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

(11) **EP 1 063 358 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**27.12.2000 Bulletin 2000/52**

(51) Int Cl.[7]: **E02D 5/38**, E02D 7/00

(21) Application number: **00305254.5**

(22) Date of filing: **21.06.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE**
Designated Extension States:
**AL LT LV MK RO SI**

(30) Priority: **23.06.1999 GB 9914727**

(71) Applicant: **Abbey Pynford Contracts Plc**
**Watford WD2 4AE (GB)**

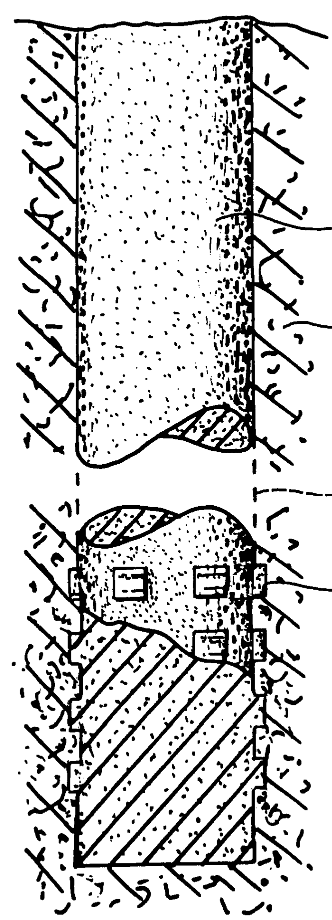
(72) Inventor: **Kiss, Paul**
**Friern Barnet, London N11 3LA (GB)**

(74) Representative: **Brunner, Michael John**
**GILL JENNINGS & EVERY**
**Broadgate House**
**7 Eldon Street**
**London EC2M 7LH (GB)**

(54) **Piling system**

(57) It is desirable to maximise the load bearing capacity of a pile and, typically, this is done by increasing the diameter or the depth of the pile but this usually involves heavier machinery and, in the case of underpinning, there is often limited headroom in which to accommodate the necessary equipment. Thus, a method of putting down a pile, the method comprising the steps of: creating a cylindrical hole (12) in the ground (13); pressing indentations (19) into the wall of the hole; and placing settable cementitious material to form a pile core (11).

Fig.1.




EP 1 063 358 A2

## Description

**[0001]** The invention is concerned with piles, which are formed by creating a hole in the ground and filling the hole with a settable cementitious material, such as concrete or grout. Such piles, which may be reinforced, are used to support new structures or in underpinning existing structures.

**[0002]** Depending on the ground conditions the load bearing ability of such a pile may depend essentially upon the skin friction between the outer periphery of the pile and the surrounding soil. It is often desirable to maximise the load bearing capacity of each pile. The capacity can be increased by increasing the diameter or depth of the pile but often involves heavier machinery and, in the case of underpinning, there is often limited head room to accommodate the necessary equipment for putting in heavy or long piles.

**[0003]** A limiting factor in the load bearing capacity of the pile is the adhesion between the outer surface of the pile and the surrounding soil.

**[0004]** In accordance with the present invention, a method of putting down a pile, comprises: creating a cylindrical hole in the ground; pressing indentations into the wall of the hole; and placing settable cementitious material to form a pile core within the hole.

**[0005]** With this arrangement the resulting pile would be formed with integral outwardly extending projections which will key into the surrounding soil and effectively increase the diameter of the pile to the cylindrical envelope defined by the radially outermost parts of the projections. This itself will increase the load bearing capacity of the pile above that of a pile having a diameter corresponding to that of the original cylindrical hole. A further advantage is that the soil stress and/or effective adhesion factors are increased thus further increasing the capacity of the pile.

**[0006]** The radial depth of each indentation may be between 2.5 and 200%, and preferably between 2.5 and 50%, of the diameter of the pile core. Thus, for example, in the case of a pile with a 200mm diameter, the indentations may extend from the periphery of the pile core in the order of 5 to 400 mm in clay soils and 5 to 100mm in other cases.

**[0007]** In order to maximise the mechanical keying between the pile projections and the surrounding soil, there should be a minimum of cylindrical plain portions exposed between adjacent axially spaced projections depending on ground conditions and pile diameter.

**[0008]** The indentations may be formed by a tool which may be lowered to the bottom of the hole, and from which one or more shoes may be extended radially into the wall of the hole to form a series of indentations. The shoes may then be withdrawn, the position of the device altered within the pile by a precalculated amount and the process repeated to create a plurality of spaced apart series of indentations. The hole may then be filled with a settable cementitious material.

**[0009]** The wall of the hole may be the ground or it may be a pile case which has been driven into the ground.

**[0010]** One tool for forming the indentations in the above new method comprises a substantially cylindrical body which is arranged to be lowered into the hole and which contains one or more shoes, and means for forcing the shoe(s) radially outwards to form the protrusion (s) so as to create the indentation(s) in the wall of the hole.

**[0011]** The radially outermost side of each shoe may be shaped in such a way as to create the desired shape of indentation and the radially innermost side shaped so as to be engaged by forcing means, such as a double acting hydraulically operated axially moving ram, for forcing the shoes radially outwardly and inwardly. The outermost side of each shoe may be shaped such that a number of axially spaced projections are formed on each shoe.

**[0012]** The innermost side of each shoe and the surface of the ram may have complementary keying formations such that, as the ram is moved axially, a T-shaped or other formation on the shoe is slidable in a keyway in the ram.

