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METHOD OF RECOVERING LOST CIRCULATION IN DRILLING WELLS

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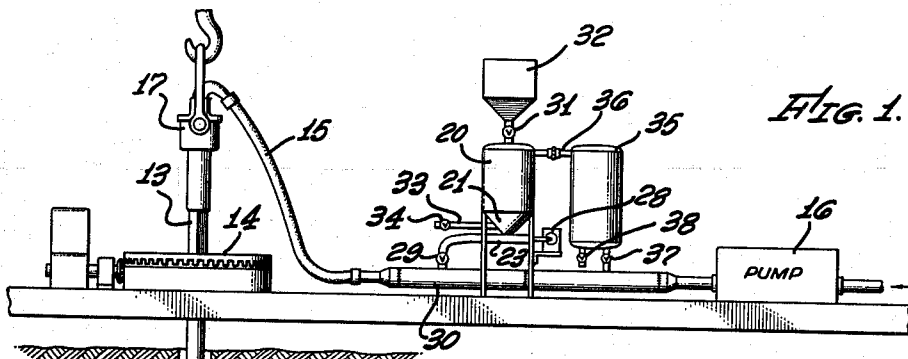


FIG. 1.

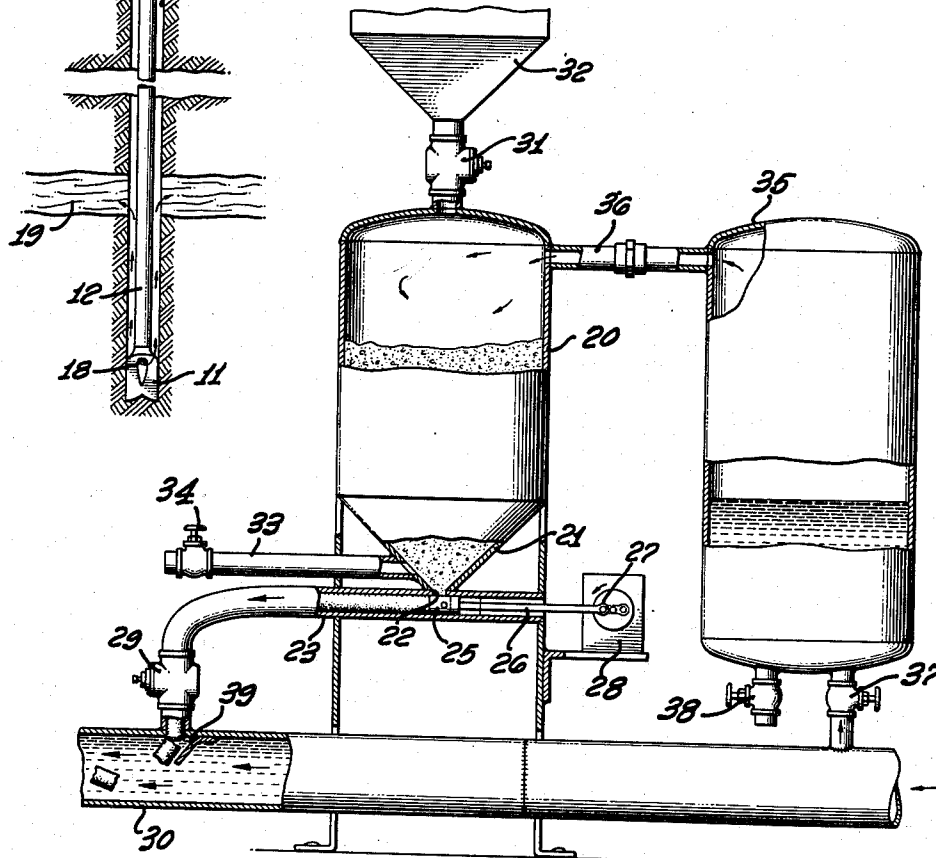


FIG. 2.

