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(54) **LARGE DIAMETER WATER WELL CONTROL**

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E21B 7/28 (2006.01)
E03B 3/15 (2006.01)
E21B 21/01 (2006.01)

(52) **U.S. Cl.**
CPC ***E03B 3/15*** (2013.01); ***E21B 7/28*** (2013.01); ***E21B 21/01*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 7/28; E21B 21/01; E21B 33/068; E21B 34/02; E21B 21/085
See application file for complete search history.

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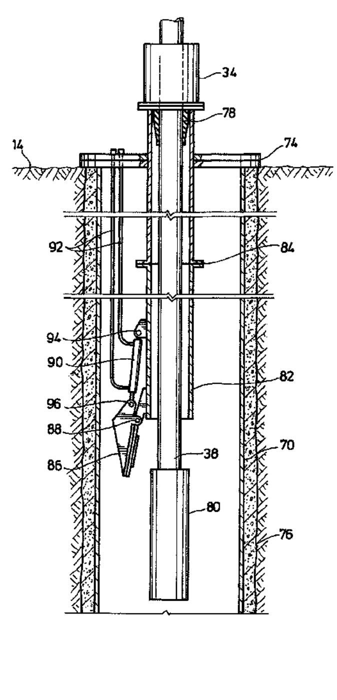
(57) **ABSTRACT**

A large diameter injection water well is drilled using a drilling derrick and rotary drilling techniques after snubbing in and drilling a short distance with drilling mud, a temporary drilling header is installed below the blowout preventers. Extending downward from the temporary drilling header is a drop pipe with a valve on the lower end thereof. Drilling pipe with attachments on the lower end thereof, are lowered into the drop pipe with the valve closed. After sealing to the drilling pipe, the valve is opened and the drilling pipe and attachments are lowered to the bottom of the well for the normal drilling operation. Thereafter, the drilling pipe and attachments are removed reversing the process of retracting into the drop pipe and closing the valve before removing the seal from the drilling pipe. The repeated insertion of the drilling pipe with various attachments on the end thereof in the drilling procedure occurs without having to kill or suppress the well until the final step when removing the drop pipe.

