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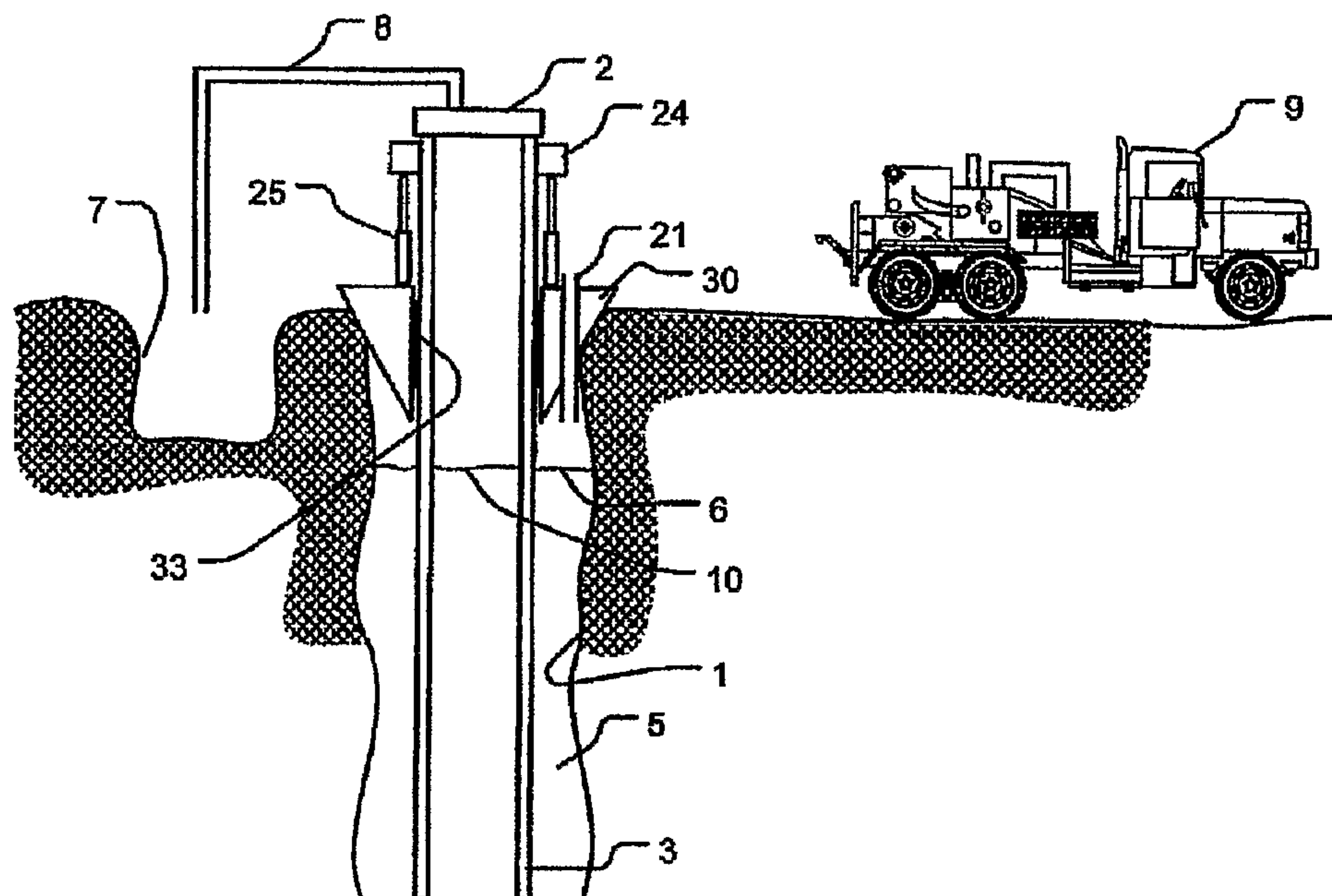
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(54) Title: METHODS AND SYSTEMS FOR CEMENTING WELLS THAT LACK SURFACE CASING



(57) **Abrégé/Abstract:**

A method for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the method having: sealing the annulus at the mouth of the well bore with a seal; pumping a cement composition into the annulus through the seal; and taking circulation fluid returns from the inner diameter of the casing. A system for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the system having: a seal of the annulus at the mouth of the well bore; a cement composition pump fluidly connected to the annulus through the seal; and a coupling connected to the exposed end of the casing for taking circulation fluid returns from the inner diameter of the casing. A seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal having: an annular plug around the casing in the annulus below and proximate the mouth of the well bore, wherein the annular plug has conduit through the annular plug allowing fluid communication with the annulus below the annular plug; an anchor attachable to the casing above the annular plug; and at least one jack positioned between the annular plug and the anchor, wherein the at least one jack pushes the annular plug downwardly away from the anchor.

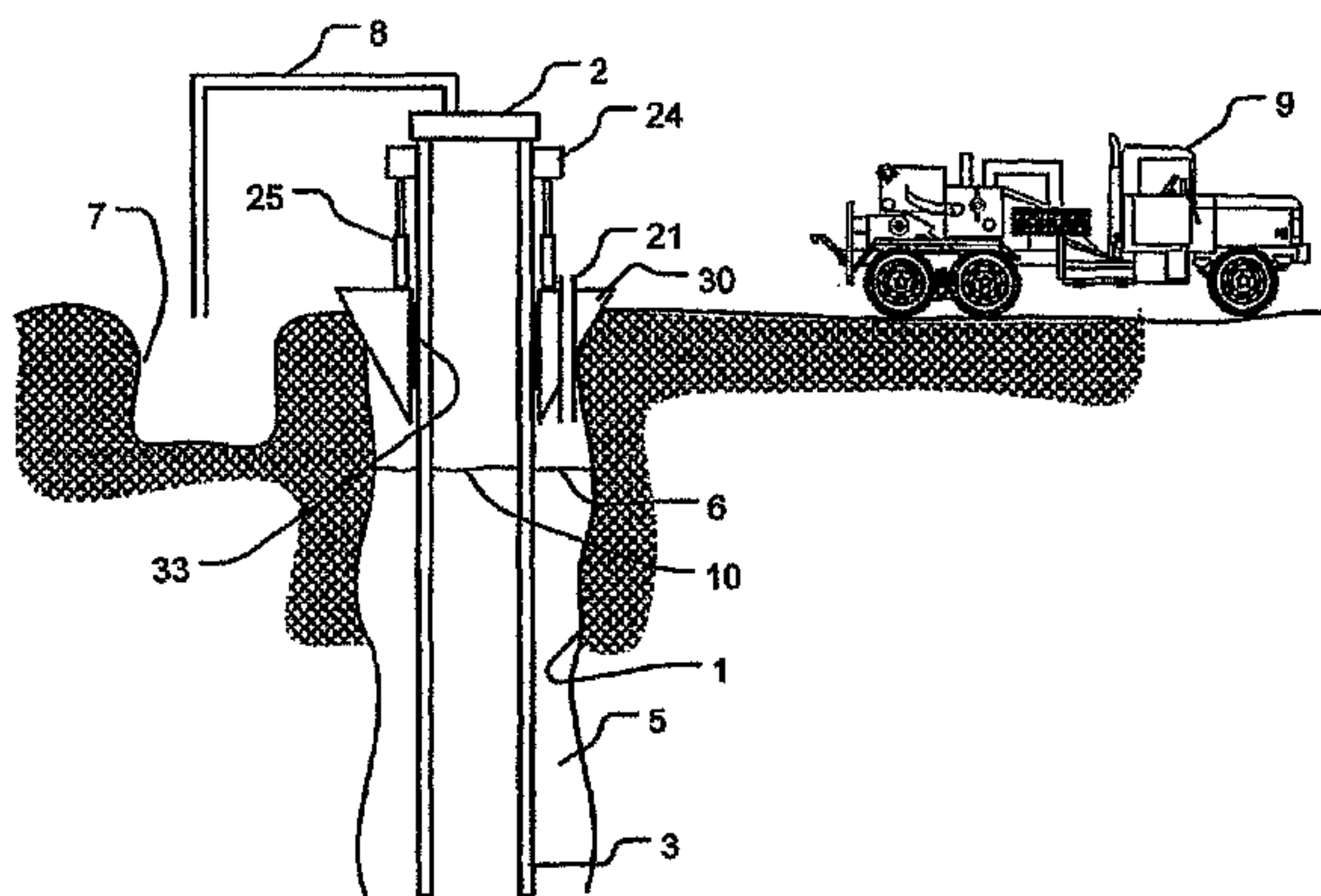




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(54) Title: METHODS AND SYSTEMS FOR CEMENTING WELLS THAT LACK SURFACE CASING



(57) Abstract: A method for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the method having: sealing the annulus at the mouth of the well bore with a seal; pumping a cement composition into the annulus through the seal; and taking circulation fluid returns from the inner diameter of the casing. A system for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the system having: a seal of the annulus at the mouth of the well bore; a cement composition pump fluidly connected to the annulus through the seal; and a coupling connected to the exposed end of the casing for taking circulation fluid returns from the inner diameter of the casing. A seal of a well bore annulus at the mouth of an open well bore having a casing extending therefrom and no surface casing, the seal having: an annular plug around the casing in the annulus below and proximate the mouth of the well bore, wherein the annular plug has conduit through the annular plug allowing fluid communication with the annulus below the annular plug; an anchor attachable to the casing above the annular plug; and at least one jack positioned between the annular plug and the anchor, wherein the at least one jack pushes the annular plug downwardly away from the anchor.

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METHODS AND SYSTEMS FOR CEMENTING WELLS THAT LACK SURFACE CASING

BACKGROUND OF THE INVENTION

This invention relates to cementing casing in well bores drilled in subterranean formations. In particular, this invention relates to methods for cementing casing in a well bore without surface casing or a well head.

Typically, prior to cement operations, a relatively larger diameter surface casing is run into the well bore to a relatively shallow depth. A casing string is then inserted in a well bore. Circulation fluid fills the inner diameter ("ID") of the casing and the casing-by-well bore annulus. For purposes of this disclosure, "circulation fluid" is defined as circulation fluid, drilling mud, formation fluids and/or any other fluid typically found in pre-cemented wells. Once the casing is run into the well bore, it is desirable to flow a cement composition into the annulus and allow the cement composition to harden to completely seal the annulus and secure the casing in the bore hole.

However, in some well bores, no surface casing is installed prior to insertion of the casing string. Figure 1 illustrates a cross-sectional, side view a well bore 1 and casing 3. An annulus 5 is defined between the well bore 1 and the casing 3. At the lower end of the casing, a casing shoe 4 is attached for circulating fluid between the annulus 5 and the inside diameter of the casing 3. The well bore 1 is filled with a circulating fluid such that an annulus circulation fluid surface 6 is at approximately the same depth as an ID circulation fluid surface 10. A reservoir 7 is located proximate to the well bore 1. Also, a truck 9 is parked in the vicinity of the well bore 1. As illustrated, the casing 3 simply protrudes from the mouth of the well bore 1 without a surface casing or a well head. Thus, Figure 1 simply illustrates an open well bore with casing sticking out of it.

