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(54) A METHOD OF CONSTRUCTING A PILE

PFAHLHERSTELLUNGSVERFAHREN

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Description

[0001] The present invention relates to a method of constructing a pile.

[0002] It is known to construct a cast in situ pile foundations by forming a bore in the ground to a required depth and filling the bore with uncast, or wet, concrete so that on hardening a cast concrete pile is formed. Typically, a rotary auger forms the bore in the ground. The auger can be withdrawn from the bore prior to concrete filling or the auger may comprise a central conduit for concrete so that the bore can be filled with concrete as the auger is withdrawn.

[0003] The term cast concrete pile, or cast in-situ pile, means that the concrete is cast in the bore and not precast prior to insertion in the bore.

[0004] Over the course of time a site that has been previously developed may be re-used for the construction of subsequent buildings, for instance for redevelopment. It is preferable when an existing building is demolished that piles used as the foundation of the existing building are re-used for subsequent buildings. However, the condition of concrete piles may decrease over time and if piles are to be re-used, then it is important that their condition can be tested to ensure they can withstand the required loading. Piles are tested by extracting samples of the pile along its length and analysing the condition of the samples. Preferably, samples are taken of the ground adjacent the piles at various depths to check for consolidation and loading capacity.

[0005] Hereto, it has not been practical to test cast concrete piles in situ and therefore it is normal practice to remove existing piles or construct additional piles prior to building construction.

[0006] JP5132929 discloses that a pile-hole is excavated in the ground, and after a flexible and hollow formed bag body is inserted and installed in the center of a pile hole and after a reinforced body and a hardening agent are inserted and inserted between the bag body and a hole wall to install in required order, fluid is poured from the upper opening of the hollow formed bag body under pressure to expand the bag body, and a hollow cast-in-place pile forming a hollow section in the centre of pile body is developed. In addition, a pile circumference formed bag body is set between the hardening agent and the hole. A hollow formed pipe and the pile circumference formed bag body are set instead of the flexible and hollow formed bag body, and the hardening agent is poured between the pipe and the bag body under pressure.

[0007] The present invention provides a method of constructing a re-usable pile, the method comprising: forming a bore in the ground to a required depth; disposing a longitudinal cavity forming means in the bore to define a longitudinal gap between the cavity forming means and the ground in which the bore is formed; securing the longitudinal cavity forming means in the bore so as to resist relative movement between the cavity forming means and the bore; filling the longitudinal gap between the bore and the cavity forming means with uncast concrete; and permitting the uncast concrete in the longitudinal cavity to harden and thereby form a cast concrete pile in the bore, which pile has a longitudinal cavity that permits access to be had to the pile along at least a portion of its length for sampling of the pile to access its suitability for re-use.

[0008] In order that the present invention is well understood, an embodiment thereof, which is given by way of example only, will now be explained with reference to the accompanying drawings, in which:

Figure 1 shows a bore formed in the ground for a pile;

Figure 2 shows the bore with concrete at the bottom;

Figure 3 shows the bore, a longitudinal cavity forming means and reinforcement members; and

Figure 4 shows the bore filled with concrete.

[0009] The Figures show one example of the method steps involved in constructing a pile and the apparatus required for performing those steps.

[0010] Referring to the Figure 1, a bore 10 is formed in the ground to a required depth by suitable boring equipment. An auger can be used for this purpose. The shape, width and depth of the bore are calculated according to the loading characteristics which the pile must sustain. As shown the bore is generally cylindrical, but other shapes are possible. For instance, a bore with triangular, square or octagonal cross-section may be formed. Further, an underream (not shown) may be formed under the bore.

[0011] Depending on the characteristics of the soil, the walls of the bore may require reinforcement to prevent the surrounding earth from collapsing into the bore. If reinforcement is required, it can be removed prior to introduction of concrete or left in situ. A bentonite slurry can be used to fill the bore to prevent collapse. A wet clay soil on the other hand may not require reinforcement as the soil particles are sufficiently cohesive to prevent collapsing.