6 Claims, 6 Drawing Sheets



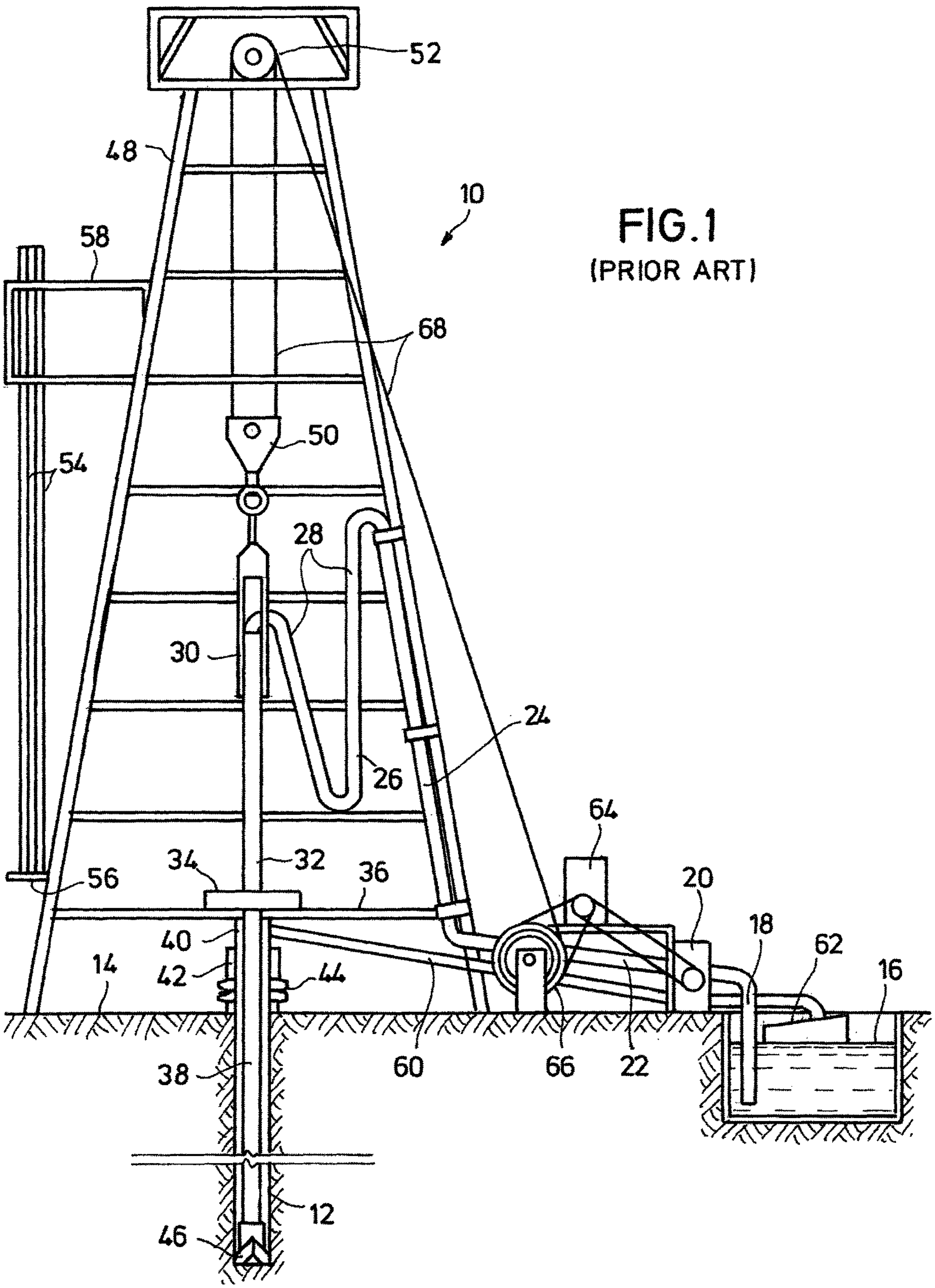
