Nov. 18, 1958 R. F. WILCOX 2,860,854

METHOD FOR DRILLING AND COMPLETING WELLS

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Fig. 1

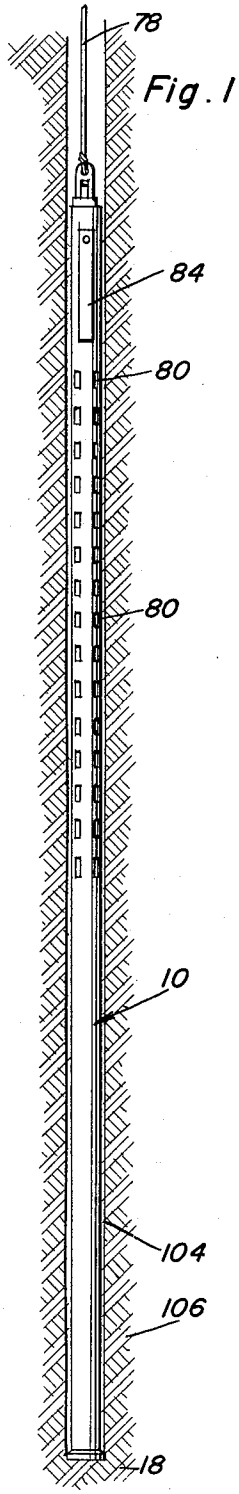



Fig. 2

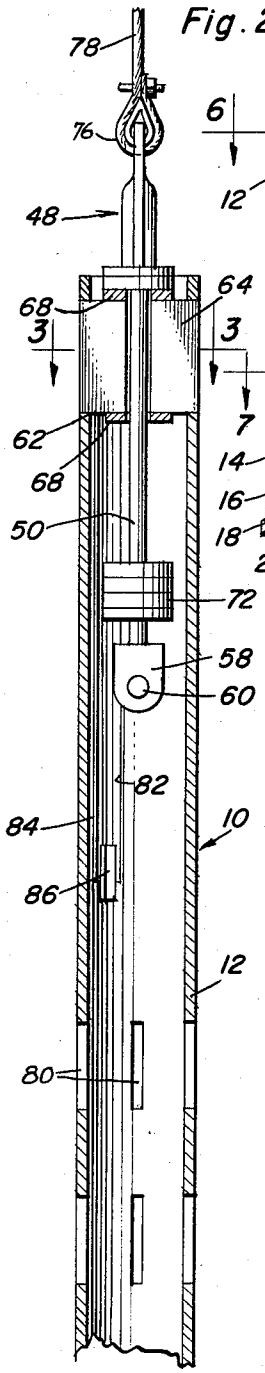



Fig. 4

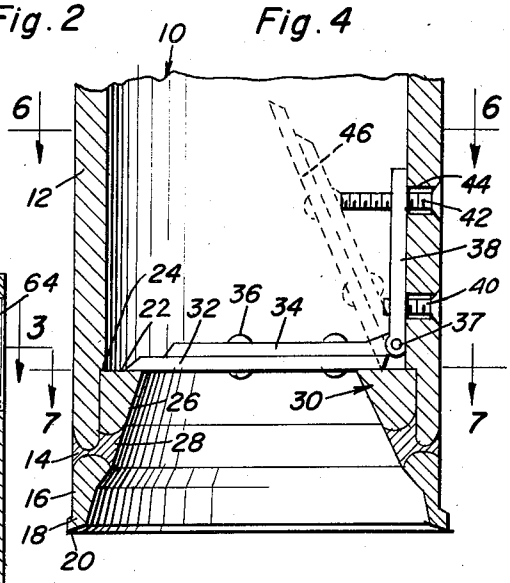
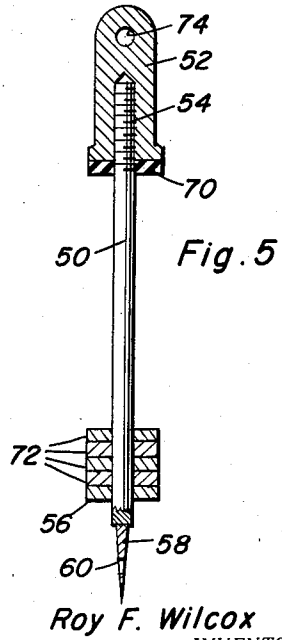



Fig. 5




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METHOD FOR DRILLING AND COMPLETING WELLS