Well configurations as illustrated in Figure 1 present additional challenges for conducting cementing operations. For example, cementing of these wells is problematic because there is no well head forming a seal of the annulus, there is no well head providing nipple connections for fluid communication with the inner diameter of the casing or the annulus, and there is increased risk of well bore cave-in.

SUMMARY OF THE INVENTION

This invention relates to cementing casing in well bores drilled in subterranean formations. In particular, this invention relates to methods for cementing casing in a well bore without surface casing or a well head.

According to one aspect of the invention, there is provided a method for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the method having: sealing the annulus at the mouth of the well bore with a seal; pumping a cement composition into the annulus through the seal; and taking circulation fluid returns from the inner diameter of the casing.

Another aspect of the invention provides a method of sealing a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the method having: positioning an annular plug around the casing in the annulus below and proximate the mouth of the well bore, wherein the annular plug has conduit through the annular plug allowing fluid communication with the annulus below the annular plug; attaching an anchor to the casing above the annular plug; and pushing the annular plug downwardly away from the anchor.

According to a further aspect of the invention, there is provided a method of sealing a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the method having: inserting a packer into the annulus below and proximate the mouth of the well bore; expanding the packer in the annulus, wherein the packer has conduit through the packer allowing fluid communication with the annulus below the packer.

A further aspect of the invention provides a method of sealing a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the method having: plugging the annulus below and proximate the mouth of the well bore with a settable material.

According to still another aspect of the invention, there is provided a method for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the method having: injecting a cement composition into the annulus at a level below the mouth of the well bore a sufficient distance to prevent the cement composition from flowing out the top of the annulus, whereby the weight of the cement composition in the annulus initiates fluid flow in the well bore in a

reverse circulation direction before the cement composition flows out the top of the annulus; and taking circulation fluid returns from the inner diameter of the casing.

Another aspect of the invention provides a system for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the system having: a seal of the annulus at the mouth of the well bore; a cement composition pump fluidly connected to the annulus through the seal; and a coupling connected to the exposed end of the casing for taking circulation fluid returns from the inner diameter of the casing.

According to a still further aspect of the invention, there is provided a seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal having: an annular plug around the casing in the annulus below and proximate the mouth of the well bore, wherein the annular plug has conduit through the annular plug allowing fluid communication with the annulus below the annular plug; an anchor attachable to the casing above the annular plug; and at least one jack positioned between the annular plug and the anchor, wherein the at least one jack pushes the annular plug downwardly away from the anchor.

A further aspect of the invention provides a seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal having: a packer into the annulus below and proximate the mouth of the well bore, wherein the packer has a conduit through the packer allowing fluid communication with the annulus below the packer.

Another aspect of the invention provides a seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal having: a settable material plug in the annulus below and proximate the mouth of the well bore; and a conduit through the settable material plug.

According to yet another aspect of the invention, there is provided a system for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the system having: a cement composition pump; a cement composition injector fluidly connected to the cement composition pump, wherein the injector is positioned at a level below the mouth of the well bore a sufficient distance to prevent the cement composition from flowing out the top of the annulus, whereby the weight of the cement composition in the annulus initiates fluid flow in the well bore in a

reverse circulation direction before the cement composition flows out the top of the annulus; and a coupler attached to an exposed end of the casing for taking circulation fluid returns from the inner diameter of the casing.

The objects, features, and advantages of the present invention will be readily apparent to those skilled in the art upon a reading of the description of the preferred embodiments that follows.

BRIEF DESCRIPTION OF THE FIGURES

The present invention is better understood by reading the following description of non-limiting embodiments with reference to the attached drawings wherein like parts of each of the several figures are identified by the same referenced characters, and which are briefly described as follows.

Figure 1 is a cross-sectional, side view of a well bore and a casing sticking out of the mouth of the well bore above the surface.

Figure 2A is a cross-sectional, side view of a well bore and casing wherein an annular plug is attached to the casing at the mouth of the well bore.

Figure 2B is a top view of the annular plug shown in Figure 2A, wherein slips and a seal are positioned within the annular plug.

Figure 3A is a cross-sectional, side view of a well bore and casing wherein a sectional plug is mounted in the annulus at the top of the well bore.

Figure 3B is a top view of the sectional plug illustrated in Figure 3A, wherein seals are positioned between the sections of the sectional plug.

Figure 4A is a cross-sectional, side view of a well bore and casing, wherein a packer is positioned in the annulus at the mouth of the well bore.

Figure 4B is a cross-sectional, side view of the well bore and casing illustrated in Figure 4A, wherein the packer is inflated to seal the annulus at the top of the well bore.

Figure 4C is a top view of the packer identified in Figures 4A and 4B.

Figure 5A is a cross-sectional, side view of a well bore and casing wherein a conduit is inserted into the annulus at the top of the well bore and attached to a pump truck.

Figure 5B is a cross-sectional, side view of the well bore and casing illustrated in Figure 5A, wherein a settable material is pumped into the annulus at the top of the well bore.

Figure 6A is a cross-sectional, side view of a well bore and casing wherein a packer and conduit are inserted into the annulus at the top of the well bore.

Figure 6B is a cross-sectional, side view of the well bore and casing illustrated in Figure 6A, wherein a settable material is pumped into the annulus at the top of the well bore on top of the inflated packer.

Figure 6C is a top view of the packer identified in Figures 6A and 6B.

Figure 7A is a cross-sectional, side view of a well bore and casing wherein a mechanical slip packer and conduit are inserted into the annulus at the top of the well bore.

Figure 7B is a cross-sectional, side view of the well bore and casing illustrated in Figure 7A, wherein a settable material is pumped into the annulus at the top of the well bore on top of the expanded mechanical slip packer.

Figure 8A is a cross-sectional, side view of a well bore and casing wherein a basket and conduit are inserted into the annulus at the top of the well bore.

Figure 8B is a cross-sectional, side view of the well bore and casing illustrated in Figure 8A, wherein a settable material is pumped into the annulus at the top of the well bore on top of the basket.

Figure 8C is a top view of the basket identified in Figures 7A and 7B.

Figure 9A is a cross-sectional, side view of a well bore and casing wherein a cross-over tool and ID line are positioned in the casing for injecting a cement composition into the annulus at the level below the mouth of the well bore.

Figure 9B is a cross-sectional, side view of the well bore and casing illustrated in Figure 9A, wherein a cement composition is pumped into the annulus below the cross-over tool.

It is to be noted, however, that the appended drawings illustrate only a few aspects of certain embodiments of this invention and are therefore not limiting of its scope, as the invention encompasses equally effective additional or equivalent embodiments.

DETAILED DESCRIPTION OF THE INVENTION

This invention relates to cementing casing in well bores drilled in subterranean formations. In particular, this invention relates to methods for cementing casing in a well bore without surface casing or a well head.

Figure 2A illustrates a cross-sectional, side view of a well bore and casing. Similar to the well bore illustrated in Figure 1, this well bore has a casing 3 sticking out of the mouth of the well bore 1 without an installed surface casing or well head. An annulus 5 is defined between the casing 3 and the well bore 1. A truck 9 is parked near the well bore and a

reservoir is also located nearby. The well bore 1 is also filed with circulation fluid such that an annulus circulation fluid surface 6 is approximately level with an ID circulation fluid surface.

An annular plug 20 is positioned over the exposed end of the casing 3 and lowered until it rests on the soil at the mouth of the well bore 1. As illustrated, the annular plug is a conical shape structure with a hole through its center. The inside hole of the annular plug 20 is also a conical shape so as to receive slips 22 between the annular plug 20 and the casing 3. An annular seal 23 is positioned between the casing 3 and the slips 22. Figure 2B illustrates a top view of the slips 22 and annular seal 23 positioned within the annular plug 20 (shown in dotted lines). Sectional seals 26 are positioned between the slips 22 to seal the gaps between the slips 22.

Referring again to Figure 2A, an anchor 24 is attached to the casing 3 above the slips 22. Any method known to persons of skill may be used to attach the anchor, such as set screws, welding, fastening two halves with bolts, etc. Jacks 25 are positioned between the slips 22 and the anchor 24. Any type of jacks known to persons of skill may be used such as hydraulic, screw, scissor, etc. A single jack or any number of jacks may be used, but in at least one embodiment, it is preferable to distribute the force from the jacks evenly across the slips 22. When the jacks 25 are activated, they anchor themselves against the anchor 24 and push the slips 22 downward into the annular plug 20. Because the inner hole of the annular plug 20 and the slips 22 are conical in shape, the slips wedge themselves between the casing 3 and the annular plug 20 as the downward force generated by the jacks 25 is increased (the annular seal 23 is positioned between the slips 22 and the casing 3). Because the slips 22 and the annular plug 20 are allowed to slide relative to the casing 3, the jacks 25 also press the annular plug 20 firmly against the soil at the mouth of the well bore 1. In this manner, the annular plug 20 completely seals the annulus 5 at the top of the well bore 1.

The annular plug 20 also has a conduit 21 extending through the main conical section. The conduit 21 may have a nipple (not shown) for connecting pipes or hoses. Also, a casing ID coupler 2 is attached to the exposed end of the casing 3 above the annular plug 20. The casing ID coupler 2 may be attached to the exterior or the ID of the casing 3, so long as it seals the open end. It may use dogs or slips to engage the casing. A return line 8 is connected to the casing ID coupler 2 for communicating circulation fluid from the ID of the casing 3 to the reservoir 7.

With the annular plug 20 and casing ID coupler 2 attached to the casing 3, a cementing operation may be conducted on the well bore 1. A pipe or hose (not shown) is connected from the truck 9 to the conduit 21. Premixed cement trucks and pump trucks are illustrated in the various figures of this disclosure. It is to be understood that any type of cement composition and any type of pumping apparatus may be used to pump the cement composition into the annulus. Cement composition is pumped into the annulus 5 through the conduit 21. As the cement composition flows in to the annulus 5, the cement composition contacts the annulus circulation fluid surface 6. Some of the cement composition will free fall in the circulation fluid. To establish fluid flow in a reverse circulation direction, a certain static pressure must be induced to overcome the static gel strength of the circulation fluid in the well bore. Thus, the cement composition is pressurized to drive the circulation fluid downward in the annulus 5. As the circulation fluid flows from the annulus 5 to the casing ID through the casing shoe 4, returns are taken at the casing ID coupler 2 through the return line 8 for deposit in the reservoir 7. The seal of the annulus provided by the annular plug 20 allows for the static fluid pressure to be increased in the annulus. As additional cement composition is pumped into the annulus, the column weight of the cement composition begins to drive fluid flow in the reverse circulation direction so that the static fluid pressure inside the annulus at the annular plug may be reduced. Flow regulators, valves, meters, etc. may also be connected to the annular plug 20, conduit 21, casing 3, casing ID coupler 2, and/or return line 8 to monitor the state of the fluids at various locations in the system.