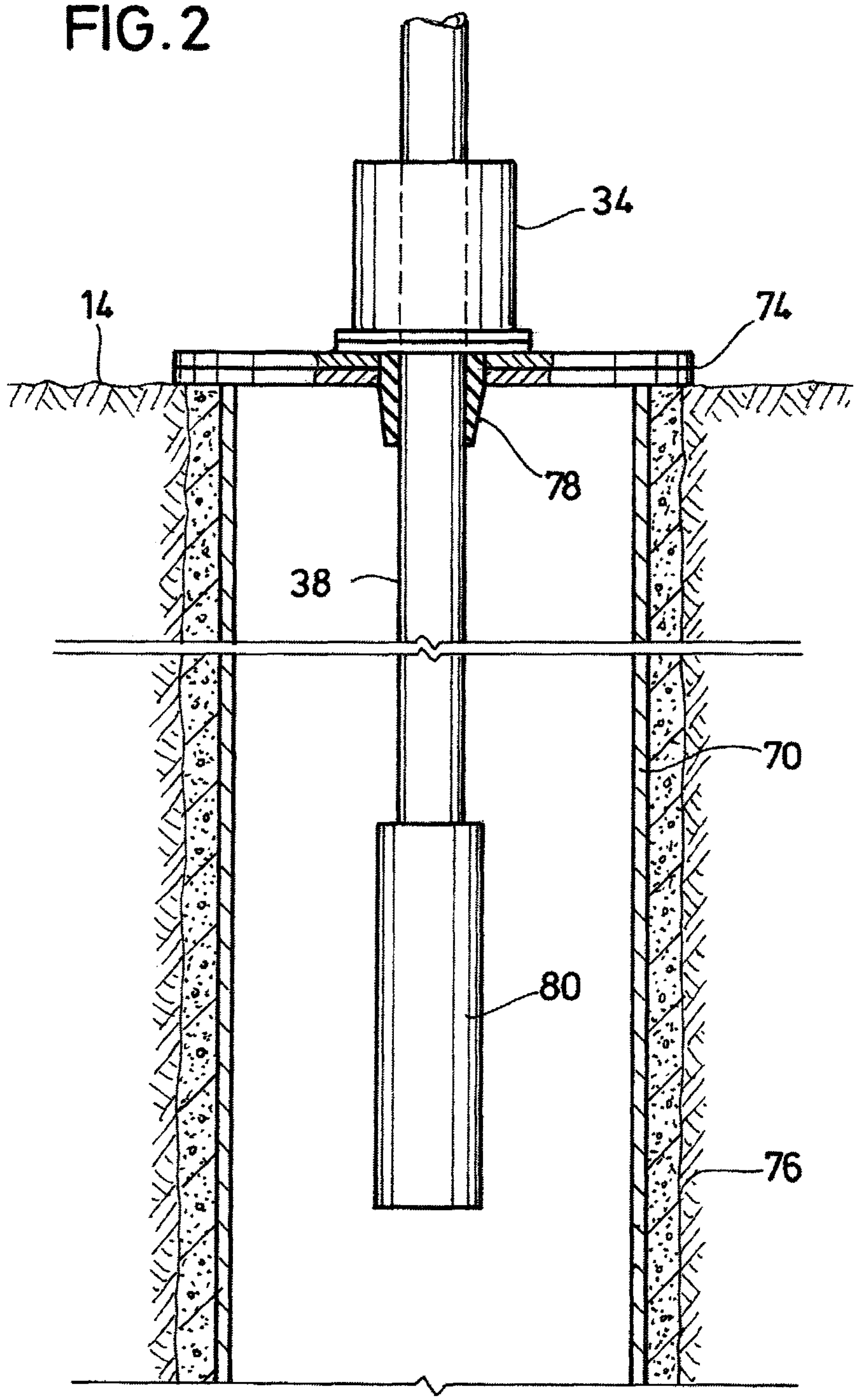
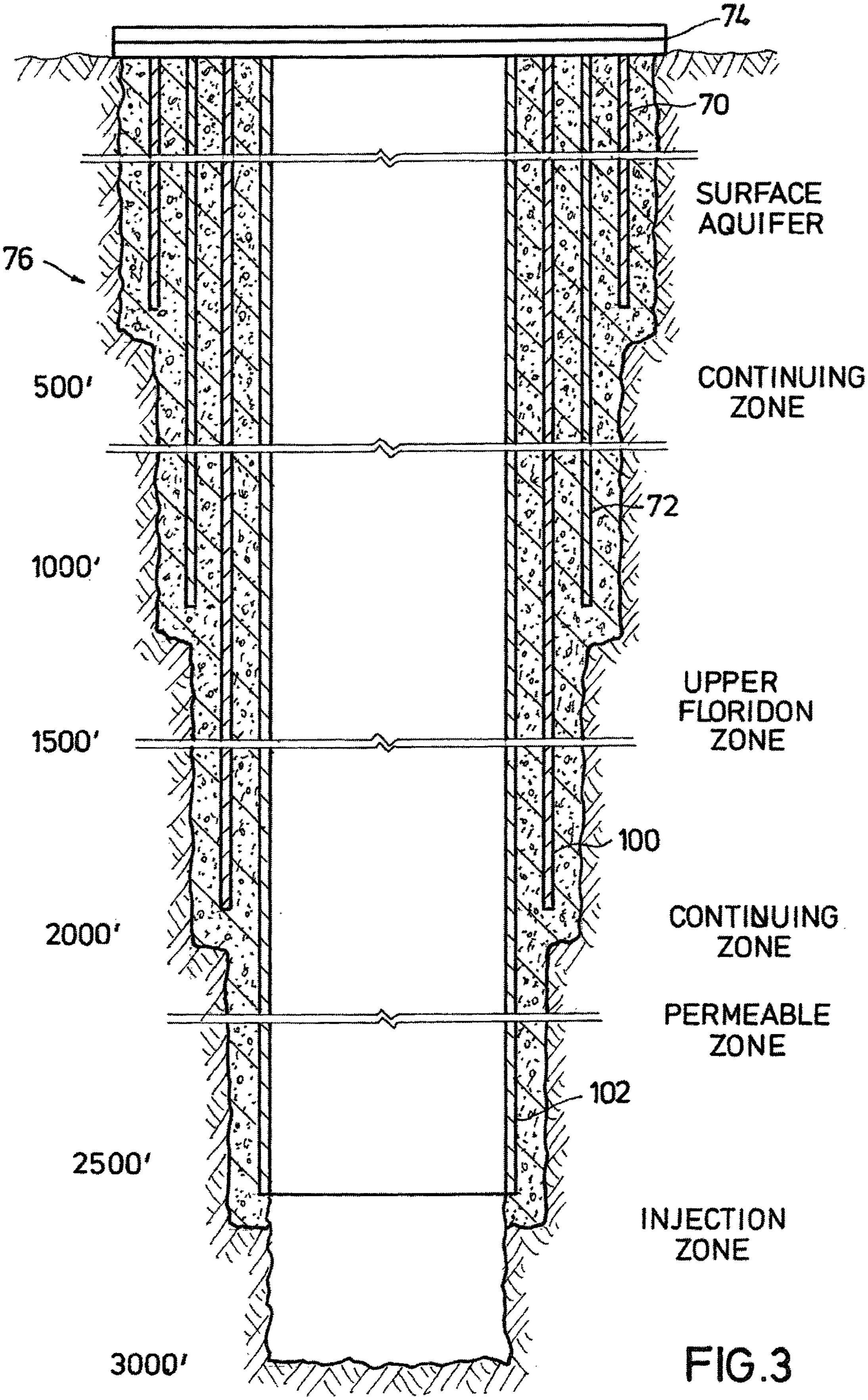


