Sept. 13, 1960 H. B. RITCH 2,952,318

SAND PACKING A FORMATION

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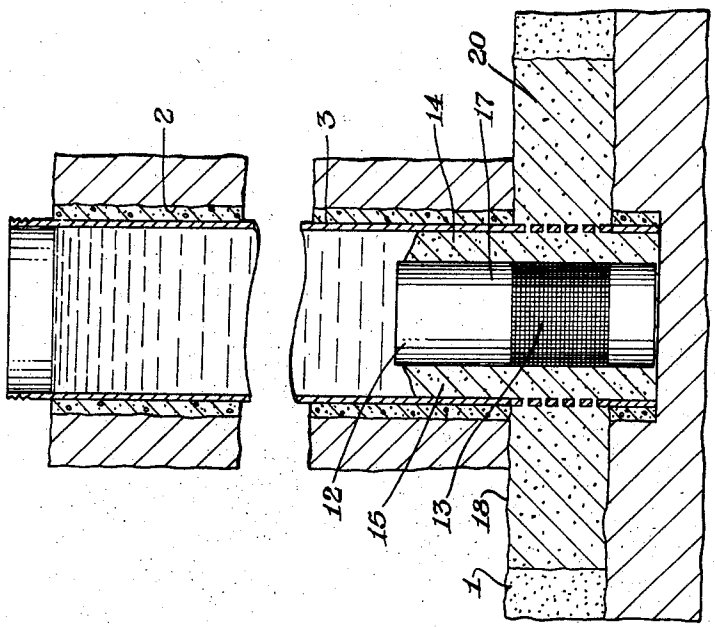

Fig. 2

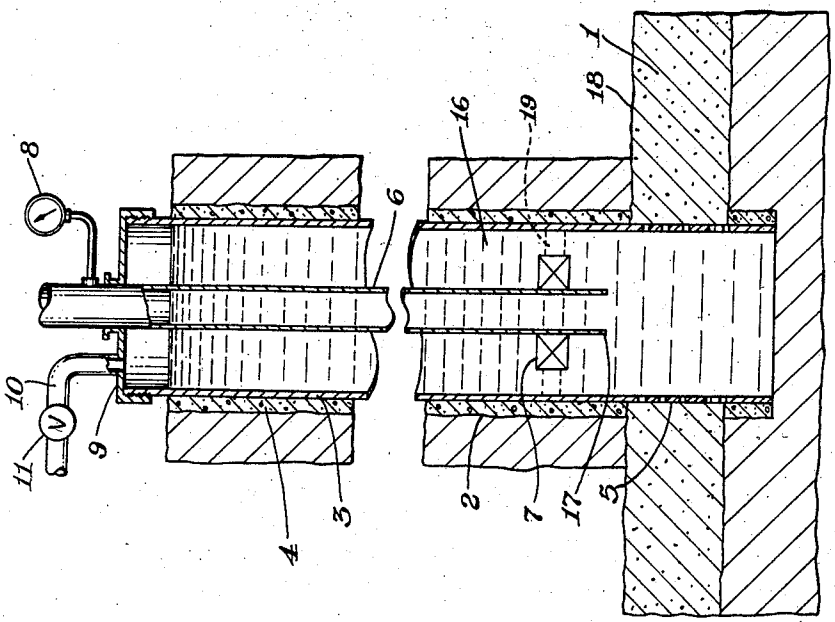

Fig. 1

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SAND PACKING A FORMATION

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The present invention relates to methods of treating wells especially those yielding oil. It more particularly concerns an improved method of treating wells penetrating a producing formation from which earth particles are carried into the well with the produced fluid and cause operating difficulties.

It is a common experience in oil and gas production to encounter producing formations from which earth particles are continually being carried by the produced fluid into the well. Many expedients have been proposed in attempts to overcome the numerous difficulties which arise in attempting to operate wells in such formations. However, none of these attempts are entirely satisfactory. It is a desideratum in the art to provide a method which greatly reduces, if not entirely prevents, earth particles from being carried by the produced fluid into the well. Accordingly, it is the principal object of the invention to provide a method which fulfills this need. Other objects and advantages will appear as the description of the invention proceeds.

