Dec. 19, 1961 M. CHURCH 3,013,608

CEMENT JACKETED WELL AND METHOD OF DRILLING SAME

Filed March 22, 1960

FIG. 1.

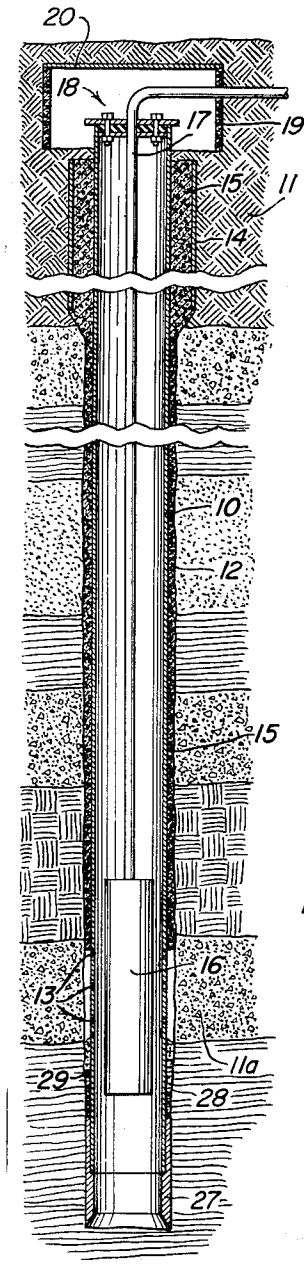


FIG. 4.

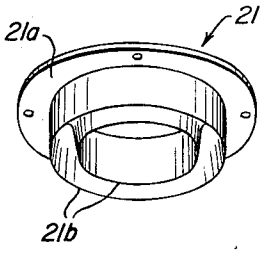


FIG. 2.

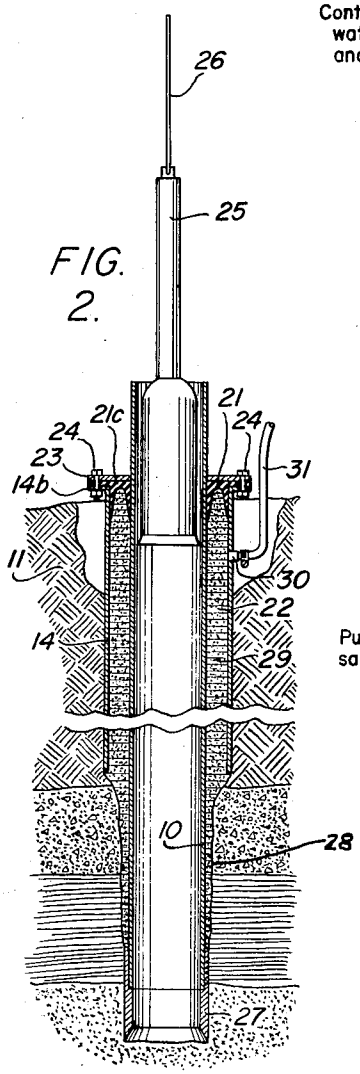
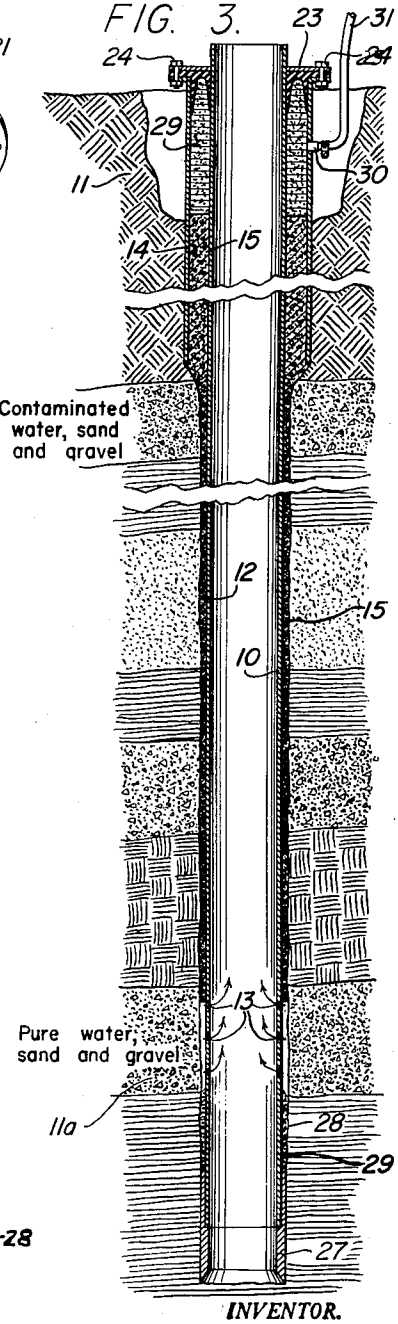


