METHOD OF FORMING PASSAGEWAYS EXTENDING FROM WELL HOLES

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18 Claims. (Cl. 166—22)

This invention relates to methods of increasing the flow of fluids to wells and more specifically to methods of forming fluid passageways in the stratum surrounding well bores by the use of mobile means, which means also prevents the passageways, thus formed, from closing. It has been proposed to inject abrasive particles of polygonal shape into wells for the purpose of scouring away portions of the walls of passageways and thus to permit the larger particles to remain in the enlarged passageways for the support of the walls thereof. However, a major object of my invention is to provide a method whereby pellets, having curved surfaces and no appreciable abrading characteristics but, instead, having anti-frictional characteristics, are injected, together with a suitable liquid under pressure, into the initially formed passageways and enlarge or extend the passageways by creating continuations or extensions thereof, by pressure splitting rather than by abrading, whereupon the pellets are permitted to remain in the altered passageways to prevent the latter from closing. Since the pellet surfaces are curved and there is no accumulation of abraded debris, the pellets will not form a tightly-packed mass with the debris but, instead, will permit a large number of interconnected passageways for the flow of the oil or other fluid into the bore.

Neither are the pellets employed in my method in any sense missiles adapted to be discharged forcibly against the stratum in attempting to shatter it. Instead it is not proposed to propel the pellets with any stratum-shattering velocity in fact, it would be substantially impossible to do so, since there are employed no high-capacity pumps to provide a jetting action of the mobile bodies forming the composition of matter I employ. In addition, it is not essential in applying the novel method to use pellets be of solid metal, hard enough to form a projectile, nor hollow metal strong enough to form an exploding projectile.

Another important object is to provide a method whereby particularly mobile pellets are employed, which are, preferably, spherical, and the specific gravity of which permits them to float in the liquid even though they may include pellets of large diameters, whereby they will be substantially evenly dispersed throughout the fluid and in positions to function as hereinafter set out in detail.

Still another important object is to provide a method employing such non-abrasive pellets, dispersed (floating) in a suitable vehicle, which vehicle also supports a plurality of sealing elements, dispersed therein, which are adapted to seal the pores, the openings, in the stratum as well as seal or block, in connection with the pellets, the mouths of the passageways, formed as continuations of the initial passageways, to prevent the dissipation of pressures and pressure liquid. However, upon subsequent widening of these mouths, the pellets are able to pass thru the mouths and the seals or blocks are broken to permit the flow of fluid in and out of the mouths, while the pellets remain in the passageways and prevent the reopening thereof.

A further important object is to provide a method as described which, in one aspect thereof, includes a step of dissolving the sealing elements subsequent to the breaking of the seals or blocks.

In another aspect of the invention, the sealing elements are caused, after breaking of the seals or blocks, to migrate to the outer extremities of the enlarged passageways, where the sealing elements have no appreciable adverse effects upon the fluid flow into the well bore.

Other objects and advantages of the invention will be apparent during the course of the following detailed description of the invention, taken in connection with the accompanying drawing, forming a portion of this disclosure, and in which drawings:

Figure 1 is a vertical section of a suitable packer which may be employed to carry out the method, and disposed within a well bore provided with a pair of initial passageways.

Figure 2 is a fragmentary horizontal section of one of the initial passageways prior to its enlargement but illustrating conditions at the time of the injection of a volume of a vehicle-pellets-sealing elements-containing-composition of matter into the initial passageway. This composition may or may not contain a slowly-acting solvent for the sealing elements.

Figure 3 is a section somewhat like that of Figure 2, but illustrating a subsequent step in which pressure has been applied to the composition of matter but the passageway has not yet widened.

Figure 4 is also a section somewhat like those of Figures 2 and 3 showing the conditions of the initial passageway and formation of a narrow extension thereof and the mouth of the latter blocked or sealed.

Figure 5 is a like section but illustrating a widening of the mouth, and the migration of the pellets and additional sealing elements into the extension.

Figure 6 is a section somewhat like Figure 5 but showing conditions after the sealing elements have been dissolved.

Figure 7 is a section somewhat like Figure 6 but showing conditions when the sealing elements are not dissolved.

Figure 8 is a graph illustrating certain conditions taking place within the passageways during practice of the methods.