The invention is predicated upon the discovery that by making successive injections of a sand-laden liquid into the producing formation a compact filter bed is formed adjacent to the well hole by which earth particles are prevented from being carried with the produced fluid into the well. The invention then consists of the improved well treating method herein fully described and particularly pointed out in the claims.

In accordance with the invention, the well preferably is first put under hydrostatic control as by filling the well hole with a liquid, such as drilling mud, oil, water, or brine, if not already filled. Once the well is filled, the first stage of the method is begun as by determining the feeding pressure of the formation to be treated. This may be accomplished by providing the well with a tubing string and packer, the latter being set either in the open hole or casing as the case may be above the formation to be treated. After setting the packer, liquid is injected into the tubing string under sufficient pressure to displace at least a portion of the liquid below the packer into and thereby breaking down or fracturing the formation. While making this injection, the pressure required may be noted together with the injection rate, thereby ascertaining a feeding rate for the liquid use and the pressure required to make an injection into the formation. After the feeding pressure is determined, the liquid in the tubing string and in the well hole below the packer is displaced, if necessary, as by releasing the packer, injecting a displacing liquid down the tubing while releasing liquid from the casing until it is calculated, from the dimensions of the tubing, that the advancing end of the displacing liquid column is below the packer. The foregoing displacing operation is performed in order to clear the tubing string and well hole below the packer of drilling mud, if such be present, otherwise this operation may be omitted. After the well hole and tubing string are filled with a

suitable liquid, such as oil, water, or brine, there is injected into the tubing string sand-laden liquid preferably oil, the sand being present in the proportions of about 125 pounds more or less per barrel of oil. As the injection of sand-laden liquid proceeds, the feeding or injection pressure rises and eventually the injection is discontinued when the injection pressure rise indicates sand is being strained out of the carrying liquid and lodging in the well hole blocking the injection. In such injection, there may be used as much as 3000 pounds, or more, of 20–40 mesh Ottawa sand, for example. When the introduction of sand-laden oil is discontinued because of pressure build up and sand straining out at the face of the formation, the packer is unseated and sand-free liquid, e.g. oil, brine, or water, or preferably oil, is introduced into the tubing string so as to displace the sand-laden oil from the tubing string and well hole below the packer out of the well, thereby leaving the well hole below the packer and the tubing string filled with sand-free liquid and maintaining control of the well. This concludes the first stage of the treatment.

The second stage is similar to the first and comprises the same steps, viz. injecting a sand-laden liquid, e.g. oil+sand in the proportions of 125 pounds of sand, more or less, per barrel of oil, into the earth formation below the packer until the injection pressure indicates that the sand is straining out of the oil filling the well hole and obstructing the injection into the formation. The sand-laden oil then remaining in the tubing string and well hole below the packer is displaced from the well as before as by releasing the packer and injecting into the tubing string a suitable sand-free liquid, e.g. oil or brine, in amount sufficient to circulate the sand out of the well, leaving the well hole and tubing string free of sand-laden oil and the well under hydrostatic control. This concludes the second stage.

Additional stages or injections of sand-laden liquid followed by flushing out the well hole with a sand-free liquid are made in the same manner as in the previously described stages, the number of stages being determined in part at least by the magnitude of the pressure required to displace the sand-laden liquid into the earth without sand straining out of the carrying liquid while the injection is being made, and by the observation of wether or not the amount of sand injected in any stage is substantial, e.g. at least 100 pounds. Each stage results in the injected sand being displaced further into the formation away from the well hole forming a filtering medium through which the liquid produced from the earth formation may pass without carrying earth particles into the well.

After the desired number of stages of sand injections have been made, a suitable screen liner may be set in the hole if necessary to hold the injected sand in place. This may be accomplished by withdrawing the tubing string and securing a detachable section of screen liner to the lower end and then rerunning the tubing string into the well. In rerunning the tubing string with the attached screen liner, it is desirable to inject oil or other liquid into the annulus between the tubing and casing, thereby washing the screen into place and cleaning the inside of the screen and tubing string of sand. After the detachable section of screen liner is at the bottom of the well hole or opposite the sand packed formation, the liner is detached from the tubing string which is then withdrawn.