[0012] A plug 12 of concrete is deposited at the bottom of the bore as shown in Figure 2 so that the concrete occupies substantially the entire bottom of the bore. Although concrete is shown for this purpose, other material may be used provided it is substantially impermeable to liquid. The purpose of the plug 12 is described in more detail below.

[0013] Referring to Figures 3 and 4, a longitudinal cavity forming means, such as a tube or cylinder 14, is inserted into the bore 10 with a suitable jig. The tube 14 is positioned generally co-axially with the bore and extends substantially along a longitudinal extent of the pile. The jig can be retained in position to fix the tube during concrete filling. Alternatively, as shown, the tube 14 extends into plug 12 and/or into the earth at the bottom of the bore

to provide stability to the tube and fix it in relation to the bore when the bore is filled with uncast concrete. Plug 12 can be cast at one longitudinal end of the tube prior to inserting the tube into the bore, or the tube can be inserted into the bore containing an uncast concrete plug, which is then allowed to hydrate fixing it to the end of the tube.

[0014] The longitudinal cavity forming means forms a longitudinal cavity 16 in the cast concrete pile as shown in Figure 4 when the uncast concrete has hydrated. The longitudinal cavity forming means can take a variety of forms, although tube 14 is the currently preferred form, whilst still allowing access to the pile after construction. For instance and without limitation, the longitudinal cavity forming means may comprise a tube with a non-circular cross-section such as triangular square or octagonal. The longitudinal cavity forming means may comprise a diaphragm or other flexible member which is arranged to create a longitudinal cavity in the finished pile. For instance, the diaphragm can be positioned in the bore and inflated with a fluid to the required shape. The longitudinal cavity forming means may consist solely of a diaphragm or one portion of an otherwise solid structure can be replaced with a diaphragm. This latter arrangement may be desirable if an irregular shaped cavity is required.

[0015] The longitudinal cavity forming means may be arranged to form a cavity which extends downwardly from bore 10 as shown into an underream or other formation. The simplest arrangement comprises a longitudinal cavity forming means which extends downwardly from the bore for extending the longitudinal cavity into the underream. Alternatively, the longitudinal cavity forming means is designed to provide a cavity which expands outwardly in a downwardly direction to follow the wal of the underream. A diaphragm can be used for this latter purpose.

[0016] Tube 14 may be made from metal, such as steel, plastics or cardboard or any other suitable material. A strong material such as steel is desirable if the tube is to be retained in situ and contribute to the overall strength and loading characteristics of the finished pile. If a weaker material such as cardboard is used, the lower end of the tube is preferably fitted with a shoe (not shown) to assist penetration of the tube into the earth at the bottom of the bore.

[0017] The longitudinal cavity forming means provides a boundary so that uncast concrete can be filled between the longitudinal cavity forming means and the ground in which the bore is formed in order to shape the concrete and produce a pile with the required internal dimensions. In this regard, the longitudinal cavity is sufficiently wide to allow a testing tool access to the longitudinal cavity so that cast concrete can be tested at a time after construction. Preferably, the longitudinal cavity is sufficiently wide to allow a person access to the longitudinal cavity so that cast concrete can be tested at a time after construction.

[0018] The longitudinal cavity forming means as shown is open at an upper end thereof. However, if desired the longitudinal cavity forming means may be closed at one or both ends. If the longitudinal cavity forming means is closed at an upper end and the longitudinal cavity forming means is left in situ in the finished pile, the closure is preferably such that that end can be readily opened to permit access to the cavity. It is preferable that the longitudinal cavity forming means is open at an upper end to permit the cavity to be filled, as described in further detail below.

[0019] Reinforcing members 18 are provided in the space between the tube 14 and bore wall for reinforcing the cast concrete of the pile. The reinforcing members may comprise fibres or steel. Reinforcing members are not always required in piles, since an unreinforced concrete pile may be adequate to achieve the necessary performance characteristics. If reinforcing members 18 are provided they can be fixed to tube 14 to facilitate insertion in the bore. Alternatively, the reinforcing members can be inserted separately.

