

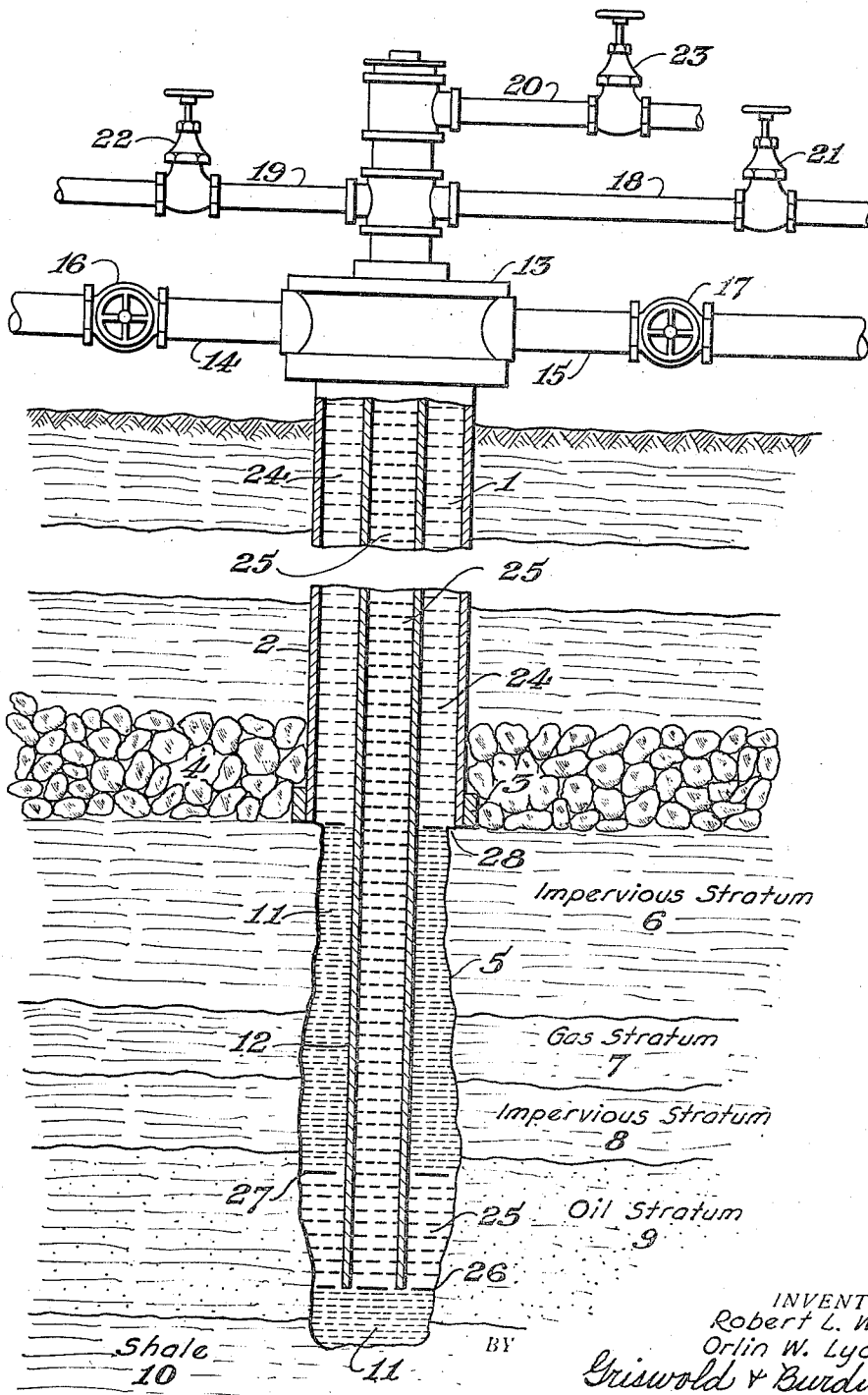
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TREATMENT OF WELLS

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TREATMENT OF WELLS

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This invention relates to a method of treating a mineral fluid bearing stratum such as that of an oil or gas well with a fluid reagent to increase the yield. It more particularly concerns a method of injecting an acid reagent into a selected portion of a productive formation penetrated by such a well.

