

July 23, 1957

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2,800,185

METHOD AND DEVICE FOR SEALING A BOREHOLE WALL

Filed Dec. 30, 1954

2 Sheets-Sheet 1

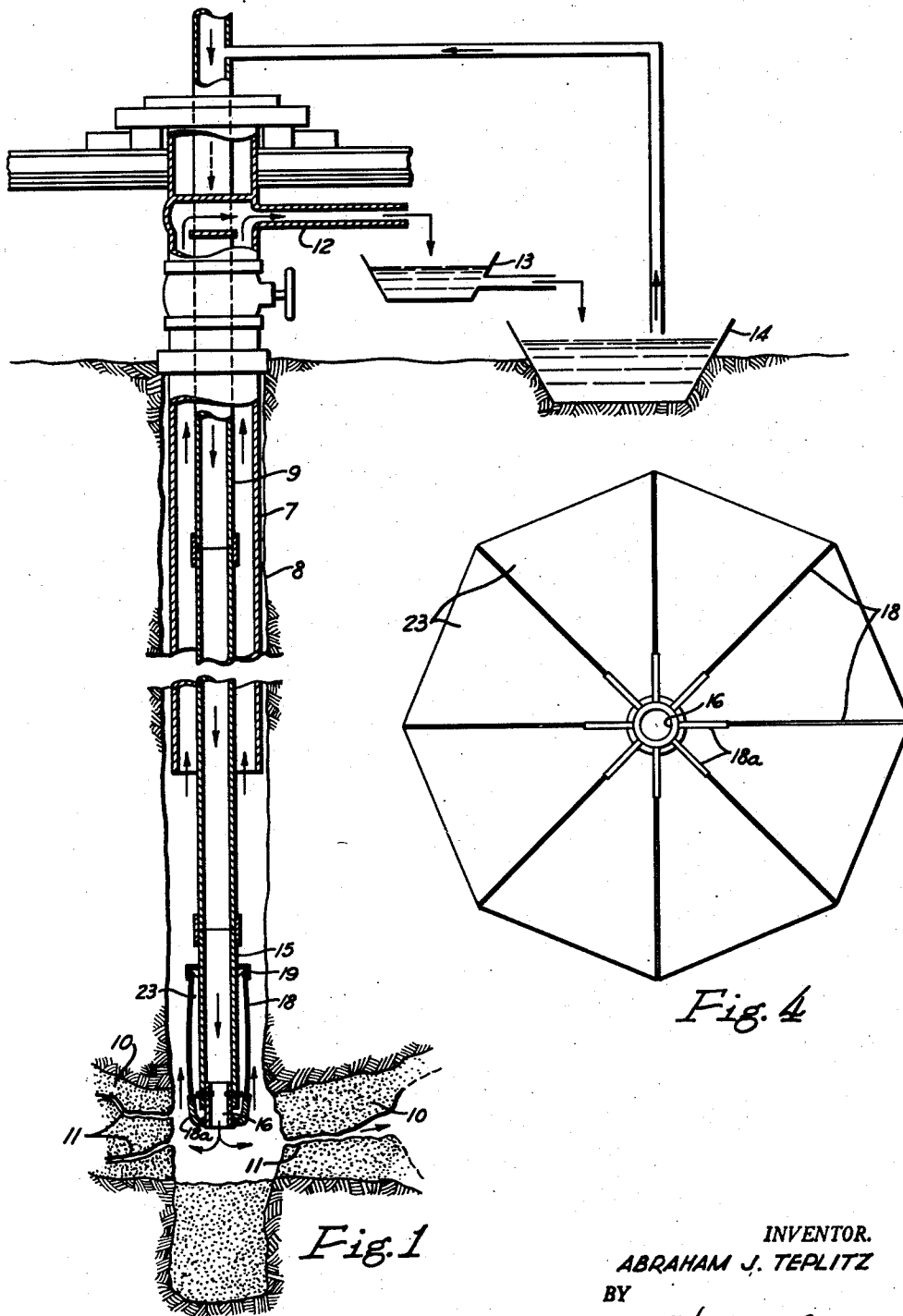


Fig. 4

Fig. 1

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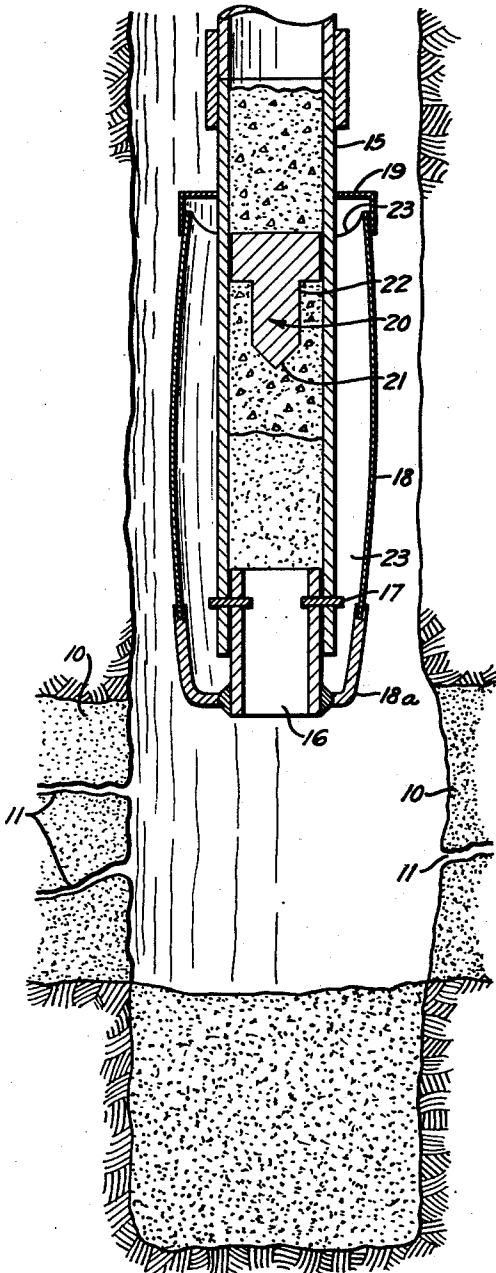


*Fig. 2*

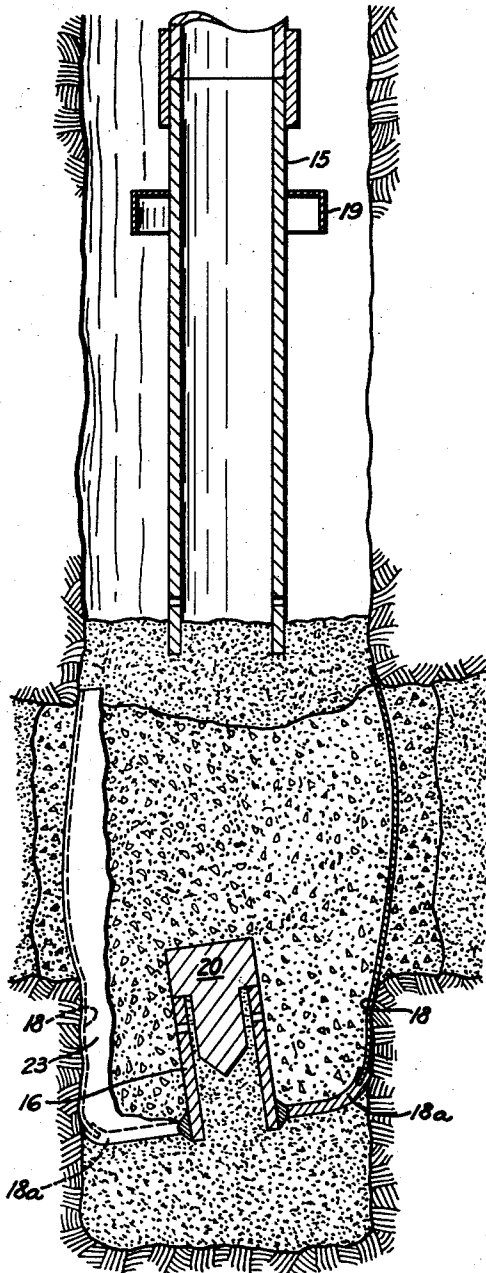


Fig. 3

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## METHOD AND DEVICE FOR SEALING A BOREHOLE WALL

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Application December 30, 1954, Serial No. 478,653

8 Claims. (Cl. 166—27)

This invention relates to method and means for sealing thief zones in formations penetrated by the borehole of a well and has particular reference to an improved method and means for restoring the full circulation of drilling muds when lost circulation of drilling mud has occurred by penetration of the mud into a loss zone.

