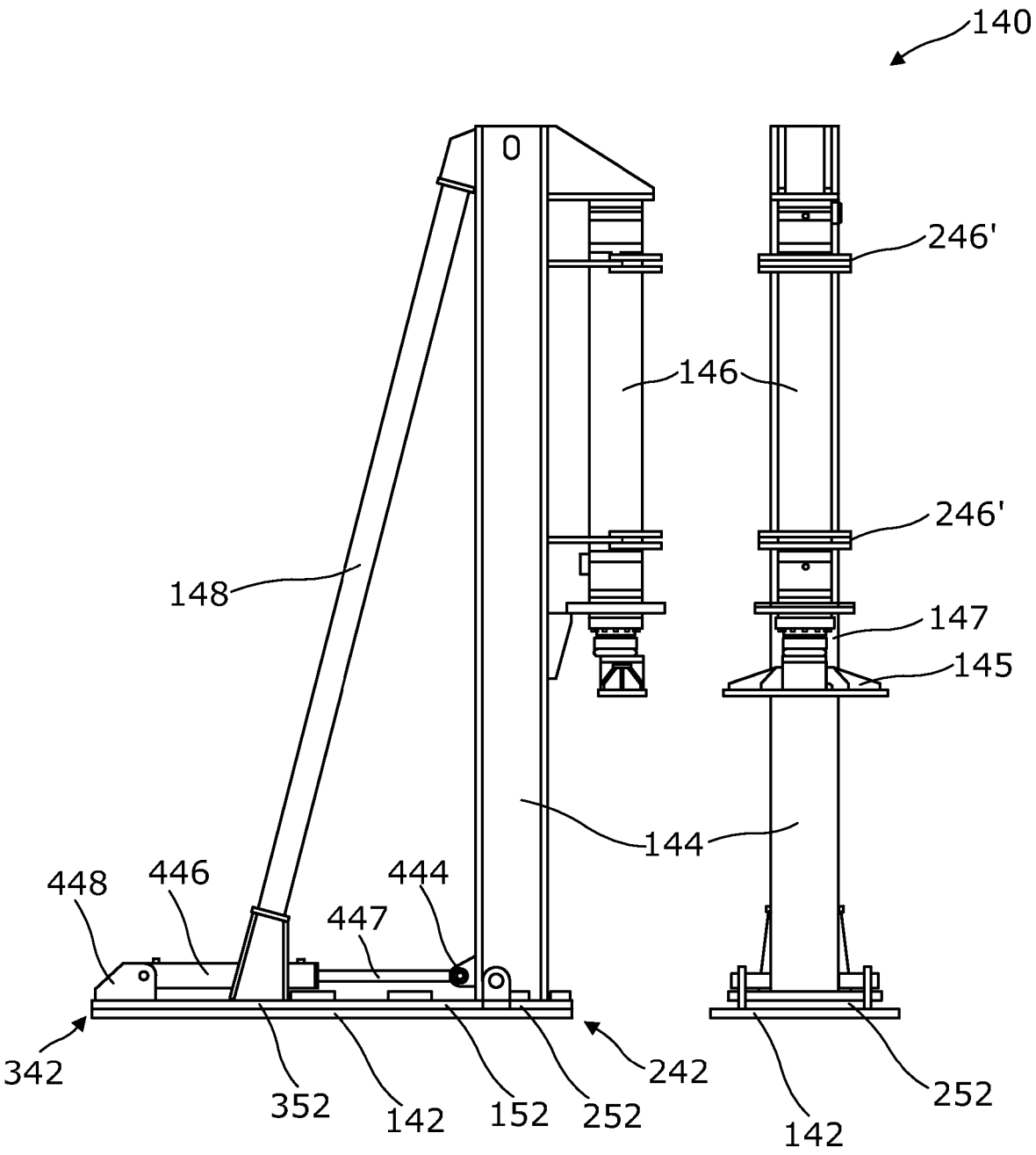

Figure 3

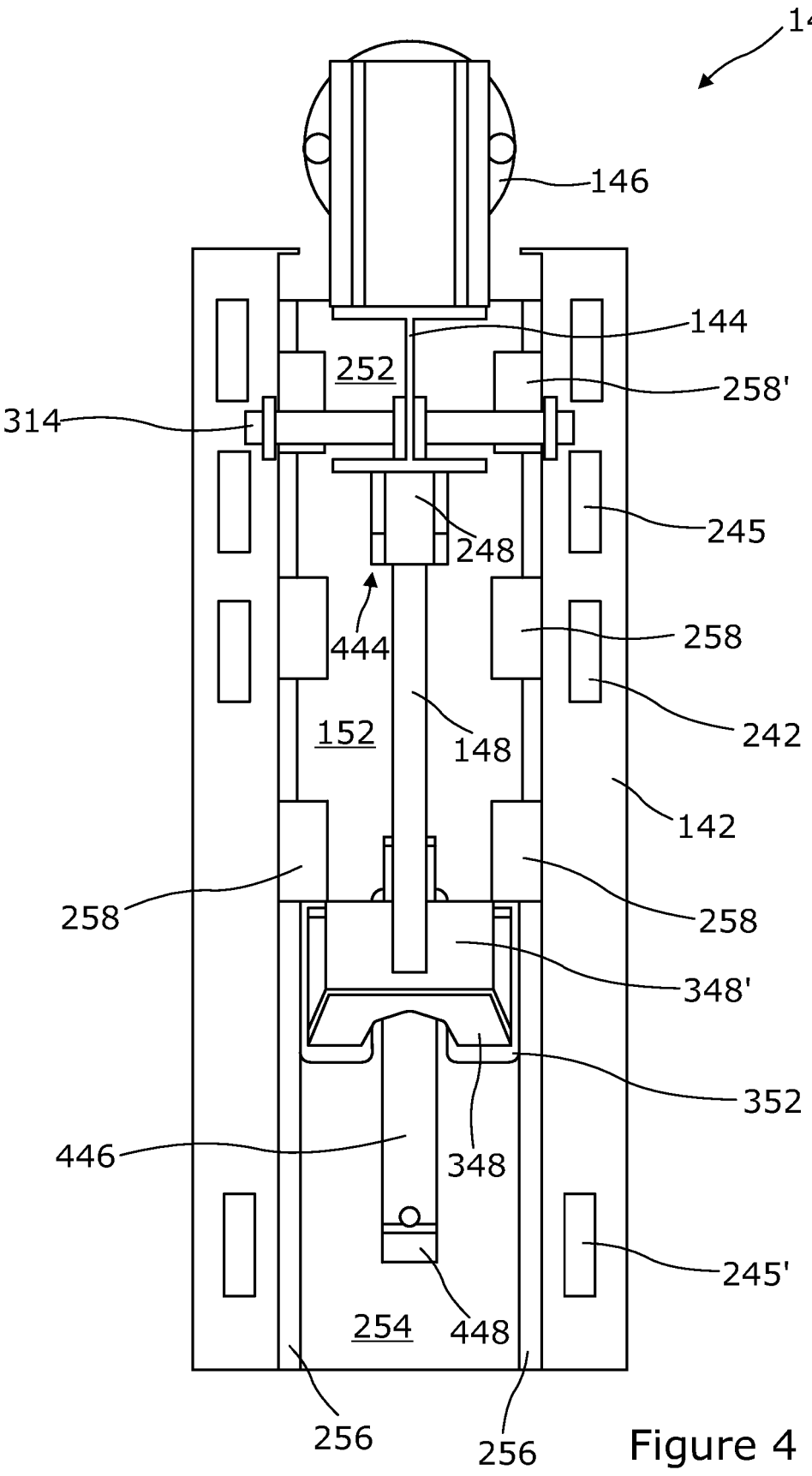

Figure 4

Apparatus for building a lined shaft

The present invention relates to an apparatus, system and method for building a lined shaft. In civil engineering there are various occasions in which it is necessary to produce an elongate hole in the ground, such as in the form of a shaft or tunnel. A vast number of methods and related equipment for this process are known. In the present instance the field of the present invention is the producing of such shafts, sometimes termed a caisson (particularly when the requirement is that the shaft be watertight) in alluvial, fluvial, lacustine or glacial till substrates, i.e. substrates comprising loose or unconsolidated soil or sediments. For the rest of this description the substrates will be collectively termed soil, for convenience.