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Fig. 3

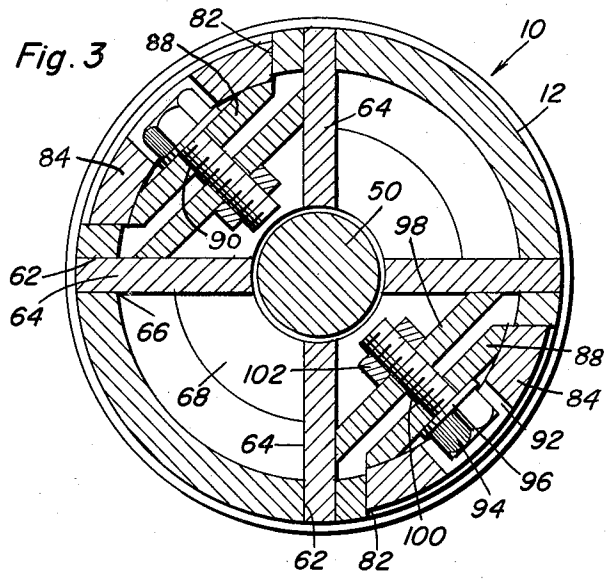



Fig. 6

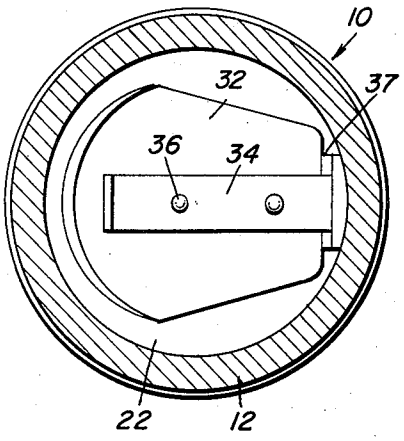



Fig. 7

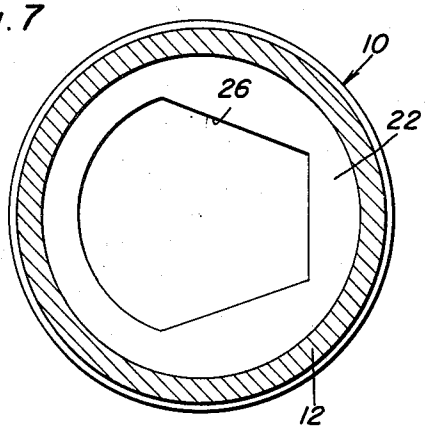



Fig. 8

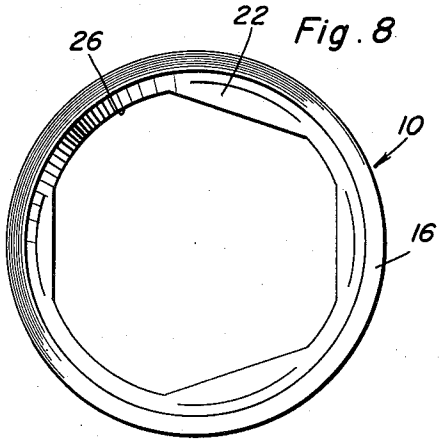
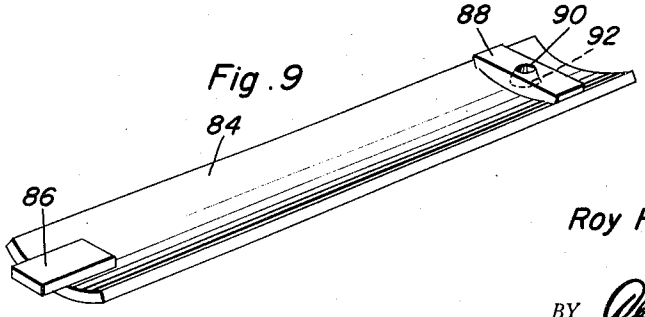



Fig. 9




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Nov. 18, 1958 R. F. WILCOX 2,860,854

