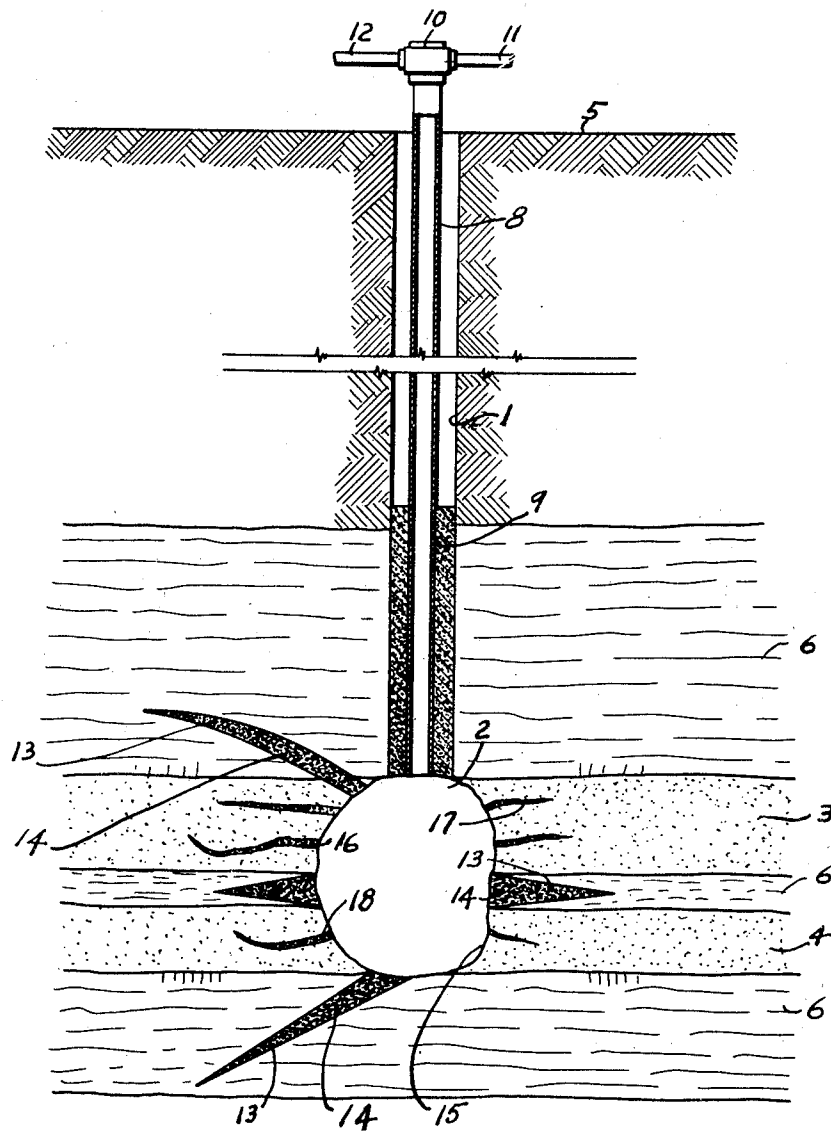


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METHOD OF PLUGGING WELLS

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METHOD OF PLUGGING WELLS

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This invention relates to plugging of wells for the recovery of oil therefrom, and more particularly to selective plugging of water injection wells and selective exclusion of fluid from producing wells.

It has been the practice in recovering oil from producing wells that are approaching depletion to force water or other fluids through the oil bearing formation from points distant from the producing well for the purpose of driving the oil through the oil bearing strata into the producing well. There are many underground formations, such as lignite, coal, rotten shales, etc., which have areas of infinite or no measurable permeability and which have widely different textures and pore sizes that determine their permeability. These formations lie over, below, through or often break into the oil bearing sand. Such formations very often "thief" the injected water and thus cause many water drive failures. In such instances the "thief" formation has no back flow while the other areas, including producing sand, have considerable back flow after the area out from the well bore has been pressured.

Many different methods have been attempted in repressuring wells, and also for the shutting off of water in oil wells, such as the forcing of water, as above mentioned, from points distant from the producing wells, by drilling inlet wells or the use of old wells, by plugging the inlet wells above the oil bearing formation and forcing water into the oil bearing formation below the plug and under sufficient pressure to drive the oil through the interstices of the strata in the producing well.