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METHOD OF RECOVERING LOST CIRCULATION IN DRILLING WELLS

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4 Claims. (Cl. 255-1.8)

1 This invention relates to a means and method of recovering lost circulation in the course of drilling wells.

In the course of drilling wells such as oil wells by the rotary well drilling apparatus, circulation fluid or mud is pumped down through the drill pipe and discharged at or near the bit at the bottom thereof. The circulation fluid then normally rises within the well bore around the drill pipe carrying with it the cuttings, and on issuing from the well bore at the surface the circulation fluid is conducted to a sump where the cuttings may settle out. This circulation fluid may then be returned to the mud pumps and forced thereby down through the drill pipe, completing a cycle of its flow.

In the course of drilling many wells in this manner porous formations, earth cracks and water sands are penetrated by the well bore so that it not infrequently occurs that the circulation fluid which is discharged at or near the bit, on rising in the well bore to the porous formations, cracks or water sands, escapes therethrough and consequently does not return to the surface and to the sump. When this occurs circulation is said to become "lost" and steps are then taken to endeavor to plug or seal the water sands, porous formations or earth cracks to prevent the escape of circulation fluid therethrough. Many types of plugging materials have heretofore been used for this purpose including bentonite, quick setting cements, plasters and like materials that are adapted to set up and harden on coming in contact with the circulation fluid. The bentonite performs its plugging action largely by its ability to swell in the presence of water. The practice heretofore has generally been to merely introduce such swellable or settable materials into the circulation fluid so that they will be carried thereby down through the drill pipe and be discharged into the well bore. These materials will also be carried to the porous formations, earth cracks or water sands where the circulation fluid is lost and sometimes coagulate and collect at these localities and harden so as to seal them off against continued escape of circulation fluid therethrough.

An important objection to this procedure resides in the fact that the materials used being designed to commence to set up or harden on coming in contact with the circulation fluid commence their setting up or hardening action immediately on being introduced into the fluid. However, in the case of deep wells especially, some considerable lapse of time must take place

2 for the introduced sealing material to be pumped down through the drill pipe, discharged at or near the bit, and rise to the locality where the seal is to be effected. This lapse of time frequently is so great that by the time the sealing material has reached the locality to be sealed off it has lost its efficiency, or its ability to set up and harden has been greatly reduced.

An object of the present invention is to provide a method and apparatus whereby finely divided sealing materials such as bentonite, quick setting cements, plasters and the like may be introduced into the circulation fluid in a compacted condition and preferably in the form of small lumps. In this manner the wetting or penetration of the interior of the lumps will be somewhat postponed or delayed affording an adequate opportunity to pump the lumps into the well and either approach or reach the locality to be sealed off before the interior of the lumps have become wetted thereby. Consequently, that material that is disposed on the interior of the lumps will be delivered to the locality to be sealed in a comparatively fresh condition and on being wetted eventually by the circulation fluid it may be capable of swelling or setting up and hardening to form an adequate seal. The material on the surfaces of the lumps may, of course, become devitalized or even rendered non-settable by reason of its prolonged contact with the circulation fluid while it is being pumped into place and, if so, such material may pass on with the circulation fluid that is being lost. However, the material within the lumps being delivered to the locality to be sealed in a vitalized condition will, on being wetted by the circulation fluid, be capable of setting up and forming a leak-proof seal.

Another object of the invention is to provide a method and apparatus for accomplishing the above results which can be used in the course of drilling so that it is not necessary, in recovering the lost circulation, to discontinue or postpone drilling operations.

With the foregoing and other objects in view, which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawings for an illustrative embodiment of the invention, wherein:

Figure 1 is a schematic view illustrating a well as being drilled by the rotary method of drilling and illustrating apparatus embodying the present invention as having been incorporated therein; and

Fig. 2 is a view in side elevation, parts being

broken away and shown in vertical section illustrating details of the apparatus employed.