[0020] Referring to Figure 4, bore 10 is filled with uncast or wet concrete 24 in the space between the bore wall and the tube 14. As described above referring to Figure 2 the tube 14 is embedded in the bottom of the pile bore or in plug 12 to resist upward movement, or floating, of tube 14 during concreting. Floating occurs when there is insufficient friction generated between the wet concrete and the reinforcing 18 (if present) or tube 14. In an alternative method to avoid floating, the plug 12 acts to seal the bottom end of tube 14 so that the tube can be filled with a liquid such as water to provide a ballast.

[0021] Vibrators 20 are used to work or compact the concrete so that the wet concrete fully takes up the space between the tube 14 and the bore wall thereby reducing the occurrence of voids in the cast concrete. The vibrators may be positioned on an internal surface of the tube 14 or alternatively the tube as a whole can be vibrated from the surface.

[0022] As shown in Figure 4, the cast concrete 24 of the pile forms an annulus around a circumference of the longitudinal cavity thereby forming a hollow pile. The annulus is generally circular in lateral cross-section. The shape of the cast concrete is not restricted to a circular cross-section or to an annulus, provided it is shaped to permit access to the pile along at least a portion of its length after the pile is constructed. For instance, an annulus may be triangular, square or octagonal in lateral cross-section. Although the cast concrete is preferably hollow, it is not required that the concrete fully surrounds the cavity. The concrete may be open along a side and additionally provided with means to prevent the ingress of earth into the cavity 16. Such means may comprise a plate formed from steel or other material.

[0023] During or after concrete hydration additional concrete may be filled at the bottom portion of tube 14, as shown in Figure 4, to form a base formation 22. The base formation 22 contributes to the loading capacity of

the pile by providing full base capacity.

[0024] Although not currently preferred the bore may first be filled with wet concrete and the longitudinal cavity forming means inserted secondly.

[0025] In the finished pile, the concrete is open at its upper end, or can be opened, to permit access to the longitudinal cavity 16 and thereby access to the pile along its length. In accordance with building regulations in some countries, a void should not remain under the ground after construction to avoid damage by expanding gases etc. Accordingly, it is preferred that the pile is filled with a filling after construction and closed at the upper end portion thereof. The filling is any suitable material such as water or polystyrene foam. The filling may be the same liquid as that used for a ballast. The upper end portion of the pile is closed in any suitable manner such as by concrete or a steel plate. When it is required to test the pile, the closure and filling are removed to provide access to the pile. Such access enables testing of the concrete 24 of the pile, the surrounding earth or the reinforcing members 18 at a time after the pile is finished so that if it is desired to re-use a site for a subsequent building or structure the pile can be assessed. The longitudinal cavity 16 is sized to permit testing tools or a person to be lowered to test the condition of the concrete or surrounding soil.

[0026] Therefore, it is possible to re-use the pile rather than removing the pile and constructing another pile or constructing additional piles on the site. Accordingly, a pile as described with reference to the Figures reduces the cost and time required for re-using a site for subsequent building.

[0027] When a site is to be used for a subsequent building or structure, it may be found that the originally designed loading capacity of the pile is not sufficient for the subsequent structure. The pile described permits a method of increasing or modifying a loading capacity of the pile. Since the pile has a longitudinal cavity a depth of the pile can be extended after the pile is constructed by passing boring equipment down the cavity and forming an extended bore with increased depth and/or width underneath the pile and at least partially filling the extended bore with uncast concrete. Such a method provides a deeper pile with increased loading capacity.

[0028] Environmental conditions in a building may be controlled by use of the thermal mass of the ground under or in the vicinity of the building. Since the currently described pile provides a longitudinal cavity which extends into the ground, the pile can beneficially be used to control such environmental conditions in a building of which the pile forms a foundation. An environmental control fluid which is used for controlling environmental conditions in the building is circulated within the longitudinal cavity so that the ambient conditions in the cavity affect a condition, such as temperature, of the control fluid. If the ambient conditions in the cavity are cooler than in the building, for instance at night, an air conditioning system of the building can circulate a fluid which is cooled by circulation in the longitudinal cavity. If the ambient conditions in the cavity are warmer than in the building, for instance during daylight, a heating system of the building can circulate fluid which is heated in the longitudinal cavity.