Another practice has been the plugging of loose sand by injecting a wax distillate and emulsions against the sand into which most of the injection water escapes. Another method has been to cover the sand by finely divided solid particles suspended in a carrying medium, such as cement or clay and water. This method has proved unsatisfactory for the reason that very often harmful results are encountered due to the fact that tight sands as well as loose sands may be plugged by this method. Bentonite, or similar materials, has also been used as a plugging agent which is forced under pressure into the sand. This method has also not proved entirely satisfactory.

The present invention contemplates the introduction of an initial blocking material, such as a cement slurry, to partially block off the area of infinite permeability or areas of too great permeability in and about the well bore or shot

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hole at a pressure sufficient only to effect placement of the cement in such formation. A coarse or fibrous material capable of quick setting might also be used for initially and partially blocking off this area. The initial blocking material is then preferably allowed to wedge in place, or, if cement, to set, and then I introduce a final blocking material, such as a fibrous material and an acid soluble material, or even material of extremely fine particle size, under substantial pressure to follow the initial partial blocking material and complete closure of the areas of infinite or too great permeability. Pressure is then released from the final blocking material so that superfluous material will be removed from the surface of the oil sand or surfaces of measurable permeability due to back flow through such area.

The drawing illustrates diagrammatically an apparatus for carrying out the method above outlined, particularly with respect to water injection wells in connection with water flooding practices as well as shutting off water in producing wells.

In the drawing 1 indicates an inlet well having a bore hole 2 extending into the oil bearing strata 3 and 4 or areas of measurable permeability from the surface 5 of the ground. 6 designates water bearing strata or areas of infinite permeability. A tubing 8 extends through the bore hole and the area between the tubing and bore hole at the lower end thereof is plugged off with cement or the like as indicated at 9. The tubing is provided with a head 10, a water line 11 leading from a source of supply (not shown), and a line 12 through which the plugging material is forced also from a source of supply (not shown).

My method will first be described in connection with water injection of inlet wells which usually include formations of infinite permeability which lie over, below and often break into the oil bearing sand, and through which formations the water will be lost in repressuring operations. In wells of this type there is no appreciable back flow from these formations, while there is considerable back flow from the sand bearing formations.

With my method I first inject water into the bore hole to build up a high pressure differential between the area of infinite or immeasurable permeability and the oil bearing sand or area of measurable permeability. Pressure will also build up in the oil sand or producing area. After the water injection is stopped and the well shut in, I preferably pump a thin slurry of cement,

approximately ten to twenty sacks, through pipe 12 and tubing 8 to the well bore. A sufficient supply of water is then injected through pipe 11 to clean the tubing and force the cement slurry away from the well hole into the "thief" area or area of infinite permeability. The back flow or pressure on the oil bearing strata or area of measurable permeability will cause the cement to take the course of least resistance to thus force the cement into the area of infinite permeability as indicated at 13. The well is then shut in and allowed to stand for from two to three days to allow the cement to set. The back flow rate from the oil bearing strata will cause any cement on the face of the bore hole to be removed and caused to flow into the "thief" area. In some instances I have found it advisable to repeat the operation of building up pressure in the oil sands and shutting in the well to clean the surface of the well hole of any cement remaining on the face thereof.

The injected cement as above set forth will form a partial plug in the area of infinite permeability, but will not entirely close off such area. In order to cause a complete shut-off of this area, I preferably pump a mixture of fibrous and other acid soluble materials through pipe 12 and tubing 8 of the bore hole under substantial pressure to cause the fibrous material to follow the set cement in the "thief" area as illustrated at 14.

In placement of this fibrous material the "squeeze" method is used and the material is placed under a maximum pressure of approximately twelve hundred pounds p. s. i. The back flow from the area of measurable permeability will again cause the fibrous material to follow the initial blocking material as above stated. After the fibrous material is placed the well may then be opened and the back flow from the oil bearing sand or area of measurable permeability will clean the face 15 of the well hole and tubing of any of the fibrous material left thereon. The producing sands 3 may have small openings, cracks or crevices, as indicated at 16, and the initial blocking material will fill such openings as indicated at 17, and the final blocking material will follow as shown at 18.