**[0013]** The invention also includes an alternative tool for forming the indentations in the above new method, the tool comprising an annular flexible membrane, a double acting hydraulically operated axially moving ram having two relatively movable parts, each movable part being sealed to a respective end of the membrane, and a fluid contained within the membrane, wherein, when the ram is extended, the membrane is substantially cylindrical and can be lowered into the hole and when the ram is retracted, the membrane protrudes radially outwards to form an annular indentation in the wall of the hole.

**[0014]** The two relatively movable parts of the ram may be provided with a respective plate to which the membrane is attached such that the circumference of the plate is in close proximity to the wall of the hole. This prevents the elastic membrane taking the path of least resistance and extending up and/or down the hole. The membrane can extend only radially and this ensures that the indentations are formed in the wall of the hole. The membrane may be formed from a rubber material.

**[0015]** The invention also includes a further alternative tool forforming the indentations in the above new method, the tool comprising an annular flexible membrane, a double acting hydraulically operated axially moving ram having two relatively movable parts, each movable part being sealed to a respective end of the membrane, and a fluid contained within the membrane, wherein, when the ram is extended, the membrane is substantially cylindrical and can be lowered into the hole and when the ram is retracted, the membrane protrudes radially outwards to form an annular indentation in the wall of the hole.

**[0016]** Conventional double acting rams comprise a piston which can be forcibly moved in two directions, usually by applying pressure to either side of a piston via a fluid such as hydraulic oil or compressed gas. This fluid must have access to both faces of the piston for the purposes of retraction and extension respectively.

**[0017]** This is usually achieved by injecting fluid through a number of ports located in the side of the cylinder. Extension ports are usually fitted near to base of the cylinder to inject fluid to the underside of the piston and retraction ports are usually fitted near to the top of the cylinder to inject fluid to the topside of the piston. Ports can also be fitted in the two endplates of the cylinder.

**[0018]** In this application of a double acting ram, the sides and one endplate of the cylinder are inaccessible because the ram is located in a hole in the ground. The clearance between the sides of the cylinder and the wall of the hole is insufficient for side ports or for pipework connected to the topplate to be used. All operating fluids must therefore flow in and out of the tool via a single endplate of the cylinder.

**[0019]** The invention also includes a double acting ram for use in the above new tools having two relatively movable parts, the ram comprising a cylinder which is arranged to be inserted coaxially into the hole fixed at its lower end to one relatively movable part of the tool, a piston which divides the cylinder into upper and lower compartments, a rigid rod which extends and is slidable through the bottom of the cylinder and is connected at its upper end to the piston and at its lower end to the other relatively movable part of the tool, an inlet through the top of the cylinder in communication with the upper compartment and a duct extending through the top of the cylinder, through the upper compartment and through the piston into communication with the lower compartment.

**[0020]** The rigid rod may be hollow in order to accommodate a pipe, forming the duct, and may have means, such as a slit or a hole, for placing the inside of the rod in fluid communication with the outside of the rod.

**[0021]** During extension fluid enters the nominal upper compartment of the cylinder through the inlet and applies pressure to the top face of the piston. The surplus fluid in the nominal lower compartment of the cylinder exits through the pipe. The piston and the rigid rod, which is attached to the piston, are forced downwardly and the shoes are extended outwardly. During retraction, fluid enters the lower compartment of the cylinder through the pipe and applies pressure to the lower face of the piston. The surplus fluid in the upper compartment of the cylinder exits via the inlet in the top of the cylinder. The piston is forced upwards and the shoes are withdrawn into the tool so that position of the tool can be changed and another indentation can be formed.

**[0022]** The construction of a pile in accordance with the present invention is illustrated diagrammatically in the accompanying drawings, in which:

Fig. 1 is a partially sectioned elevation of one completed bored pile and;

Figs. 2 and 3 are detailed sectional views showing successive stages in the production of the first pile;

Fig. 4 is a perspective view of a tool for use in the method;

Fig. 5 is a cross-section through the tool;

Figs. 6 and 7 are partially sectioned elevations showing successive stages in the formation of a driven pile;

Figs. 8, 9 and 10 are views similar to Figs. 2, 3 and 5 but showing the production of the driven pile;

Figs. 11 and 12, and Figs. 13 and 14 are respectively partially sectioned elevations showing alternative tools for forming indentations; and

Fig. 15 is a partially sectional view of a double acting ram for use in the tools.

**[0023]** The bored pile shown in Fig. 1 has a reinforced concrete core 11 which is cast in situ in a bored hole 12 in the ground 13. The load bearing capacity of the pile is enhanced by a number of rings of integral projections 14 which are cast with the pile core and which extend into preformed indentations in the wall 12 of the hole.

**[0024]** The indentations are formed as shown in Figs. 2 to 5. Use is made of a tool which, as shown in Fig. 4, has a cylindrical body 15 which can be lowered into the hole 12 on suspension supports 16 and which has windows 17 through which shoes, in this case double headed shoes 18, can be caused to protrude radially outwards, each to form two indentations 19 in the wall of the hole. The shoes are forced radially outwards and inwards by axial movement of a plunger 20 forming or connected to a double acting ram supplied with hydraulic fluid through lines 21.

**[0025]** After the cylindrical hole 12 has been bored, the tool is lowered down the hole to an appropriate depth and the plunger 20 operated to force the shoes 18 outwards from the Fig. 2 to the Fig. 3 position, corresponding to the left and right hand sides of Fig. 5, respectively, and form the indentations 19. The shoes are then retracted, the tool moved an appropriate axial distance, usually up the hole 12, and the indentation forming process repeated as often as necessary. The tool is then removed from the hole, reinforcement inserted, and the concrete poured to create the pile core 11 with integral projections 14.