It will be understood that in the matter of removing the sand which becomes strained out of the carrying liquid and deposited in the well hole as each stage approaches the finish this may be circulated out of the well in any suitable manner while maintaining hydrostatic

control of the well, if necessary. The method aforementioned of releasing the packer and injecting a sand-free liquid into the tubing string while allowing the displaced material to escape from the casing head is generally the most satisfactory. Nevertheless, if desired, the circulation can be accomplished by making the injection of sand-free liquid down the casing or annulus and allowing the displaced material to escape at the head of the tubing string. This method has the advantage that the tubing string may be lowered to the bottom of the well hole so as to facilitate the removal of any sand which may be lodged on the bottom of the well hole.

The invention may be further explained in connection with the accompanying drawing which diagrammatically illustrates a mode of practicing the invention.

In the said drawing, Fig. 1 is a schematic view of a well in vertical section showing an apparatus in place in the well in carrying out the method.

Fig. 2 is a similar view to that of Fig. 1 showing a completion of the method.

Referring to the drawing in detail, the well as shown in Fig. 1 comprises a pay formation 1 penetrated by a well bore 2 which is lined with a casing 3, the casing being cemented in place with cement 4. The casing has a slotted section 5 opposite the formation 1. The well is provided with a tubing string 6 near the lower end of which is a conventional packer 7 which is capable of being seated against the casing and released as needed by manipulating the tubing as understood in the art. The tubing string may be provided with a pressure gauge 8 for indicating injection pressures. The removable casing head 9 may be provided with an outlet 10 having a valve 11.

In Fig. 2, the well of Fig. 1 is shown with the tubing string and packer removed and a liner 12 having a screen section 13 placed in the bottom of the well opposite the pay formation. The pay formation adjacent to the well hole is shown packed with filter sand (Ottawa sand) 14 which also fills the annular space 15 between the screen section 13 and the well bore 2.