In the drawings, wherein similar reference characters designate corresponding parts throughout the several views, the packer which may be used to carry out the methods is designated as A, a source B of pressure fluid; C a composition of matter employed in one form of the novel method, including a vehicle D, pellets E and sealing elements F; G a composition of matter employed in another form of the novel method and including a vehicle D, pellets E and sealing elements F; H a conduit system between B, K and A; in which may be interposed a pump or impeller M; N a well bore from which extend lateral passageways O into which are introduced by continuations or additional passageways P.

The initial passageways O may be provided by the means illustrated and described in my co-pending application Serial Number 47,364, filed September 2, 1948, for Machines for Increasing the Subterranean Flow of Fluid Into and From Wells, where vertical passageways are illustrated in Figs. 13 and 15, considerably longer vertically than wide horizontally, as may be appreciated by comparing Fig. 14 with Fig. 13 of said application Serial No. 47,364, wherein a packer, having the general characteristics of the apparatus A, may be run into the well bore N and in a position substantially like that shown in Figure 1. This device A preferably includes a body portion 15 having a longitudinal passageway 16 and a lateral passageway 17 opening into the passageway 16 and exteriorly of the body portion 15. The body portion 15 carries a plurality of spaced-apart packing means, as the cups 18, a coupling 19 carried by the body portion 15 to connect the passageway 16 with the source B of pressure fluid and source C of additional fluid, and means to substantially equalize the pressures in both sides of the packing device A. This last means may comprise a conduit 20 opening at its lower end 21 below the body portion 15, extending upwardly thru the body portion and opening exteriorly of the body portion above the uppermost packing means.

The composition of matter C consists of a vehicle (which also functions as a preliminary sealing means) D, pellets E, sealing elements F and a solvent for the sealing elements but not for the pellets. This solvent may be mixed with the vehicle D when the vehicle D is introduced
3. into the passageways O or subsequent to the introduction of the vehicle D.

The vehicle D is, preferably, a drilling fluid having a filter factor of 2.0 c.c. by the American Petroleum Institute Standard Test for Filter Ratio of Drilling Fluid.

The vehicle may be, for example, one, or combinations of, the drilling fluids described in U. S. Patents 2,356,776, dated August 29, 1944, 2,316,967 dated April 20, 1941, and 2,316,968 dated April 20, 1944, all granted to George Miller. Or it may be the oil-base drilling fluid described by E. W. Simon, "Control Development and Technology," American Institute of Mining and Metallurgical Engineers, 1941, under "Characteristics and Application of Oil Base Mud," pages 78-79. Or the vehicle may be an emulsion drilling fluid as described in U. S. Patent 2,430,039 granted to Francis M. Anderson on November 11, 1947.

The vehicle may be weighed to a desired specific gravity by addition of a commonly-used weighting material, such as ground barytes.

The pellets E are bodies having substantially no scouring nor abrasive surfaces. Preferably, they are bodies having curved surfaces, such as spheres, ovals and ellipsoids. Their diameters may vary. A preferred size of pellet has a diameter or greatest diameter of substantial buoyancy in the fluid D, common well fluids, and the solvents to be hereinafter named. The pellets may be, for example, of glass, plastic or well-rounded pebbles, having no appreciable abrasive surface, and any which will permit them to float in the vehicle D and be substantially evenly dispersed therein.

The sealing elements F may be strips, sheets, flakes, shavings, strands, fibres or somewhat analogous forms which have been employed as additions to drilling muds, and my sealing elements are, preferably somewhat pliable, and may be, for example, of (1) polyvinyl chloride; (2) polyvinyl acetate; (3) cellulose acetate; (4) methyl methacrylate; (5) nitrate or (6) polystyrene. Their essential characteristics are that they are relatively slowly soluble in suitable solvents, but not quickly soluble in the vehicle D nor in common well fluids.

The selection of the solvent or solvents G depends, of course, on the composition of the sealing elements or elements F employed. Preferably, the solvent is an aromatic hydrocarbon, suitable esters or ketones. For example, for sealing elements of 1, 2 or 5 above, I may employ benzene, xylene, xylene: toluene: xylene, methyl isobutyl ketone, toluene: acetone, methyl ethyl ketone, nitrobenzene, or methyl acetate, for 3 above I may use acetic, diacetone alcohol, ethyl acetate, or n-butyl acetate; for 4 above I may use acetic, diacetone alcohol, ethyl acetate or methyl acetate, and for 1, 2 or 4 above I may employ ethyl acetate, diacetone alcohol, xylene, n-butyl acetate or n-amyl acetate. Obviously, if desired, I may employ sealing elements of two or more of the above, for example, having common solvent.