Figure 3A illustrates a cross-sectional, side view of a well bore and casing. Similar to the well bore illustrated in Figure 1, this well bore has a casing 3 sticking out of the mouth of the well bore 1 without an installed surface casing or well head. An annulus 5 is defined between the casing 3 and the well bore 1. A truck 9 is parked near the well bore and a reservoir is also located nearby. The well bore 1 is also filled with circulation fluid such that an annulus circulation fluid surface 6 is approximately level with an ID circulation fluid surface.

In this embodiment, a sectional plug 30 is used to seal the annulus 5 at the top of the well bore 1. Figure 3B illustrates a top view of the sectional plug shown in Figure 3A. The sectional plug 30 has three arcuate sections, which together combine to form an annular structure for insertion into the annulus 5. The sectional plug 30 is a conical structure with a hole in the middle. The hole in the middle is cylindrical and has a diameter slightly larger

than the outside diameter of the casing 3. A cylindrical annular seal 33 is positioned between the sectional plug 30 and the casing 3. While the illustrated embodiment has three arcuate sections forming the sectional plug 30, it should be understood that any number of arcuate sections may be used to form the annular structure.

To seal the annulus 5, the annular seal 33 is fitted around the casing immediately below the mouth of the well bore 1. The sections of the sectional plug 30 are then inserted into the annulus 5 between the annular seal 33 and the mouth of the well bore 1. Sectional seals 32 are positioned between adjacent sections of the sectional plug 30. With the seals and sectional plug in place, an anchor 24 is attached to the casing 3 above the sectional plug 30. Jacks 25 are then positioned between the anchor 24 and the sectional plug 30. As described above, any anchor or jack may be used. When the jacks 25 are extended, the jacks press against the anchor 24 to drive the sectional plug 30 deeper into the annulus 5. Because the sectional plug 30 is a conical shape, the sectional plug becomes tightly wedged in the annulus 5. As the sectional plug 30 moves deeper in the annulus, the well bore 1 presses the sectional plug 30 toward the casing 3 to shrink fit the sectional plug 30 around the annular seal 33 and squeeze the sectional seals 32.

In alternative embodiments of the invention, the sections of the sectional plug 30 may be coupled together after they are inserted into the mouth of the annulus. Also, a solid annular ring may be positioned between the sectional plug 30 and the jacks 25 so that force applied by the jacks is even distributed to the sectional plug 30.

The sectional plug 30 also has a conduit 21 for communicating fluid to and from the annulus 5. A casing ID coupler 2 is also attached to the casing 3 to seal the ID of the casing 3. A return line 8 is attached to the casing ID coupler 2 for communicating fluids from the ID of the casing 3 to a reservoir 7. With the sectional plug 30 firmly in place in the annulus at the mouth of the well bore 1, cement may be pumped into the annulus 5 through the conduit 21. As illustrated, the annular circulation fluid surface 6 is level with the ID circulation fluid surface 10. When a cement composition is pumped into the annulus 5 through conduit 21, the fluid pressure in the annulus 5 begins to build. The static fluid pressure in the annulus 5 eventually becomes great enough to overcome the gel strength of the circulation fluid in the well bore 1, so as to initiate fluid flow in the well bore in a reverse circulation direction. As more cement composition is pumped into the annulus, fluid returns are taken from the ID of the casing 3 through the return line 8 for deposit in the reservoir 7. While a certain static

fluid pressure overcomes the gel strength of the circulation fluid, the sectional plug 30 provides a sufficient seal at the mouth of the well bore to prevent the cement composition from leaking out the top of the annulus 5. Once fluid flow through the well bore is established, the static fluid pressure in the annulus 5 at the mouth of the well bore may be reduced. As more and more cement composition is pumped into the annulus, the additional weight of the cement composition continues to drive fluid flow in the well bore in the reverse circulation direction.

Referring the Figure 4A, a cross-sectional, side view of a well bore and casing are illustrated. The casing 3 extends from the mouth of the well bore 1. A truck 9 is parked in the vicinity of the well bore 1. In this embodiment of the invention, the mouth of the well bore 1 is sealed by an inflatable packer 40. A top view of the packer 40 is shown in Figure 4C. The packer 40 is an annular element having an inflation nipple 42 and a conduit 21. The packer 40 is slipped over the top of the casing 3 and pushed down over the casing 3 into the mouth of the well bore 1. When the packer 40 is properly positioned, the inflation nipple 42 is used to inject a fluid or gas into the packer for inflation. Figure 4B is a cross-sectional, side view of the well bore illustrated in Figure 4A. In Figure 4B, the packer 40 is inflated to completely seal the annulus 5 at the mouth of the well bore 1. In particular, the packer 40 expands between the casing 3 and the well bore 1 to form the seal.

When the packer 40 is set in the annulus 5, a casing ID coupler 2 may then be attached to the top of the casing 3. A return line 8 may also be attached to the casing ID coupler 2. When these preparations are completed, a truck 9 or any other pump, container or known device may be used to inject a cement composition or other fluid into the annulus 5 through the conduit 21. The cement composition is pumped into the annulus and returns are taken from the ID of the casing as previously described.

In an alternative embodiment of the invention, a mechanically set packer is used to seal the annulus at the mouth of the well bore. The mechanically set packer is positioned in the annulus and mechanically manipulated to expand an annular packer element between the casing and the well bore. Typical mechanically set packers compress the annular packer element in a longitudinal direction to expand the element radially and outwardly. Most commercial balloon-type packers may be modified for use with the present invention. For example, packers manufactured by Weatherford International called an Annulus Casing Packer and by Halliburton called an External Sleeve Inflatable Packer Collar or a Full

Opening Inflatable Packer Collar may be modified to include a conduit. Most commercial mechanical set packers may be modified for use with the present invention. For example, packers manufactured by Halliburton called Cup-Type Casing Packer Shoes may be modified to include a conduit.

Referring to Figure 5A, a cross-sectional side view of a well bore and casing are illustrated. The casing 3 extends from the mouth of the well bore 1 and an annulus 5 is defined between the casing 3 and the well bore 1. A truck 9 is parked in the vicinity of the well bore 1. Also, a reservoir 7 is positioned near the well bore 1. The well bore is also filled with a circulation fluid. In particular, an annular circulation fluid surface 6 is approximately level with an ID circulation fluid surface 10.

In this embodiment of the invention, the mouth of the annulus is sealed by a settable material. A conduit 50 is inserted into the annulus 5 at the mouth of the well bore 1 until its lower end is approximately at the same depth as the annulus circulation fluid surface 6. The conduit 50 is also fluidly connected to a pump truck 9 via a hose 51. When the conduit 50 is properly positioned, a settable material is pumped down the conduit in liquid form and allowed to float on top of the circulation fluid in the annulus 5.

Referring to Figure 5B, a cross-sectional, side view is shown of the well bore and casing of Figure 5A. In this illustration, the settable material 52 has been pumped down the conduit 50 into the annulus 5 at the mouth of the well bore 1. The settable material 52 is light weight and less dense than the circulation fluid already present in the well bore 1. Thus, the settable material 52 floats on top of the circulation fluid in the annulus. As additional settable material 52 is pumped into the annulus 5, it rises in the annulus 5 toward the mouth of the well bore 1. When a desired amount of settable material 52 is pumped into the annulus 5, a small volume of circulation fluid is pumped behind the settable material to flush the settable material 52 from the conduit 50. The conduit 50 is then closed or otherwise maintained so as to prevent the settable material from flowing back into the conduit 50. The settable material 52 is then allowed to stand in the annulus a sufficient period of time to set or solidify. Once the settable material 52 has hardened, a cement composition or other fluid may be pumped into the annulus 5 through the conduit 50. As the cement composition is pumped into the annulus, the static fluid pressure of the fluid in the annulus 5 begins to build under the seal formed by the settable material 52. Eventually, the static fluid pressure overcomes the gel strength of the circulation fluid in the well bore so as to begin flow in a reverse circulation

direction. As additional cement composition is pumped into the annulus 5, the weight of the cement composition maintains the fluid flow through the well bore until a desired amount of cement composition has been pumped into the annulus 5.

The settable material may be any material capable of flowing through the conduit and setting once positioned in the annulus. It is also preferable for the settable material to be less dense than the circulation fluid so that the material will float on top of the circulation fluid in the annulus. Depending on the particular application, a 10 foot column of settable material is sufficient to seal the mouth of the annulus. Also, it may be necessary to adjust the depth of the annulus circulation fluid surface 6 by adding or withdrawing circulation fluid. Because the settable material floats on this surface, the depth of the annulus circulation fluid surface 6 defines the bottom of the plug formed by the settable material. Settable materials that may be used with the present invention include: Cal-Seal or Micro Matrix Cement.

The settable material may be a flash-set composition that is made to flash set with an activator or a flash set composition without the activator. In both cases the activator is mixed with the composition before or as it is injected through conduit 50. Examples of activators which flash set a typical cement slurry include sodium or potassium carbonate and bicarbonate salts, sodium silicate salts, sodium aluminate salts, ferrous and ferric salts such as ferric chloride, ferric sulfate, calcium nitrate, calcium acetate, calcium chloride, calcium nitrite, polyacrylic acid salts and the like. It is preferable that these activators are used in the solid form especially if they form high pH solution when exposed to water. Examples of flash setting cement compositions include high aluminate cements and phosphate cements. In the case of high aluminate cements, typical formulations contain Portland cement, calcium aluminate, calcium sulfate and lime. The calcium aluminate cement may be in the 10% to 50% by weight of total composition 2% to 15% calcium sulfate, 0.5% to 20% and 40% to 80% Portland cement in the total composition. An example of phosphate cement suitable for use as a settable material comprises magnesium oxide and alkali metal phosphate salts. Such compositions are described in US 6,204,214, incorporated herein by reference.

The settable material may also be any light weight cement slurry, including water extended slurries with materials such as bentonite, sodium silicate, pozzalanic materials, fly ash, micro-spheres, perlite, Gilsonite, Diacel, and/or polymers. An example of a suitable light weight cement slurry is commercially available as TXI. Any other light weight cement that is available commercially may also be suitable for use as a settable material. Also,

cement foamed with nitrogen, air or another gas may also be suitable for use as a settable material.

The settable material may also be a non cement material such as resins like epoxy, Epseal, Permseal, etc. (these may be expensive but a small volume of epoxy resin could replace a larger volume of cement to effect a seal). The settable material may also be a polymer pill that reacts with well bore fluid, such as commercially available polymers named Gunk, Flex Plug, etc.