METHOD FOR DRILLING AND COMPLETING WELLS

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Fig. 10

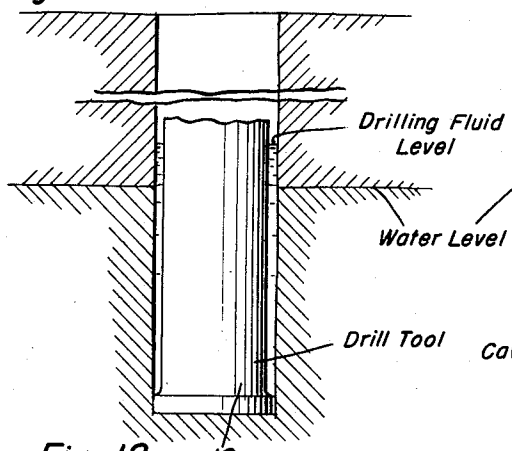



Fig. 11

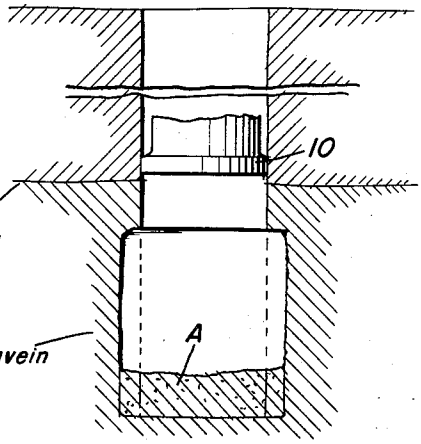



Fig. 12

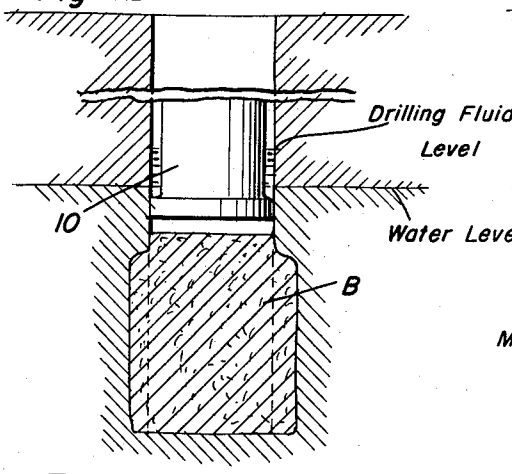



Fig. 13

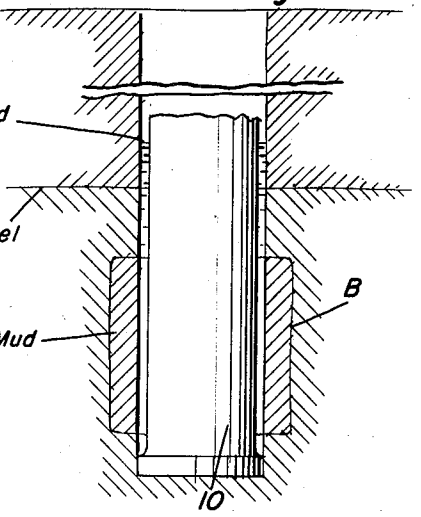
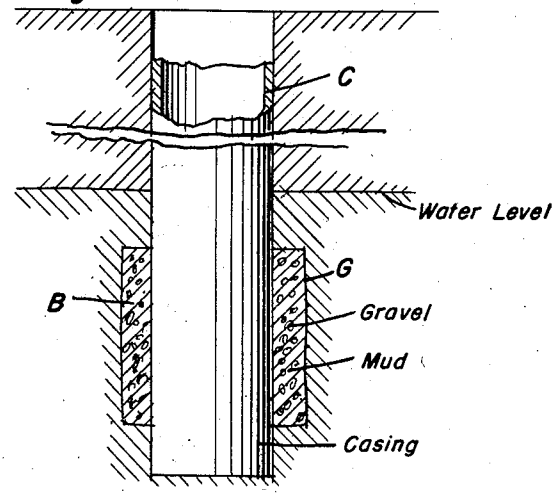



Fig. 14




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United States Patent Office 2,860,854 Patented Nov. 18, 1958



2,860,854

# METHOD FOR DRILLING AND COMPLETING WELLS

Roy F. Wilcox, McCook, Nebr.

Application September 1, 1955, Serial No. 532,050

7 Claims. (Cl. 255—1.8)

This invention relates to novel and useful improvements in a method for drilling and completing wells and constitutes a continuation-in-part of my prior copending application Serial No. 197,370, filed November 24, 1950, for Apparatus and Method of Drilling and Completing Wells and which has now matured into Patent No. 2,721,059, issued October 18, 1955.

The primary object of this invention is to increase drilling speed and to afford a convenient means for the driller to keep an accurate log of the well.

Another important object of this invention is to provide a cable drilling tool which may be used without casing or drive pipe to prevent cave-ins.

Another important object of the present invention is to provide a cable drilling tool and method of operating the same, which will plaster or mud the side walls of the hole to prevent cave-ins.

A further important object of the present invention is to provide a drill tool which will rotate in a single direction during vertical travel in one direction.

