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(71) Applicant: **Cheema Holdings Ltd.**
Strood, Kent ME2 2EG (GB)

(72) Inventor: **Manning, Roger Frank**
Kent TN17 4EP (GB)

(74) Representative: **Shaw, Laurence**
Laurence Shaw & Associates,
5th Floor Metropolitan House,
1 Hagley Road
Edgbaston, Birmingham B16 8TG (GB)

(54) Lining shafts

(57) A concrete shaft, in which a sprayed concrete construction technique is used, is made by excavating a relatively enlarged hole at the blind end of the excavation and forming a concrete floor, dimensioned and shaped to absorb ground forces.

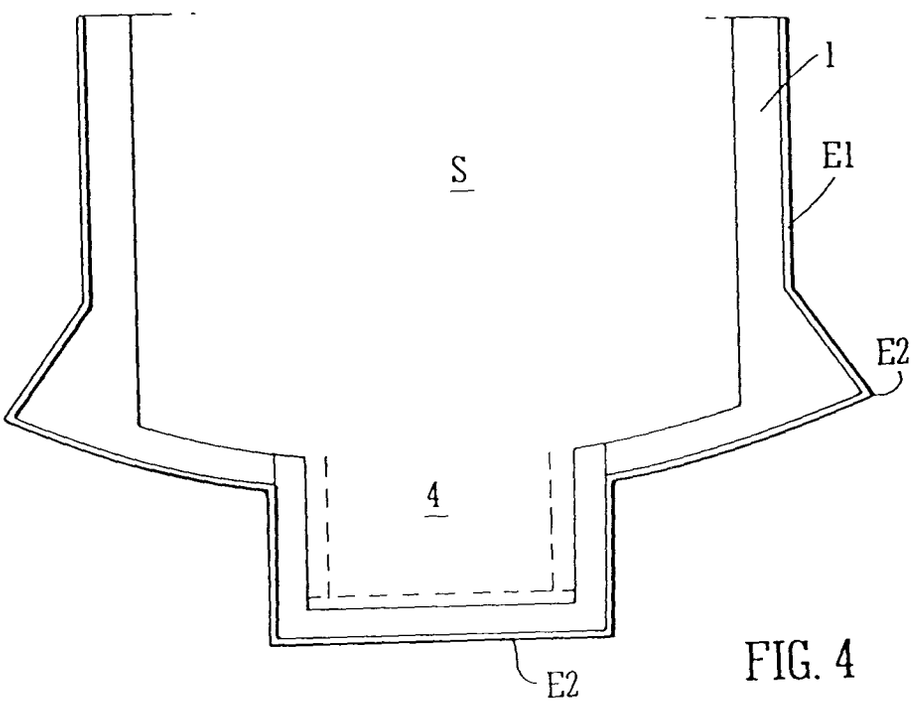

FIG. 4

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Description

[0001] The invention relates to a method of forming a shaft in a substrate, and to the shaft so formed. The invention is particularly applicable to shafts to receive and store water or other liquids and to shafts located in substrates where ground water is a factor. The invention is however capable of other uses such as tunnel access shafts but for convenience will be described in relation to the formation of a storm water container.

[0002] It is known that shafts are constructed using pre-cast concrete segments, cast iron segments or in a few cases vibrated reinforced concrete that is placed in situ on completion of the shaft excavation. The segment construction usually requires back grouting, which gives rise to additional time and cost. To resist hydrostatic upthrust it is common practice to over excavate the shaft by some 3 or 4 metres and back-fill with dense reinforced concrete to provide dead weight and absorb the floor stresses. In urban areas the environmental nuisance of removing and transporting excavated material, to a suitable point of disposal, must be taken into consideration, thus any reduction in excavated material must reduce the environmental impact. It is one object of this invention to provide a simplified method of forming a shaft.

[0003] According to the invention in one aspect there is provided a method of forming a lined shaft in a substrate, the method comprising excavating a hole in the substrate and applying a lining on to the side of the excavation, **characterised by** excavating a relatively enlarged hole at the blind end of the excavation and forming a concrete end wall therein dimensioned to absorb ground forces.

[0004] According to the invention in another aspect there is provided a shaft in a substrate, the shaft having a monolithic sprayed concrete lining along all, or a substantial part of the vertical wall of the shaft and the wall at the blind end, the end wall being dimensioned to absorb ground forces.