Referring the Figure 6A, a cross-sectional, side view of a well bore and casing are illustrated. The casing 3 extends from the mouth of the well bore 1. A truck 9 is parked in the vicinity of the well bore 1. In this embodiment of the invention, the mouth of the well bore 1 is sealed by a settable material that is placed in the mouth of the annulus at some level above the annulus circulation fluid surface 6. If it is not desirable to raise the annulus circulation fluid surface 6 by injecting additional fluid into the well bore, a packer 40 may be used. A top view of the packer 40 is shown in Figure 6C. The packer 40 is an annular element having an inflation nipple 42 and a conduit 21. The packer 40 is slipped over the top of the casing 3 and pushed down over the casing 3 into the mouth of the well bore 1. The packer 40 is pushed down into the well bore 1 to a desired location below the mouth of the annulus 5. Depending on the particular application, a depth of fifteen feet is sufficient. The conduit 21 is long enough to extend out of the mouth of the well bore 1. When the packer 40 is properly positioned, the inflation nipple 42 and hose 43 are used to inject a fluid or gas into the packer for inflation.

Figure 6B is a cross-sectional, side view of the well bore illustrated in Figure 6A. In Figure 6B, the packer 40 is inflated to completely seal the annulus 5 at a position well below the mouth of the well bore 1. In particular, the packer 40 expands between the casing 3 and the well bore 1 to form the seal. With the packer 40 set in the well bore, a settable material 52 is then pumped into the annulus at the surface from the truck 9. The settable material 52 is retained in the annulus 5 above the packer 40. The settable material 52 is allowed to stand in the annulus so as to solidify or harden. In this embodiment of the invention, a more dense settable material 52 may be used as there is no need for the settable material 52 to "float" on top of the circulation fluid.

Figures 7A and 7B illustrate an alternative embodiment of the invention similar to that illustrated in Figures 6A through 6C. However, rather than an inflatable packer, a

mechanical slip packer is used. the mechanical slip packer has a seal member that expands in the radial direction when it is compressed by the slips in the longitudinal direction. Any mechanical set packer known to persons of skill may be used with the invention.

Figure 8A illustrates a cross-sectional, side view of a well bore and casing. The casing 3 extends from the mouth of the well bore 1. A truck 9 is parked in the vicinity of the well bore 1 and a reservoir 7 is located nearby. In this embodiment of the invention, the mouth of the well bore 1 is sealed by a settable material that is placed in the mouth of the annulus above a basket 70. A top view of the basket 70 is shown in Figure 8C. The basket 70 has an annular band 71 that has an inside diameter slightly larger than the outside diameter of the casing. This enables the band 71 to slide over the top of the casing 3 and be pushed down over the casing 3 into the mouth of the well bore 1. An inverted skirt 72 is attached to the band 71 and a conduit 21 extends through the band 71. The basket 70 is pushed down into the annulus 5 to a desired location below the mouth of the well bore 1. Depending on the particular application, a depth of fifteen feet is sufficient. The conduit 21 is long enough to extend out of the mouth of the well bore 1. Also an anchor 73 is used to attach the top of the conduit 21 to the casing 3 to prevent the basket 70 from sliding any further down in the annulus 5. When the basket 70 is properly positioned and anchored to the casing 3, a settable material may be injected into the annulus 5.

Figure 8B shows a cross-sectional, side view of the well bore illustrated in Figure 8A. In Figure 8B, the inverted skirt 72 of the basket 70 has completely flared out in the annulus 5 to catch the falling settable material 52. In particular, the basket 70 expands like an up-side-down umbrella between the casing 3 and the well bore 1 to block the annulus 5. With the basket 70 anchored in the well bore, a settable material 52 is then pumped into the annulus 5 at the surface from the truck 9. The settable material 52 is retained in the annulus 5 above the basket 70. The settable material 52 is allowed to stand in the annulus so as to solidify or harden. In this embodiment of the invention, a more dense settable material 52 may be used as there is no need for the settable material 52 to "float" on top of the circulation fluid. The depth of the annulus circulation fluid surface 6 may be above, level with, or below the depth of the basket 70. No matter whether the basket 70 is submerged in the circulation fluid or not, the basket 70 catches the free falling settable material. Once the settable material has solidified or hardened, cement operations may be conducted through the conduit 21.

Any number of commercially available baskets may be used with the present invention. For example, casing baskets manufactured by Top-co Industries; Industrial Rubber; and Antelope Oil Tool and Manufacturing Co. may be modified to include a conduit.

Figure 9A illustrates a cross-sectional, side view of a well bore and casing. The casing 3 extends from the mouth of the well bore 1. A truck 9 is parked in the vicinity of the well bore 1 and a reservoir 7 is located nearby. In this embodiment of the invention, the mouth of the well bore 1 is not sealed at all. Rather, a cement composition is flowed into the annulus at a location below mouth of the well bore. In particular, a cross-over tool 80 is positioned in the ID of the casing a certain distance in the well bore 1. A casing ID coupler 2 is attached to the exposed end of the casing 3. An ID line 81 extends from the casing ID coupler 2 to the cross-over tool 80 for fluid communication with the ID of the casing 3 below the cross-over tool 80. A hose 51 is connected between the truck 9 and the casing ID coupler 2 for fluid communication with the ID of the casing 3 above the cross-over tool 80.

Referring to Figure 9B, a cross-sectional, side view of the well bore of Figure 9A is again illustrated. In this figure, a cement composition 11 has been pumped from the truck 9, through the hose 51, through the casing ID coupler 2, down through the ID of the casing above the cross-over tool 80, out through ports 82 into the annulus 5, and down toward the casing shoe 4. When the cement composition 11 begins to enter the ID of the casing 3 at the casing ID coupler, it is likely that circulation fluid may flow out of the annulus at the mouth of the well bore rather than through the return line 8. Thus, during the initial stages of the process, circulation fluid may need to be pumped out of the annulus at the mouth of the well bore. However, after a significant amount of cement composition 11 has entered the annulus 5 through the ports 82, the weight of the cement composition will push downwardly on the circulation fluid in the annulus to initiate fluid flow in a reverse circulation direction through the casing shoe 4. From this point forward, returns may be taken from the ID of the casing 3 through the ID line 81.

Any number of commercially available cross-over tools may be used with the present invention. For example, cross-over tools manufactured by Weatherford International are suitable.

In an alternative embodiment of the invention similar to the embodiment illustrated in Figures 9A and 9B, a casing ID coupler 2 is attached to the exposed end of the casing 3. However, rather than using a cross-over tool and ports in the casing to inject the cement

composition in the annulus 5, the hose 51 is simply inserted a good distance into the annulus 5 from the mouth of the well bore. Because a certain amount of cement composition is needed to initiate fluid flow in the reverse circulation direction, the end of the hose is inserted to a sufficient depth to allow enough cement composition to be pumped into the annulus without the cement composition spilling out of the mouth of the well bore. As before, when the cement composition is first pumped into the annulus, returns will likely need to be taken directly from the annulus at the mouth of the well bore. However, after enough cement composition has been pumped into the annulus, fluid flow in the reverse circulation direction will be initiated and returns may be taken through the casing ID coupler.

Therefore, the present invention is well adapted to carry out the objects and attain the ends and advantages mentioned as well as those that are inherent therein. While numerous changes may be made by those skilled in the art, such changes are encompassed within the spirit of this invention as defined by the appended claims.

What is claimed is:

1. A method for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the method comprising:

sealing the annulus at the mouth of the well bore with a seal;
pumping a cement composition into the annulus through the seal; and
taking circulation fluid returns from the inner diameter of the casing.

2. A method as claimed in claim 1, wherein said sealing comprises installing an annular plug around the casing at the mouth of the well bore.

3. A method as claimed in claim 2, wherein said installing an annular plug comprises:

positioning the annular plug around the casing in the annulus at the mouth of the well bore;
attaching an anchor to the casing above the annular plug; and
pushing the annular plug downwardly away from the anchor.

4. A method as claimed in claim 3, wherein said positioning the annular plug comprises placing a unitary annular plug over an exposed end of the casing.

5. A method as claimed in claim 3, wherein said positioning the annular plug comprises placing a plurality of plug segments around the casing in the annulus at the mouth of the well bore.

6. A method as claimed in claim 3, wherein said positioning the annular plug comprises inserting slips between the casing and the annular plug, and wherein said pushing comprises pushing the slips downwardly.

7. A method as claimed in claim 2, wherein said pumping a cement composition into the annulus through the seal comprises pumping through a conduit that extends through the annular plug.

8. A method as claimed in claim 1, wherein said sealing comprises expanding a packer in the annulus at the mouth of the well bore.

9. A method as claimed in claim 8, wherein said expanding a packer comprises inflating a packer.

10. A method as claimed in claim 8, wherein said expanding a packer comprises

compressing a flexible element in a longitudinal direction to expand the element in a radial outward direction.

11. A method as claimed in claim 8, wherein said pumping a cement composition into the annulus through the seal comprises pumping through a conduit that extends through the packer.

12. A method as claimed in claim 1, wherein said sealing comprises plugging the annulus below the mouth of the well bore with a settable material.

13. A method as claimed in claim 12, wherein the settable material comprises a cement slurry.

14. A method as claimed in claim 13, wherein the cement slurry of the settable material comprises high aluminate cement.

15. A method as claimed in claim 13, wherein the cement slurry of the settable material comprises light weight cement.

16. A method as claimed in claim 13, wherein the cement slurry of the settable material comprises gas foamed cement.

17. A method as claimed in claim 13, wherein the cement slurry of the settable material comprises phosphate cement.

18. A method as claimed in claim 12, wherein the settable material comprises an epoxy.

19. A method as claimed in claim 12, wherein the settable material comprises a polymer.

20. A method as claimed in claim 12, wherein said plugging the annulus below the mouth of the well bore with a settable material comprises:

inserting a conduit into the annulus;

injecting the settable material through the conduit;

standing the settable material in the annulus, whereby the settable material is allowed to solidify over time.

21. A method as claimed in claim 20, wherein said standing the settable material in the annulus comprises floating the settable material on top of a circulation fluid in the annulus.

22. A method as claimed in claim 20, wherein said standing the settable material in the annulus comprises suspending the settable material in the annulus on top of a packer.

23. A method as claimed in claim 20, wherein said standing the settable material in the annulus comprises suspending the settable material in the annulus on top of a basket.

24. A method as claimed in claim 12, wherein said pumping a cement composition into the annulus through the seal comprises pumping through a conduit that extends through the settable material.

25. A method as claimed in claim 1, wherein said taking circulation fluid returns from the inner diameter of the casing comprises attaching a coupler to an exposed end of the casing and connecting a flow line to the coupler, wherein the flow line fluidly communicates with the inner diameter of the casing through the coupler.

26. A method of sealing a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the method comprising:

positioning an annular plug around the casing in the annulus below and proximate the mouth of the well bore, wherein the annular plug has conduit through the annular plug allowing fluid communication with the annulus below the annular plug;

attaching an anchor to the casing above the annular plug; and
pushing the annular plug downwardly away from the anchor.