It is still another important object of the present invention to provide a cable-type drilling tool of the hollow type having a valve adjacent its lower end which will not bind or stick in use, and which will reduce and break up a core upon the advance of the drill to prevent a core from jamming the valve.

Yet another important object of the present invention is to provide jars for rotatably supporting the tool which will not sand up to lock the same against free rotation.

It is also another important object of this invention to provide a method and apparatus for ascertaining the water level in a loose sanded formation or other structurally weak formation susceptible to cave-ins before casing off the formation, so that the well need only be cased after it has been drilled to a sufficient depth to produce water in the desired quantities.

A very important object of the invention claimed herein is to provide a method, particularly adapted for use with cable tools, for determining with accuracy the depth at which a water level lies and thereby drill a well having a predetermined depth of water therein.

A further object is to devise a method in accordance with the preceding method, which will enable the well bore to be completed to the precise depth desired into the water table before the well casing is set.

A meritorious feature of the present invention resides in the valve and restricted non-circular throat construction at the lower end of the tool, which will prevent jamming of the valve by a core entering the lower end of the tool, with the non-circular restricted throat serving to wear and break off such a core during the twisting of the tool about its vertical axis.

Another important feature of the present invention resides in the jar construction provided which will not sand up to prevent rotation of the tool and which also



affords a fluid passage through the upper end of the hollow tool.

Still another important feature of the present invention resides in the provision of a blade on the jaw construction which serves to break up material in the hollow tool.

Final important features to be specifically enumerated herein reside in the provision of slots in the tubular body to afford mud circulation together with the clean-out openings and the removable cover plates therefor, such clean-out openings being adapted to be used in lieu of the slots in the tubular body.

These, together with various ancillary features and objects of the invention which will later become apparent as the following description proceeds, are attained by the present invention, a preferred embodiment of which has been illustrated by way of example only in the accompanying drawings, wherein:

Figure 1 is a side elevational view of the present invention, this view showing the same in drilling position at the bottom of a well hole;

Figure 2 is an enlarged central vertical sectional view of the upper end of the drilling tool illustrating particularly the jaw construction shown in side elevation therein;

Figure 3 is an enlarged horizontal sectional view taken upon the plane of the section line 3—3 of Figure 2;

Figure 4 is an enlarged vertical sectional view through the lower end of the tool, illustrating particularly the restricted throat construction and the manner in which the valve plate is hingedly secured to the tool, the open position of the valve plate being indicated in dotted lines;

Figure 5 is a detail view of a portion of the jar construction, this view showing the same in side elevation with portions broken away to show the internal construction of the same;

Figure 6 is a horizontal sectional view taken upon the plane of the section line 6—6 of Figure 4;

Figure 7 is another horizontal sectional view of the present invention, this view being taken upon the plane of the section line 7—7 of Figure 4;

Figure 8 is a bottom plan view of the present invention;

Figure 9 is a perspective view of the removable closure plate used for a clean-out opening in drilling tool;

Figures 10–14 are diagrammatic views, parts being broken away, which illustrate the various steps in the novel method of this invention in completing a well at a desired depth into a water producing formation, and wherein;

Figure 10 is a diagrammatic view showing a well bore drilled to a depth estimated to be at a desired distance below the level of the water table of a water producing formation;

Figure 11 is a diagrammatic view illustrating the drill raised above the water level, with the drilling fluid removed and showing the well bore caved-in by the hydrostatic pressure of the waterbearing formation upon release of the drilling fluid pressure;

Figure 12 is a diagrammatic view illustrating the filling of the caved-in well bore with drilling mud and the restoration of the drilling fluid pressure in preparation for resumption of drilling;

Figure 13 is a diagrammatic view illustrating the completion of the drilling operation by continuing drilling through the mud to the predetermned depth below the cave-in and the water level; and

Figure 14 is a diagrammatic view showing the setting

and gravelling of the well casing, the removal of the drilling string and the completion of the well.

Reference is now made more specifically to the accompanying drawings, wherein like numerals designate similar parts throughout the various views, and in which the drilling tool is designated generally at **10**.

As best shown in Figures 1 and 4, the drilling tool **10** comprises an elongated tubular body **12** that has secured to its lower end, as by welding **14**, an annular drilling bit **16**. The annular drilling bit **16** is radially enlarged at its lower end as at **18**, and is provided with a cutting edge **20** for a purpose to be seen presently.

An annular valve seat **22** is disposed in the lower end of the body **12** and is seated against the underside of a shoulder **24** therein. As best shown in Figures 4, 7 and 8, the valve seat **22** is formed with a non-circular opening **26** therein which tapers upwardly.