FIG.1
(PRIOR ART)

FIG. 2





74
70
SURFACE AQUIFER
76
CONTINUING ZONE
500'
72
1000'
UPPER FLORIDON ZONE
1500'
100
CONTINUING ZONE
2000'
PERMEABLE ZONE
102
2500'
INJECTION ZONE
3000'

FIG.3

FIG. 4

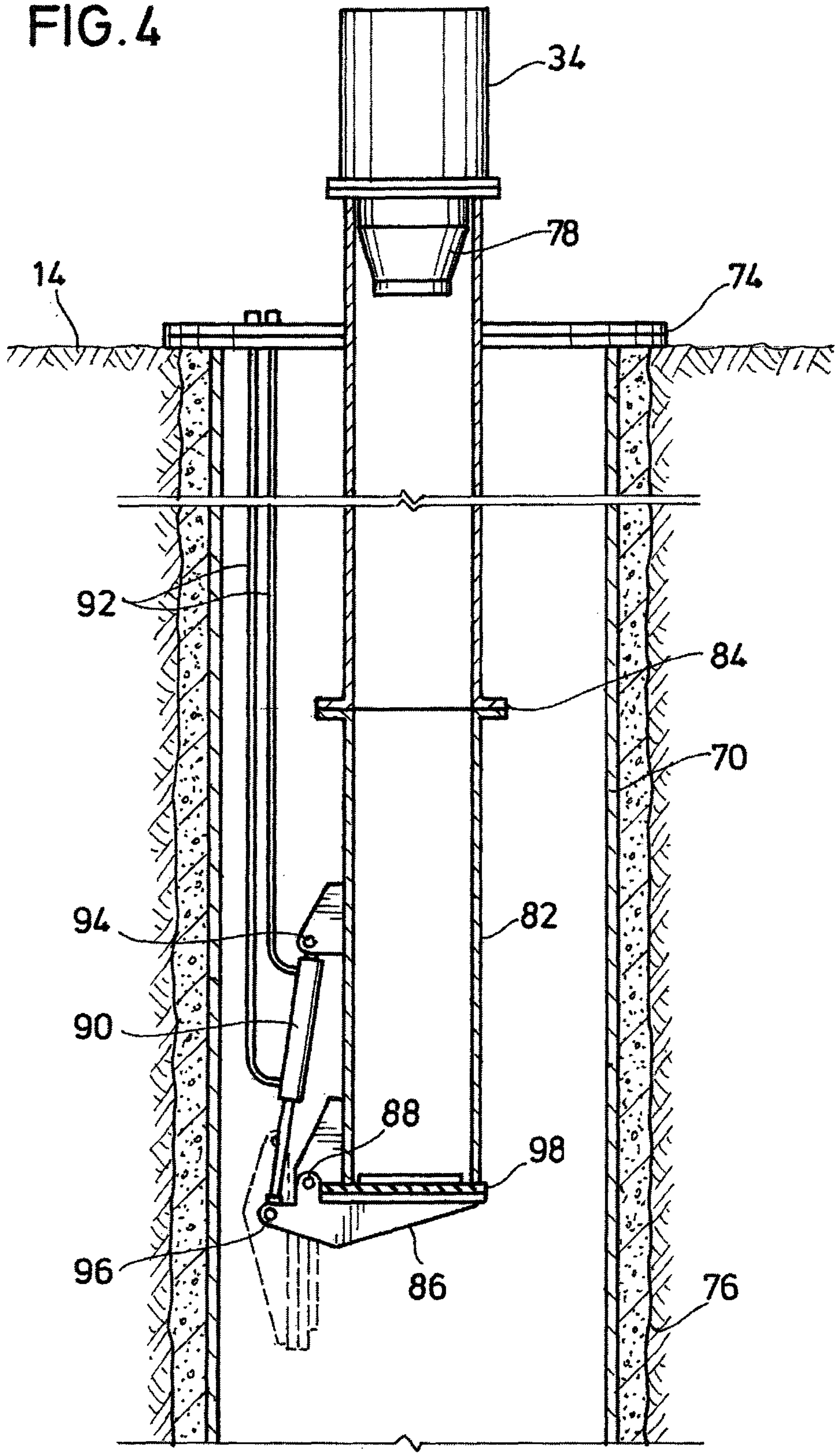


FIG.5

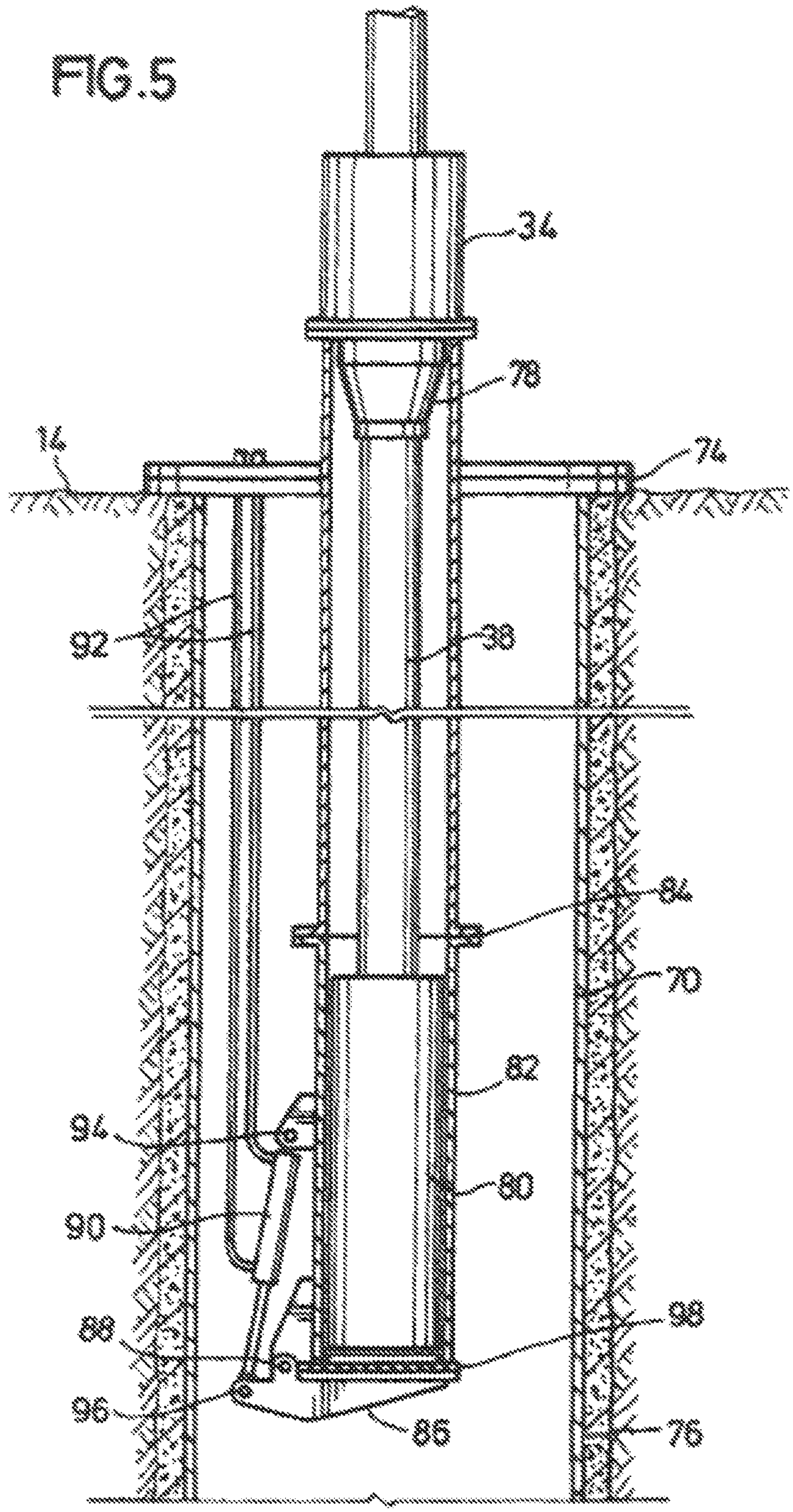
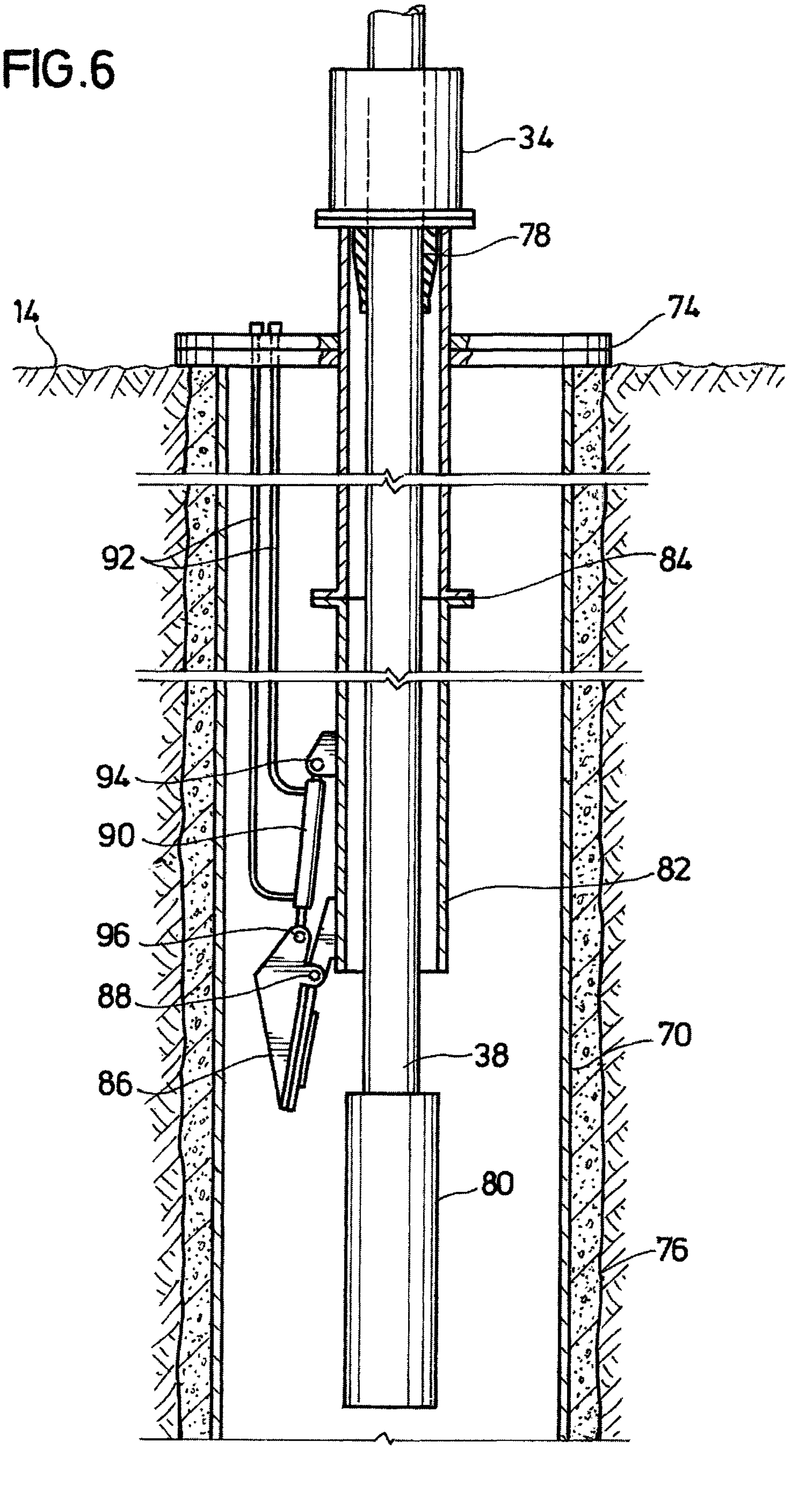


FIG. 6



LARGE DIAMETER WATER WELL CONTROL

CROSS-REFERENCE TO RELATED PATENTS

This is an improvement over patent application Ser. No. 15/987,409 filed on May 23, 2018 which issued on Dec. 3, 2019 as U.S. Pat. No. 10,494,896, and a formal utility patent application claiming priority to Provisional Patent Application No. 62/961,523 filed on Jan. 15, 2020, both of which are incorporated herein by reference.

BACKGROUND OF INVENTION

Field of the Invention

This invention relates generally to the drilling of a large diameter injection well, more particularly, to the control of artesian flow without the use of weighted well drilling material such as salt or barite.

Description of the Prior Art

Perforations in the earth's surface to find and release hydrocarbons is well known. Typically an oil well is created by a drilling hole into the earth with a drilling rig that rotates a drill string with a bit attached to the lower end. As the hole is drilled to an ascribed depth, sections of steel casing are set in a hole. The casing is slightly smaller in diameter than the borehole. The casing provides structural integrity to the newly drilled wellbore and isolates zones from each other and from the surface. As the well is drilled deeper, smaller casing and smaller bits are used.

Generally, the same type of equipment used in drilling an oil and/or gas well can be used in drilling injection wells from the surface. In the state of Florida, injection wells have been used for disposal of both storm water and municipal waste water for many years. In Florida, disposal of municipal waste water, including treated waste water, is injected deep underground into highly permeable rock formations that naturally contain saline water. The geological formation that most commonly receives the injected water is the lower most portion of the Floridian Aquifer System, which is between the depths of approximately 2,500 to 3,400 feet below the land surface. The formation at this depth is made up of limestone and dolostone which contain highly transmissive solution channels. This zone is commonly referred to as the "Boulder Zone".