**[0026]** Figs. 6 to 10 show the application of the invention to a driven pile having a steel case 22. In conventional fashion the case is first driven into the ground. However, before the conventional subsequent step of filling the case with concrete, the tool as previously described is inserted into the case and the shoes 18 extended to produce indentations 19A in the case, and hence also into the surrounding earth. After sufficient indentations 19A have been created, the tool is removed and concrete poured into the case to create the pile core.

**[0027]** An alternative tool is shown in Figures 11 and 12. The tool has a double acting ram 23 which has two relatively movable parts 24,25 and a plate 26 provided on each movable part 24,25. A respective end of an annular membrane 27 is sealed to each plate and the membrane is filled with a fluid 28. The tool is suspended on a tube 29 containing hydraulic lines 21A.

**[0028]** To form indentation 19B, the tool is inserted into the hole 12 when the ram is fully extended. Thus the annular membrane is substantially cylindrical as shown in Figure 11. The tool is lowered to the required depth and the ram is retracted. The plates 26 are thus moved toward each other and the membrane 27 and fluid 28 are displaced and forced to protrude radially outwards to form the indentation. The ram is then extended and the position of the tool can be altered so that another indentation can be formed. After a suitable number of indentations have been formed, the tool can be removed from the hole.

**[0029]** The further alternative tool shown in Figs. 13 and 14 differs from that shown in Figs. 11 and 12 in that the membrane 27 and fluid 28 are replaced by a ring of pivotal elbows 30 each consisting of a pair of levers 31 which are interconnected at a pivotal joint 32 and are each pivotally connected at a pivotal joint 33 to a respective one of the end plates 26. In this example, there are 4 of the elbows positioned at equangularly spaced intervals around the axis of the ram. It is envisaged, however, that 6 or even 8 elbows could be used. The tool is lowered and raised in the hole 12 on the tube 29 with the ram 23 extended and the elbows 30 radially retracted. When indentations 19C are to be formed, the ram is retracted from the position shown in Fig. 13 to that shown in Fig. 14 so that the elbows fold and are radially outwardly extended. As before, the procedure can then be repeated at different axial locations in the hole 12.

**[0030]** The double acting ram 15,23 used in the tools is shown in Fig. 15 and has a cylindrical body 34, a top plate 35 fixed to the suspension tube 29 and a base plate 36. A two part piston 37 is located in the cylindrical body 34 and divides it into upper 38 and lower 39 compartments. A number of seals 40 are located between the two parts of the piston 37 to prevent leakage of fluid between the upper 38 and lower 39 compartments. The two parts of the piston 37 are held together by a number of screws 40. A hollow rigid rod 41 extends through the base plate 36 and is connected at its upper end to the piston 37. The lower end of the rigid rod 41 is arranged to be attached to either the movable plunger 20 shown in Fig. 5 or to the endplate 26 shown in Figs 11 and 13. A lower part of the cylindrical body 34 is screw threaded and engages with a threaded gland 42 which is securely fastened to the rest of the tool by screws 43.

**[0031]** During extension, fluid enters the upper compartment 38 via an inlet 44 in the top plate and applies a downward pressure to the upper surface of the piston 37, which causes the piston to move downwards and displace fluid in the lower compartment 39. The excess fluid from the lower compartment 39 exits via a number of openings 45 which place the lower compartment 39 in hydraulic communication with the inside of the rigid rod 41. The fluid enters the rigid rod 41 and is forced to flow through a duct 46 provided in a tube 47 which extends into the rigid rod 41 with a clearance, through the piston 37 and through the top plate 35 of the ram. As the piston 37 is forced downwardly, the rigid rod 41 causes the movable ram 20 either to push the shoes radially outwards or, in the embodiments shown in Figs 11 to 14, to disengage the tool from the pile wall.

**[0032]** During retraction, fluid enters the lower compartment 39 via the duct 46, the rigid rod 41 and the openings 45. An upward force is thus applied to the lower surface of the piston 37, which causes the piston to move upwards to displace fluid in the upper compartment 38 and the excess fluid in the upper compartment 38 is expelled through the inlet 44. As the piston is moved upwardly, the rigid rod causes the movable ram either to pull the shoes radially inwards or, in the embodiments shown in Figs 11 to 14, to form the required indentations.

## Claims

1. A method of putting down a pile, the method comprising the steps of:

    creating a cylindrical hole (12) in the ground (13);
    pressing indentations (14) into the wall of the hole; and
    placing settable cementitious material to form a pile core (11) within the hole.

2. A method according to claim 1, wherein the radial depth of each indentation (14) is between 2.5 and 200% of the diameter of the pile core (11).

3. A method according to either claim 1 or claim 2, wherein the indentations (14) are formed by a tool which is lowered to the bottom of the hole (12).

4. A method according to claim 3, wherein one or more shoes (18) are extended radially from the tool into the wall of the hole (12) to form a series of indentations (14).

5. A method according to claim 4, wherein the shoes (18) are then withdrawn, the position of the tool is altered within the pile by a precalculated amount and the process is then repeated to create a plurality of spaced apart series of indentations (14).

6. A method according to any one of the preceding claims, wherein the hole (12) is filled with a settable cementitious material.