In the preferred construction, the inner surface of the bit **16** is circular in transverse section and tapers upwardly and smoothly merges with the surface of welding **28** that secures the valve seat **22** to both the tubular body **12** and the bit **16**. The surface of the welding **28** is likewise tapered upwardly and in turn smoothly merges with the side walls of the valve seat **22** defining the opening **26**. The inner surface of the welding **28** and the side walls of the valve seat **22** defining the opening **26** are so contoured as to smoothly change from the circular form of the bit to what may be generally described as a truncated sector at the most restricted part of the opening **26**, that is, the upper end of the opening **26**. It will thus be seen that the inner surfaces of the bit **16**, the welding **28**, and the valve seat **22** define a restricted non-circular throat at the lower end of the body **12**, and that the throat **30** tapers upwardly progressively changing from being circular in transverse section to being roughly a truncated sector in transverse section at its upper end. The purpose of the restricted throat **30** will be presently set forth.

A valve plate **32**, also having what may be described as the shape of a truncated sector is seated on the valve seat. A hinge strap **34** is riveted to the plate, as at **36**, and at the minor or narrow end of the plate **32** is hinged to the lower end of the mounting plate **38**. The mounting plate **38** is, in turn, detachably secured to the body **12** by means of threaded fasteners **40** and **42** extending through countersunk smooth bores **44** in the body **12** and threadingly engaging the mounting plate **38**. As shown in Figure 4, the fastener **42** extends into the body **12** to limit opening movement of the plate **32** to the alternate position shown in dotted outlined at **46**.

A jar construction designated generally at **48** is provided at the upper end of the tubular body **12** for supporting the tubular body **12** for rotation about its longitudinal vertical axis. As best shown in Figure 5, the jar construction **48** includes a jar stem **50**, the upper end of which is externally threaded and threadingly engaged in a socket formed at the lower end of a combined jar and connecting member **52**, as at **54**. A fixed jar or abutment **56** is secured as by welding to the jar stem **50** adjacent its lower end, and the lower end of the jar stem **50** has welded thereto a depending blade or cutter **58** having a transverse opening **60** therethrough. It will be understood that by merely extending a tool through the opening **60** the jar stem **50** may be secured against rotation and the member **52** easily disengaged from the upper end of the jar stem **50**. For an illustration of the manner in which the jar stem **50** is mounted in the tubular body **12**, attention is directed to Figures 2 and 3, wherein it will be seen that the tubular body **12** is provided with a plurality of circumferentially spaced elongated slots **62**. A spider construction is mounted in the slots **62** which includes a plurality of plates **64** seated in the slots **62** to extend radially inwardly into the body **12** to terminate in spaced relationship to each other, the plates **64** being secured to the body **12** as by welding. The jar stem **50** is slidably and rotatably received between the inner ends of the plates **64**. Reinforcing washers or abutments **68** loosely embrace the jar stem **50** and are secured as by welding or the like to the upper and lower ends of the plates **64** in spaced relation to the inner walls of the tubular body **12**. It will be noted that the member **52** is spaced above the washers **68** and the jar **56** is spaced below the washers **68** so that relative vertical movement of the jar stem **60** and the body **12** is limited by engagement of the member **52** and the jar **56** with the washers **68**. In order to prolong the life of the jar construction **48**, the present invention includes resilient cushion washers **70** and **72** secured to the member **52** and the jar **56**, respectively. It should also be noted at this point that by virture of the washer **68** being spaced from the inner wall of the tubular body **12**, fluids may freely pass vertically through the tubular body **12** past the jar construction **48**, and that in addition, the jar stem **50** is journaled in the tubular body **12** in such a manner that the same will not sand up to prevent relative rotation as occurs in other constructions of this general character.

The upper end of the member **52** is provided with a transverse opening **74** which receives the attaching eye **76** formed at the lower end of a conventional twisted strand steel cable **78**. It will be understood that the cable **78** is of the type which will produce torsion when either placed under or released from tension. As thus far described, it will be appreciated that in raising and dropping the tool **10** by the use of the cable **78**, the tubular body **12** will be rotated when the cable **78** is tensioned to raise the same by virtue of the frictional engagement of the cushion washers **72** with the lowermost washer **68**.