The Boulder Zone has highly brackish water with a salinity that is similar to seawater. Separating the brackish water from the fresh water contained in the Surficial Aquifer are intermediate layers of less permeable clays which are 300 or more feet thick.

A typical injection well will be about sixty inches in diameter at the top going down to about 24 inches in diameter at the bottom. The injection wells operate at very low pressure normally around 20 PSI. The injection wells are used to dispose of run-off water that should not be released into the streams, but is not heavily polluted water that might be found in an oil field environment.

The upper part of the injection well is the largest diameter and typically would have casing of approximately 54 inches in diameter cemented into place for approximately 100 feet in what is commonly known as "snubbing in." After snubbing in, a slightly smaller diameter hole and a smaller diameter casing will be set as the injection well is being drilled. Each time a string of casing is installed and

cemented into place, a pilot hole of typically 12 inches in diameter is drilled a few hundred feet past the expected length of the next string of casing. The pilot hole is for testing using both geophysical logging tools and inflatable packers to determine the best depth for the next string of casing or completion of the well. Typically, there would be three to five sets of subsequently smaller hole sizes being drilled, each drilled inside of one another and each cemented with a different diameter casing.

Throughout the drilling process, typically a temporary drilling header, sometimes referred to as a "rotating control device," is used at the surface to control or prevent artesian flow out of the well. The temporary drilling header includes stripping rubber that seals around the drill pipe while allowing a drill pipe to move up and down. The stripping rubber removes material stuck to the drill pipe. The problem with this type of temporary drilling header is that the bit, weights, and/or drill collars are larger in diameter than the drill pipe. While the drill pipe can go through the temporary header, these larger diameter devices cannot.

In the past, when inserting or removing the larger diameter devices from the well, the temporary drilling header had to be removed. To remove the temporary drilling header, the well would have to be killed using a heavy drilling mud. The killing or suppressing of a well during the drilling process is time consuming and expensive. A heavy drilling mud would need to be mixed and injected into the well, which heavy drilling mud would then intermix with native well bore fluids. It may later be difficult to remove the heavy drilling mud from the native well bore fluids. Also, the possibility of loss of well control during well suppression or killing activities could occur. While salt and barite are the two most common materials used to create a heavy drilling mud to kill and/or suppress the well, other materials could also be used. In large artesian aquifer zones, it is common to use a truckload or more of salt or barite to mix into slurry each time a well is killed. During the typical construction of a large diameter injection well, the well is suppressed/killed approximately twenty times.

While drilling an injection well and setting the first two strings of casing, the well bore is filled with bentonite drilling fluid, commonly called "mud". The mud is pumped down through the drilling pipe and returns to the surface between the outside of the drilling pipe and the well bore. The mud carry the cuttings suspended therein.

After the second string of casing is cemented, the mud is evacuated from the casing and replaced with water. From this point forward, drilling fluid (mud) is no longer used with the present invention.

SUMMARY OF THE INVENTION

It is an object of the present invention to control artesian flow while drilling an injection well without using a weighted drilling fluid.

It is another object of the present invention to reduce the number of times a large diameter water well must be killed or suppressed during drilling.

It is yet another object of the present invention to have a temporary drilling header at the top of a large diameter disposal well during the drilling process, which temporary drilling header is installed after the disposal well is snubbed in. A second casing is set down to approximately 1000 feet in depth. After installing the temporary drilling header, a drop pipe is installed that extends below the temporary drilling header. The drop pipe is connected to the temporary drilling header by any convenience means, such as bolted to flanges or a welded connection to the previously installed casing. Above the temporary drilling header on the drill pipe is connected a rotating control device with stripper rubber for cleaning the drill pipe as it goes in or out of the well. Connected to a lower end of the drop pipe is a valve operated by a hydraulic cylinder to open or close the lower end of the drop pipe. By the use of the drop pipe, access to the inside of the disposal well being drilled can be obtained without killing or suppressing the well.

In the past, if the temporary drilling header had to be removed to set drill collars, replace drill bits, do geographical logging or anything else requiring larger diameter items pass through temporary drilling header to access lower regions of the disposal well, the disposal well would have to be killed or suppressed by using heavy drilling fluid to stop any artesian flow. By use of a drop pipe with a hydraulically actuated lower valve, it is not necessary to kill the well when moving larger diameter items through the temporary well header via the drop pipe.

A bottom hole assembly can be lowered through the temporary well header into the drop pipe when the valve on the lower end of the drop pipe is closed. Thereafter, the rotating control device and a stripper rubber is secured against the drill pipe so that when the lower valve is open, there will not be any artesian flow from the well being drilled.

In the drilling of a disposal well, pilot holes are drilled beyond the lower end of the casing, which pilot holes are used for geophysical logging tools and inflatable packers. Also, if samples need to be obtained, they can be obtained by having a bottom hole assembly connecting through the temporary drilling header into the drop pipe while the lower valve of the drop pipe is closed. Thereafter, once the rotating control device and stripper rubber are in place, the lower valve on the drop pipe can be opened and the bottom hole assembly lowered to collect samples. This typically occurs several times for each disposal well. By use of the drop pipe and the hydraulically operated valve, this can be done repeatedly without having to kill or suppress the well. The length of the drop pipe is determined by the bottom hole assembly that is to be used in drilling the injection well. Typically the drop pipe that would be two to three hundred feet in length. By using the drop pipe, large amounts of heavy fluid to suppress or kill the artesian flow from the well is no longer necessary.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a pictorial illustration of a prior art oil drilling rig.