27. A method as claimed in claim 26, wherein said positioning the annular plug comprises placing a unitary annular plug over an exposed end of the casing.

28. A method as claimed in claim 26, wherein said positioning the annular plug comprises placing a plurality of plug segments around the casing in the annulus at the mouth of the well bore.

29. A method as claimed in claim 26, wherein said positioning the annular plug comprises inserting slips between the casing and the annular plug, and wherein said pushing comprises pushing the slips downwardly.

30. A method of sealing a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the method comprising:

inserting a packer into the annulus below and proximate the mouth of the well bore;

expanding the packer in the annulus, wherein the packer has conduit through the packer allowing fluid communication with the annulus below the packer.

31. A method as claimed in claim 30, wherein said expanding a packer comprises

inflating a packer.

32. A method as claimed in claim 30, wherein said expanding a packer comprises compressing a flexible element in a longitudinal direction to expand the element in a radial outward direction.

33. A method of sealing a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the method comprising:

plugging the annulus below and proximate the mouth of the well bore with a settable material.

34. A method as claimed in claim 36, wherein said plugging the annulus below the mouth of the well bore with a settable material comprises:

inserting a conduit into the annulus;

injecting the settable material through the conduit;

standing the settable material in the annulus, whereby the settable material is allowed to solidify over time.

35. A method as claimed in claim 36, wherein said standing the settable material in the annulus comprises floating the settable material on top of a circulation fluid in the annulus.

36. A method as claimed in claim 36, wherein said standing the settable material in the annulus comprises suspending the settable material in the annulus on top of a packer.

37. A method as claimed in claim 36, wherein said standing the settable material in the annulus comprises suspending the settable material in the annulus on top of a basket.

38. A method as claimed in claim 36, wherein the settable material comprises a cement slurry.

39. A method as claimed in claim 38, wherein the cement slurry of the settable material comprises high aluminate cement.

40. A method as claimed in claim 38, wherein the cement slurry of the settable material comprises light weight cement.

41. A method as claimed in claim 38, wherein the cement slurry of the settable material comprises gas foamed cement.

42. A method as claimed in claim 38, wherein the cement slurry of the settable material comprises phosphate cement.

43. A method as claimed in claim 36, wherein the settable material comprises an

epoxy.

44. A method as claimed in claim 36, wherein the settable material comprises a polymer.

45. A method for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the method comprising:

injecting a cement composition into the annulus at a level below the mouth of the well bore a sufficient distance to prevent the cement composition from flowing out the top of the annulus, whereby the weight of the cement composition in the annulus initiates fluid flow in the well bore in a reverse circulation direction before the cement composition flows out the top of the annulus; and

taking circulation fluid returns from the inner diameter of the casing.

46. A method for cementing a casing as claimed in claim 45, wherein said injecting a cement composition into the annulus comprises:

placing a cross-over tool in the inner diameter of the casing;

forming ports in the casing at a location above the cross-over tool; and

pumping cement composition through the inner diameter of the casing and out through the ports in the casing into the annulus.

47. A method for cement a casing as claimed in claim 45, wherein said taking circulation fluid returns from the inner diameter of the casing comprises: placing a flow line in the well bore that fluidly communicates with the inner diameter of the casing below the cross-over tool; and drawing circulation fluid from the casing inner diameter through the flow line.

48. A method for cementing a casing as claimed in claim 45, wherein said injecting a cement composition into the annulus comprises:

inserting a conduit into the annulus to a level below the mouth of the well bore a sufficient distance to prevent the cement composition from flowing out the top of the annulus; and

pumping cement composition through the conduit into the annulus.

49. A method for cementing a casing as claimed in claim 45, wherein said taking circulation fluid returns from the inner diameter of the casing comprises attaching a coupler to an exposed end of the casing and connecting a flow line to the coupler, wherein the flow

line fluidly communicates with the inner diameter of the casing through the coupler.

50. A system for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the system comprising:

a seal of the annulus at the mouth of the well bore;

a cement composition pump fluidly connected to the annulus through the seal;

and

a coupling connected to the exposed end of the casing for taking circulation fluid returns from the inner diameter of the casing.

51. A system as claimed in claim 50, wherein said seal comprises an annular plug around the casing at the mouth of the well bore.

52. A system as claimed in claim 51, wherein said annular plug comprises:

an anchor attached to the casing above the annular plug; and

at least one jack positioned between the anchor and the annular plug, wherein the at least one jack pushes the annular plug downwardly away from the anchor.

53. A system as claimed in claim 51, wherein said annular plug comprises a unitary annular plug.

54. A system as claimed in claim 51, wherein said annular plug comprises a plurality of plug segments that together form the annular plug.

55. A system as claimed in claim 51, further comprising slips positioned between the casing and the annular plug, and wherein the at least one jack is positioned between the anchor and the slips, wherein the at least one jack pushes the slips downwardly away from the anchor.

56. A system as claimed in claim 50, further comprising a conduit that extends through the annular plug.

57. A system as claimed in claim 50, wherein said seal comprises a packer in the annulus at the mouth of the well bore.

58. A system as claimed in claim 57, wherein said packer comprises an inflatable packer.

59. A system as claimed in claim 57, wherein said packer comprises a mechanically set packer having a flexible element that expands in a radial outward direction when compressed in a longitudinal direction.

60. A system as claimed in claim 57, further comprising a conduit that extends through the packer.

61. A system as claimed in claim 50, wherein said seal comprises a settable material plug in the annulus below the mouth of the well bore.

62. A system as claimed in claim 61, further comprising a conduit that extends through the settable material plug.

63. A system as claimed in claim 61, wherein the settable material plug floats on top of a circulation fluid in the annulus.

64. A system as claimed in claim 61, further comprises a packer in the annulus, wherein the settable material plug is positioned on top of the packer.

65. A system as claimed in claim 61, further comprising a basket in the annulus, wherein the settable material plug is positioned on top of the basket.

66. A system as claimed in claim 50, further comprising a coupler attached to an exposed end of the casing and connect to a flow line, wherein the flow line fluidly communicates with the inner diameter of the casing through the coupler.

67. A method as claimed in claim 61, wherein the settable material comprises a cement slurry.

68. A method as claimed in claim 67, wherein the cement slurry of the settable material comprises high aluminate cement.

69. A method as claimed in claim 67, wherein the cement slurry of the settable material comprises light weight cement.

70. A method as claimed in claim 67, wherein the cement slurry of the settable material comprises gas foamed cement.

71. A method as claimed in claim 67, wherein the cement slurry of the settable material comprises phosphate cement.

72. A method as claimed in claim 61, wherein the settable material comprises an epoxy.

73. A method as claimed in claim 61, wherein the settable material comprises a polymer.

74. A seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal comprising:

an annular plug around the casing in the annulus below and proximate the

mouth of the well bore, wherein the annular plug has conduit through the annular plug allowing fluid communication with the annulus below the annular plug;

an anchor attachable to the casing above the annular plug; and

at least one jack positioned between the annular plug and the anchor, wherein the at least one jack pushes the annular plug downwardly away from the anchor.

75. A seal as claimed in claim 74, wherein said annular plug comprises a unitary annular plug.

76. A seal as claimed in claim 74, wherein said annular plug comprises a plurality of plug segments that collectively form the annular plug.

77. A seal as claimed in claim 74, further comprising slips inserted between the casing and the annular plug, and wherein said at least one jack pushes the slips downwardly.

78. A seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal comprising:

a packer into the annulus below and proximate the mouth of the well bore, wherein the packer has a conduit through the packer allowing fluid communication with the annulus below the packer.

79. A seal as claimed in claim 78, wherein said packer comprises an inflatable packer.

80. A seal as claimed in claim 78, wherein said packer comprises a mechanically set packer comprising a flexible element that expands in a radial outward direction when compressed in a longitudinal direction.

81. A seal of a well bore annulus at the mouth of an open well bore having a casing extending there from and no surface casing, the seal comprising:

a settable material plug in the annulus below and proximate the mouth of the well bore; and

a conduit through the settable material plug.

82. A seal as claimed in claim 81, wherein said settable material plug floats on top of a circulation fluid in the annulus.

83. A seal as claimed in claim 81, further comprising a packer, wherein said settable material plug is suspended in the annulus on top of the packer.

84. A seal as claimed in claim 81, further comprising a basket, wherein said settable material plug is suspended in the annulus on top of the basket.

85. A system for cementing a casing in an open well bore having no surface casing, wherein an annulus is defined between the casing and the well bore, the system comprising:

a cement composition pump;

a cement composition injector fluidly connected to the cement composition pump, wherein the injector is positioned at a level below the mouth of the well bore a sufficient distance to prevent the cement composition from flowing out the top of the annulus, whereby the weight of the cement composition in the annulus initiates fluid flow in the well bore in a reverse circulation direction before the cement composition flows out the top of the annulus; and

a coupler attached to an exposed end of the casing for taking circulation fluid returns from the inner diameter of the casing.

86. A system for cementing a casing as claimed in claim 85, further comprising:

a cross-over tool positioned in the inner diameter of the casing;

at least one port in the casing at a location above the cross-over tool; and

a flow line in the well bore that fluidly communicates with the inner diameter of the casing below the cross-over tool,