When producing a shaft, particularly a vertical shaft in soil, a known method is the construction of a tubular structure, placing that tubular structure with an open end abutting the soil, excavating soil through the length of the tube and urging the tube further into the soil, such as under gravity or with additional force, so as to enter the excavation and form a lining to that excavation. Over a period of time this process serves to provide a shaft, the walls of which are lined by the tubular structure thus forming a lined shaft or caisson.

Particularly in larger constructions the tubular structure may be formed in situ, for example, by the use of a series of tubes stacked successively upon one another. Other possibilities include the formation of the tube from a plurality of segments, similar to building a brick wall but using precast concrete segments.

A relevant example of these known methods is provided in figure 1. Figure 1 shows a cross-section of a left half of a shaft under construction. This figure further shows soil 10, such as glacial till, having a surface 12 and into which a shaft or caisson is being formed. The shaft is lined by tubular elements 30, 30' which are urged downwards by means of a ram 40 mounted upon a toroidal base 50 (the toroid, or used in this description to simply mean that base, in whatever, form rather than the base of the apparatus). Initially, a first tube 36 is placed on the surface 12, soil 10 excavated 60 from within the tube and the tube urged downwards, after which further tubes 30 are placed upon the first tube and the process repeated so is to form the shaft. Such a method of construction is disclosed in US 4,797,031.

In one method of construction a jacking ram 40 may be used. A relevant method follows the general scheme of providing the base 50, such as made of a relatively heavy structure, many hundreds of tons not being unusual. This structure may be toroidal, an inner face of the toroid 52 defining an external periphery of the liner 34, being composed of individual tubular elements 30, 30'. An initial tubular element 36 may have a shaped leading-edge to facilitate downward movement of the liner 34 and as the excavation 60 proceeds the liner descends and additional liner elements 30 are progressively added. To urge the liner downward ram 40 is used. The ram 40 comprises a base 42 which is secured to the tubular base 50 and supports a column 44 to which a piston 46, such as a hydraulic ram is attached and positioned so as to urge the tubular elements 30 downwards. Hydraulic Rams are well known in the construction industry for the provision of force in supporting excavations, such as disclosed in US 2012/0144998.

One problem with current construction techniques is that the construction of the tube which is extended into the excavation is encumbered by the presence of the jacking rams and the jacking rams once placed on the toroid are not readily adjusted such as if the tube starts to misalign, such as for example when soil condition varies on one side of the excavation.

Whilst various methods are known for the construction of shafts in soil there continues to be scope for improvement, optimisation and the provision of additional features suited to particular types of shaft, soil and equipment for providing improved productivity, safety and effectiveness, such as in accuracy and control.

The present invention in its various aspects is as set out in the appended claims.

The present invention relates to an improved jacking ram 140 as defined in the claims. With reference to the Drawings; the jacking ram 140 comprises a ram 146 supported by a stanchion 144. The stanchion 144 is braced by optional brace 148 attached to the stanchion 144 at an upper end 244. The brace serves to stop distortion of stanchion 144 when ram 146 is under load such that bending moment towards brace 148 occurs. This allows for a lighter construction of the jacking ram. However, this is not a self-evidently desirable condition since the performance of the ram depends upon its vertical force, which is to some extent constrained by the weight of the ram. Further, in conventional rams the presence of a brace is not