FIG. 3.



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CEMENT JACKETED WELL AND METHOD OF DRILLING SAME

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This invention relates to the drilling of wells, particularly water wells, and is concerned with doing so in such a manner that a completed well will be effectively protected from external conditions, such as pollution by contaminated water nearer the surface than that ultimately tapped by the well.

Water wells are commonly drilled by the so-called "cabletool" method, wherein a drilling tool is repeatedly lifted and dropped by a cable to which it is attached and successive lengths of steel pipe are driven into the resulting hole until the desired well depth is reached. The first pipe of the string is provided with a bit-like shoe at its lower end for reaming the hole drilled by the tool.

The shoe is ordinarily a short, case hardened, steel tube of somewhat greater diameter than the pipe. Its lower end is sharpened; its upper end is formed as a socket for receiving the pipe. Pipe and shoe are welded together at the commencement of the well drilling operation. When most of this first length of pipe is in the ground another length is welded to its upper end, and the drilling operation proceeds. Successive lengths are added as the drilling progresses, until the well casing formed by the string of pipe has tapped a porous stratum containing a suitable supply of water.

Many water wells are driven for the purpose of obtaining potable water for culinary use. Some are driven to supply individual households. Some are driven by municipalities to furnish or augment the municipal water supply. In each instance, it is exceedingly important that the water not be polluted.

To avoid polluted surface water, wells are usually drilled deep enough to tap sources several hundred feet below the surface. However, since the well casing extends down from the surface and often must traverse one or more shallow aquifers which are likely to be polluted, there is always the possibility that polluted water will seep downward along the casing to the normally unpolluted water source.

While the driller usually drills deep enough to be sure that one or more relatively impervious layers of earth—preferably clay—is interposed between shallow water-bearing strata, it is not always certain that effective sealing against downward migration of water along the casing will be had. Moreover, well casings rust with time, and this brings a new danger of introducing polluted water directly into the casing.

In order to combat these threats to water purity, efforts have been made in the past to encase the well casing with cement. Thus, a cement grout is sometimes forced under pressure into the narrow, annular space, between earth and casing exterior, formed by the shoe as it is driven downwardly in advance of the casing itself. The cement is introduced either from the surface directly into the space or from the bottom of the well by way of the interior of the casing, but in either instance it is often extremely difficult if not impossible to obtain full coverage. At least a portion of the earth depth traversed by the casing is almost always loose sand or gravel, which caves against the casing and closes passage through the annular space.

The driving of double, concentric casings having an annular space therebetween for the reception of cement grout is sometimes resorted to for avoiding such condition, but this is so expensive as to effectively preclude its use in most instances.

A principal object of this invention is to avoid the expense of a double casing throughout the depth of a well, but to still effectively jacket substantially the entire well casing with cement.

Outstanding features of the method are the maintaining of the annular space, formed by the shoe exteriorly of the casing, open during the driving of the well by continually introducing a drilling mud thereinto under pressure, and the jacketing of the well casing with cement by progressively replacing the drilling mud with a cement grout.