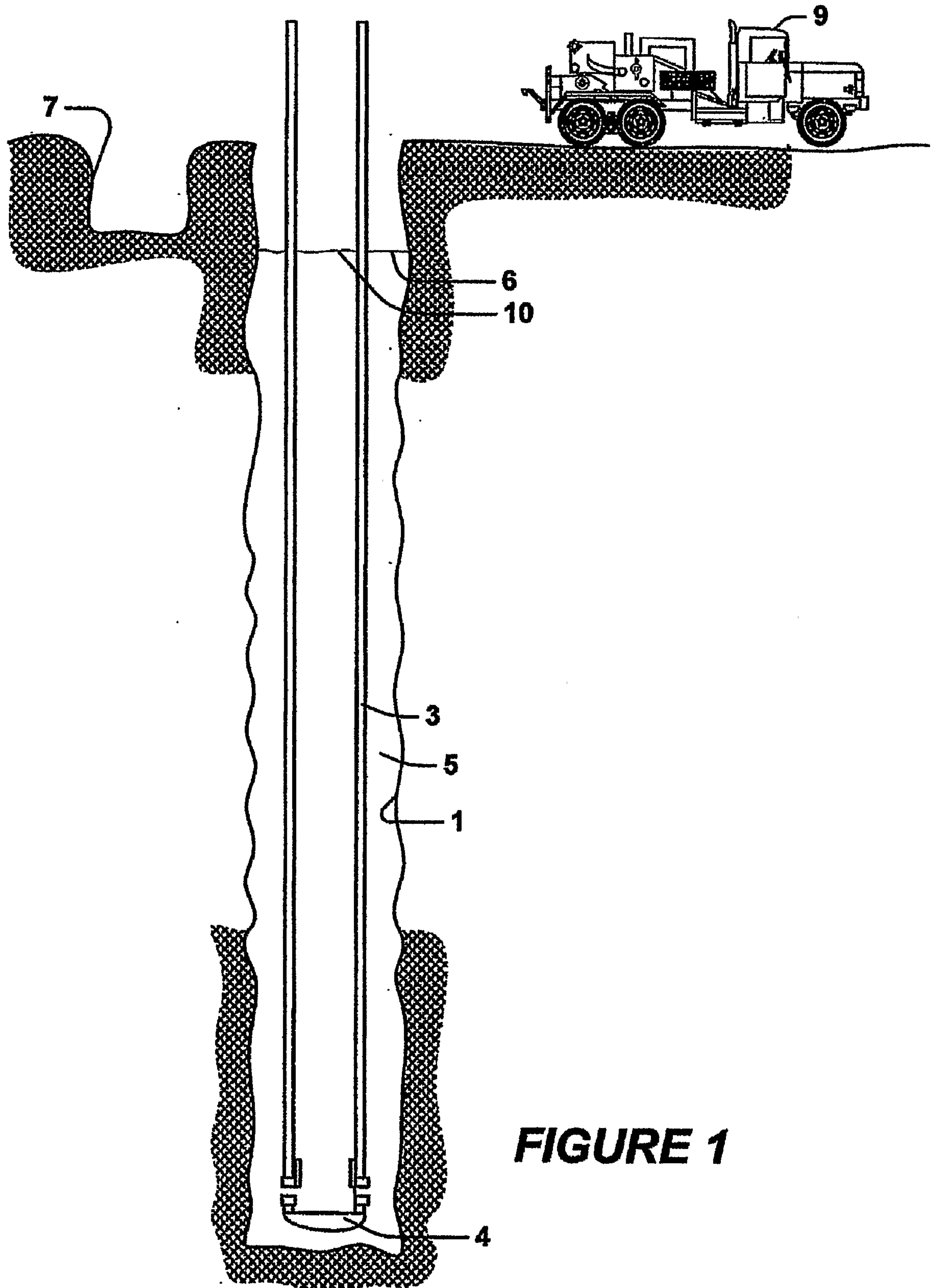
wherein said injector comprises a conduit between the pump and the inner diameter of the casing above the cross-over tool.

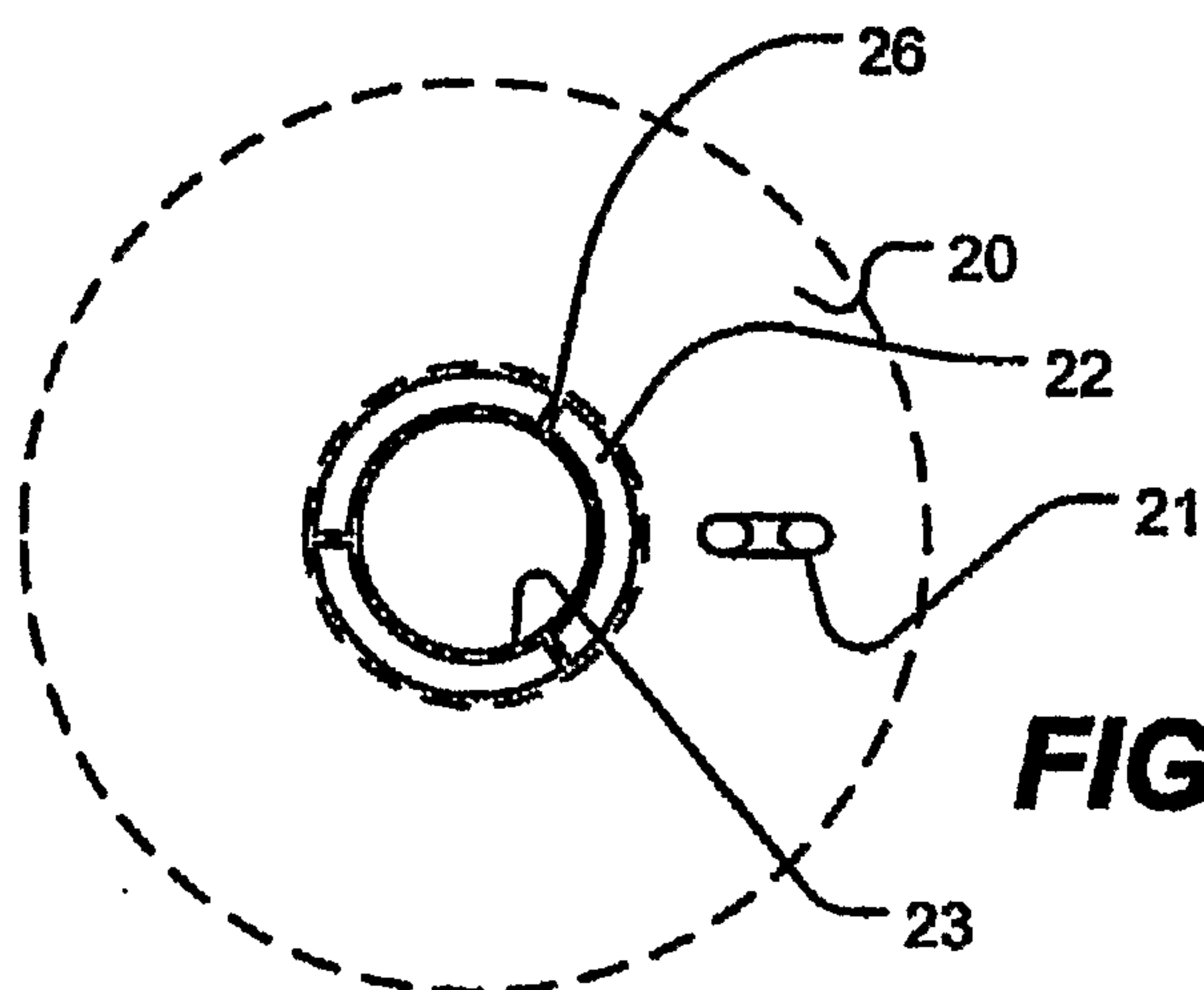
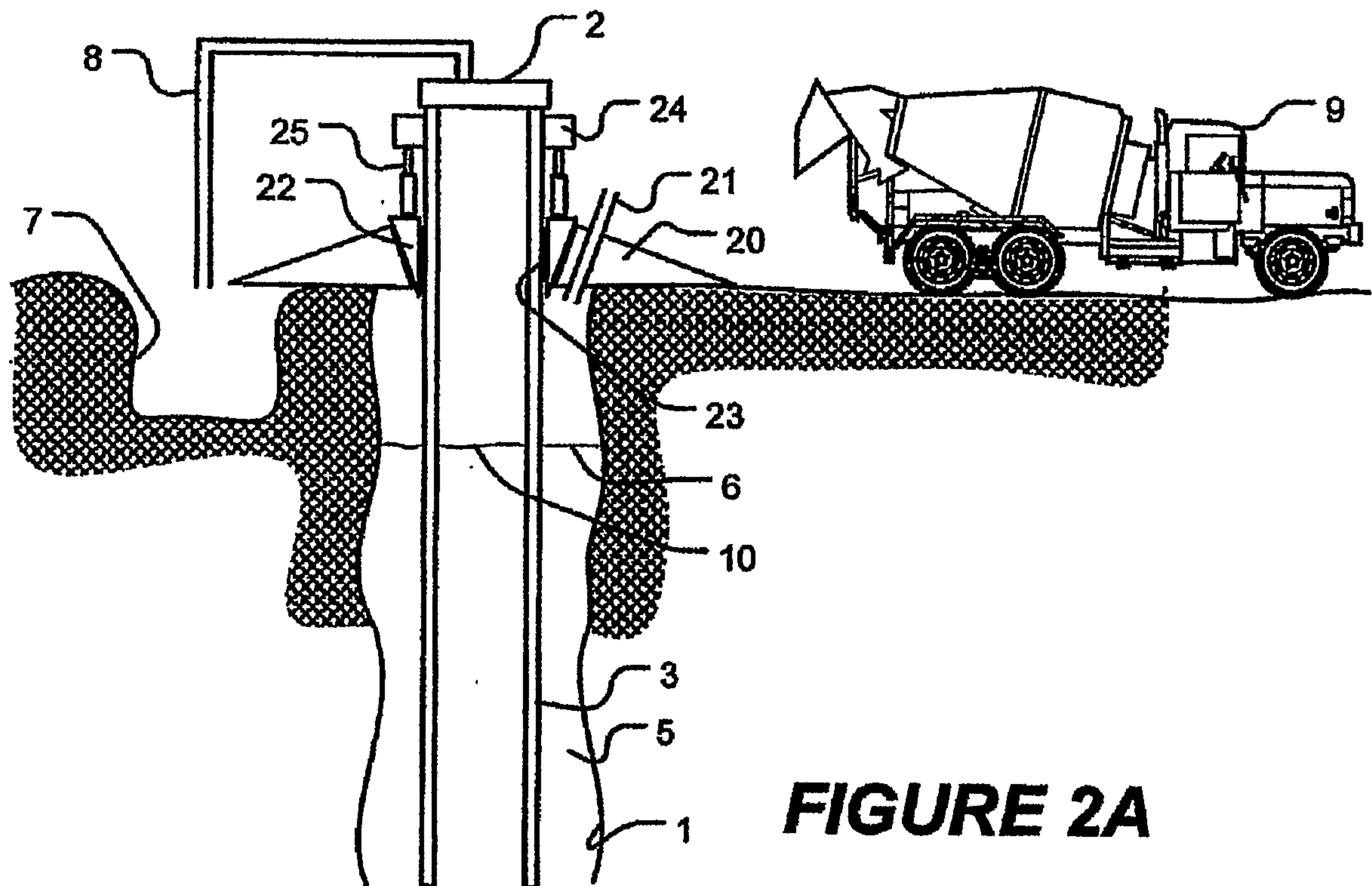
87. A system for cementing a casing as claimed in claim 85, wherein said injector comprises:

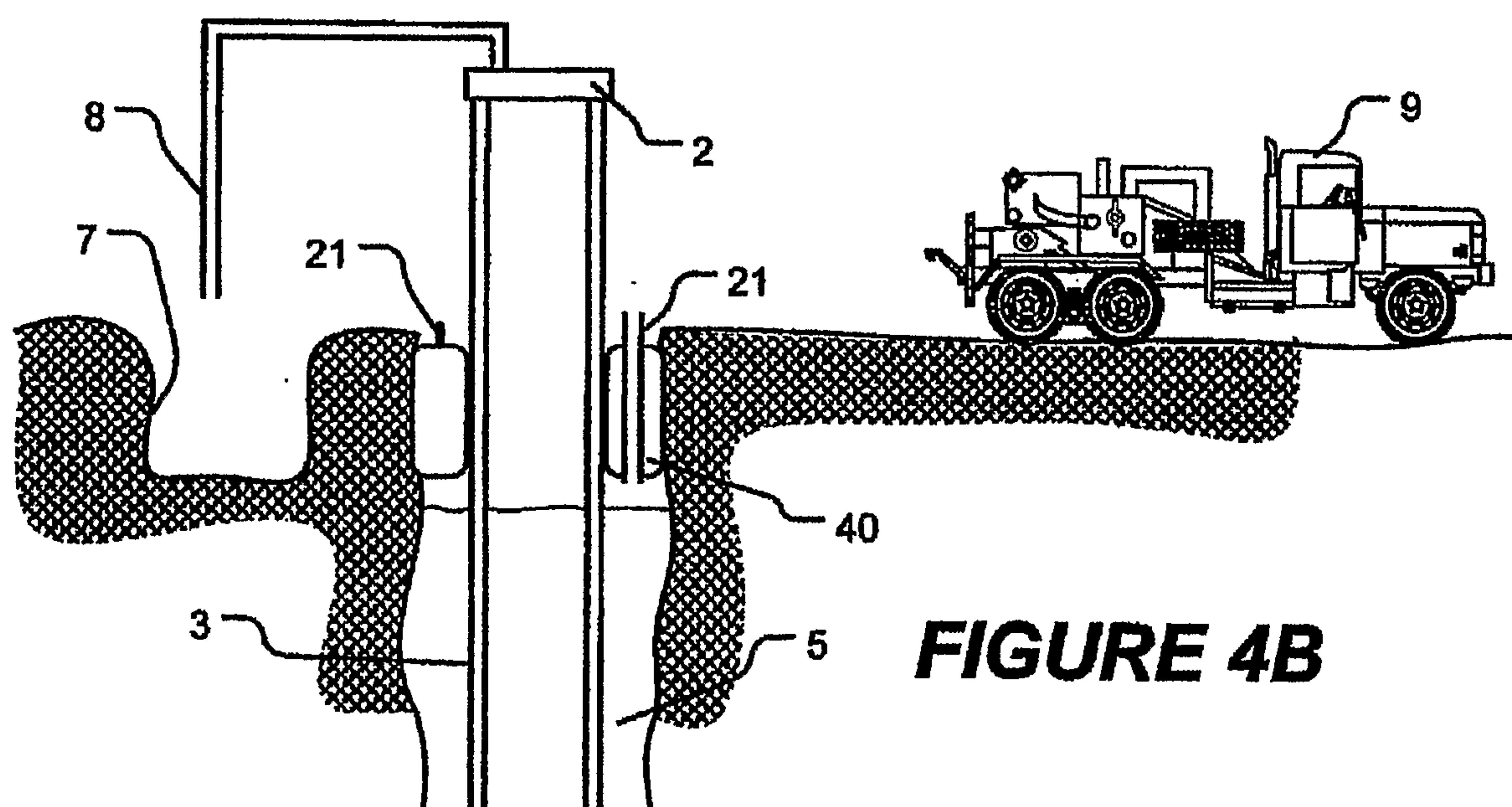
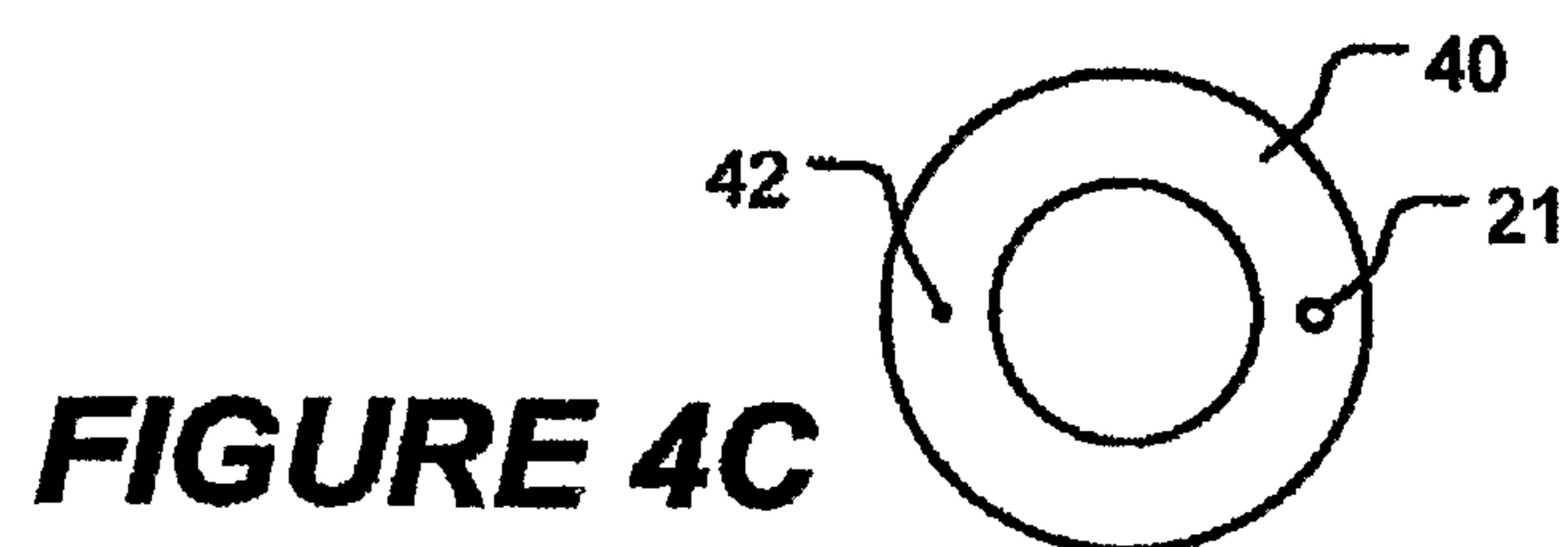
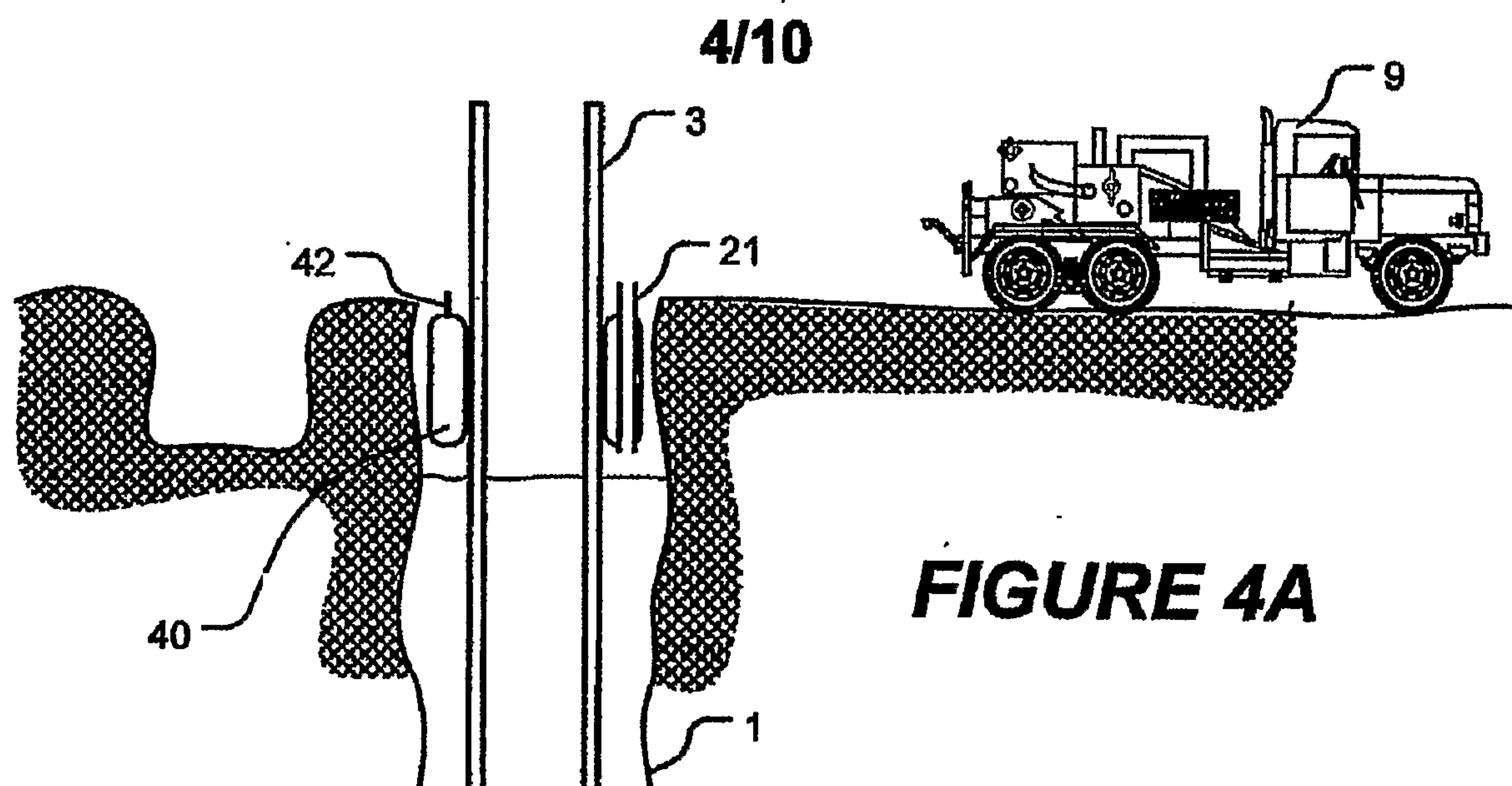
a conduit inserted into the annulus to a level below the mouth of the well bore a sufficient distance to prevent the cement composition from flowing out the top of the annulus.

88. A system for cementing a casing as claimed in claim 85, wherein said coupler for taking circulation fluid returns from the inner diameter of the casing is connected to a flow line, wherein the flow line fluidly communicates with the inner diameter of the casing through the coupler.