[0005] The shape and dimensions of the end wall, (which typically will be a floor) is selected to absorb upward pressures generated by ground forces and transfer them to the side wall lining. For this purpose it is preferred that the end wall be outwardly radiussed. The floor may be shaped, e.g. to have a sump, and for this purpose the lower portion of the shaft may flare outwardly downwardly, e.g. in the manner of a wedge, say in the shape of an elephants foot.

[0006] While in some substrates the enlarged hole may be formed and then the sidewall and the end wall can be lined in one operation the method preferably includes the step by step operation of spraying concrete on the sides of the hole to form a lining and then underreaming at the base of the lining to form the enlarged hole, following which the concrete end wall is formed.

[0007] The concrete composition to be sprayed may be applied by any wet or dry process. The composition may be of any known type. The method may include the step of locating reinforcement in the end wall, and in the sidewall lining. Such reinforcement may consist of steel fabric, steelbar, steel fibres and/or a lattice type of reinforcement may be formed.

[0008] In order that the invention may be well understood it will now be described by way of example with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a partial vertical section through one shaft of the invention;

Figure 2 is a transverse section through the shaft of Figure 1;

Figure 3 is a partial vertical section taken on lines III-III on Figure 2; and

Figure 4 is a partial vertical section taken on lines IV-IV on Figure 2.

[0009] The shaft S is formed in an excavation E in a substrate, typically earth. The shaft comprises a vertical cylinder 1 having an outwardly flared bell shaped basal slab 2. The walls lining the cylinder and the basal slab are formed of monolithic concrete applied by a wet spraying technique called **SHOTCRETE** (registered trade mark). The excavation E has an upper vertical cylinder shape E1 and a lower wider excavation E2. The lower basal slab E3 radius, which by design absorbs the upward pressures and transfers them to the outer, can be shaped to provide a sump, typically wedge like, as shown in Figure 1. The basal slab is outwardly curved. As shown in Figure 3, from one side the basal bells out in an elephant foot shape, being wider at the bottom than the top. The shaft has a preformed lid 5 (these features will vary according to the installation required, as will the dimensions).

[0010] A shaft constructed by this invention is formed by excavating the hole El, usually by mechanical means. As the excavation proceeds the side of the excavation is lined with concrete, applied by **SHOTCRETE** process, to give an intimate contact and adherence. In some circumstances of loose or wet substrates the cast concrete segments may be used to line the upper section of the shaft. When the required vertical dimension is reached the diameter and depth of the hole is enlarged to form the bell shaped area E2. The exposed floor surface is then sprayed to form the basal slab, which joins the lower end of the cylinder to form a monolithic structure. The enlarged section and the basal slab may be excavated in stages but the final **SHOTCRETE** spraying will be applied in such a way as to achieve a monolithic structural integrity.

[0011] It will be seen that the invention is a monolithic reinforced concrete shaft construction method, designed to accommodate hydrostatic up-thrust, in which

a sprayed concrete construction technique is used to create an intimate contact with the excavated surfaces and form a thin section radiussed floor, with a thickened undercut floor/wall joint that contains the forces, to give a soil support interaction.

[0012] The invention is not limited to the embodiment shown. The hole may be excavated in one operation and the lining sprayed in one operation. The upper surface of the floor of the shaft may be flat. The shaft need not be truly vertical and it need not be of circular cross-section. The dimensions of the excavation and of the walls may be varied according to circumstances.

Claims

1. A method of forming a lined shaft in a substrate, the method comprising excavating a hole in the substrate and applying a lining on to the wall of the excavation, **characterised by** excavating a relatively enlarged hole at the blind end of the excavation and forming a concrete end wall therein dimensioned to absorb ground forces.

2. A method according to Claim 1, wherein the enlarged hole is generally wedge shaped.

3. A method according to claim 1 or 2, including the step of spraying concrete on the sidewalls of the hole to form a lining and then under-reaming at the base of the lining to form the enlarged hole.

4. A method according to Claim 1,2 or 3, wherein the enlarged hole has an arcuate end wall whereby the end wall formed has an arcuate shaped.