[0029] As the longitudinal cavity is pre-formed in the pile, piping can readily be installed in the ground, avoiding the requirement to form additional bores in the ground for the piping.

Claims

1. A method of constructing a re-usable pile, the method comprising:

   forming a bore in the ground to a required depth;
   disposing a longitudinal cavity forming means in the bore to define a longitudinal gap between the cavity forming means and the ground in which the bore is formed;
   securing the longitudinal cavity forming means in the bore so as to resist relative movement between the cavity forming means and the bore;
   filling the longitudinal gap between the bore and the cavity forming means with uncast concrete; and
   permitting the uncast concrete in the longitudinal cavity to harden and thereby form a cast concrete pile in the bore, which pile has a longitudinal cavity that permits access to be had to the pile along at least a portion of its length for sampling of the pile to assess its suitability for re-use.

2. A method as claimed in claim 1 , wherein the longitudinal cavity is open at an upper end of the pile to facilitate access from above ground to the longitudinal cavity.

3. A method as claimed in claim 1 or 2, wherein the longitudinal cavity extends substantially along a longitudinal extent of the pile.

4. A method as claimed in any one of the preceding claims, wherein the longitudinal cavity is sufficiently wide to allow a testing tool access to the longitudinal cavity so that cast concrete can be tested at a time after construction.

5. A method as claimed in any one of the preceding claims, wherein the longitudinal cavity is sufficiently wide to allow a person access to the longitudinal cavity so that cast concrete can be tested at a time after construction.

6. A method as claimed in any one of the preceding claims, wherein the concrete of the pile forms an annulus around a circumference of the longitudinal cavity.

7. A method as claimed in any one of the preceding claims, wherein the longitudinal cavity forming means comprises a cylinder.

8. A method as claimed in claims 7, wherein the cylinder is closed at a lower end portion thereof.

9. A method as claimed in claim 8, wherein the longitudinal cavity forming means is secured within the bore by filling the longitudinal cavity forming means with liquid to resist upward movement thereof when the bore is filled with uncast concrete.

10. A method as claimed in any one of the preceding claims, wherein the longitudinal cavity forming means is secured in the bore by fixing the cavity forming means in a plug at the bottom of the bore so that the cavity forming means resists upward movement thereof when said longitudinal gap is filled with uncast concrete.

11. A method as claimed in any preceding claim, wherein the longitudinal cavity forming means is secured in the bore by inserting an end of the cavity forming means into the ground at the bottom of the bore.

12. A method as claimed in any one of the preceding claims, wherein reinforcing members are disposed in the longitudinal gap between the longitudinal cavity forming means and the ground in which the bore is formed to reinforce the concrete of the pile on hardening.

13. A method as claimed in claim 12, wherein the reinforcing members are in substantially fixed relationship with the longitudinal cavity forming means prior to insertion in the bore.

14. A method as claimed in any one of the preceding claims, wherein prior to the step of allowing the concrete to harden, the uncast concrete is worked by vibrating the longitudinal cavity forming means.

15. A method according to any preceding claim, comprising - following hardening of the pile - the further step of inserting pipework into the longitudinal cavity of the pile to permit an environmental control fluid to be circulated through said longitudinal cavity so that the ambient environmental conditions in the cavity affect a condition of said control fluid.

Patentansprüche

1. Ein Verfahren zur Konstruktion eines wiederverwendbaren Pfeilers, wobei das Verfahren folgendes umfasst:

Bilden eines Bohrlochs im Boden mit einer erforderlichen Tiefe;
Anordnen eines Mittels zum Bilden eines Längshohlraums in dem Bohrloch, um einen Längsspalt zwischen dem hohlraumbildenden Mittel und dem Boden, in dem das Bohrloch gebildet ist, zu definieren;
Sichern des Mittels zum Bilden eines Längshohlraums in dem Bohrloch, um einer relativen Bewegung zwischen dem hohlraumbildenden Mittel und dem Bohrloch zu widerstehen;
Füllen des Längsspalts zwischen dem Bohrloch und dem hohlraumbildenden Mittel mit nicht-ausgehärtetem Beton; und
Aushärtenlassen des nicht-ausgehärteten Betons in dem Längshohlraum und dadurch Bilden eines ausgehärteten Betonpfeilers in dem Bohrloch, wobei der Pfeiler einen Längshohlraum aufweist, der einen Zugang zu dem Pfeiler entlang mindestens eines Teils seiner Länge zur Beprobung des Pfeilers gestattet, um seine Eignung zur Wiederverwendung zu bewerten.