As clearly shown in Figures 1 and 2, commencing a considerable distance above the lower end of the tubular body **12**, the latter is provided with a plurality of rows of vertically spaced and elongated slots **80** for a purpose to be presently set forth. In addition, as clearly shown in Figures 2, 3 and 9, the upper end of the body **12** is provided with vertically elongated, circumferentially spaced clean-out openings **82** adjacent the jar construction **48**. Closure plates are provided for removably closing the clean-out openings **82**, such cover plates each consisting of an elongated plate **84** that is arcuate in transverse cross-section to be substantially of the same curvature as the outside surface of the tubular body **12**. The plates **84** are received within the openings **82**, and have secured to their lower ends retaining lugs **86** which project downwardly to engage the inner surface of the tubular body **12**. The straight transverse bar **88** is secured to the inner side of each of the plates **84** at the end remote from the lugs **86**, and the bars and the plates are provided with aligned openings **90** and **92**, respectively. Headed threaded fasteners **94** are disposed in the openings **90** and **92**, and are rotatably retained therein by means of washers **96** that are secured to the heads of the fasteners **94** that extend radially to be received between the plates **84** and the bars **88**, it being noted that the openings **92** are sufficiently large to permit access to the headed end of the fasteners **94** by means of a socket wrench or the like. Mounting bracket plates **98** are welded or otherwise suitably secured to adjacent plates **64** to provide additional lateral bracing for the plates **64**, and are provided with smooth openings through which the inner ends of the fasteners **94** extend. Nuts **102** are threaded on the inner ends of the fasteners **94** and engaged against the plates **98** to secure the plates **84** in positions closing the openings **82**. It will be appreciated that in lieu of the provision of the nuts **102**, the openings **100** may be interiorly threaded so as to engage the fasteners **94**.

It is thought that the use of the present invention will be readily understood. In drilling through formations above ground water level, a fluid level is maintained

within the hole sufficient to stand above at least the lowermost of the slots **80**. It will thus be seen that the enlarged portion **18** of the bit **16** will cut a hole **104** through the formation **106** slightly exceeding in diameter the outside diameter of the tubular body **12**. Upon downward movement of the tool **10**, the valve plate **32** is forced upwardly by fluid pressure to permit the flow of fluid upwardly into the tubular body **12**. Upon raising the tool **10**, the valve plate **32** is closed by fluid pressure so that the fluid may now flow through the inside of the tubular body **12**, outwardly through the slots **80**, downwardly in the annular space in the hole **104** surrounding the tubular body **12**, and thence upon the next downward movement of the tool upwardly through the valve into the interior of the tubular body **12**. While prepared muds or simply surface soil may be added to water and placed in the tool **10**, it has been found in practice that the mere working of the tool **10** in water will provide a drilling fluid of sufficient consistency to produce the desired effect of plastering or mudding the side walls of the hole **104** during the circulation of the drilling fluid thereagainst. As is well known, the plastering or mudding of the walls of a well hole will seal the same against cave-ins or the like, and it is by virtue of this operation or function of the present invention that the use of casing or drive pipe through structurally weak, or loose sanded formations will prevent cave-ins.

In drilling in formations below ground water level, it is desired to use hydrostatic pressure within the hole **104** to oppose the hydraulic forces existing in the formations that tend to produce cave-ins in the well hole, and, accordingly, during such drilling a fluid level is maintained within the hole that is above the ground water level existing in the formation or at least at a sufficiently high level to prevent cave-ins. In all other respects, the drilling below ground water level is accomplished in substantially the same manner as above ground water level, and the drilling fluid circulates in the same manner and tends to cement or seal the walls of the well hole by plastering or mudding the same.

It will be evident that in using a hole drilling tool of this type the tool **10** will tend to form a core which will extend upwardly into the lower end of the tubular body **12** that would tend to interfere seriously with the operation of the valve at the lower end of the body; however, in the use of the present invention, the turning effect on the tool produced by the twisted cable **78** coupled with the shape of the upwardly tapered, noncircular throat at the lower end of the body below the valve cooperate to wear down the size of such a core and to break off the same into chunks which may pass upwardly through the valve seat **22** without interfering with the operation of the valve plate **32**. In addition, it should be noted that the chunks of material broken off by the restricted throat will be of small enough size to pass upwardly through the valve without interfering with the operation of the same, but will also be large enough so that upon raising the tool **10** to the surface, the driller may, upon inspection of the same, determine with accuracy the character of the formation through which the tool is passing.

It should also be noted that in the event the slots **80** become congested with material within the tubular body **12** to such an extent that the circulation of the drilling fluid would be reduced, the drilling fluid will be free to pass upwardly through the tubular body **12** to the exterior of the tool **10** through the passages afforded between the plates **64** and between the washer **68** and the inner surfaces of the tubular body **12**, and in fact, such an operation or function of the tool has proven so satisfactory that the slots **80** may be dispensed with entirely if desired. In addition, the circulation of the drilling fluid may, under certain adverse conditions, be further expedited by the removal of the plates **84** so that the drilling fluid circulation may pass through the openings **82** as well as upwardly past the jar construction **48**.