5. A method according to any preceding Claim, including the step of locating reinforcement in the end wall.

6. A shaft in a substrate, the shaft having a monolithic sprayed concrete lining along the vertical walls of the shaft and an end wall at the blind end, the end wall being dimensioned to absorb ground forces.

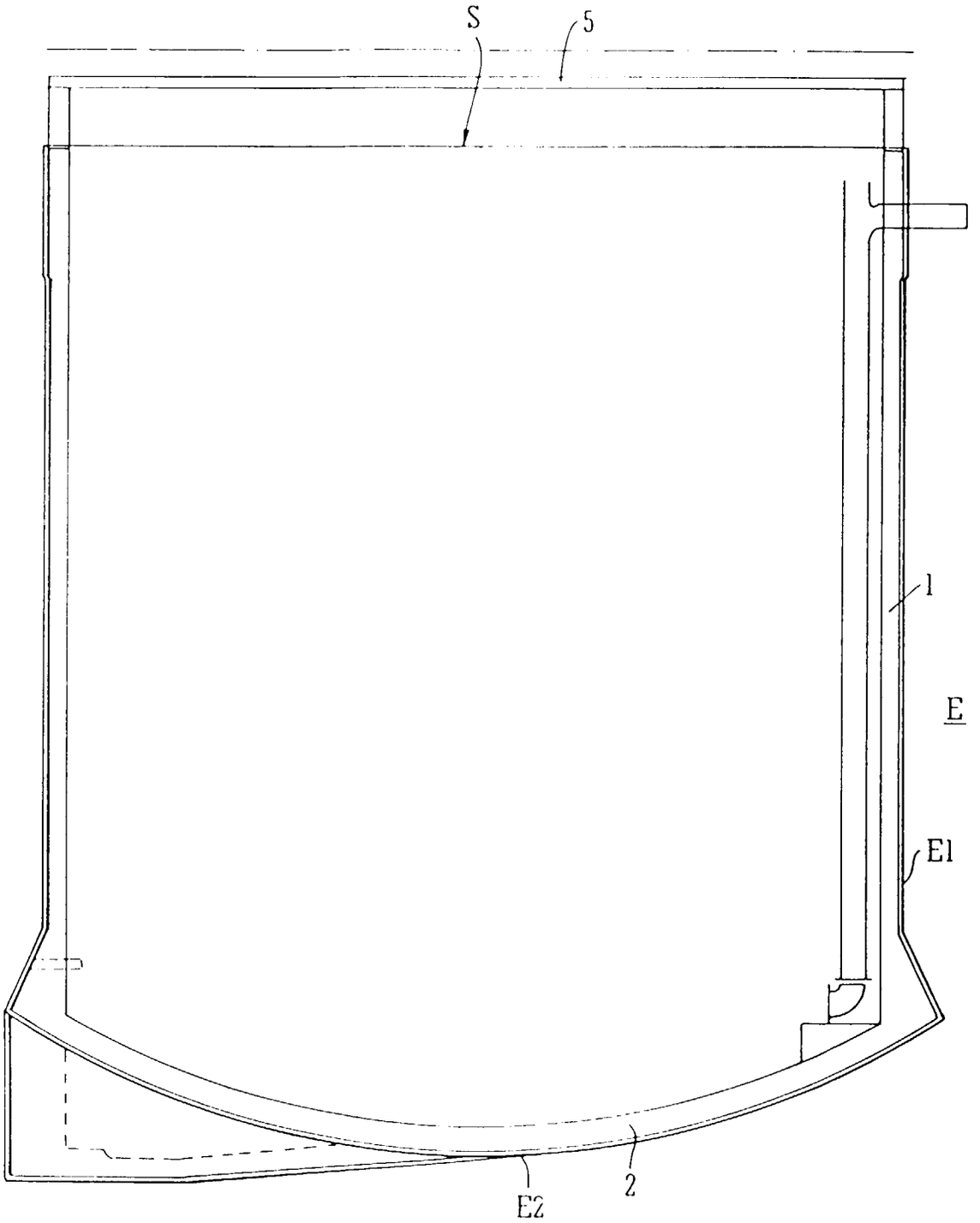

FIG. 1

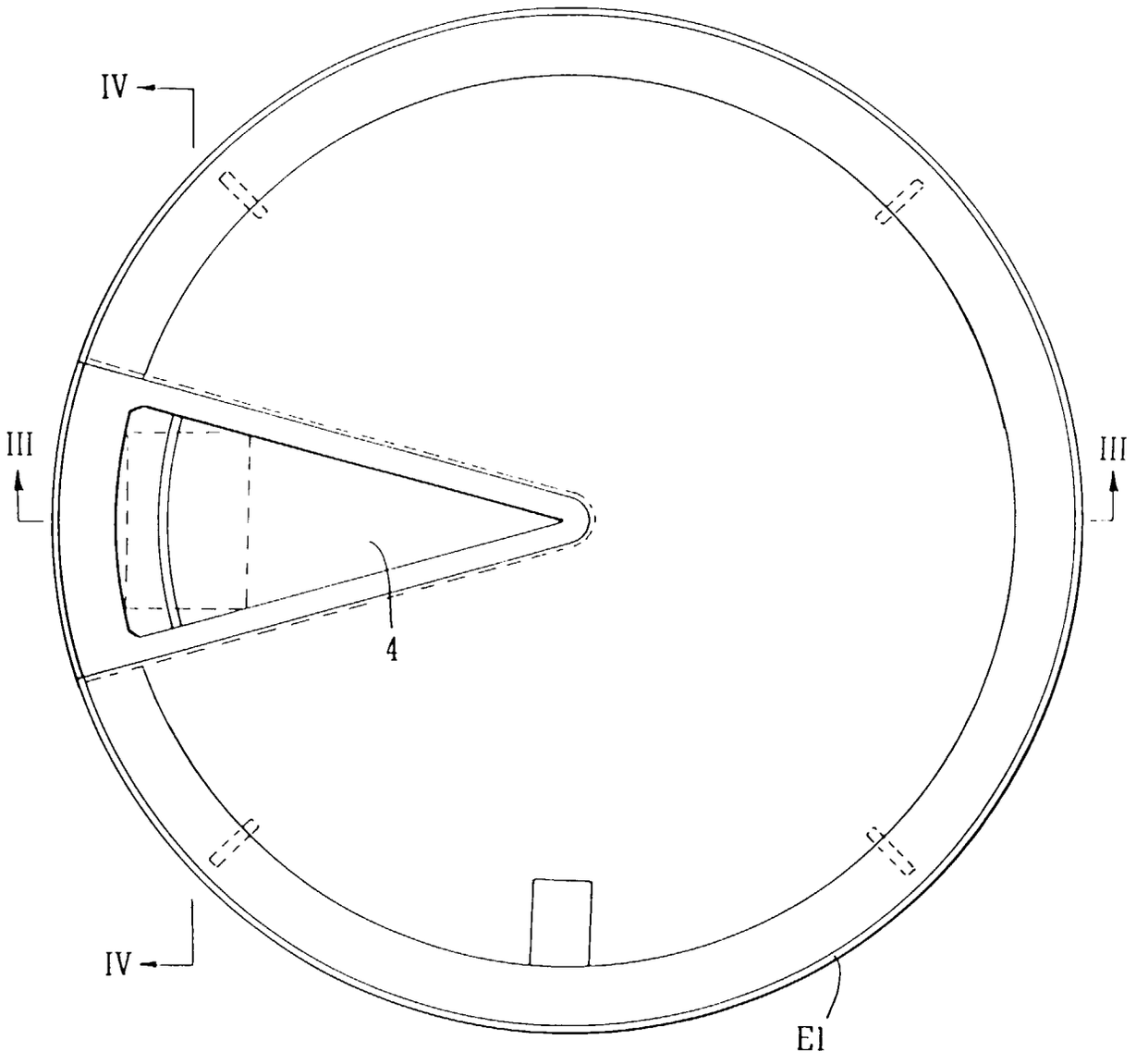

FIG. 2

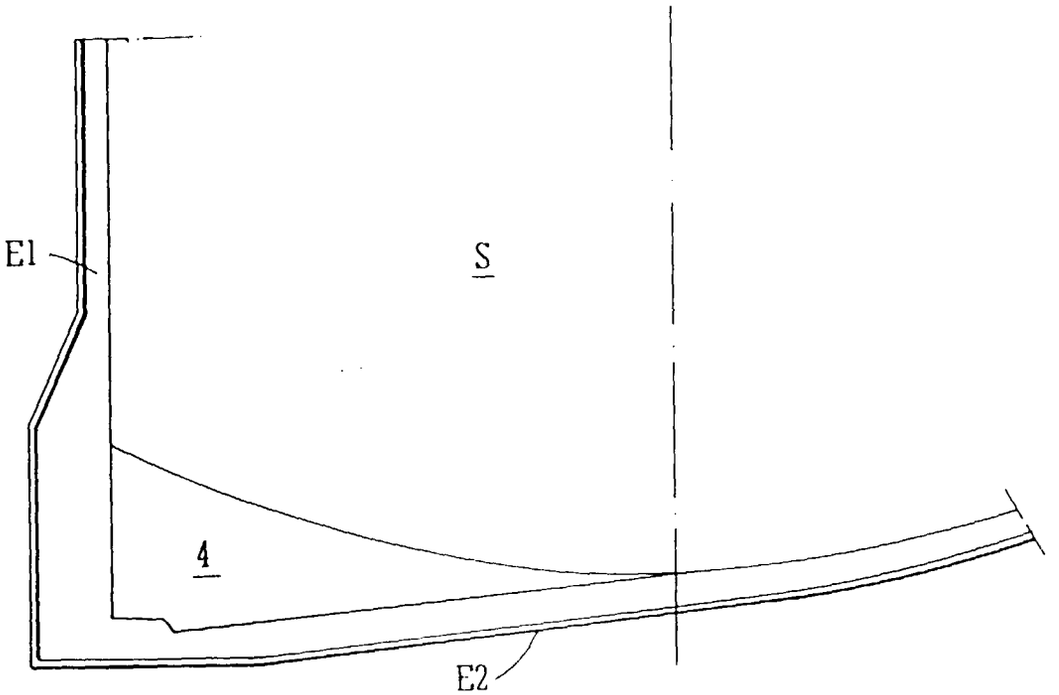

FIG. 3