usually desirable as it can encumber the work area. A significant issue being the ability to put further tubular sections or segments to form the lining tube mentioned earlier. Stanchion 144 and brace 148 are secured at their lower ends 344, 348 at, respectively a first end of the carriage 252 and a second end of the carriage 352. The carriage 252 rides on base 142 in a channel 254 defined by walls 256, by the main part of the base plate 142 on a lower side and on an upper side by a plurality of retainers 258 attached to the upper side of the walls 256. The carriage 252 is slideable in the channel 254 so that it may move towards a first, front, end 242 of the base in a first extended position for operation of the ram 146 and be retracted into a second, back, end 342 of the base in a second retracted position in which the ram 146 is typically retracted. A hydraulic cylinder 446 (functionally another form of ram 146) is attached at a first end and to base 142 by means of a pivot pin attachment. Hydraulic cylinder 446 comprises extendable and retractable piston 447. It is attached at a second end to by a similar pivot pin attachment to the stanchion 144 at a lower end. When extended the hydraulic cylinder serves to place the carriage assembly comprising the carriage 252, stanchion 144, brace148, and ram 146 to a first, front end of the base 242, in which position the carriage assembly places the ram 146 forward of the front end of the base 242 such that it enables ram 146 to extend piston 147 having shoe 145 at its extremity such that the shoe 145 can be used to, in use, press a lining tube downward so is to extend the lining tube into an excavation in the forming of a shaft. When retracted the hydraulic cylinder serves to place the carriage assembly in a second, retracted position wherein the carriage assembly and particularly the ram 146, piston 147 and shoe 145 are brought back clear of the front of the base 142 thus enabling, in use, ready access a lining tube such that e-learning tube may be readily extended, unencumbered by the presence of the ram.

The hydraulic cylinder 446 is preferably mounted centrally on the base 142 as is, also the carriage assembly 340 so as to maintain a centre gravity of the apparatus below the main axis of the stanchion. To this end at the bottom end of brace 148, i.e. 348 is in the form of a saddle 348' which straddles over the hydraulic cylinder 4464 fixing the bottom end of the brace 148 to the carriage 152. This also distributes the compressive force from the brace 148 more evenly on the carriage 152 so as to reduce the possibility for carriage distortion.

In practice, it is not necessary to fully extend or retract the hydraulic cylinder and hence the carriage may be placed in a variety of intermediate positions, particularly where the ram 146 places the shoe 145 forward of the front edge of the base 142. This enables subtlety of positioning of the ram on the top age of a tube such that force may be applied to an outer edge of the tube, or an inner edge or centrally on the top rim of a tube. This positioning allows some flexibility in application of the force provided by the ram and, in particular, allows a relatively subtle change in the way force is applied to the tube. As will be appreciated, the jacking rams of the present invention are not only used simply to apply additional vertical force to a tube but also to guide the tube and steer it in the shaft forming process. As such, a plurality of jacking rams will be placed around the periphery of a tube and differential force is applied across the rams so as to steer the tube. The jacking rams of the present invention are particularly effective when used together, around the periphery of a tube, since some rams may be in position and providing force whilst other rams may be retracted and their carriages retracted. This is, for example, helpful when continuous force is required and alternate rams may be withdrawn, the tube built-up, the carriages then extended and the rams extended to themselves provide force on the tube whilst the rams previously engaged can be withdrawn. This enables procedures where continuous force is required to be readily carried out, whilst not encumbering the work area. This, for example, enables the tube to be built-up in situ by means of shuttering and in situ poured concrete into that shuttering so that preformed tube members are not required. In some circumstances this can be particularly useful, where the geometry of the shaft presents a complex geometry which can best be dealt with by in situ formed shuttering rather than importing predefined geometric building elements.

The jacking ram of the present invention further comprises a lifting point 300, in the form of an aperture formed on the upper end of the stanchion 144. Since the apparatus enables the carriage assembly 340 to slide along the base 142 then when the jacking ram is lifted using, for example, a crane hook at lifting point 300 and the carriage assembly is in the retracted position the centre of gravity of the whole apparatus can be conveniently arranged so that it is directly underneath lifting point 300. This has a significant advantage in that using a single suspension cable the apparatus can be lifted into place on the toroid with the base substantially horizontal

this being facilitated by the device being left/right symmetrical relative to the lifting point 300 so that the base 142 is horizontal in both planes when lifted onto the surface on which it is to be mounted. This is itself a significant advantage since it means that a piece of apparatus claim many tonnes can be placed onto a flat, horizontal surface, very accurately. In addition, the ability of the carriage assembly 340 to be moved over a range of movement means that when the apparatus becomes old, damaged or worn and the centre of gravity may change then the carriage apparatus may be suitably adjusted so that its end stop corresponds to a new centre of gravity. To this end adjustable stop pieces (not shown) may be placed on the apparatus so as to adjust the throw of the carriage assembly in the channel so that the end stop of the apparatus corresponds to its centre of gravity being located below the lifting point.