**7.** A method according to any one of the preceding claims, wherein the wall of the hole (12) is either the ground or a pile case (22) which has been driven into the ground (13).

**8.** A tool for use in the method according to any one of claims 1 to 7, the tool comprising:

a substantially cylindrical body (15) which is arranged to be lowered into the hole (12) and which contains one or more shoes (18); and
means for forcing the shoe(s) radially outwards so as to create the indentation(s) (14) in the wall of the hole.

**9.** A tool according to claim 8, wherein the radially outermost side of each shoe (18) is shaped in such a way as to create the desired shape of indentation (14).

**10.** A tool according to either claim 8 or claim 9, wherein the radially innermost side of each shoe (18) is shaped so as to be engaged by forcing means (20).

**11.** A tool according to claim 10, wherein the forcing means is a double acting hydraulically operated axially moving ram (23) for forcing the shoes (18) radially outwardly and inwardly.

**12.** A tool according to any one of claims 8 to 11, wherein the outermost side of each shoe (18) is shaped such that a number of axially spaced projections are formed on each shoe.

**13.** A tool according to any one of claims 8 to 12, wherein the innermost side of each shoe (18) and a surface of the forcing means (20) have complementary keying formations such that, as the forcing means (20) is moved axially, the shoe is slidable in a keyway in the forcing means.

**14.** A tool according to claim 13, wherein the keying formations are T-shaped.

**15.** A tool for use in the method according to any one of claims 1 to 7, the tool comprising:

an annular flexible membrane (27);
a double acting hydraulically operated axially moving ram (23) having two relatively movable parts (24,25), each movable part being sealed to a respective end of the membrane; and
a fluid (28) contained within the membrane, wherein, when the ram is extended, the membrane is substantially cylindrical and can be lowered into the hole (12) and when the ram is retracted, the membrane protrudes radially outwards to form an annular indentation (14) in the wall of the hole.

**16.** A tool according to claim 15, wherein the two relatively movable parts (24,25) of the ram (23) are provided with respective plates (26) to which the membrane is attached such that the circumference of the plate is in close proximity to the wall of the hole (12).

**17.** A tool according to either claim 15 or claim 16, wherein the membrane (27) is formed from a rubber material.

**18.** A tool for use in the method according to any one of claims 1 to 7, the tool comprising:

a ring of hinged elbows (30); and
a double acting hydraulically operated axially moving ram (23) having two relatively movable parts (24,25), each movable part being pivotally connected to a respective end of each of the elbows (30) whereby, when the ram is retracted, the elbows fold to form respective indentations (14) in the wall of the hole(12).

**19.** A double acting ram (23) for use in a tool according to any one of claims 8 to 18, the ram comprising:

a cylinder (34) which is arranged to be inserted coaxially into the hole (12) fixed at its lower end to one relatively movable part of the tool;
a piston (37) which divides the cylinder into upper (38) and lower (39) compartments;
a rigid rod (41) which extends and is slidable through the bottom of the cylinder and is connected at its upper end to the piston and its lower end to the other relatively movable part of the tool;
an inlet (44) through the top of the cylinder in communication with the upper compartment; and
a duct (46) extending through the top of the cylinder, through the upper compartment and through the piston into communication with the lower compartment.

**20.** A ram according to claim 19, wherein the rigid rod (41) is hollow in order to accommodate a pipe which forms the duct (46).

**21.** A ram according to either claim 19 or claim 20, further comprising means (45) for placing the inside of the rod (41) in fluid communication with the outside of the rod.

Fig.1.

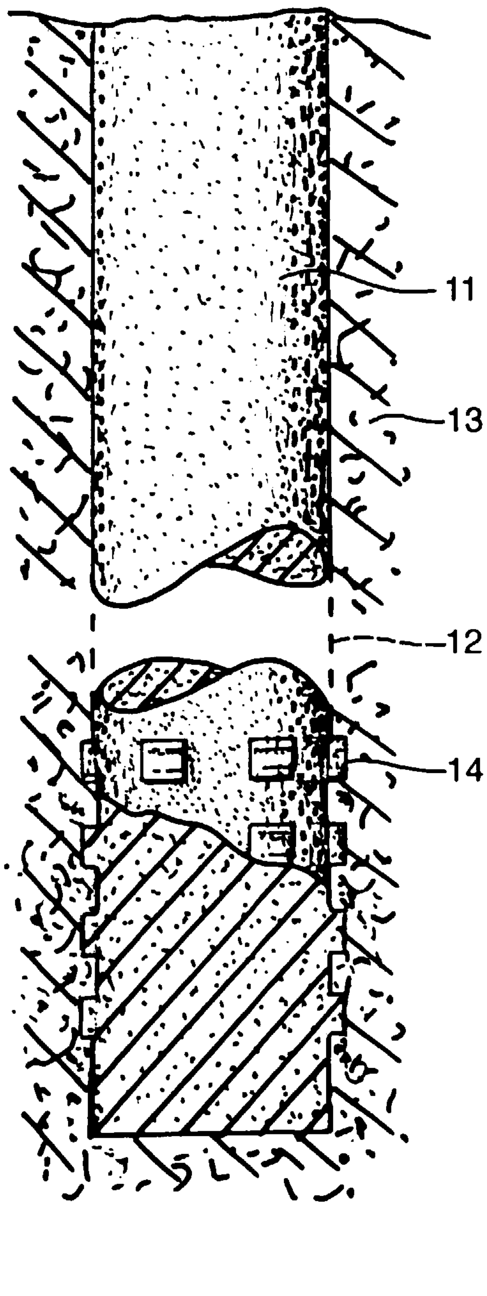


Fig.2.