The method is best carried out by first driving one or more lengths of conductor pipe of diameter sufficiently greater than that of the well casing to provide an annular chamber about the upper portion of such well casing when the latter is sunk concentrically therethrough. The top of this chamber is ordinarily sealed, and drilling mud is pumped thereinto under sufficient pressure to force it progressively downwardly into the annular space, between casing and surrounding earth, formed by the shoe as the drilling proceeds. At the termination of drilling and following perforation of the casing, a cement grout is pumped into the chamber above the mud, forcing the mud downwardly. Pumping the well during this procedure removes the mud being forced into the casing at its lower end. Replacement of mud by cement in the water being pumped from the well indicates that cementing is complete.

Where an unusually deep well is being drilled, it is often practical to use a sufficient length of conductor pipe to insure static pressure of the mud great enough to accomplish the purposes of the invention without sealing or pumping. In other words, the mud will flow under the influence of gravity. Nevertheless, even in these wells forced displacement of both mud and cement is much to be preferred.

An embodiment representing what is presently regarded as the best mode of carrying out the invention is illustrated in the accompanying drawing.

In the drawing:

FIG. 1 is a view in vertical section taken axially through a completed water well drilled and jacketed in accordance with the method of the invention, intermediate portions being broken out for convenience of illustration;

FIG. 2, a similar view taken at an early stage in the drilling procedure;

FIG. 3, a similar view taken upon the completion of drilling and cementing but prior to final capping of the well; and

FIG. 4, a perspective view of the special sealing device employed at the upper end of the conductor pipe during the drilling and cementing procedures.

In the particular form illustrated, the completed well (FIG. 1) comprises a usual well casing **10** of any desired diameter and length found suitable under existing conditions and requirements. Such casing **10** is made up of a series of easily handled lengths of steel pipe, which are welded end to end in customary fashion and are driven down into the earth **11** to the depth required to tap a productive source **11***a* of pure water. Such source is usually several hundred feet below the surface in a porous stratum of sand and gravel as indicated. The well casing ordinarily passes through many strata representative of various earth formations, all as indicated, before it reaches the desired water source.

In most instances, one or more of the strata considerably nearer the surface than that of the desired water source is also water-bearing, as indicated, but the water is contaminated and poses a potential threat to even a deeply underlying water source, such as **11***a*.

In order to protect the well against this threat, the cas-

ing 10 is encased or jacketed with cement 12, which fills what would otherwise be an annular space between the outer surface of the casing and the earth formations through which it extends. This cement jacket or annular filling of cement 12 is continuous and complete throughout the length and outer circumferential periphery of the casing 10, from the inflow ports 13 near the lower end of the casing to a location near the upper termination of such casing. The ports 13 result from perforating the casing at the pure-water-yielding stratum 11*a* in conventional manner following the sinking of the well casing in a special manner described in detail hereinafter.

Concentrically encircling a portion of the length of the well casing 10 adjacent to its upper end is a pipe 14 of greater diameter than such casing but considerably shorter in length, say thirty feet as compared to two hundred feet for the casing or one hundred feet as compared to six hundred feet for the casing, etc. with considerable variation depending upon particular conditions in the individual instance. Between pipe 14 and casing 10 is an annular filling of cement 15 entirely and continuously filling what would otherwise be an annular space between such pipe and casing. The cement filling 15 is integral with the considerably larger cement filling or jacket 12.

In this illustrated instance, the well is serviced by a submerged pump (not shown) whose delivery pipe 17 extends through a conventional mechanical seal 18 at the top of the casing 10 and runs underground to a suitable pressure tank (not shown) or other utility system. As is customary in installations of this type, the upper end of casing 10 extends into a concrete box 19 having a removable cover 20 located just under ground surface so as to be completely out of sight and yet available for servicing the well as may be required from time to time.