A major factor in the high cost of drilling many wells is the lost circulation of drilling fluid or mud; such lost circulation in addition to involving loss of costly materials and expensive rig time can result in stuck drill pipe, a lost hole, blow-out or abandonment. One solution for the lost circulation problem has been the placement of a plug that hardens or stiffens in the loss zone by introducing time-setting material into the well and displacing such material into the loss zone through open-ended pipe with drilling fluid. A fundamental difficulty encountered by the foregoing treatment is the lack of control of the placement of the sealing material. Frequently the exact location of the zone of loss is unknown and thus the proper volume of fluid needed to displace the sealing material in such manner as to deposit it at the point of loss cannot be determined. If too much displacing fluid is used the sealing material will be driven too far back into the zone of loss to be effective; if too little is used the material will not reach the zone of loss. Even if the location of the loss zone is known it is difficult properly to place the sealing material with the presently employed techniques. Usually when a zone of loss is encountered, the fluid level in the well drops below the surface and subsequently becomes static at depths that will vary from 100 feet or so to about 2,000 feet depending on the drilling fluid weights employed and the natural formation pressures existing in the area being drilled. The rate of attainment of equilibrium fluid level will vary over extremely wide ranges from well to well. Under these conditions, therefore, when sealing material and displacing fluid are introduced at the top of the well generally the fluid level builds up for a time and then drops with a surge so that the positioning of the sealing material cannot be controlled. Even quick setting cement or rapidly hydratable bentonite-oil mixtures have in many cases proved incapable of sealing off a serious loss zone owing to the difficulty of controlling the flow into the formation during placement. Unless such control can be exercised, the sealing material will penetrate too far into the formation and not seal.

Briefly stated, my invention comprises a method of sealing loss formations in which a time-setting material is introduced into the borehole and to the vicinity of the loss formation, drilling fluid being displaced in the formation until the sealing material enters the formation, in which a diaphragm is introduced immediately following the time-setting material, and in which additional fluid is added immediately following the diaphragm, so that when the diaphragm comes to rest against the loss formation the said additional fluid will hold it firmly in place. After allowing the well to stand and the time-setting material to harden, the obstructing portion of the diaphragm as-

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sembly is drilled out of the borehole. This method solves the problem created heretofore by the excessive penetration of time-setting material into the loss formation before it had an opportunity to harden and plug the formation. In the preferred method of applying my invention the diaphragm is introduced immediately following a major portion of the time-setting material and an additional portion of time-setting material is added immediately following the diaphragm. My invention further comprehends an apparatus for introducing the time-setting material and, while charging the time-setting material, for introducing a sealing sheath or retainer, the said apparatus consisting essentially of: an elongated tube that is detachably connected, usually by threading the one end, to open ended drill pipe, the said tube having an outside diameter less than that of the borehole wall and preferably substantially the same as that of the tubing or drill pipe; a short detachable section or spool connected to the other end of the tube; fastening means connecting the spool to the tube and arranged to be automatically or remotely released; a plurality of ribs positively attached at one end to the said spool at points arranged around the outer circumference of the spool, at least a section of said ribs extending from the point of their attachment to the spool consisting of a leaf spring; a releasable retainer for holding the ribs, at the ends opposite to their attachment to the spool, closely around the vessel; a webbing supported on the ribs and fitted snugly to the said spool; and means for releasing the said spool piece, for example, a shearing plug, actuatable from the well, or ground surface, whereby the spool is released from the tube and the ribs from the retaining means. Once released, the radially extending webbed ribs spring out from the tube and the spool drops in the stream of cement until it reaches the stagnant mud layer, immediately below the loss zone, the ribs then fitting, as a sheath, against the borehole wall. The shearing plug, or like releasing means, and the spool consist of drillable material. The ribs must be of sufficient length that the webbing supported thereon when pressing against the borehole wall upon release of the ribs from the retainer and release of the springs will cover the loss zone to be cemented. The springs can be composed of spring steel and the remainder of the ribs can be steel, cast iron, or an alloy. The webbing can be canvas or preferably rubber or some other waterproof fabric having sufficient stability and strength.

Fig. 1 is a cross-sectional elevational view through a well showing a borehole and the apparatus of invention being lowered into position.