The bore of an oil or gas well may and often does pass through one or more permeable producing strata. It is usual to find that the permeability of the different strata varies not only from stratum to stratum but also from one level to another in the same stratum. In the treatment of such wells with a fluid reagent it is oftentimes desirable to be able to inject it into the more impermeable of the several strata or even into a relatively impermeable portion of a single stratum. Such directional control of the fluid reagent is desirable because otherwise most, if not all, of it tends to drain away into the more porous stratum or portions thereof since the more porous stratum offers a comparatively low resistance to such inflow. Very little, if any, increase in production can be obtained by conventional treatment of such wells, as the mineral fluids already flow easily from the porous sections, while they are retained in the relatively impermeable sections. For example, in treating a well with an acid solution capable of dissolving constituents of the earth and rock in attempts to increase the permeability and thereby permit the oil or gas to flow into the well more easily, it has been observed that the major portion of the acid appears to be absorbed by the porous sections. When such porous sections overlie the portion of the relatively impermeable formation it is desired to treat, it is practically impossible by the use of conventional methods to inject the acid into the more impermeable sections. We have found, however, that by preventing the acid from entering these porous sections and directing it instead into the relatively impermeable portions of the producing formation, these can be rendered more porous, thus generally greatly increasing the production as well as reducing the quantity of reagent needed.

It is, therefore, an object of our invention to provide a method of treating a well with a fluid reagent, whereby it is directed into a predetermined portion of the producing formation.

Another object is to provide a method of treating with an acid a relatively impermeable well stratum underlying a relatively permeable stratum, whereby the acid may be directed into the relatively impermeable stratum and substantially

excluded from the relatively permeable stratum.

Further objects and advantages will be apparent from the following description.

Briefly the method of the invention comprises first introducing into the well a quantity of a non-penetrating liquid mixture sufficient in amount to fill the well to a level preferably considerably above the stratum to be treated and such permeable stratum as may be contiguous to and overlying the same. The reagent is then introduced into the well through the tubing so positioned that its lower end is located opposite that portion of the selected stratum to be treated. The fluid reagent which is then introduced through the tubing is permitted to displace the non-penetrating liquid mixture upwardly in the well bore until the portion of the formation to be treated is exposed to the action of the reagent. Pressure is then applied on the non-penetrating liquid mixture so as to prevent further displacement. While the pressure is held on the liquid mixture, the fluid reagent is forced into the formation without causing the non-penetrating mixture to be displaced upwardly into the well bore. By the foregoing method the reagent is forced into only a predetermined portion of the formation and prevented from draining into the other portions which lie above and below it.

The term "non-penetrating liquid mixture" used herein and in the appended claims means a liquid mixture comprising a dispersion or suspension in a liquid of a material which prevents the liquid from penetrating porous formations such as those traversed by a well bore, but of sufficient fluidity to be introduced into the well and readily withdrawn therefrom.

The accompanying drawing forming a part of this specification and which illustrates a mode of carrying out the invention is a diagrammatic view in vertical section of an oil well.

The single figure is a view showing a well equipped for carrying out a treatment according to the invention.

In the drawing the upper portion 1 of the well is cased and passes through non-productive earth and rock, the casing 2 being provided with a casing seat 3 cemented in the rock stratum 4. The lower uncased portion 5 of the well passes through an impervious stratum 6, a relatively permeable gas stratum 7, a substantially impervious stratum 8, an oil stratum 9, and terminates in an impervious non-productive shale 10. Opposite the oil bearing stratum 9 the tubing 12 is shown with the lower end in position for a treatment according to the invention. The well

is shown with an acid reagent 25, for example, filling the tubing 12 and in the well bore outside the tubing, the acid covers the producing stratum 9 over the area to be treated between the levels 26 and 27. Above and below the acid in the uncased portion of the well the space is shown filled with a non-penetrating liquid mixture which covers the permeable gas stratum 7 and fills the well to level 28 below the casing seat 3. The space above the non-penetrating liquid mixture is shown filled with oil 24, which is used for controlling the level to which the non-penetrating liquid mixture is permitted to rise in the well bore. Above the ground level the casing head 13, through which the tubing 12 extends into the well, is shown equipped with pipes 14 and 15 communicating with the casing, said pipes being provided with valves 16 and 17. To the tubing 12 above the casing head, pipes 18, 19, and 20 controlled by valves 21, 22, and 23 respectively, are connected, suitably arranged for carrying out the method according to the invention and for putting the well into production.