Referring to the accompanying drawings wherein similar reference characters designate similar parts throughout, 10 indicates a well bore which is being drilled by means of a bit 11 mounted at the bottom of a string of rotary drill pipe 12. The drill pipe is illustrated as having a kelly 13 mounted at its upper end which extends through the rotational rotary table 14. 15 indicates the rotary hose that receives mud or circulation fluid from a mud pump 16 and conducts it to a swivel case 17 at the top of the kelly so as to be forced downwardly through the drill pipe 12 for discharge through circulation ports 18 in the bit 11. In the normal course of operation the discharged circulation fluid rises in the well bore 10 and is conducted therefrom to a sump from which the circulation fluid may be returned to the pump 16. However, in the situation illustrated the well bore 10 may be assumed to have penetrated a highly porous stratum, water sand, or to have traversed an earth crack indicated at 19 so that the circulation fluid instead of returning to the surface escapes through the stratum 19 and becomes lost.

In accordance with the present invention a suitable container 20 is provided which preferably has a conical bottom 21 in which there is a port 22. This port leads into a conduit 23 a portion of which provides a cylinder for a reciprocating piston 25. The piston 25 can be reciprocated in any suitable manner such as by a connecting rod 26 which is connected to the wrist pin of the piston 25 and to a crank 27 that can be rotated in any suitable manner such as by a motor 28. The conduit 23 leads through a valve 29 to a manifold 30 that conducts the circulation fluid from the pump 16 to the rotary hose 15. At the top of the container 20 there is disposed an inlet valve 31 above which there may be a hopper 32 and near the bottom of the container there is preferably provided a drain 33 equipped with a valve 34. Adjacent the container 20 there is a suitable reservoir or tank 35 that is connected to the container 20 such as indicated at 36. This tank has its lower end likewise connected to the manifold 30 by means of a valved conduit 37 and preferably has a valve controlled drain at 38.

In using the above described apparatus the following operations may be formed. Any material, such as bentonite, cement, plaster or Cal-Seal, adapted to set up or harden on coming in contact with the circulation fluid, may be employed and may be positioned in a finely divided condition in the hopper 32. On opening valve 31 this material is allowed to enter the container 20 after which the valve 31 is closed. Valve 37 may then be opened allowing circulation fluid to enter the tank 35 as indicated in Fig. 2. This compresses the air in the top of the tank to the pressure existing in the manifold 30 and the pressure is, of course, transmitted through 36 to the interior of the container 20. The motor 28 may then be started to reciprocate the piston 25 and the valve 29 opened. The piston 25 is so arranged that as it reciprocates it will expose or open the port 22 to permit successive increments of the material to descend from the container 20 into the conduit 23. On forward strokes of the piston these successive increments will be highly compressed by the piston against the pressure of the circulation fluid in the manifold 30 and in the conduit 23 and will be forced through the conduit into the manifold. The valve 29

which may be in the form of a rotary plug type valve should be of such a construction as to avoid restricting the passage of the compacted material through the conduit 23. As the material used in the hopper is in a very finely divided condition it acts somewhat in the nature of a fluid in flowing from the container through the port 22 but on being highly compressed by the piston it is in effect compacted so that as it issues from the conduit 23 into the manifold 30 it is somewhat in the nature of a solid. These solids as they are forced from the conduit 23 into the manifold 30 will, of course, break off from time to time by the flowing circulation fluid, but will to a large extent remain in their compacted condition or in the form of lumps. These lumps will be carried by the circulation fluid into the rotary hose 15, down through the drill pipe 12 and be discharged through the ports 18 and eventually rise to the location 19 that is to be sealed. The compacted or lumpy condition of the sealing material prevents immediate wetting of the interior of the lumps by the circulation fluid and although the external surfaces of the lumps may be immediately wetted within the manifold 30, the interiors of the lumps will be kept comparatively dry while the lumps are being pumped to the location 19. Consequently that portion of the material that is within the lumps will reach or approach the location 19 in a comparatively fresh or vitalized condition and as soon as the circulation fluid penetrates the lumps to wet the interiors thereof this fresh sealing material will then be wetted and will be in a condition to set up and form a hard seal.

Most materials used for this purpose are designed to set up or harden on merely contacting with the water constituent of the circulation fluid. It will, of course, be appreciated, however, that materials designed to set up or harden in coming in contact with an acid or alkali can be employed and the necessary acid or alkali can be introduced into the circulation fluid.