The following example is illustrative of the practice of the method on a conventional oil well using the apparatus illustrated in the drawing: The well treated had a total depth of 4209 feet (in the Chareton pool in St. Mary Parish, Louisiana) with a pay formation 1 of fine sand extending from 4196 feet to 4205 feet, the slotted section 5 of the casing being opposite the pay formation. In carrying out the method, the well was filled with salt water 16 so as to maintain hydrostatic control of the well. Then the tubing string 6 with the packer 7 was lowered into the salt water until the lower end 17 of the tubing string was 4 feet above the top 18 of the formation 1 and the packer 7 was 28 feet above the lower end of the tubing. After lowering the tubing string, the packer was seated against the casing 3 as indicated in dotted outline 19. A test was then made to determine whether the slotted section of the casing would accept fluid. This was done by injecting several barrels of salt water down the tubing with valve 11 closed. This injection proceeded without undue pressure rise on the tubing, thereby indicating that the slotted section 5 allowed the passage of liquid into the formation 1. The packer 7 was then unseated and then 10 barrels of lease oil was injected into the tubing string followed by 12 barrels of sand-laden oil containing 1500 pounds of 20–40 mesh Ottawa sand. During the foregoing injections, salt water was allowed to escape from the casing by opening valve 11. When it was anticipated that the sand-laden oil was about to reach the well hole the packer was seated as indicated at 19 and a further quantity of 12 barrels of sand-laden oil was injected into the tubing string. This was followed by 10 barrels of oil and 24 barrels of salt water. The maximum pressure recorded by the pressure gauge 8 was 1700 p.s.i. and sand was displaced into the formation thus completing the first stage of the treatment. The second stage was similar to the first and was commenced by unseating the packer 7 and circulating salt water down the tubing string and out the valve 11 so as to wash out any sand left in the well hole from the first stage. The packer was then seated as at 19 and 24 barrels of oil uniformly mixed with 3000 pounds of 20–40 mesh Ottawa sand was injected into the tubing, the injection being discontinued when the pressure rose to 1900 p.s.i. indicating that sand was being strained out at the face of the well hole blocking further injection. The packer 7 was then unseated and the well hole flushed with sand-free liquid in preparation for a third stage. In this about 40 barrels of oil uniformly mixed with 5000 pounds of 20–40 mesh Ottawa sand was injected as in the other stages, the injection being discontinued when the tubing pressure reached 2000 p.s.i. which indicated that the sand was no longer entering the formation but was instead being strained out and deposited in the well hole. The packer 7 was released and the tubing string and well hole were flushed with sand-free oil in preparation for a fourth stage. In the fourth stage, about 31 barrels of sand-laden oil containing 3900 pounds of 20–40 mesh Ottawa sand was injected, the injection being discontinued when the tubing pressure reached 3000 p.s.i. The successive injections of sand into the formation produced the compact sand mass indicated by numeral 20 in the portion of the formation adjacent to the slotted section 5. Following the fourth stage of sand injection, the packer 7 was unseated and salt water was injected into the casing through valve 11 while allowing the sand-laden oil remaining in the tubing string to be flushed out while the tubing string was lowered to a depth of 4196 feet, that is, to the top 18 of the pay formation. After the successive sand injections were completed, the tubing string was raised 40 feet and a quantity of sand and water was introduced into the tubing so as to make a deposit of sand in the well hole to a depth of about 30 feet above the slotted section 5. The tubing string with the attached packer was then removed from the well hole and a 10 foot screen assembly (shown in Fig. 2 as No. 12 detached from the tubing string) of 45 mesh screen was detachably attached to the lower end of the tubing string which was then run into the well until the bottom of the screen rested upon the top of the sand column in the well. Salt water was then injected into the casing at the same time the tubing string was lowered further, thereby washing the screen section 13 into place and leaving sand in the well hole between the screen section and the casing as indicated by numeral 14. Thereafter the tubing string was detached from the screen section 12 which was left in the well hole, as shown in Fig. 2. The well so-treated was put into production and tested for a 2.5 months' period for sand. It was found that the well delivered sand-free oil at a satisfactory rate through the injected sand mass 20, whereas prior to the treatment the well hole and subsurface pumping equipment in the well became sanded up and the well could not be operated satisfactorily.

It is manifest from the foregoing example that the size of each of the injections of the sand-laden liquid may and usually does vary one from the other and depends upon whether or not the formation will accept the sand-laden liquid without screening out or straining out at the face of the formation or in the slots or openings of the well liner if such be in the well hole. The occurrence of the straining out is made evident to the operator by a sharply rising pressure as the injection proceeds, or a diminishing injection rate at constant injection pressure. On the appearance of such retardation in injection rate or sharp build up of injection pressure, the injection is

discontinued as aforesaid and the well hole is flushed out so as to clear the face of the formation and slots of the liner, if present, of sand particles and permit another injection to be made of sand-laden liquid. In general from 3 to 5 stages of injection will accomplish the desired results but a greater number of injections may be made if the formation will accept them without immediate straining out of the sand from the carrying liquid.

As to the size of the sand particles to use, this may vary over a considerable range and is selected preferably with due regard for the size of earth particles to be retained in the formation. A size of from about 20 to 40 mesh is generally suitable.

The liquid used as a carrying medium for the sand is preferably an oil having a considerable viscosity, such as refined oil, so as to facilitate holding the sand in suspension while making the injection. Lease oil may be used.

I claim:

1. The method of treating a well penetrating a fluid producing formation from which earth particles are carried into the well by the produced fluid so as to retain the earth particles in the formation during production

which comprises making successive injections of a sand-laden liquid into the well and thence into the formation through a perforate liner therein, each injection being discontinued when there is a rise in the injection pressure indicating that sand is straining out of the sand-laden liquid at the face of the formation, and flushing the well hole of the sand strained out of the sand-laden liquid at the face of the formation between the injections.

2. The method according to claim 1 including setting a screen in the well hole after the last injection of sand-laden liquid and packing sand in the annular space between the said screen and the liner of the well hole.

3. The method according to claim 1 in which the number of injections is from 3 to 5, inclusive.

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