Fig. 2 is a cross-sectional elevational view of the borehole at the time cement is being initially charged to the loss formation.

Fig. 3 is a cross-sectional elevational view showing a part of the borehole and the basket sheath in detail at the time that the charge of cement has been completed, and

Fig. 4 is a cross-sectional view of the basket sheath.

Referring now to Fig. 1, an uncompleted well is shown in cross section with parts broken away, casing 7 having been driven into borehole 8 to an intermediate depth and drill pipe 9 having been lowered to a point preferably just above loss formation 10 containing one or more fractures 11. During the course of drilling (the drill bit, having been removed, is not shown), drilling mud is pumped down through the drill pipe through ports in the bit and upwardly through the annular space between the borehole wall or casing and through a line 12 to a settling trough 13 and a sump pit 14 whence it is returned to the kelly and thence to the interior of the borehole. The well is shown after a condition of lost circulation has occurred and full returns are no longer

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being received through the line 12. The drill pipe having been raised and the rotary bit removed, the pipe has again been lowered to a point in the borehole above the loss zone. The borehole below the loss zone contains stagnant mud. An elongated section of pipe or tube 15 is attached to the end of the drill pipe 9 before it is lowered into the borehole; a spool 16 is connected by shear pins 17 to the other end of tube 15. Attached to the lower end of the spool 16 are ribs 18 which extend in flexed position upwardly along the side of the tube 15. Circumferentially fitted around the tube 15 just below its connection with drill pipe 9 is a retaining ring 19 shaped so as to hold the free ends of the ribs 18, or the like, which ribs are inserted into the retaining ring from below to restrain the ribs from springing outward. The lower portion of the ribs 18 consist of flexed springs 18a. The springs 18a should be longer than the net radius of the annular space between the tube 15 and the borehole wall and the ribs 18 should be of sufficient length to cover the loss zone. The flexed spring section 18a can constitute the entire rib 18. A webbing 23 is fitted on the ribs 18 to form an expandable sheath.

Referring now to Fig. 2, the tube 15 is shown partially filled with downwardly flowing cement. In some intermediate position in the column of cement flowing downwardly in the tube is a drillable, for example, hard rubber, shearing plug 20 having a conical or tapered bottom or forward end 21, a section 22 of reduced diameter extending from said cone to the rear portion of the plug 20, the rear portion having a diameter only slightly less than that of the inside diameter of the tube 15. Spool 16, that is attached to the tube by the shear pins 17, has connected at its lower end a plurality of the steel springs 18a retained in a flexed position; connected to the springs are the ribs 18 which are retained as above described by the retaining ring 19. As shown in Figs. 1 and 2 mud flowing downwardly through the drill pipe 9 is at least in part being lost through the fractures 11 of the loss zone 10.

As the shearing plug 20 descends in tube 15 it will sever or break the shear pins 17 and thus release spool 16 and ribs 18 from their retention in the retaining ring 19. The sheath formed by the said ribs and by webbing 23 will descend in the borehole until it comes to rest on the stagnant mud lying in the borehole below the zone of loss. The pressure differential between the borehole and the interior of the loss formation 10 which has hitherto caused a flow of mud from the borehole into the zone will force the ribs and webbing against the walls of the borehole. The situation will then be substantially that which is shown in Fig. 3.

In Fig. 3 the spool 16 and shearing plug 19 are shown resting on the stagnant mud. Connected to the spool 16 are the springs 18a which are no longer flexed. The rib 18 is thus permitted to expand against the borehole and to seal the loss formation. It can be seen from the configuration of the ribs 18 shown in the Fig. 3 that it is preferable that these ribs be formed of some flexible material. As the shearing plug 20 was introduced into the borehole at a point intermediate in the charge of cement delivered thereto, cement will have penetrated into the loss formation 10 prior to the shearing of pins 17 and a resultant release of the flexible sheath to effect such seal. There no longer being any force to drive cement back into the loss zone 10 the introduced cement will remain in an annular ring-like section immediately peripheral to the borehole wall and will harden thereby sealing off lost circulation with a minimum amount of cement.

Fig. 4 shows a simplified plan view of the expanded basket sheath comprising the spool 16, springs 18a, ribs 18 and the webbing 23.