The pressure tank 35 is merely used as a means for equalizing the pressure in the top of container 20 with the pressure that may exist in the conduit 23 so that the sealing material in the tank may readily flow by successive increments from the tank into the conduit 23 whenever the port 22 is opened by the piston 25.

When sufficient sealing material to effect a seal is pumped into the well, any remaining sealing material in the tank 20 can be drained therefrom through the drain 33 on opening valve 34. Likewise if any liquid in the pressure tank 35 should be inadvertently or accidentally driven over through 36 into container 20, this can be withdrawn through the drain 33 so that the sealing material will not set up within the container 20. As the sealing material is fed out of container 20 into conduit 23, the level of liquid in the pressure tank 35 will, of course, rise. This may be lowered or the pressure tank may be emptied at the conclusion of the operation by closing valve 37 and opening the drain valve 38. It will be appreciated, of course, that in using the improved apparatus and method of recovering lost circulation in the well it is unnecessary to interrupt or discontinue drilling operations and if the manifold 30 is initially equipped with the valves 29 and 37 the apparatus may be connected thereto and disconnected therefrom while drilling operations are continuing.

It is, of course, desirable to have the lumps of sufficiently small size so that they may readily

pass through the circulation ports in the bit. To this end it is desirable to have the lumps in the neighborhood of $\frac{3}{8}$ " in diameter by $\frac{1}{2}$ " to 1" in length so that by using a bit having large circulation holes these lumps may readily pass therethrough. To this end it may be desirable to install in the manifold 30 a deflector 39 which will cause the lumps of the extruded sealing material to break off before they have exceeded a predetermined maximum length.

From the above described method and apparatus it will be appreciated that this invention enables finely divided sealing material that is adapted to set up or harden on coming in contact with the circulation fluid to be delivered at or near the location to be sealed off in a relatively fresh or vitalized condition and that its effectiveness to form a hard seal is not lost or reduced as in the practices heretofore employed wherein the finely divided sealing material was delivered in a finely divided condition into the path of the circulation fluid at the surface and consequently immediately began to set up.

Various changes may be made in the details of construction without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. The method of recovering lost circulation in drilling wells in which there is a drilling string and a bit attached thereto which comprises pressure compacting into lumps of as large a size as may be reasonably expected to pass through the circulation ports in the bit a finely divided material which will commence setting up on contacting the circulation fluid and feeding the lumps into the circulation fluid forced into the well whereby due to the compacted nature of the material penetration of the circulation fluid to the interiors of the lumps will be delayed until the material approaches or has reached the location it is desired to seal in order to recover circulation.

2. The method of recovering lost circulation in drilling wells in which there is a drilling string and a bit attached thereto which comprises feeding into circulation fluid as it is forced into the well pressure compacted lumps of such a size as may be reasonably expected to pass through the circulation ports of the bit of finely divided material which will commence setting up on contacting the circulation fluid whereby due to the com-

packed nature of the lumps setting up of the material on the interiors of the lumps will be delayed until the material approaches or has reached the location it is desired to seal in order to recover circulation.

3. The method of recovering lost circulation in drilling wells in which there is a drilling string and a bit attached thereto which comprises feeding into circulation fluid as it is forced into the well pressure-compacted lumps as large as may be reasonably expected to pass through the circulation ports of the bit of finely divided sealing material which will commence setting up on contacting this circulation fluid whereby due to the compacted nature of the lumps setting up of the material on the interiors of the lumps will be delayed until the material approaches or has reached the location it is desired to seal.

4. The method of recovering lost circulation in drilling wells in which there is a drilling string and a bit attached thereto which comprises compressing against the pressure of circulation fluid forced into the well a finely divided material which commences setting on contacting the circulation fluid, and forcing the compressed material into the stream of circulation fluid so that it will be supplied thereto in lumpy masses of as large a size as may be reasonably expected to pass through the circulation ports of the bit whereby the material may be carried toward or to the location to be sealed before the interiors of the masses have been completely wetted by the circulation fluid and consequently setting of the entire material will be delayed until the locality to be sealed is at least approached.

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