FIG. **2** is a simplified, partial, cross-sectional view of the upper portion of a large diameter injection water well being drilled.

FIG. **3** is an illustrative sectional view of the underground portion of a large diameter injection water well.

FIG. **4** is a partial, cross-sectional view of the upper portion of a large diameter injection water well with a hydraulically actuated valve opening or closing a lower end of a drop pipe.

FIG. **5** is a partial, cross-sectional view of the upper portion of a large diameter injection water well having a drop pipe with a bottom hole assembly therein prior to opening a lower valve.

FIG. **6** is a partial, cross-section of the upper portion of a large diameter injection water well with a bottom hole assembly extending through a drop pipe and a lower valve into lower portions of the large diameter injection water well.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Before explaining the present invention, an explanation as to how an oil well is drilled is helpful. Referring to FIG. **1**, a simplified pictorial representation of an oil field derrick **10** drilling an oil well **12** in the earth's surface **14** is shown. A mud tank **16** holds a drilling mud, such as barite, which may be delivered via a suction line **18** to mud pump **20**, through vibrating hose **22**, standpipe **24**, kelly hose **26**, goose necks **28**, swivel **30** to Kelly drive **32**. From the Kelly drive **32**, the drilling mud travels through the rotary table **34** and drilling floor **36** to the drill string **38**. However, before reaching the drill string **38**, the drilling mud must travel through bell nipple **40**, an angular blowout preventer **42**, and ram blowout preventers **44**.

While FIG. **1** shows a rotary table **34**, a tophead rotary drive may be used. Either one uses rotary drive to turn the drill string **38**.

As the rotary table **34** turns the drill string **38** drilling mud from the mud tanks **16** is delivered under pressure through drilling string **38** to the drill bit **46**. As the oil well **12** is drilled deeper, derrick **48** uses traveling block **50** and crown block **52** to add additional drill pipes from the stand **54** of drill pipes, which stand **54** holds the pipe rack **56** by monkey board **58**. As additional pipe is added to the drill string **38**, flow of the mud from the mud tank **16** is stopped. The weight of the drilling mud will keep pressures inside the oil well **12** from blowing out the top of the oil well **12**. Blow out preventers **42** and **44** also ensure that pressures inside of the oil well **12** will not escape.

Mud from the mud tank **16** flows into the oil well **12** by flowing downward through the drill string **38**. The mud returns between the drill string **38** and the well **12** being drilled in the earth simultaneously carrying any cuttings to the surface. The returning mud and cuttings flows through flow line **60** to a shell shaker **62** for removal of cuttings before returning the mud to the mud tank **16**.

Motor **64** with draw works **66** operate drill lines **68** to move traveling block **50** and rotate crown block **52** when adding more pipe from stand **54** to the drill string **38**. This is a simplified description of how an oil well is drilled using standard techniques.

In the drilling of the large diameter disposal water wells, similar techniques are used during the drilling process. A large diameter disposal water well that might be drilled in central or southern Florida would typically be snubbed in with a 54 inch steel casing **70**. See FIG. **3**. After the 54 inch steel casing **70** is cemented into place, mud will continue to flow through the drill string **38**. See FIG. **1**. Subsequently, a 44 inch steel casing **72** will have to be installed and cemented into place down to approximately 1000 feet in depth. Through the cementing in place of the 44 inch steel casing **72**, drilling mud may be used, which drilling mud is pumped down through a drill string **38** and up through the annulus back to the surface. Everything through this point is the same as the prior art except there are larger diameters and lower pressures.

Upon setting the 44" steel casing **72** into place the drilling mud is removed and a temporary drilling header **74** is installed. See FIG. **2**. The temporary drilling header **74** is located below the blowout preventers **42** and **44**. See FIG. **1**. The next step in drilling the disposal water well is to drill a pilot hole approximately twelve inches in diameter to approximately two-thousand feet. The temporary drilling header **74** is normally installed after the drilling of the pilot hole. Typically, three or four core samples will be needed when drilling from 1000-2000 feet in depth. This requires tripping the drill string **38** out of the well **76**. To prevent artesian flow therefrom, the well **76** will have to be either suppressed or killed. As the drill string **38** is removed from the well **76** as shown in FIG. **2**, stripper rubber **78** will remove material from the drill string **38**. On the bottom of the drill string **38** is located bottom hole assembly **80**. The bottom hole assembly **80** may be a drill bit, packer, coring bell, a logging device, etc. However, the bottom hole assembly **80** normally cannot get past the rubber stripper **78** and/or temporary drilling header **74** nor past the rotary table **34**. In the past, each time the bottom hole assembly **80** has to come out of the well **76**, pressures inside the well **76** have to be either killed or suppressed. Previously, to kill or suppress pressures inside of the well **76** required a large amount of barite or salt to mix into a drilling mud. It is expensive and time consuming to have to kill or suppress the well using large amount of salt or barite. When drilling operations are to be resumed, the drilling mud or slurry will need to be reduced and/or removed from the well **76**. The weight of the slurry/drilling mud prevents artesian flow from well **76**.

To prevent having to repeatedly kill the well **76**, the temporary drilling header **74** has been modified so that a drop pipe **82** extends downward from the temporary drilling header **74**. See FIG. **4**. While the length of the drop pipe **82** may vary, it is estimated that drop pipe would be approximately two hundred feet in length. The drop pipe **82** is attached at the upper end to temporary drilling header **74**. Flanges **84** are welded, or threaded connections may be used to add the necessary length to the drop pipe.

