METHOD OF WELL DEVELOPMENT


Application November 27, 1934, Serial No. 755,046

4 Claims. (Cl. 166—21)

This invention relates to a method in developing a well, and more particularly a water well of the gravel type.

In developing wells of this type, the boring tool, in initially forming the well bore, operates in so-called slush or water with a relatively high percentage of mud in suspension, and, during the boring operation, the muddy water or slush is plastered against the wall of the well bore by the action of the boring tool and serves as an effective medium for preventing collapse of the sand stratas of the well through which the water finds its way into the well. This mud wall must obviously be removed and it has been heretofore proposed, particularly in applications filed by us, Serial Nos. 726,818 and 791,712, to remove the mud wall by hydraulic action, the present application being in effect a continuation in part of said applications and particularly application Serial No. 726,818.

Furthermore, in wells of this type, in order to increase the volume flow of water through the sand strata to the well bore, the sand area or areas must be cut away to materially increase the diameter of the well bore in such area or areas for the purposes mentioned. This cutting away or under-leaming of the well has been previously accomplished by mechanical under-reamers which dig out the sand to the diameter desired and in the use of such mechanical under-reamers, they have been operated in the presence of the slush or muddy water with a view to causing the under-reamers to plaster over the wall formed by the under-leaming action a layer of mud which will serve as the binding medium, in combination with the hydraulic pressure or hydraulic head, prevent collapse of the sand following completion of the under-leaming action.

The hydraulic head, of course, is the difference between the static head, that is the determined level of the water in the well incident to the flow through the sands into the well, and the level of the slush or wash mud head plus the differential in specific gravity between the slush and the clear water flowing through the sands into the well. That is to say, if the water were permitted to flow through the sands into the well, it would reach a certain level in the well which may be termed a static head. This is, of course, below the top of the well and as the slush or wash mud head extends at least to the top of the well, there is a difference in pressure acting against the mud layer on the sand wall due to this difference in level and this difference in level pressure is augmented by the difference in specific gravity between the clear water through the sand and the wash mud or slush. In any event, this mud wall is plastered onto the sand and is held in place both by its own character and by the pressure against it to prevent the collapse of the sand.

Following the mechanical under-leaming of this type, the gravel is introduced either before or after the insertion of the well tube and as the gravel affords a more or less effective medium against the collapse of the sand, the pumping action of the well is intended to break down and remove this mud wall under the out-flowing water in clearing the well. As a matter of fact, however, it has been found that this mud wall will tend to fill up the interstices between the gravel and thus interfere with the maximum flow of water and further tend, for a very considerable period, to be present in the water drawn from the well.

In our application, Serial No. 726,818, provision is made for hydraulically under-leaming the well, wherein the diameter of the well throughout the sand area may be increased to any desired extent within reasonable limits by the use of flexible arms through which water is directed under pressure, which flexible arms tend to assume a definite relation and are permitted to assume this relation as the sand is washed away. The hydraulic action dislodges a very considerable portion of the sand and provision is made in the application referred to for removing this sand from the well.

In this application, and generally in wells of this type as heretofore developed, it has been considered necessary to supply gravel to the well immediately at the completion of the under-leaming action and, in effect, before the under-leaming action is completed, so that when the limit of under-leaming action incident to hydraulic flow is reached, the gravel will immediately take the place of the displaced sand and prevent further collapse of the sand. In this type of well there is practically an uninterrupted flow of water through the sand area under pumping action, at least the flow is not impeded by a mud wall to be removed nor is the filtering action of the gravel interfered with by the presence of mud particles in the interstices between the gravel.

Therefore, this hydraulic under-leaming is not only effective in permitting a materially increased under-leaming as compared with mechanical means, but it overcomes the disadvantage of the presence of mud which must be dislodged by pumping and which experience has proven cannot be completely dislodged. The disadvantage,
if it can be so called, of this under-reaming development of the well is primarily incident to the fact that it has been presumed that, as stated in the application referred to, the gravel must be placed during the under-reaming action to take the place of the excavated sand and prevent further collapse of the sand when the under-reaming action cesses.

The present method is more particularly concerned with the under-reaming stem and is directed to providing against the collapse of the sand in the under-reamed area wholly regardless of the introduction of the gravel. This permits the removal of the under-reaming tool from the well and the introduction of gravel bodily into the well to fill out the under-reamed area and provide the necessary protection against collapse of the sand and the filtering action during the pumping operation on the well.