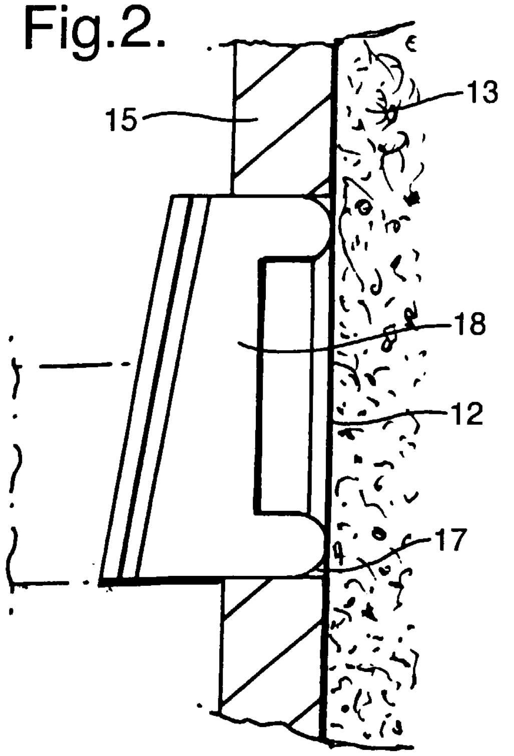



Fig.3.

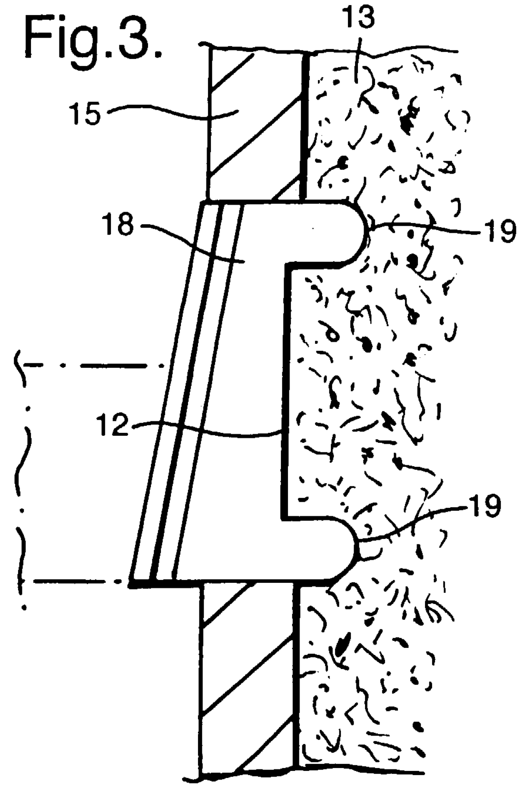



Fig.5.

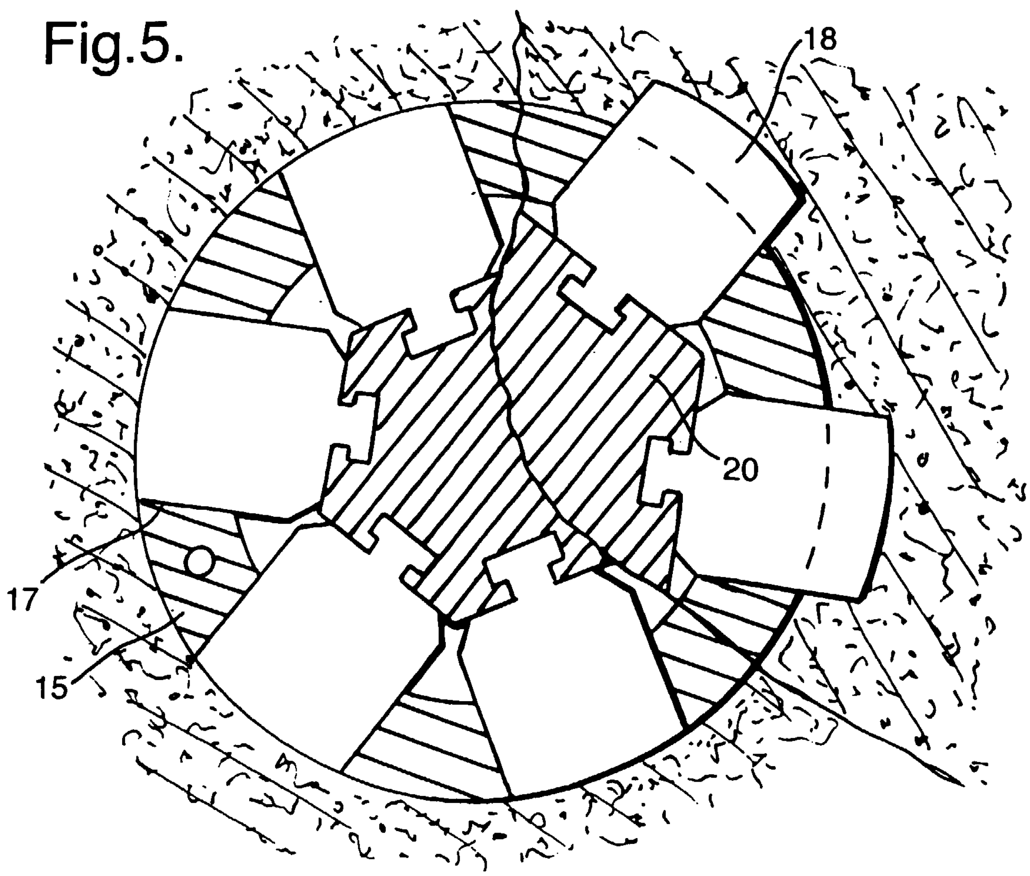


Fig.7.