The invention is applicable, of course, to other types of installations where the well casing projects from the ground and all equipment is located above ground.

In all instances, the well of this invention is effectively protected externally along substantially its entire length and about its complete circumference by cement and is further protected along the vulnerable near-surface zone by double casing sandwiching cement therebetween.

Drilling techniques used in sinking the well are largely conventional in accordance with accepted cabletool drilling procedures. Not conventional, however, is countersinking of the well casing so as to provide double casing along a surface-adjacent zone of the completed well and a chamber for the introduction of, first, drilling mud, and then, cement grout into the narrow, annular, elongate space formed by the drill shoe between well casing and surrouinding earth formations as the casing is sunk.

Referring particularly to FIG. 2, one or more lengths of relatively large diameter steel pipe 14 are first sunk into the ground in conventional fashion to a depth considerably short of the ultimate depth of the well. The usual cable rig and tools are employed for the purpose. Thereafter, successive lengths of smaller diameter steel well casing pipe 10 are sunk through the opening of what may be appropriately referred to as the "conductor" pipe pipe 14, concentrically therewith, to ultimate well depth.

Following spotting and preliminary driving of the first length of such well casing pipe 10, a special sealing device 21 is inserted between it and the conductor pipe 14. Such device may be of various types effective to seal the upper end of the annular chamber or passage 22 between pipes 10 and 14 and to permit driving of pipe 10 relative to pipe 14 without breaking the seal, but preferably and as illustrated is formed of a synthetic rubber such as "Neoprene" molded, as in FIG. 4, to provide a circumferential flange 21*a* and mutually spaced, concentric legs 21*b* depending from a capping ring 21*c*.

For securing such device in place, an outwardly projecting flange 14*b* is welded to the upper end of conductor pipe 14 to receive flange 21*a*, and an annular cover plate 23 is tightly clamped thereover by means of bolts 24.

Drilling proceeds in customary fashion by use of conventional tool 25 suspended on cable 26. Casing pipe 10 is driven in conventional manner by means of a customary collar (not shown) secured to tool 25 when and as required. The lower end of casing pipe 10 is provided with a customary annular shoe 27, which serves to ream the drilled hole and to produce an annular space 28 between casing and surrounding earth formations as the pipe is driven.

Simultaneously with the sinking of successive lengths of casing pipe 10, bentonite drilling mud 29 or the like is forced into annular passage 22 under pressure, as by means of a conventional mud pump (not shown). For this purpose, a pipe coupling 30 is installed in a suitable receiving opening through conductor 14, as by welding, and a hose 31 from the mud pump is attached thereto.

The drilling mud 29 closely follows the well casing as it is driven, and serves progressively to keep open the annular space 28 throughout the entire length thereof. In some instances it may be desirable to jacket conductor pipe 14 with cement (not shown) before introducing the drilling mud, by forcing the cement outwardly and upwardly around such pipe from its interior in known manner, thereby positively sealing against loss of the mud upwardly.

When the well has been sunk to ultimate depth, see FIG. 3, casing 10 is perforated at a proper location near its lower end in conventional manner to tap the pure-water-yielding stratum 11*a*.

Thereafter, a grout, made up preferably of a neat cement slurry, utilizing a fast-setting Portland cement, is pumped through hose 31 in lieu of drilling mud, serving to progressively displace from space 28 the drilling mud previously introduced and to effectively jacket the well casing 10 with cement 12. The mud is forced into the interior of casing 10 through perforations or ports 13 and is removed along with inflowing water by pumping from the well.

When a showing of cement appears in the water being pumped it is known that the displacement of mud by grout is about completed, and further pumping of grout is carefully controlled accordingly. In order to make the showing more positive, color may be added to the cement as an indicator.

It is desirable to add chlorine or some other suitable germicide to the drilling mud, thereby disinfecting tools, casing, and earth formations against possible contamination from shallow aquifers traversed during the drilling procedure.