In carrying out the method, the slush or muddy water is used in the hydraulic under-reaming operation. Of course, while the jets from the under-reaming flexible area are effective for dislodging the sand, the mud in suspension in the water, which by the jets is directed against the sand surface, is continuously washed away and floated to the surface of the well. When the hydraulic under-reaming action has reached its limit of effectiveness, namely a point at which the force of the jets will no longer dislodge the sand, there is an accumulation of slush or muddy water over the sand wall resulting from the excavation. This slush or muddy water is not under any effective pressure from the jets because their effective limits have been reached, and, therefore, the mud or slush of the water used in the hydraulic action is not plastered or forced by the jets against the sand wall.

However, incident to the difference in pressures above referred to, it has been found that a very light layer of the mud or slush in the water will, by reason of these pressures, be caused to adhere to the sand wall. That is to say, the pressure will serve to direct mud or slush particles from the muddy water against the sand wall and while this accumulation is very slight as compared with the usual mud wall, it is nevertheless sufficient to act as a binder between the particles of sand or small gravel or the like which form this sand wall, and as the result of this binder, coupled with the pressure above referred to which acts against the collapse of the sand wall, it has been proven that the sand wall will be held against collapse. In other words, after the limit of the hydraulic action has been reached, the effective pressure acting against the sand wall will cause the mud particles in the hydraulic fluid to be applied to that sand wall in just sufficient quantity to act as a binder and, with the addition of the pressure referred to, prevent collapse of the sand.

The hydraulic tool may then be removed and the sand wall will, by the binding action of the mud or slush plus the favoring pressure, be held against collapse. It is necessary to stop the hydraulic action. The gravel may then be introduced into an otherwise clear well or the well tube may be introduced with the conventional screens and the gravel later introduced to surround the well tube. Of course, if the gravel is first introduced, the well tube must be bailed down through the gravel, which is a well understood operation.

As the length of the flexible jets of the underreaming tool determines the extent of underreaming, it is, of course, possible to under-ream to any desired extent, within reasonable limits, by regulating the length of the jet tubes, and as the sand wall, after the under-reaming action is completed, will be held in the manner described against collapse, the under-reaming tool may be removed and well later supplied with gravel. This is essentially a very much easier, less expensive and more readily effected operation than in the methods previously described.

After the well has been completed under the method described, a pumping action will settle initially separate the fluid particles of mud or slush with the incoming water, and will, by reason of the comparatively slight quantity of such mud or slush particles, readily carry such particles, mostly in solution, through the gravel and into the well screen very early in the clearing operation of the well. Thus, following the pumping operation to initially clear the well, substantially all of the mud particles which have been used as a binder against the sand wall have been removed, and even if any of these particles should tend to lodge in the interstices between the gravel, they are in such relatively small quantity as to have very little effect, if any, upon the maximum water flow.

Thus, under the present method, the sand wall is held against collapse during the removal of the hydraulic under-reamer and for as long a period thereafter as may be desired, because the binding action of the slush or mud particles on the sand wall, plus the pressure against the sand wall incident to the difference between the static head and wash mud pressure differential specific gravities, will maintain the sand wall against collapse, permitting the introduction of the gravel and the well screen at a later period in a well free of any obstruction and with a substantial and decidedly economical advantage.

Of course, if the well is of the two-gravel type, a separating tube may be introduced into the well and the gravels of different characters applied on the outside and inside of the tube, with the well tube and screen either within the gravel separating tube before the application of the gravel or bailed down through the gravel in the gravel straining tube, all of which are conventional in well practice and need no specific description herein.

The salient feature of the present method is the utilization of the slush or muddy water ordinarily employed in the well either with its maximum mud or slush content as ordinarily employed in boring or with a lesser predetermined mud or slush content as may be found advisable as the hydraulic medium and the utilization of such mud or slush particles to be forced against the sand wall after the completion of the hydraulic action by the favoring pressures previously referred to, with the effect to provide sufficient of the mud particles to act merely as a binder between the grains of sand in the mud wall, which binder plus the pressure referred to will prevent collapse of the sand wall. The subsequent introduction of the gravel, the manner of that introduction, and the completion of the well, either by a two-type gravel or by the introduction of the well tube and screen, are not particularly important in connection with the present method.

In order to more particularly disclose the method, reference is had to the accompanying drawing, in which:

Figure 1 is a sectional view of a well with the hydraulic under-reamer in position of initial use.
Figure 2 is a broken section, showing the position of the under-reamer at the end of the hydraulic under-reaming action.

Figure 3 is a view similar to Figures 1 and 2, with the hydraulic under-reamer withdrawn and the black dots indicating the accumulation of mud or slush against the sand wall for the binding action.

Figure 4 is a view illustrating the hydraulic under-reaming and the application of gravel to serve as a filtering media and prevent the collapse of the sand wall.