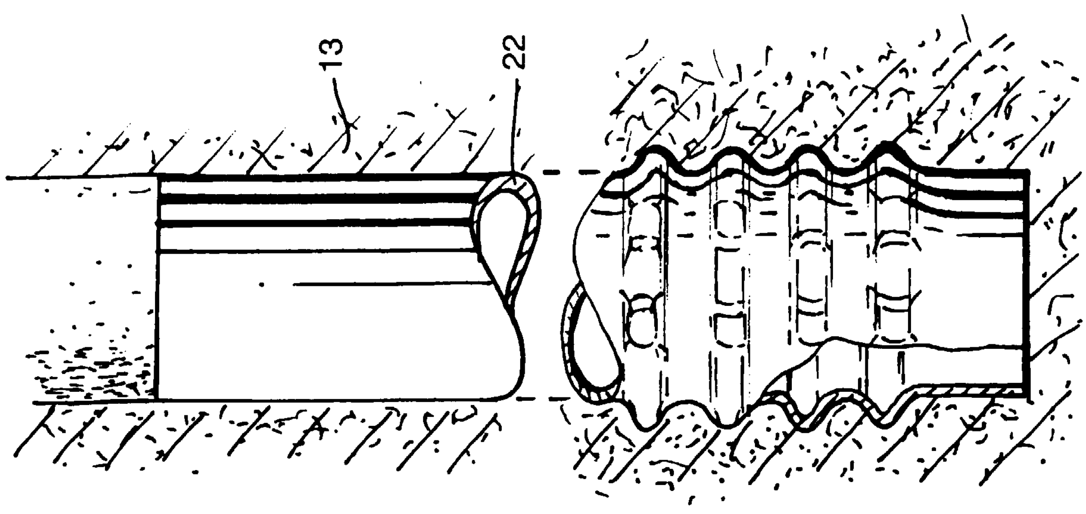



Fig.6.

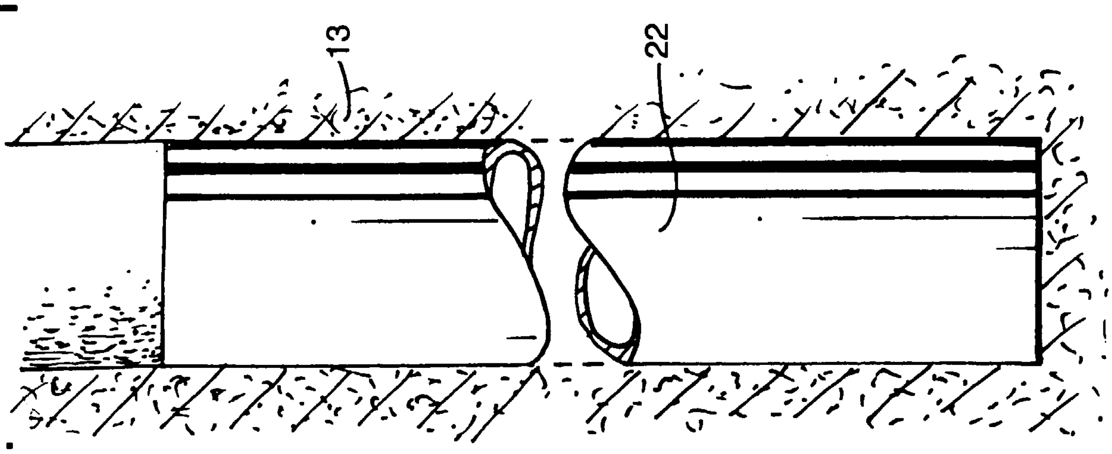



Fig.4.

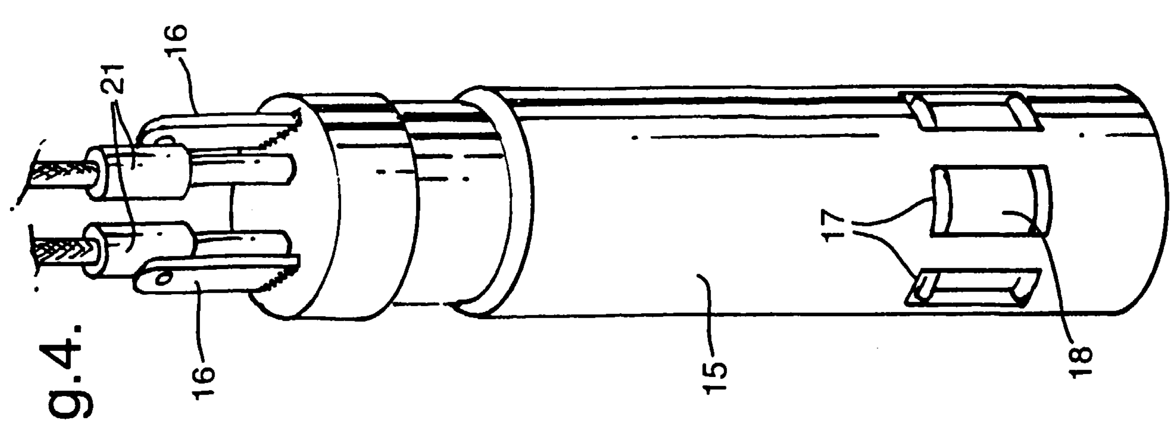


Fig.8.