It will be further appreciated that the tool **10** is capable of dual functions, that is, the tool **10** may not only be used as a drill and a drilling fluid pump, but may also be used as a bail bucket by virtue of the spacing of the lowermost of the slots **80** above the valve.

The present invention is particularly well adapted for bringing in wells in loose sanded formations. By the expression "loose sanded formations" it is meant throughout this specification any formation which is structurally weak and susceptible to caving in to the well hole through the action of hydraulic forces obtaining therein. The newly discovered method of completing wells in loose sanded formations resides in drilling into such a loose sanded formation while maintaining a fluid level in the hole sufficiently high to prevent the caving in of the formation. Generally speaking, maintaining a fluid level in the hole above the top of the loose sanded formation or above the ground water level therein is sufficient to prevent the caving in of the formation. After the well is drilled to such a depth that it is believed that the same will be capable of producing water in the quantities desired, the present invention contemplates a procedure whereby this fact may be ascertained with certainty prior to the setting of the casing, so that if the well has not been drilled sufficiently deep, the same may be deepened to the necessary extent prior to even going to the time and labor consuming procedure of setting the casing.

In the present invention, this may be accomplished by lowering the fluid level within the well hole until a cave-in occurs. It has been found by experience that a cave-in brought about in this manner will only occur for a short vertical length of the hole immediately below the fluid level at the time the cave-in occurs. It has also been found that such a cave-in occurs a short vertical distance below the ground water level in the loose sanded formation, so that by knowing the level at which the cave-in occurred, the driller is readily apprised of the approximate location of the ground water level in the formation.

Figure 10 indicates the foregoing operation in which the well bore has been drilled to a depth estimated to be somewhat below the level of the ground water. Any cave-in is of course prevented by the drilling fluid in the well bore.

As shown in Figure 11, the drill tool is lifted a sufficient distance to be above the water level and any cave-in to avoid being buried thereby. Then the drilling fluid level at the well bore is lowered, permitting the hydrostatic head of the water in the formation to cave in the well bore as shown in Figure 11 by the caved-in material A.

If the estimate as to the ground water level was incorrect, so that no cave-in occurred, the drilling fluid would be again applied and the drilling continued to a greater depth. This would be repeated until a depth was reached beneath the water level, whereupon a cave-in as shown in Figure 11 would be effected. The cave-in would indicate approximately the water level of the water producing formation, and with this level now ascertained the requisite depth to which the well bore must be drilled to give the desired depth of water in the well can be easily determined.

Immediately upon the occurrence of the cave-in, and so that the cave-in will be minimized and not creep upwardly in the hole, the driller raises in any conventional manner the fluid level within the hole, and then drills through the caved-in material in the hole. This next step is illustrated at Figure 12 wherein it will be noted that the well bore has been filled in above the caved-in portion by mud B, and the drilling fluid level restored in order to prevent, by its pressure on the formation, any further cave-in. The driller then drills the bottom of the hole to whatever depth is required to

produce the desired feet of water head of the ground water level above the bottom of the hole, it being obvious that if the well hole was already sufficiently deep, no further drilling will be required, and the casing may then be set. It has also been found by experience that a cave-in produced under the conditions set forth above will not cause caved-in material to fall clear to the bottom of the hole, but such caved-in material only extends across the hole at the level of the cave-in so that the same may be readily drilled out without requiring any redrilling below the level of the cave-in. Obviously, if no cave-in occurs at all during the lowering in any suitable manner of the level of the fluid within the hole, the hole has not been drilled to a sufficient depth below ground water level, or may in fact not even be down to ground water level, under which circumstances the driller will deepen the hole a considerably greater depth and then repeat the above steps.

The completion of the drilling operation is indicated in Figure 13, with the well bore now drilled through the mud B to the required depth to complete the well bore. Thereafter, the casing C is inserted as in Figure 14, the drill tool is removed and the casing is gravelled as at G and the well is now completed.

The tool **10** is well suited for the above method for the reason that the tool may be used both for lowering the fluid level within the hole as well as for raising the same inasmuch as the same serves the auxiliary function of serving as a bail bucket. The advantage in the use of the tool **10** in raising the fluid level in the hole resides in the fact that the fluid may be lowered gently into the hole rather than simply poured into the same, which latter procedure would tend to wash down the sides of the hole and thus induce the possibility of a cave-in at a higher level within the hole.