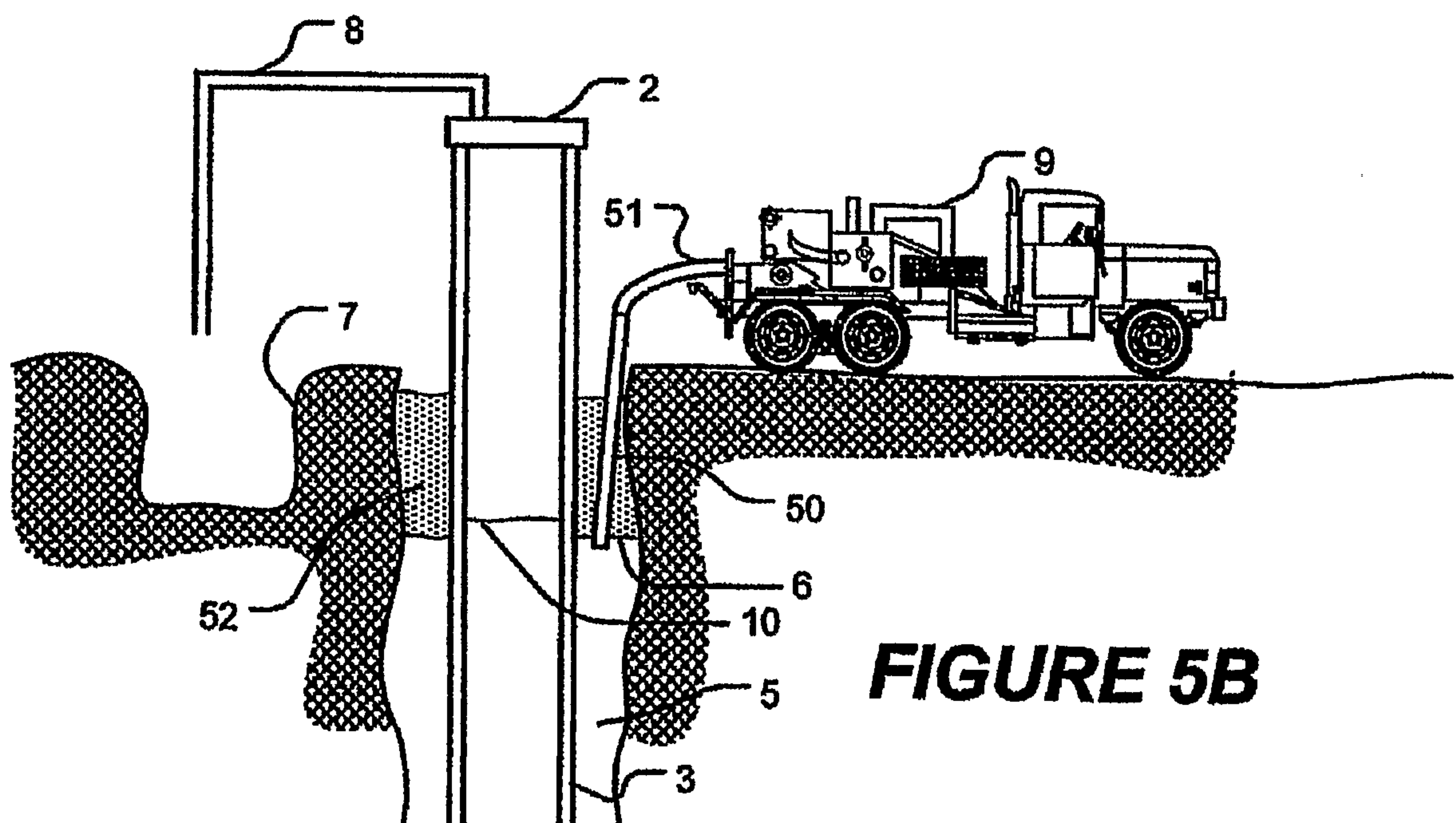
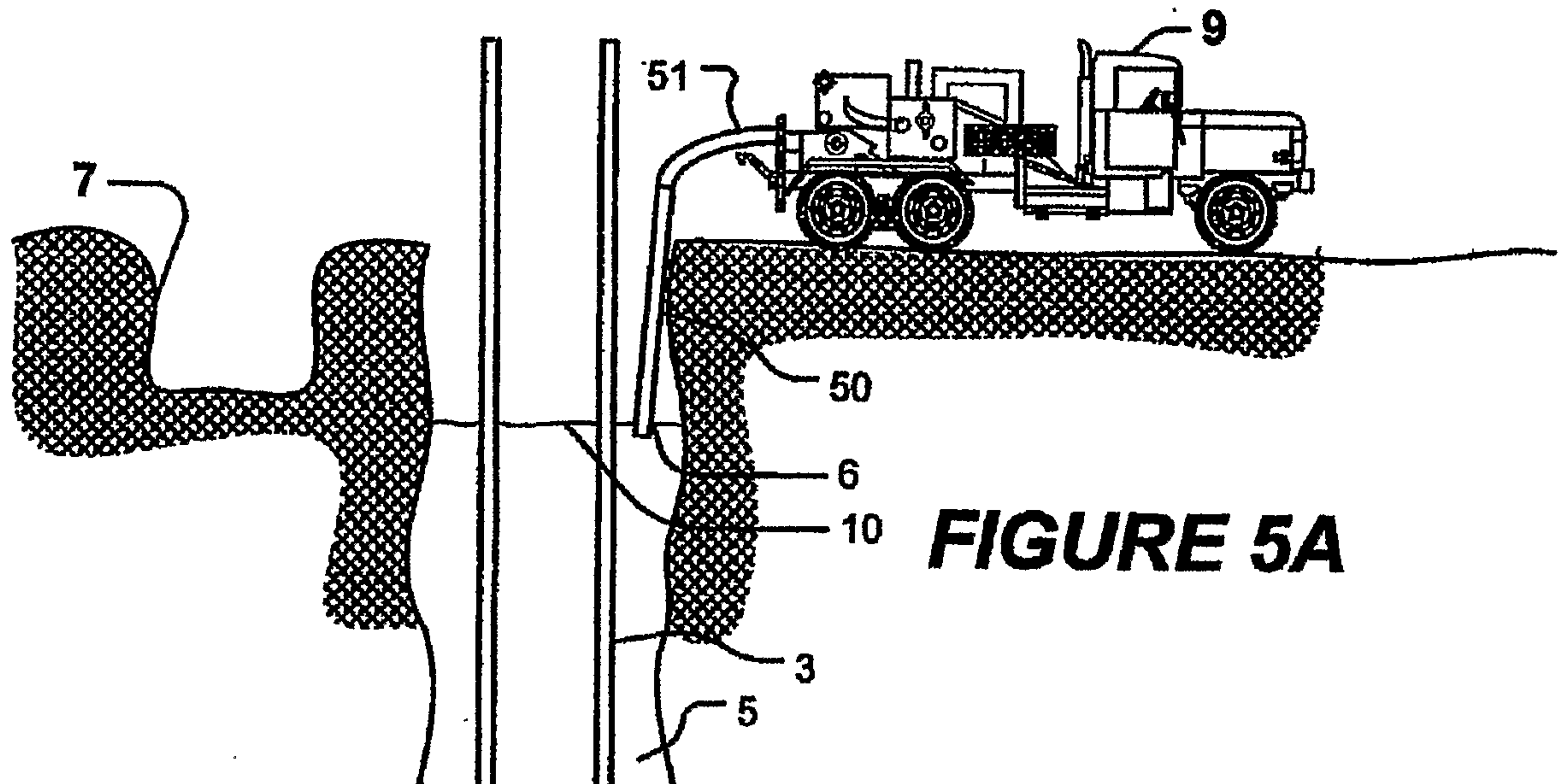
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**FIGURE 1**

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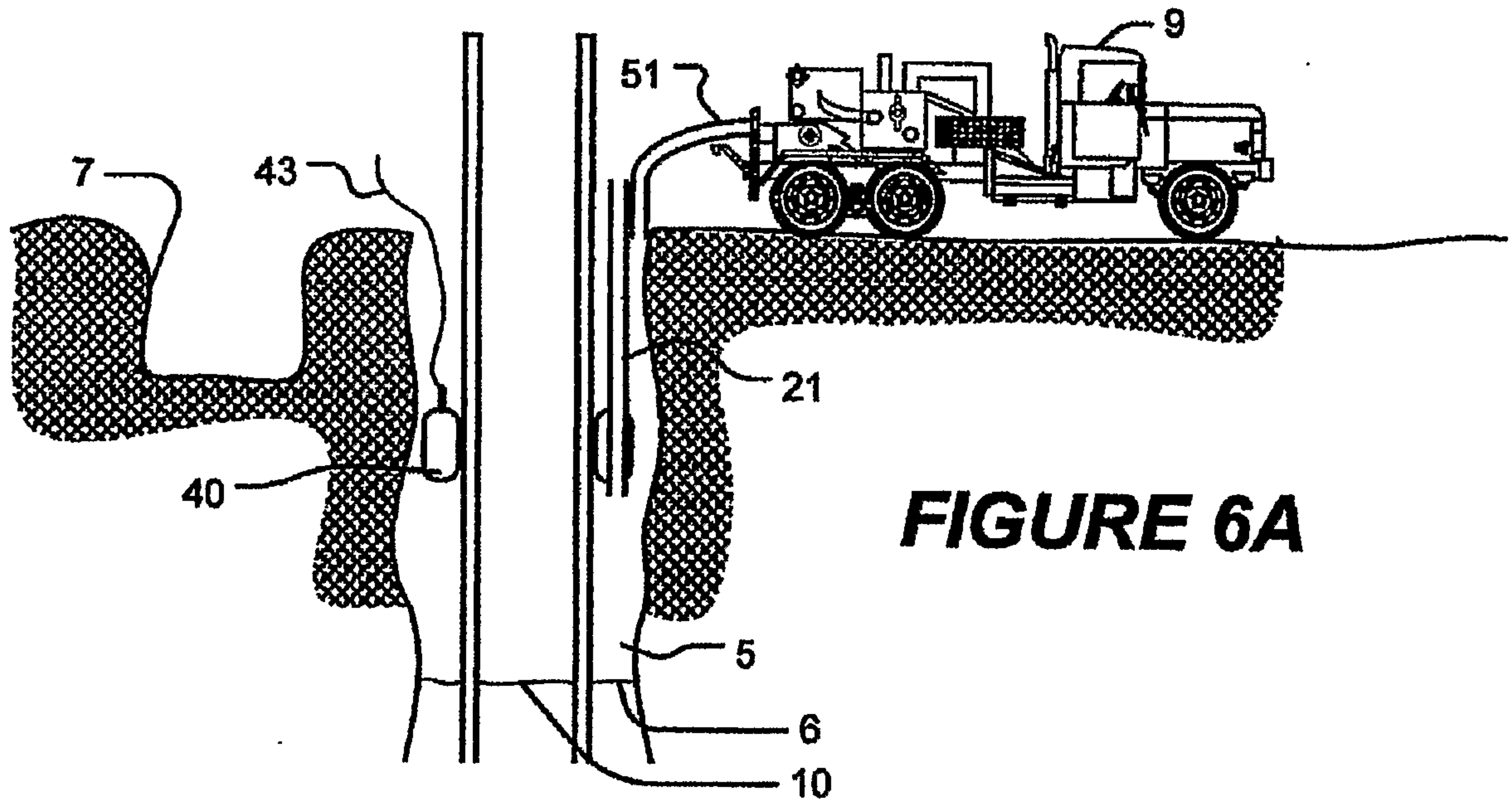


FIGURE 6C