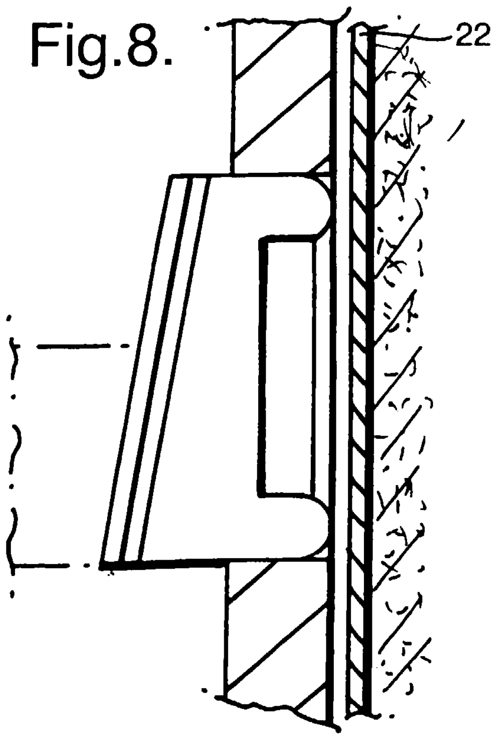



Fig.9.

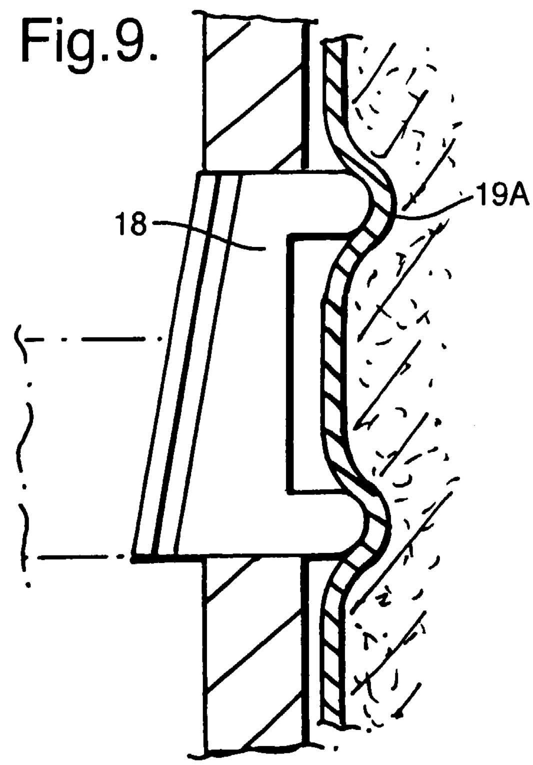



Fig.10.

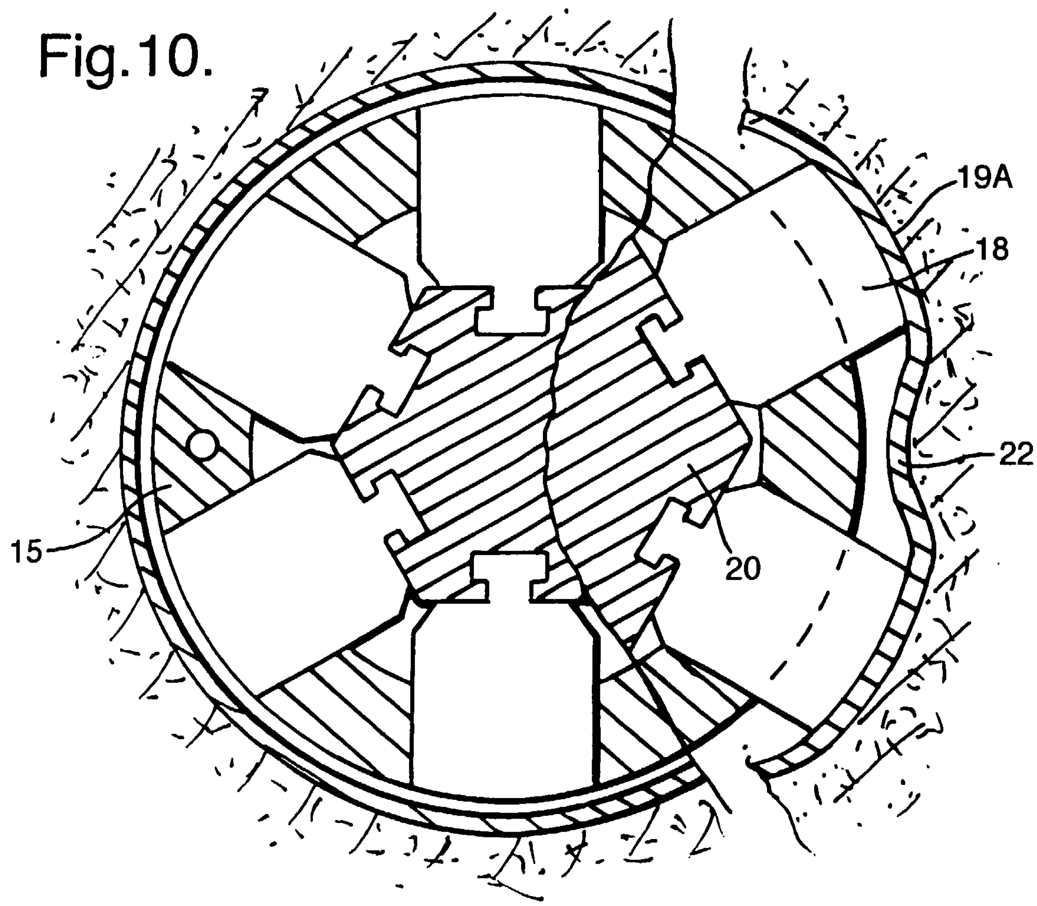


Fig.11.