In the drawing, the well bore is, as the result of the boring action, covered by a mud wall, indicated at 2. The under-reamer comprises a head 3 of any desired or conventional design and flexible jet tubes 4 through which the water delivered into the head from the top of the well is jetted from the ends of the tubes. The tubes are flexible, first to permit the convenient introduction of the head and tubes into the well, but more particularly to secure an automatic under-reaming action as the tubes are of a character that, while resilient, have nevertheless an inherent tendency to straighten out, so that under this inherent tendency due to the pressure of the water flowing through them, there is a considerable and appreciable force tending to straighten out the tubes. As soon as the water jetted from the tubes dislodges the sand area and thereby removes obstructions from the ends of the tubes which have held the tubes in bent relation, the tubes will tend to straighten and thus direct the jetted stream more and more directly against the sand wall. This dislodges the sand wall and provides the under-reaming effect.

Of course, the under-reaming effect, that is the relative diameter of the under-reamed portion with that of the well bore, can readily be determined within reasonable limits by the length of the tubes and by the force of the water delivered through them, for the longer the tubes and the greater the pressure of the hydraulic medium, the greater the effect of the jets against the sand wall and naturally the greater the quantity of sand dislodged by the jets. Eventually, however, the pressure of the dislodging action of the fluid forced through the tubes will cease and the under-reaming limit has thus been reached.

With the use of the slush or muddy water as the hydraulic medium, there will be a body of this medium overlying the sand wall of the under-reamed area after the effective hydraulic action of the jets has ceased. Incident to the difference in pressures hereinbefore referred to, this volume of muddy water is held against the sand wall and, as the result of this pressure, particles of mud, slush and the like in the water will be moved into contact with the sand wall, with the result that particles of such mud and slush will serve as a binder against the grains of sand and the like of the sand wall, which binder, together with the favoring pressure referred to, will prevent collapse of the sand wall.

Of course, the sand dislodged during the hydraulic action of the black dots in Figure 3, supplemented by the difference in pressure referred to, is held against collapse, the subsequent necessary operations in completing the well may be carried out at a later period and with greater convenience.

Herefore it has been found desirable, if not absolutely necessary, to introduce the filtering gravel into the well during the under-reaming action to utilize the gravel as the medium for preventing collapse of the sand wall. In the present method, however, the collapse of the sand wall prevented as described is wholly independent of any gravel accumulation and the under-reaming tool may be rapidly removed from the well and after the well is cleared, the gravel may be introduced by any one of several accepted methods and the well otherwise completed in the usual manner. This gravel, of course, will naturally fill the under-reamed portion of the well and will thereafter serve as the medium for preventing collapse of the sand wall.

After completion of the well, the initial pumping action, creating now a pressure in opposition to the pressure utilized to hold the sand wall against collapse, will draw the water through the sand wall and into the well. This water naturally displaces the binding particles, either carrying them bodily through the gravel or dislodging them, so that these particles of what may be termed binder material are carried through the gravel, through the screen and out through the well, leaving the clear sand and gravel throughout the under-reamed area.

It is to be emphasized that in no instance is the binder action of the mud or slush particles in the hydraulic medium obtained as a result of the hydraulic action. There is no mud, slush or the like plastered against the sand wall by the hydraulic jets. These jets will wash away and absolutely prevent the plastering of any mud or slush against the sand wall and, of course, when the limit of the hydraulic action of the jets is reached, they can have no plastering effect upon the mud or slush in the water.

Therefore, it is only incident to the favoring pressure referred to that the binder particles of the slush or mud are brought into contact with and lodged against the sand wall. These particles do not become a layer, they are not forced into the sand wall as would be a plastered layer, but they are merely a surface layer or a plastered volume or even an extremely thin layer held against the sand wall by the means referred to.

This is essentially important because it must be easy for the water flowing through the sand and into the well under the pumping operation to dislodge these binder particles or layer and carry them off through the well tube almost at once. This could not be accomplished if the mud or slush were plastered in a layer against the mud wall as would be the case in mechanical under-reaming, because where the mud or slush is plastered against the sand wall, it has been found effective to prevent collapse of the wall but is of such a character and is driven to such depth into the sand that it cannot effectively be removed by any pumping operation which the well will stand.

Experience has proven that a plastered mud wall may be broken down in a short and may eventually, after a long period of time, be substantially dislodged under the pumping operation, but during all this time the water delivered from the well suffers from the mud content due to the gradually dislodging of the mud wall, and, furthermore, incident to the character and volume of this mud wall, the interstices of the gravel during the pumping action are so restricted...
or filled that the otherwise possible output volume of the well is very materially reduced.