In the event I employ the modified composition G, which contains a vehicle D, pellets E and sealing elements F, but no appreciable volume of solvent, I may substitute a wider range of materials for the sealing elements since the characteristics of the sealing elements H do not require any solvability. In fact, the common fluids found within wells and in drilling are generally such that they do not act chemically toward them. Such sealing elements H therefore may be of the same compositions as the sealing elements F and, in addition, may be, for example, of mica, regenerated cellusole or cotton seed hulls.

In carrying out the steps of one form of the invention, i.e., cylindrical pellets E, sealing elements F and solvent for the sealing elements F are combined as in the reservoir K and form the composition of matter C, which flows thru a position where the packer A is discharged into the initial passageways O with the elements of the composition of matter C being dispersed somewhat after the flowing in Figure 2, whereupon the composition of matter C enters the passage way and continues on to the portion of the passageway B where the pressure is reduced, and the pressure fluid B is, for example, a suitable vehicle. A sufficient pressure, the step of introducing the pressure fluid B may be omitted.

If the introduced composition C, under sufficient pressure, will be affected as follows: colloids of the vehicle will migrate to the surfaces of the initial passageways and close most of the smaller pores therein while some of the sealing elements F will also tend to migrate to these surfaces in some of the remaining pores, thus decreasing pressure loss. Conditions, at this point, are substantially as shown in Figure 3. Building up of pressure will force the opposite walls or one of them of the initial passageway O apart (or one away from the other). The intusk of the vehicle D (and some of the sealing elements F) into the continuation P will cause the pellets E to the mouth of the continuation P but, because the mouth is then narrower than the diameters of the pellets E, the latter cannot enter the continuation but pile up at the mouth, forming a bridge, for example as shown in Figure 4. However, the vehicle may still flow thru the passageways between the pellets (their curved surfaces, in contact, supporting their weight and not surface contact) and this tends to draw the sealing elements F to the bridge, where they are caught by the pellets of the bridge and quickly form a seal across the mouth of the continuation P. As a result dissipation of pressure and the vehicle into the stratus surrounding the continuation P is stopped and the pressure utilized, instead, in widening the passageway O (i.e., in the same fashion pressure is augmented by further building up the pressure by again employing more pressure fluid.)

Finally, the mouth of the continuation P is widened, by continued pressure upon the walls of the initial passageway O, to permit the pellets forming the bridge to enter the continuation and lodge thereon and this breakage of the bridge will rupture the seal formed by the sealing elements. Pressure upon the vehicle may now be released. Obviously, by introducing into the vehicle, in the passageway O, a number of pellets of a larger diameter than those initially introduced, permitting them to disperse throughout (A) and building up pressure to cause some of them to migrate to the mouth of the continuation P, the bridge and seal may be formed again, a still wider and longer continuation provided, and the bridge and seal broken as before, simplifying the above-mentioned purposes. Some of the larger pellets will, of course, enter the enlarged continuation and lodge therein in part supporting its walls and the smaller (or initially introduced) pellets will migrate further along the continuation and lodge therein, also supporting the walls thereof.

The solvent will, in time, dissolve the sealing elements.

The sub-modification of the method just disclosed contemplates the introduction of the solvent subsequent to the introduction of a vehicle-pellets-sealing elements mixture. That is, the solvent may be applied in a subsequent step or even after the last step described. This sub-modification permits the use of a rapidly-acting solvent.

A further modification contemplates the use of a vehicle-pellets-sealing elements mixture or composition following the steps as described but omitting entirely a solvent for the sealing elements. This is the composition G wherein, too, the sealing elements may be classes of materials mentioned, including regenerated cellusole and cotton seed hulls, and other suitable materials substantially insoluble in conventional solvents which could be employed. Practicing this composition is desirable, in some instances, because solvents for plastics, particularly such solvents as aromatic hydrocarbons, may also exert a solvent action on some of the aspheric materials in the oil base mud, tending to impair the pore-sealing properties mentioned.

In the modified method, a portion of the sealing elements are drawn by pressure to the outer extremity of the passageway continuation (where their presence has no appreciable undesirable effects) and the others removed with the vehicle and loose pellets, as by bailing.

It will be noted that by practicing any of the several methods described, there is substantially no change in the integral mass of the stratus surrounding the bore during the steps of the method, in that there is substantially no deposit built up along the bore to form the passageway continuation. In addition, it will be noted that the pellets not only provide a partial means to close the mouth of the continuation but, without subsequent mechanical manipulation of the pellets, they are caused
to provide an additional function when migrated to the continuation.