2. Ein Verfahren, wie in Anspruch 1 beansprucht, wobei der Längshohlraum an einem oberen Ende des Pfeilers offen ist, um den Zugang von oberhalb des Bodens zu dem Längshohlraum zu erleichtern.

3. Ein Verfahren, wie in Anspruch 1 oder 2 beansprucht, wobei der Längshohlraum sich im Wesentlichen entlang eines Längsausmaßes des Pfeilers erstreckt.

4. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei der Längshohlraum ausreichend weit ist, um einem Prüfwerkzeug Zugang zu dem Längshohlraum zu gestatten, so dass der ausgehärtete Beton zu einer Zeit nach Konstruktion geprüft werden kann.

5. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei der Längshohlraum ausreichend weit ist, um einer Person Zugang zu dem Längshohlraum zu gestatten, so dass der ausgehärtete Beton zu einer Zeit nach Konstruktion geprüft werden kann.

6. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei der Beton des Pfeilers einen Ring um einen Umfang des Längshohlraums bildet.

7. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei das Mittel zum Bilden eines Längshohlraums einen Zylinder umfasst.

8. Ein Verfahren, wie in Anspruch 7 beansprucht, wobei der Zylinder an einem unteren Endabschnitt davon

geschlossen ist.

9. Ein Verfahren, wie in Anspruch 8 beansprucht, wobei das Mittel zum Bilden eines Längshohlraums in dem Bohrloch durch Füllen des Mittels zum Bilden eines Längshohlraums mit Flüssigkeit gesichert wird, um einer Aufwärtsbewegung davon zu widerstehen, wenn das Bohrloch mit nicht-ausgehärtetem Beton gefüllt wird.

10. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei das Mittel zum Bilden eines Längshohlraums in dem Bohrloch durch Fixieren des hohlraumbildenden Mittels in einem Anschluss an dem Boden des Bohrlochs gesichert wird, so dass das hohlraumbildende Mittel einer Aufwärtsbewegung davon widersteht, wenn der Längsspalt mit nicht-ausgehärtetem Beton gefüllt wird.

11. Ein Verfahren, wie in einem vorstehenden Anspruch beansprucht, wobei das Mittel zum Bilden eines Längshohlraums in dem Bohrloch durch Einsetzen eines Endes des hohlraumbildenden Mittels in den Boden an dem Boden des Bohrlochs gesichert wird.

12. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei Verstärkungselemente in dem Längsspalt zwischen dem Mittel zum Bilden eines Längshohlraums und dem Boden, in dem das Bohrloch gebildet ist, angeordnet sind, um den Beton des Pfeilers beim Aushärten zu verstärken.

13. Ein Verfahren, wie in Anspruch 12 beansprucht, wobei die Verstärkungselemente sich in einem im Wesentlichen fixierten Verhältnis mit dem Mittel zum Bilden eines Längshohlraums vor dem Einsetzen in das Bohrloch befinden.

14. Ein Verfahren, wie in einem der vorstehenden Ansprüche beansprucht, wobei vor dem Schritt des Aushärtenlassens des Betons der nichtausgehärtete Beton durch Vibrieren des Mittels zum Bilden eines Längshohlraums bearbeitet wird.

15. Ein Verfahren nach einem vorstehenden Anspruch, umfassend - nach Aushärten des Pfeilers - den weiteren Schritt des Einsetzens einer Verrohrung in den Längshohlraum des Pfeilers, um das Zirkulieren einer Umgebungskontrollflüssigkeit durch den Längshohlraum zu gestatten, so dass die Umgebungsbedingungen in dem Hohlraum einen Zustand der Kontrollflüssigkeit beeinträchtigen.