In other words, where a plastered mud wall is used as the retaining medium, the well is practically useless, the water being contaminated for a very long period and for recurring periods and the volume of incoming water very materially reduced, while with the method described the fine binder particles or extremely thin layer which is not plastered in position but merely held by the favoring pressures, is dislodged almost at once or shortly after the initial pumping operation and cannot thereafter contaminate the water delivered nor can it interfere to any appreciable extent in the maximum possible out-flow from the well.

It may be found desirable in some instances, and the present method contemplates such a step, that the water used in the hydraulic action is substantially clear or at best of very slight mud or slush content, because the object is to obtain the minimum amount of binder mud or slush which will, with the favoring pressure referred to, prevent collapse of the sand wall, and in some areas and under some conditions a very slight accumulation of mud or slush in the hydraulic medium will be found effective.

It is, of course, to be understood that as described in the application of Serial No. 726,818, the gravel may be introduced into the well simultaneously with the hydraulic action or immediately succeeding such action in order to serve as a filtering media for the water during the operation of the well, the gravel, indicated at 16, being introduced at the particular time for the purposes of preventing collapse of the sand in the hydraulically reamed area of the well. While the gravel may be introduced in numerous ways, it is preferred that it be introduced through the medium of a pipe 6.

If desired and as preferred, the pipe 7 by which the hydraulic medium is delivered to the head 3 may be surrounded by a pipe 8 which has a diameter exceeding that of the pipe 7 and provides between it and the pipe 7 a passage 9 opening at the lower end at a point above the hydraulic head and connected at the upper end to a source of suction, indicated at 10, through which passage materials dislodged by the jets in the underreaming action may be forcibly withdrawn. This insures that even dislodged particles, which would ordinarily not be subjected to delivery to the top of the well by the flotation method, can be satisfactorily withdrawn.

The term "muddy water" as used herein and in the claims is intended to mean any water having sufficient sediment to carry out the function previously described. It is, of course, apparent that incident to varying conditions in the water-bearing area, the muddy consistency of the water used, that is the proportion of sediment in such water, will necessarily vary in accordance with such conditions. Thus, under some circumstances, the muddy water may be light in sediment and, under other circumstances, the sediment character of the water may vary up to a maximum sediment condition. As the conditions of the water-bearing area can be readily determined, the character of the muddy water can be varied in accordance with such conditions. Hence the term "muddy water" used herein and in the claims is intended to indicate a water having that proportion of sediment which will carry out the functions of this application with due regard to the conditions of the water-bearing area.

What is claimed to be new is:

1. A method of well development consisting in hydraulically reaming the unconsolidated water-bearing area of the well with muddy water as the hydraulic medium, the effective pressure of the column of muddy water in the well being utilized to direct and maintain particles of mud and the like from such muddy water in the interstices and between the sand particles of the reamed wall to thereby substantially seal the reamed wall against substantial passage of water therethrough from the well, the effective hydrostatic head in the well being utilized to prevent collapse of the reamed wall following cessation of the hydraulic action.

2. A method of developing a water well consisting in subjecting the unconsolidated water-bearing area to reaming by hydraulic action, with the use of muddy water as the hydraulic medium, the effective pressure of the hydraulic medium in the well against the reamed wall being utilized to bind the particles of such wall together and substantially seal the interstices between the particles of such wall by the mud particles in the hydraulic medium to cause the effective hydrostatic head in the well to maintain such wall against collapse following cessation of the hydraulic action.

3. A method of developing a water well consisting in reaming the unconsolidated water-bearing area by hydraulic action, with utilization of muddy water as the hydraulic medium, the particles of mud in the hydraulic medium being forced under the hydraulic action into the interstices of the unconsolidated area to substantially seal such area against the passage of water from the well through the reamed wall, the effective hydrostatic head in the well being maintained following cessation of the hydraulic action, where by the pressure of the water in the well against the substantially sealed reamed wall will effectively maintain said wall against collapse notwithstanding cessation of the hydraulic mining pressure.

4. A method of well development consisting in boring a well, hydraulically reaming the unconsolidated water-bearing area through the use of muddy water, the hydraulic pressure during reaming being utilized to direct against the wall sufficient particles from the muddy water of the hydraulic medium to act as a binder for the particles and a seal between the particles in the surface of the reamed wall, an effective overbalancing pressure in the well in opposition to the static head of water flowing from the sand area into the well being maintained to cause a sufficient pressure against the reamed wall to hold said wall against collapse following cessation of the hydraulic action.

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