The practicing of the methods herein disclosed result in the increase of production of a fluid therefrom which includes the steps of drilling a borehole into the formation, under-cutting a selected portion of the borehole in the formation to weaken the same and to increase the area subjected to lifting forces when hydraulic pressure is applied and then pumping a liquid into the borehole and into the formation a liquid having substantially constant viscosity, applying hydrostatic pressure to the liquid and on the selected portion of the formation sufficient to fracture the formation.

A method of treating an earth formation for the purpose of increasing the production of a fluid therefrom which includes the steps of drilling a borehole into the formation, under-cutting a selected portion of the borehole in the formation to weaken the same and to increase the area subjected to lifting forces when hydraulic pressure is applied and then pumping a liquid into the borehole and into the formation a liquid having substantially constant viscosity, applying hydrostatic pressure to the liquid and on the selected portion of the formation sufficient to fracture the formation.

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from which includes the steps of drilling a borehole into the formation, undercutting a selected portion of the borehole in the formation to weaken the same and to increase the area subjected to parting forces, when hydraulic pressure is applied, then pumping a slurry into the undercut portion of the borehole and into the formation and applying hydrostatic pressure on the liquid and on the selected portion of the formation to fracture the formation, the filter cake being used to assist in confining the fracturing liquid while it is being pumped.

17. A method of treating a formation in the earth for the purpose of increasing the production of a fluid therefrom which consists of the steps of drilling a borehole into the formation, undercutting a selected portion of the borehole in the formation to weaken the same and to increase the area subjected to parting forces when hydrostatic pressure is applied, then creating an initial fluid passageway extending from the initial borehole in the formation to weaken the same and to increase the area subjected to parting forces when hydrostatic pressure is applied, then pumping a slurry into the undercut portion of the borehole and into the formation and applying hydrostatic pressure on the liquid and on the selected portion of the formation to fracture the formation, the filter cake being used to assist in confining the fracturing liquid while it is being pumped, and then removing some of the fracturing liquid from the borehole to cause the created fluid passageway to flush the fractured portion of the formation and force fracturing liquid back into the borehole.

18. A method of enlarging a mechanically-formed initial fluid passageway extending from a well-bore into the formation, consisting of the steps of drilling a borehole into the formation, undercutting a selected portion of the borehole in the formation to weaken the same and to increase the area subjected to parting forces when hydrostatic pressure is applied, then creating an initial fluid passageway extending from the initial borehole in the formation to weaken the same and to increase the area subjected to parting forces when hydrostatic pressure is applied, then pumping a slurry into the undercut portion of the borehole and into the formation and applying hydrostatic pressure on the liquid and on the selected portion of the formation to fracture the formation, the filter cake being used to assist in confining the fracturing liquid while it is being pumped, and then removing some of the fracturing liquid from the borehole to cause the created fluid passageway to flush the fractured portion of the formation and force fracturing liquid back into the borehole.

19. A method of treating a formation in the earth for the purpose of increasing the production of a fluid therefrom which consists of the steps of drilling a borehole into the formation, undercutting a selected portion of the borehole in the formation to weaken the same and to increase the area subjected to parting forces when hydrostatic pressure is applied, then pumping a slurry into the undercut portion of the borehole and into the formation and applying hydrostatic pressure on the liquid and on the selected portion of the formation to fracture the formation, the filter cake being used to assist in confining the fracturing liquid while it is being pumped, and then removing some of the fracturing liquid from the borehole to cause the created fluid passageway to flush the fractured portion of the formation and force fracturing liquid back into the borehole.

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from the other wall and the formation beyond the initial passageway is fractured to provide a second passageway extending from the initial passageway and having a mouth opening to the initial passageway, continuing pressuring of the mobile body against the opposite walls of the initial passageway until some of the pellets and sealing elements float in the vehicle to the mouth and the pellets are blocked against entry into the second passageway by the walls of the initial passageway at the mouth and pile up at the mouth, and some of the sealing elements are blocked against entry into the second passageway by the piled-up pellets and accumulate over the surface of the pile of pellets to form a seal against entry of the vehicle into the second passageway, and increasing the pressure upon the mobile body within the initial passageway until the second passageway is widened and at least some of the piled-up pellets and at least some of the sealing elements, which accumulated over the surface of the pile, float into the second passageway and the pellets therein lodge against the walls of the second passageway to prop the walls thereof.

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