The jacking ram apparatus further comprises securing point 310 located on the front end 242 of the base 142 which can be used for securing lanyards to assist in adjustment and movement of the apparatus. Securing means 310, 312, 314 is provided so as to secure the carriage in the first, extended, position such that the securing means supplements the vertical restraining force capacity of the retainers.This securing point 310 is located such that a further, corresponding securing point 312 at the base of the stanchion 244 places an aperture of the securing point 310 on a common axis with an aperture of the stanchion securing point 312 such that a bar 314 may be placed through those apertures so is to secure the carriage assembly 340 in the forward position in which the ram 146 is operated. To facilitate fine adjustment of the carriage assembly 341 or other of the apertures may be elongate. The function of Bath 314 is also to provide a further means of transmitting force exerted by the ram 146 and transmitted through the stanchion 144 in the form of a tensile stress to the base 142 so that forward retainers 258' are reinforced giving less potential for distortion of the apparatus under load.

The base 142 of the jacking ram 140 provides a plurality of apertures 245 adjacent the outer sides of the base 142 and through which securing means, such as bolts or studding, may be inserted for, in use, securing the apparatus to the toroid. This may preferably be achieved by placing studding in shuttering before casting the toroid in concrete so that the studding (i.e. sections of machine screw) protrude proud of the toroid and can be then used to pass through apertures 252 so is to secure the

apparatus to the toroid by means of nuts. The apetures are 245 are preferably placed adjacent the corners of the rectangular base 142, preferably a plurality of apertures 245 are made toward the front end of the base 142 adjacent to the forward location of the stanchion 144, this distributes the load more evenly and prevents distortion of the base which is particularly important since the carriage must slide in the channel 254 of the base 142.

In use, the jacking ram 140 is intended to be used in a number of different situations as such it is therefore useful to be able to interchange ram 146 to provide different configurations. For example, a ram 146 with a longer or shorter throw all with a higher or lower pressure/force capacity may be required. As such the stanchion 146 is provided with collars 246 in the form of other 246' and lower 246 collars comprising a first semi circular recess for locating the cylinder of ram 146 and two straps pivoted on one side of the recess for wrapping round the cylinder of the ram 146 and securing on another side of the recess so is to provide a convenient securing means for a ram 146. Similarly, if at an upper end of the stanchion 244 there is provided bracket 346 for transmitting the vertical force exerted by the ram 146 to the rest of the apparatus. This enables collars 246 to be all relatively light construction and hence more easily opened for replacing the ram 146. The ram 146 is preferably provided with a collar 546 on its lower end, adjacent the piston 147 exit so as to remove the need for the collars 246 to have a vertical restraining force and, once again, enabling the whole apparatus to be readily adjusted and the ram changed. Whilst the jacking ram of the present invention 140 is preferably used with an interlock mechanism such that the hydraulic cylinder 446 cannot be operated when the ram 146 is under load it is appreciated that in normal use occasions will arise when this will occur. This is particularly so given that a multiple of the jacking rams 140 will be used on site and the interconnection of the apparatus complex. Hence, there is a reasonable likelihood that due to the siding nature of the carriage assembly in may be tempted to move the carriage when the ram 146 is ordered load and hence the piston 147 is likely to be bent. Hence, ready replacement of the ram 146 is important. Nevertheless, the jacking ram of the present invention preferably comprises an interlock such that hydraulic cylinder 446 does not operate when jacking ram 146 is extended. This may be achieved by routing hoses supplying the ram 146 through a valve mechanism which is only open when piston 147 of brand

146 is in the fully retracted position. However, this solution is not preferred since in the event of all the damage to the brand 146 it will not be possible to retract the carriage assembly since the piston 147 of the ram 146 may be stuck in an open position. As such, an interlock assembly in a hydraulic manifold supplying the whole jacking ram 140 is preferred such that the operation of hydraulic cylinder for 46 may only occur when the pressure in hoses supplying the ram 146 is below a given threshold, the threshold being determined by a no-force (on the issue 145) reference hydraulic pressure.