On the lower end of the drop pipe **82** is located a valve **86** that is pivotally mounted on pivot pin **88**. The operation of the hydraulic cylinder **90** causes valve **86** to be opened or closed. Hydraulic fluid for the hydraulic cylinder **90** is provided through hydraulic hoses **92**. Each end of the hydraulic cylinder **90** is free to pivot on pivot pins **94** and **96**. If the valve **86** is closed, a rubber sealing element **98** prevents leakage through the drop pipe **82**.

Referring to FIGS. **5** and **6** in combination, the present invention will be illustrated in further detail. In FIG. **5** the well **76** is being drilled into the earth **14**. The initial steel casing **70** has been snubbed in into position and cemented in place. The **44"** steel casing **72** (See FIG. **3**) may, or may not, need suppression while it is being installed. A temporary drilling header **74** is installed at the top of the steel casing **70**. The drop pipe **82** extends downward from the temporary drilling header **74**. In the FIG. **5** hydraulic cylinder **90** has closed the valve **86** located at the bottom of the drop pipe **82**. With the valve of **86** closed, drill pipe **38** along with bottom hole assembly **80** are lowered into the drop pipe **82**. The upper part of the drill pipe **38** is sealed with the stripper rubber **78** and turned by rotary table **34**.

Pressure inside of the well **76** does not need to be suppressed or killed when inserting drill string **38** and bottom hole assembly **80** because valve **86** is closed with rubber sealing **98** preventing leakage there through. After the bottom hole assembly **80** is inside of drop pipe **82**, then stripper rubber **78** and rotary table **34** are secured to the drill string **38**. By opening the valve **86** with the hydraulic cylinder **90**, the drill string **38** and the bottom hole assembly **80** can be lowered to the bottom of well **76**. The bottom hole assembly **80** can include drill bit for drilling the hole deeper or a drill collar. The bottom hole assembly **80** can include coring equipment to get core samples. For injection water wells in Florida, it is important to run logging tools into the pilot holes.

With the use of the drop pipe **82** just as described in FIGS. **5** and **6**, numerous trips can be made into the well **76** without having to kill or suppress the well. Pilot holes can be drilled and logged. Smaller **34"** steel casing **100**, and **24"** steel casing **102** can be installed and cemented in place using tremie tubing (not shown). It is only necessary to kill or suppress the well **76** one time[; namely, when] after the drop pipe **82** is [being] removed following [at] the final completion of each successive steel casing **72**, **100** and **102**, respectively, of the well **76**.

We claim:

1. A process for drilling a water injection well using a drilling derrick with rotary drilling, including a rotary table, drill pipe, attachments, and blowout preventer, initially using drilling mud, a source of power outside said injection well, said process including the following steps:

(a) drilling a first hole with said drill pipe and said drilling derrick;
(b) snubbing in a casing having a diameter smaller than said hole;
(c) drilling a first pilot hole below the lower end of said casing;
(d) installing a temporary well header below said rotary drive and said blowout preventors;
(e) attaching a drop pipe to an underside of said temporary well header, which drop pipe extends downward therefrom, diameter of said drop pipe being larger than said attachments but less than said casings;
(f) said drop pipe having a valve secured on a lower end of said drop pipe;
(g) pivotally connecting an actuator to said valve to open or close a bottom opening in said drop pipe, said actuator being opened or closed by said source of power from outside said injection well;
(h) lowering said drill pipe and attachments into said drop pipe with said valve being closed;
(i) securing said rotary drive and stripper rubber to said drill pipe above said temporary well header;
(j) opening said valve with said actuator;
(k) repeatedly extending said drill pipe and attachments into said pilot hole for as needed testing;
(l) repeatedly retracting said drilling pipe and attachment back into said drop pipe during said testing;
(m) closing said valve with said actuator;
(n) killing said well and removing said temporary well header;
(o) removing said drilling pipe, attachment and drop pipe;
(p) reinserting said drilling pipe to drill a reduced diameter casing hole to receive a reduced diameter casing therein;
(q) cementing said reduced diameter casing;
(r) repeating steps (c) through (q) for each successively smaller diameter casing being inserted therein.

2. The process for drilling a water injection well as recited in claim **1** wherein said actuator is a hydraulic cylinder pivotally connected to said valve to open or close said bottom opening, said hydraulic cylinder being operated by hydraulic fluid provided by said source of power.

3. The process for drilling a water injection well as recited in claim **2** wherein during repeating steps (c)-(q) drilling of a second pilot hole occurs through said reduced diameter casing and testing in said second pilot hole occurs without killing or suppressing said water injection well until said second pilot hole is drilled and said needed testing is complete.

4. The process for drilling a water injection well as recited in claim **3** wherein during repeating steps (c)-(q) drilling of a third pilot hole occurs through a second reduced diameter casing, and testing in said third pilot hole occurs without killing or suppressing said water injection well until said second pilot hole is drilled and said needed testing is complete.

5. The process for drilling a water injection well as recited in claims **3** or **4** wherein during repeating steps (c)-(q) logging equipment is lowered through said drop pipe to run logs of said water injection well, said logging occurring without killing or suppressing said water injection well.

6. The process for drilling a water injection well as recited in claims **3** or **4** wherein during said repeating steps core sampling equipment is lowered through said drop pipe to take samples in said pilot holes of said injection well as it is being drilled, said sampling occurring without killing or suppressing said water injection well.

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