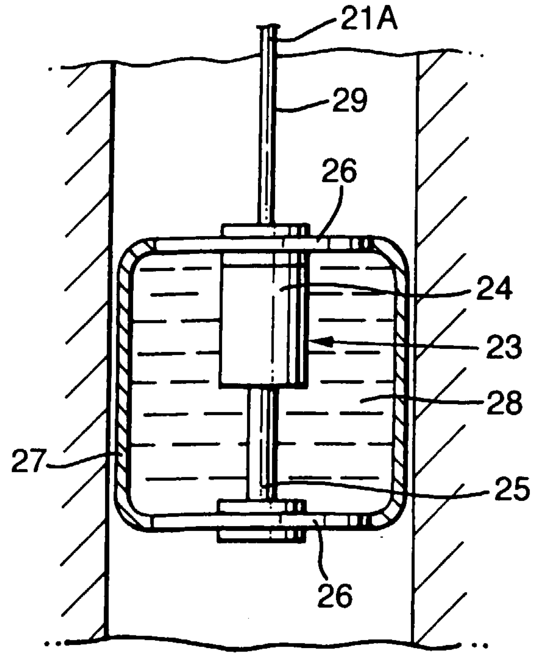



Fig.12.

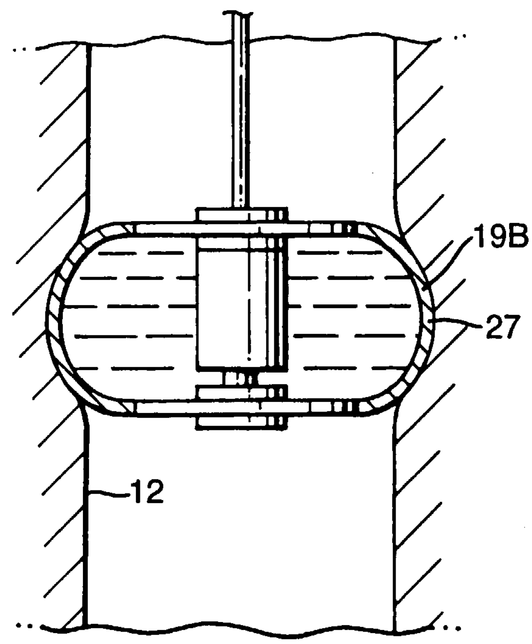



Fig.13.

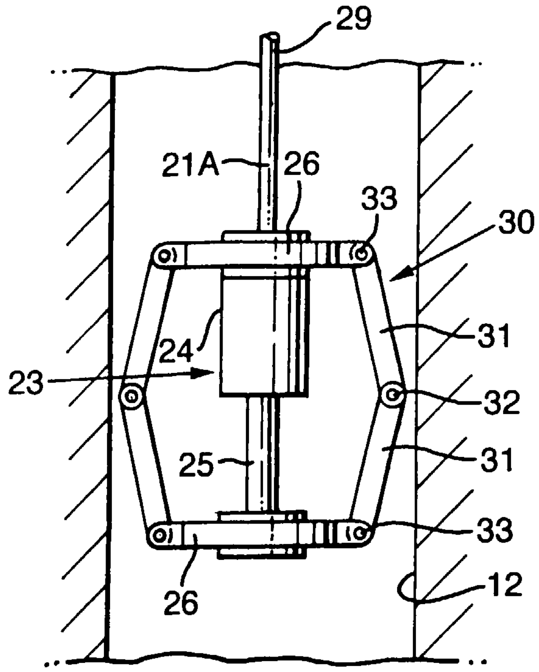



Fig.14.

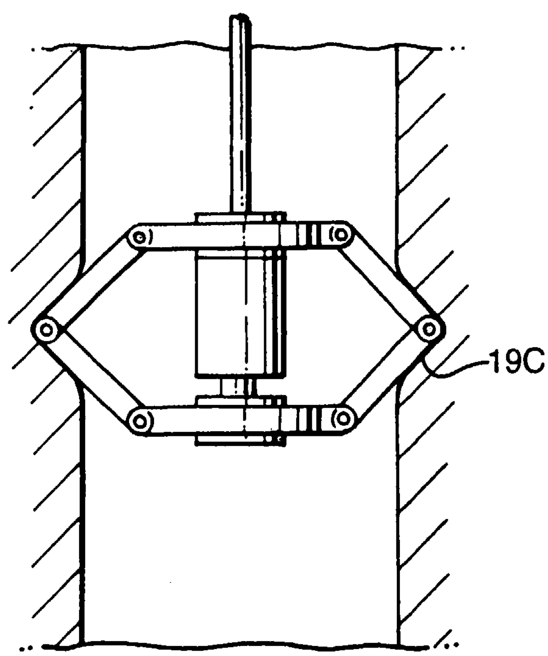


Fig.15.