Piston 147 of ram 146 is terminated in shoe 145. Shoe 145 is laterally extended so is to spread force to either side of the stanchion 146 and is relatively narrow in the depth of the apparatus so is to provide greater clearance of the retracted carriage. Shoe 145 is located forward of the axis of the piston 147. Shoe 145 may be rigidly attached to the end of the piston 147 so as to ensure that the force exerted by the shoe is always vertical. Other rams 146 may be provided with a pivotable coupling between the piston 147 and the shoe 145 so is to allow the shoe to press evenly on a surface which is not horizontal.

Stanchion 144 preferably has tube an 'I' section rigid steel joist profile and brace 148 preferably has a rectangular tube section. This combination provides for optimal rigidity of the apparatus under load. Base 142 preferably comprises

For completeness, it is here noted that the hydraulic cylinder 446 and the ram 146 intended to be operated by hydraulic fluid from a compressor apparatus.

Claims,

1. An improved jacking ram 140 suitable for use in the sinking of a shaft lining, the jacking ram comprising:

a base 142, the base 142 having a channel 254 formed by one face of a base member, lateral walls 256 and retainers 258 within which a carriage apparatus may be slid, the base being configured to be attached, so as to in use withstand a tensile force to a further base 50;

the carriage apparatus 340 comprising a stanchion 144 mounted upon a first end 252 of a carriage 152 and braced between an upper end 244 of the stanchion 144 and a second end 352 of the carriage 152 remote from said first end of the carriage by means of a brace 148, the stanchion being mounted on a first side of the stanchion 144 and upon an opposite side of the stanchion 144 is mounted a hydraulic ram 146,

the ram being configured to extend a piston 147 vertically towards the base for, in use, exerting force on a shaft liner; wherein

the carriage apparatus may be slid from a first, extended, position in which the hydraulic ram 146 being held clear of the base 142 to a second, retracted, position in which the hydraulic ram 146 is positioned over the base 142.

2. The jacking ram of claim 1 wherein a hydraulic cylinder 446 is provided to enable the carriage to be moved between the first and second positions.

3. The jacking ram of claim 1 or claim 2 wherein securing means 310, 312, 314 is provided so as to secure the carriage in the first, extended, position such that the securing means supplements the vertical restraining force capacity of the retainers.

4. The jacking ram of any of claims 1 to 3 wherein the brace 148 is mounted over the hydraulic cylinder 446 by means of a saddle 348' at a lower end of the brace 148.

5. The jacking ram of any of claims 1 to 4 wherein an upper end of the stanchion 144 comprises a lifting point 300 such that the apparatus is configured to make the lifting point 300 the centre of gravity of the apparatus when the carriage is in the second, retracted, position.

6. The jacking ram of any preceding claim wherein the ram 146 is secured to the stanchion 144 by means of releasable collars 246', 246'', and restrained from motion toward an upper end of the stanchion 244 by a bracket 346 fixed to the upper end of the stanchion 144 and restrained from motion toward a lower end of the stanchion 344 by means of a collar 546 engaging with a bracket 548.

7. A system for use in the construction of lined shafts, the system comprising a jacking ram as disclosed in any proceeding claim, a compressor for providing hydraulic fluid to the ram 146 and the hydraulic cylinder 446 and a valve assembly for selectively directing hydraulic fluid selectively to the ram 146 and the hydraulic cylinder 446.

8. The system of claim 7 wherein the valve assembly comprises an interlock to prevent operation of the hydraulic cylinder for 46 and the consequence movement of the carriage assembly 340 when the fluid supplied to the ram 146 is under pressure and/or when the piston 147 of the ram 146 is extended.

9. The use of a jacking ram as disclosed in any proceeding claim for the use in constructing a lined shaft.

10. A jacking ram as hereinbefore disclosed with reference to figures 2, 3 and 4 and the associated description.

11. A kit of parts comprising a jacking ram as defined in any previous claim and related equipment for building a lined shaft.