Displacement of the final quantity of mud from space 28 is preferably accomplished by following introduction of the cement grout with just enough drilling mud to fill the upper part of chamber 22 with mud 29 instead of cement 15, see FIG. 3. This enables the driller to conviently cut off the upper part of conductor pipe 14 with an acetylene torch and reuse it on a subsequent well by welding it to the upper end of the conductor pipe used there.

The thus completed well is finished off in any suitable manner, such as shown in FIG. 1.

It will be noted from FIGS. 1 and 3 that the mud 29 remains in the annular space 28 below the perforations 13 after cement grout 15 has replaced the mud in the portion of such annular space located above such perforations. It will be apparent to those skilled in the art of well drilling, who know that occasionally water wells are drilled to tap several aquifers at different depths, that such mud 29 below the uppermost set of perforations 13 will tend to remain in place as a seal between those aquifers which are tapped.

The present invention may be used wherever found suitable in the well drilling art for protecting a well from undesirable under ground conditions external thereto.

It should be noted that, in all instances, the drilling mud utilized to temporarily fill the annular space 28 between well casing and earth formations during the drilling of the well so that such earth formations will not cave into such space, also effectively penetrates porous zones and prevents the loss of cement grout to such porous zones in the subsequent cementing procedure. In this connection, it should be realized that various materials customarily used in the drilling of oil wells to control lost circulation may be added to the mud in the present instance should problems of excessive loss of mud to porous earth formations arise.

Whereas there is here illustrated and described a certain preferred procedure which I presently regard as the best mode of carrying out my invention, it should be understood that various changes may be made without departing from the disclosed inventive subject matter particularly pointed out and distinctly claimed herebelow.

I claim:

1. A method of drilling a well, comprising drilling and sinking conductor pipe of relatively large diameter to a predetermined depth considerably short of the ultimate depth of the well; thereafter substantially concurrently drilling and sinking well casing of smaller diameter through said conductor pipe, substantially concentrically therewith, to ultimate well depth as the well is being drilled, said casing having an annular shoe of somewhat greater diameter at its lower end as a pilot producing an annular space between well casing and earth formations, there being an annular passage between said pipe and said well casing but the area surrounding said pipe being substantially sealed; simultaneously with the sinking of said well casing, introducing drilling mud into the upper portion of said annular passage; continuously forcing drilling mud from said passage into the annular space as the sinking of the well casing proceeds; and replacing drilling mud in said passage and said space with cement grout by forced displacement of the former by the latter upon the sinking of the well casing to ultimate depth.

2. The method of claim 1, wherein the drilling mud in said passage and said space is replaced with cement grout by pumping the cement grout into the upper portion of said passage and flowing the drilling mud from the lower

end of said space into the well casing; and wherein said drilling mud is removed from the well by way of said well casing.

3. The method of claim 1, wherein the drilling mud is forced downwardly from said passage into said space by static pressure.

4. The method of claim 1, wherein the drilling mud is forced downwardly from said passage into said space by the steps of tightly sealing the upper end of said passage; and forcing additional drilling mud into the so-sealed passage under pressure.

5. The method of claim 1, including the step of perforating the well casing at the location of an aquifer above the lower end of said well casing, the drilling mud above said location being displaced through the well casing perforations resulting from said perforating.

6. A method of drilling a well, comprising drilling and sinking conductor pipe of relatively large diameter to a predetermined depth considerably short of the ultimate depth of the well; thereafter substantially concurrently drilling and sinking well casing of smaller diameter through said conductor pipe, substantially concentrically therewith, to ultimate well depth as the well is being drilled, said casing having an annular shoe of somewhat greater diameter at its lower end as a pilot producing an annular space between well casing and earth formations, there being an annular passage between said pipe and said well casing but the area surrounding said pipe being substantially sealed; simultaneously with the sinking of said well casing, introducing drilling mud into the upper portion of said annular passage; and continuously forcing drilling mud from said passage into the annular space as the sinking of the well casing proceeds.

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