From the foregoing, the construction and operation of the device will be readily understood and further explanation is believed to be unnecessary. However, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the appended claims.

What is claimed as new is as follows:

1. A method for completing in a loose sanded formation a water well having a predetermined standing water level therein which comprises; drilling an open hole into a loose sanded formation below the ground water level, maintaining during said drilling a fluid level in said hole above said ground water level by introducing fluid as required into said hole, progressively lowering the fluid level by withdrawing fluid from the hole until the fluid level is below the ground water level and a cave-in occurs and thereby ascertaining the water level in the loose sanded formation adjacent the hole, raising the fluid level above said ground water level by again introducing fluid into said hole, thereafter and while maintaining said fluid level above said ground water level drilling until the hole is extended to the desired depth below said ascertained ground water level.

2. A method for completing in a loose sanded formation a water well having a predetermined standing water level therein which comprises; drilling an open hole into a loose sanded formation below the ground water level, maintaining during said drilling a fluid level in said hole above said ground water level by introducing fluid as required into said hole, progressively lowering the fluid level by withdrawing fluid from the hole until the fluid level is below the ground water level and a cave-in occurs and thereby ascertaining the water level in the loose sanded formation adjacent the hole, raising the fluid level above said ground water level by again introducing fluid into said hole, thereafter removing the caved-in material from said hole and while maintaining said fluid level above said ground water level drilling until the hole is extended to the desired depth below said ascertained ground water level.

3. A method for completing in a loose sanded formation a water well having a predetermined standing water level therein which comprises; drilling an open hole into a loose sanded formation below the ground water level, maintaining during said drilling a fluid level in said hole above said ground water level by introducing fluid as required into said hole, then raising the drilling tool in the hole above the ground water level, progressively lowering the fluid level by withdrawing fluid from the hole until the fluid level is below the ground water level and a cave-in occurs and thereby ascertaining the water level in the loose sanded formation adjacent the hole, raising the fluid level above said ground water level by again introducing fluid into said hole, thereafter lowering the drilling tool into drilling position and while maintaining said fluid level above said ground water level drilling until the hole is extended to the desired depth below said ascertained ground water level.

4. A method for completing in a loose sanded formation a water well having a predetermined standing water level therein which comprises; drilling an open hole into a loose sanded formation below the ground water level, maintaining during said drilling a fluid level in said hole above said ground water level by introducing fluid as required into said hole, progressively lowering the fluid level by withdrawing fluid from the hole until the fluid level is below the ground water level and a cave-in occurs and thereby ascertaining the water level in the loose sanded formation adjacent the hole, preventing upward creeping of the cave-in by raising the fluid level above said ground water level by again introducing fluid into said hole, thereafter and maintaining said fluid level above said ground water level drilling until the hole is extended to the desired depth below said ascertained ground water level.

5. A method for completing in a loose sanded formation a water well having a predetermined standing water level therein which comprises; drilling an open hole into a loose sanded formation below the ground water level, maintaining during said drilling a fluid level in said hole above said ground water level by introducing fluid as required into said hole, progressively lowering the fluid level by withdrawing fluid from the hole until the fluid level is below the ground water level and a cave-in occurs and thereby ascertaining the water level in the loose sanded formation adjacent the hole, raising the fluid level above said ground water level by again introducing fluid into said hole, thereafter and while maintaining said fluid level above said ground water level drilling until the hole is extended to the desired depth below said ascertained ground water level, and finally positioning a casing in the hole to the bottom thereof and thereby preventing further caving in of the loose sanded formation.

6. A method of completing a water well in a loose sanded formation, comprising the steps of drilling an open hole into a loose sanded formation below the adjacent ground water level of said formation, maintaining during said step of drilling a fluid level in the hole above said ground water level by introducing fluid into said hole as required, thereafter progressively lowering the fluid level in the hole until it falls below the ground water level and a cave-in occurs, then preventing enlarging of the cave-in by again introducing fluid into the hole and raising the fluid level above said ground water level and thereafter drilling the hole to completion.

7. A method of completing a water well in a loose sanded formation, comprising the steps of drilling an open hole into a loose sanded formation below the adjacent ground water level of said formation, maintaining during said step of drilling a fluid level in the hole above

said ground water level by introducing fluid into said hole as required, then raising the drilling tool in the hole and thereafter progressively lowering the fluid level in the hole until it falls below the ground water level and a cave-in occurs, then preventing enlarging of the cave-in by again introducing fluid into the hole and raising the fluid level above said ground water level and again lowering the drilling tool into drilling position and thereafter drilling the hole to completion.



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