After the cement has had sufficient opportunity to set, the drill string is drawn from the well, tube 15 with its retaining ring 19 is removed from the end of the drill

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pipe 9 and the drill bit is replaced. The drill is then lowered into the borehole and the cement plug is drilled out along with the sealing plug and the spool which also consists of drillable material. The drilling operation can then be resumed without further loss of drilling mud at the sealed zone of loss.

The tube 15 can be fitted with another basket sheath and be used in another sealing operation.

Having described my invention, I claim:

1. A method of sealing a formation causing loss of circulation penetrated by the borehole of a well comprising pumping a charge of time-setting material down the well and into the formation causing loss of circulation, thereafter positioning a flexible diaphragm in the well against the face of the formation causing loss of circulation, and maintaining pressure on the well to hold the flexible diaphragm against the formation causing loss of circulation until the time-setting material previously forced therein sets.

2. A method of sealing a formation causing loss of circulation penetrated by the borehole of a well comprising pumping a charge of time-setting material down the well and into the formation causing loss of circulation, thereafter positioning a flexible webbing against the face of the formation causing loss of circulation to prevent further flow into the formation, pumping additional time-setting material down the well and into the borehole of the well thereby holding the flexible webbing against the face of the formation causing loss of circulation until the time-setting material hardens, and thereafter drilling through the time-setting material in the borehole.

3. Apparatus for sealing the borehole wall of a well with a time-setting material the said apparatus comprising a tube adapted at one end to be attached to the end of a drill pipe and having an outside diameter less than that of the borehole and an inside diameter substantially the same as that of the drill pipe, a spool attached to the other end of the tube, means for attaching the spool to the tube releasable at the ground surface, a plurality of resilient ribs each positively attached at one end to the outer surface of the spool and spaced around the spool, a flexible webbing mounted on said ribs, a retaining means attached to the tube for holding the ribs in a flexed position along the tube, and means for releasing the said spool piece actuatable from the ground surface whereby a basket sheath consisting essentially of said spool piece and the attached webbed ribs is detached from the said tube.

4. The apparatus of claim 3 in which the ribs consist in part of a leaf spring one end of which is rigidly attached to the spool.

5. Apparatus for sealing a borehole wall with a time-setting material, the said apparatus comprising a tube attachable at one end to a drill pipe and having an outside diameter less than the diameter of the borehole and an inside diameter sufficient to permit the unrestricted passage of drilling fluids therethrough, a spool attachable to the other end of the tube and having an inside diameter sufficient to permit the unrestricted passage of drilling fluids therethrough, means for attaching the spool to the tube that are releasable by action at the well surface, means to effect such release, a plurality of ribs each fixedly attached at one end to the outside of said spool and extending along the spool and tube, the said ribs consisting at least in part of springs, a retaining means rigidly connected to the tube at the end opposite the spool for holding the unattached ends of the ribs in a flexed position close to the tube, and a webbing fastened on the said ribs and extending entirely around the tube of sufficient size to permit a relative horizontal expansion of the ribs and webbing, the detached spool and webbed ribs forming a basket sheath against the borehole wall.

6. The apparatus of claim 5 in which the spring portion of the ribs is attached to the spool piece and extends

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therefrom, forming a part of the rib, for a length a least equivalent to the net annular radius between the tube and the borehole wall.

7. Apparatus for sealing the borehole wall of a well with a time-setting material comprising a tube adapted at one end to be attached to the end of a drill pipe and having an outside diameter less than that of the borehole, a spool attached to the other end of the tube, a flexible webbing secured at its lower end to the spool, resilient means adapted to urge the upper end of the webbing towards the borehole wall, retaining means attached to the tube holding the upper end of the webbing along the tube, and means for detaching the spool from the lower end of the tube whereby a basket sheath consisting essentially of said spool piece and the attached webbing is detached from the tube.

8. Apparatus for sealing the borehole of a well to prevent flow of drilling fluids into a zone of lost circulation comprising a spool adapted to be attached to the lower end of tubing for lowering into the well, said spool having an opening extending therethrough to allow flow of fluids through the tubing, means that are releasable

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from the well head for attaching the spool to the tubing, a flexible diaphragm means secured at its lower end to the spool, resilient means connected to the diaphragm means adapted to urge the upper portion of the diaphragm means outwardly against the borehole wall, and retaining means engaging the upper end of the diaphragm means to hold it in a collapsed position out of engagement with the borehole wall, said diaphragm means adapted to move out of engagement with the retaining means upon release of the spool from the tubing.

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