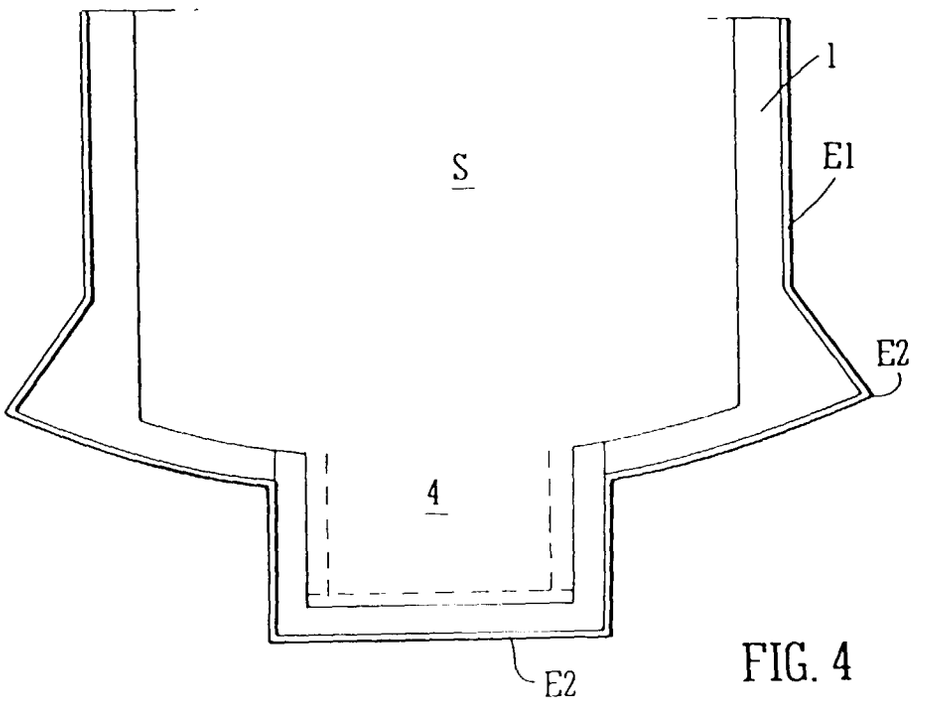

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 5078

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 September 1999	Fonseca Fernandez, H

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