Revendications

1. Procédé de fabrication d'un pieu réutilisable, le procédé comprenant :

- la formation d'un trou dans le sol à une profondeur requise ;
- la disposition d'un moyen formant cavité longitudinale dans le trou pour définir un espace longitudinale entre le moyen formant cavité et le sol dans lequel le trou est formé ;
- la fixation du moyen formant cavité longitudinale dans le trou de façon à résister à un déplacement relatif entre le moyen formant cavité et le trou ;
- le remplissage de l'espace longitudinal entre le trou et le moyen formant cavité par du béton non coulé ; et
- l'étape consistant à permettre au béton non coulé dans la cavité longitudinale de durcir et de former ainsi dans le trou un pieu en béton coulé, lequel pieu a une cavité longitudinale qui permet un accès au pieu le long d'au moins une partie de sa longueur pour l'échantillonnage du pieu en vue d'évaluer son aptitude à une réutilisation.

2. Procédé selon la revendication 1, dans lequel la cavité longitudinale est ouverte à une extrémité supérieure du pieu pour faciliter un accès depuis la surface à la cavité longitudinale.

3. Procédé selon la revendication 1 ou 2, dans lequel la cavité longitudinale s'étend sensiblement le long d'une étendue longitudinale du pieu.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la cavité longitudinale est suffisamment large pour permettre un accès, par un outil d'essai, à la cavité longitudinale, de telle sorte que du béton coulé peut être contrôlé après fabrication.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la cavité longitudinale est suffisamment large pour permettre un accès, par une personne, à la cavité longitudinale, de telle sorte que du béton coulé peut être contrôlé après fabrication.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel le béton du pieu forme un anneau autour d'une circonférence de la cavité longitudinale.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel le moyen formant cavité longitudinale comprend un cylindre.

8. Procédé selon la revendication 7, dans lequel le cylindre est fermé à une partie d'extrémité inférieure de celui-ci.

9. Procédé selon la revendication 8, dans lequel le moyen formant cavité longitudinale est fixé à l'inté-

rieur du trou par remplissage du moyen formant cavité longitudinale par un liquide pour résister à un déplacement vers le haut de celui-ci lorsque le trou est rempli de béton non coulé.

10. Procédé selon l'une quelconque des revendications précédentes, dans lequel le moyen formant cavité longitudinale est fixé dans le trou par fixation du moyen formant cavité dans un bouchon au fond du trou, de telle sorte que le moyen formant cavité résiste à un déplacement vers le haut de celui-ci lorsque ledit espace longitudinal est rempli de béton non coulé.

11. Procédé selon l'une quelconque des revendications précédentes, dans lequel le moyen formant cavité longitudinale est fixé dans le trou par introduction d'une extrémité du moyen formant cavité dans le sol au fond du trou.

12. Procédé selon l'une quelconque des revendications précédentes, dans lequel des éléments de renforcement sont disposés dans l'espace longitudinal entre le moyen formant cavité longitudinale et le sol dans lequel le trou est formé, pour renforcer le béton du pieu lorsqu'il durcit.

13. Procédé selon la revendication 12, dans lequel les éléments de renforcement sont dans une relation sensiblement fixe avec le moyen formant cavité longitudinale avant introduction dans le trou.

14. Procédé selon l'une quelconque des revendications précédentes, dans lequel, avant l'étape consistant à permettre au béton de durcir, le béton non coulé est travaillé par vibration du moyen formant cavité longitudinale.

15. Procédé selon l'une quelconque des revendications précédentes, comprenant - à la suite du durcissement du pieu - l'étape supplémentaire d'introduction d'une tuyauterie dans la cavité longitudinale du pieu pour permettre à un fluide de régulation d'ambiance de circuler à travers ladite cavité longitudinale, de telle sorte que les conditions d'ambiance dans la cavité affectent un état dudit fluide de régulation d'ambiance.