I have found a mixture of fibrous material and an acid soluble material, such as lime or limestone to give good results in practicing my method. One example of such fibrous material is paper ground to sufficient fineness to pass to the "thief" area mixed with lime and water to form a slurry adapted to be pumped to the bore hole. It will, of course, be obvious that if the fibrous material is acid soluble, it will not be necessary to add an acid soluble material to the fibrous material in the mixture. I preferably use a fibrous material such as ground paper which is capable of swelling when wet, and hardening after wetting, but an inert fibrous material, such as asbestos, or an organic material, such as cotton, hemp or other plant fibre may be used.

After the area of infinite permeability has been sealed off, the supply of water under pressure to the inlet well may be continued so as to drive the oil through the oil bearing strata or area of measurable permeability to the producing well without loss of water through the "thief" area in the water injection or repressuring well. Increasing of the water pressure by sealing off the "thief" area will drive the oil through the oil bearing strata more rapidly, thus greatly reduc-

ing the time element and result in greater production of oil from the oil producing well.

I have found that without the use of the partial plug method such as I have described, it is practically impossible to plug off the "thief" area. In some instances I have found the plugging materials have been pumped from the injection well through the "thief" area to the oil bearing well and practically no shut-off resulting.

The same method of sealing off the areas of infinite permeability in an oil producing well to prevent flow of water to the well hole may be practiced. However, due to differential pressures between the oil bearing sand and limestone and other formations producing water, the back flow is sometimes not sufficient to completely clean off the plugging material from the face of the oil bearing sand after the final "squeeze" is made in placing the fibrous material. In such instances the face of the producing formation may be cleaned of the plugging material by the injection of acid (such as muriatic or other well-known acid or other well-known methods) to the bore hole.

It will be obvious from the foregoing that I have devised an improved method of selective plugging off of water injection wells as well as selective exclusion of fluid from oil producing wells which is simple, economical and produces efficient results. While I have here illustrated as an example of a cement slurry for a partial block and a fibrous material for the final block material, it will be understood that other materials may be used without departing from the spirit of my invention.

What I claim and desire to secure by Letters Patent is:

1. A process for recovering oil from subterranean oil bearing strata in a producing well having different permeabilities which comprises the step of introducing water in said well under pressure to establish a pressure differential between areas of infinite permeability and areas of measurable permeability, introducing a quantity of cement slurry to said area of infinite permeability in said input well under reduced pressure, injecting water in said input well to force the cement slurry from the well bore to said area of infinite permeability, shutting in the well for a time sufficient for the cement slurry to set and partially plug the areas of infinite permeability, introducing a mixture of comminuted fibrous material and limestone under substantial pressure to follow said cement in said area of infinite permeability to complete closure of said area, and cleaning the excess of said material from the face of the strata of measurable permeability.

2. The method of selectively plugging off flow of fluid through areas of infinite permeability in formations exposed to a well without plugging areas of measurable permeability which includes, introducing a quantity of cement slurry into the well under pressure whereby the difference in flow through the permeable areas causes the cement slurry to enter the areas of infinite permeability, injecting water into the well to carry the cement slurry from the well bore to the area of infinite permeability, shutting in the well for a time sufficient for the cement slurry to set and partially plug the areas of infinite permeability, introducing into the well a mixture of comminuted fibrous material and limestone under sufficient pressure to force same into the partially

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plugged areas of infinite permeability until the flow therethrough is completely plugged, and opening the well whereby back flow from the areas of measurable permeability cleans the fibrous material and limestone from said areas of measurable permeability in the well bore.

3. The method of selectively plugging off flow of fluid through areas of infinite permeability in formations exposed to a well without plugging areas of measurable permeability which includes, injecting water into a well under pressure and in greater quantity than the escape of said water through the permeable areas to establish a pressure in said areas, the difference in flow through the permeable areas causing a pressure differential between the areas of infinite permeability and areas of measurable permeability, introducing a quantity of cement slurry into the well under less pressure than that at which the water was injected whereby the differential pressure and flow in the areas causes the cement slurry to enter the areas of infinite permeability, injecting more water into the well to carry the cement slurry from the well bore to the areas of infinite permeability, shutting in the well for a

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time sufficient for the cement slurry to set and partially plug the areas of infinite permeability, introducing into the well a mixture of comminuted fibrous material and limestone under sufficient pressure to force same into the partially plugged areas of infinite permeability until flow therethrough is completely plugged, and opening the well whereby back flow from the areas of measurable permeability cleans the fibrous material and limestone from said areas of measurable permeability and the well bore.

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