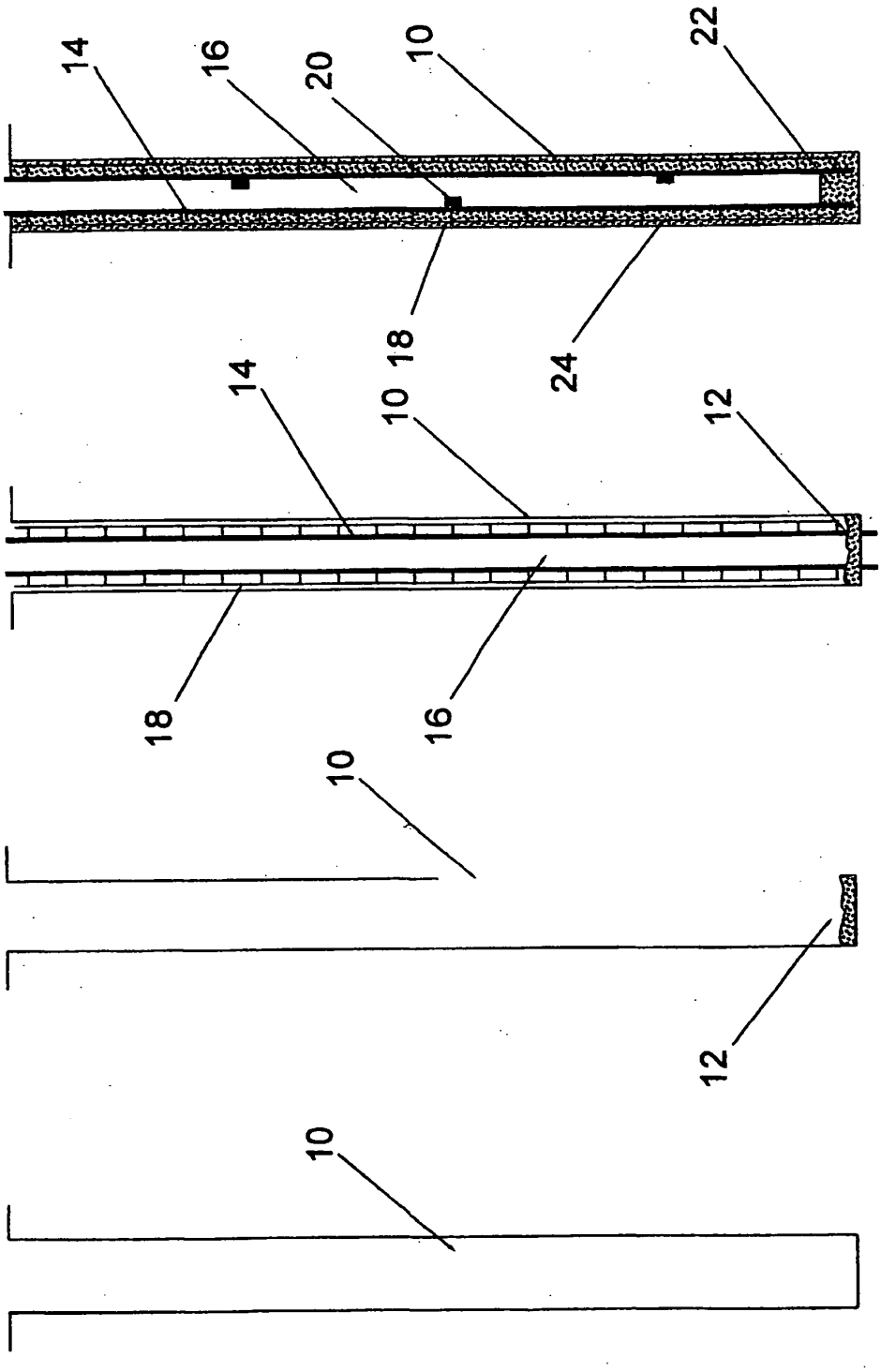

Fig. 4

Fig. 3

Fig. 2

Fig. 1

REFERENCES CITED IN THE DESCRIPTION

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