In accordance with the invention, an acid treatment, for example, may be carried out in the following manner when it is desired that the action of the acid be confined to the oil bearing stratum 9. The lower end of the well tubing 12 is located at a level such as 26 below which it is desired that no acid will enter the oil bearing stratum 9. A quantity of a non-penetrating liquid mixture 11, sufficient in amount to fill the well to a level above the permeable gas stratum 7, is then introduced into the well through the tubing 12 while maintaining a pressure on the well in excess of the bottom hole pressure. The amount of said mixture is readily ascertained with sufficient accuracy for the purpose from a knowledge of the level of the gas stratum 7 and the total depth of the well. The remainder of the well bore exterior of the tubing 12 and above the non-penetrating liquid mixture 11 is then filled with oil 24, introduced into the well through pipe 15 connected with the casing 2. The acid is then introduced into the well through pipe 20 and tubing 12 while maintaining valve 16 in an open position (the other valves being closed), thus allowing oil in the casing to escape through the pipe 14. After the tubing is filled the acid is allowed to displace the non-penetrating liquid mixture upward in the well until the formation to be treated is exposed to the acid. At the same time a corresponding volume of oil also displaced is permitted to escape from the pipe 14. When the proper amount of oil has escaped and the acid has reached the level 27 the valve 16 is closed and pressure is applied, if necessary, to force the acid into the oil bearing stratum 9. The level to which the non-penetrating liquid mixture rises in the well bore during the initial introduction of the acid is readily calculated from a knowledge of the volume of tubing and well bore and the amount of fluid (oil) that escapes from the casing. During the injection of the acid into the formation its position is controlled by the column of non-penetrating liquid mixture and oil filling the well, thus being prevented from rising in the well bore above the level 27 of the oil stratum 9. Upon completing the introduction of the desired quantity of acid, any of it remaining in the tubing 12 is displaced therefrom by applying pressure on the tubing, as by introducing oil. The well may be then closed in to allow the reaction to complete itself after

which the treating fluids may be removed from the well by pumping, or in other suitable manner. The well may then be put into production.

Among the non-penetrating liquid mixtures that are useful for the purpose at hand are those liquid mixtures having non-penetrating characteristics and of substantially the same specific gravity as that of the fluid reagent. Examples of suitable liquid mixtures are the relatively thick oil-water emulsions. These may be prepared by passing oil and water through a mixing head or homogenizer at a relatively high speed in conventional manner. Any of the well known emulsifying agents may be incorporated in the mixture to facilitate the forming of the emulsion. Such an emulsion may be made having any suitable consistency, by varying the proportions of the ingredients. Another type of non-penetrating liquid mixture consists of a solution or dispersion of an organic jellifying material in water. By an "organic jellifying material" is meant an organic material capable of being dispersed or dissolved in water to make a mobile liquid dispersion or solution, which liquid exhibits jellifying characteristics after a time. Suitable organic jellifying materials may be prepared from starches such as those of cassava or rice, by mixing them with water to form a thin paste and boiling the mixture until the starch is hydrolyzed. The cooked starch is dried at about 80° C. and the dried material ground preferably to a fine powder. The powder so produced may be mixed with water in a concentration of from about 1 to 8 per cent by weight to give a dispersion or solution which possesses suitable non-penetrating characteristics. Still another type of non-penetrating liquid mixture may be made by mixing a material such as bentonite with water in amounts of between about 1 to 5 per cent by weight.

Other non-penetrating liquid mixtures may be used for the purpose at hand provided they are not attacked readily by the fluid reagent used in the method and do not substantially penetrate relatively permeable formations.

Various modifications of the described method may be advantageously used in some instances. For example, it is sometimes desirable to separate the fluid treating agent from the non-penetrating liquid mixture during their introduction into the well to prevent the one becoming unduly diluted or mixed with the other. The two liquids may be kept apart during their introduction into the well by making use of a quantity of a separating liquid. The term "separating liquid" as used means a liquid preferably immiscible with the treating reagent and having about the same specific gravity. By introducing a quantity of a separating liquid, such as oil, into the tubing between the non-penetrating liquid mixture and the fluid reagent, mixing and dilution of the treating reagent is substantially prevented. It is also to be understood that the method may be suitably used for the injection of fluid reagents into the desired portion of the formation when the well bore penetrates any number of permeable strata, regardless of the location of the portion it is desired to treat, it being only necessary to maintain in the well bore during the injection of the fluid reagent, according to the method, a quantity of the non-penetrating liquid mixture in an amount sufficient to fill the well bore to a level above that of all of the permeable strata, and to so position the tubing within the

mixture that its open end is opposite the formation to be treated.

The method is also particularly useful wherein it is desired to inject the fluid reagent into only a specific portion of one stratum. Such introduction of the fluid reagent into a specific portion of one stratum is accomplished by accurately locating the lower open end of the tubing opposite the portion to be treated and allowing the column of non-penetrating liquid mixture to part only enough to expose the portion of the formation to be treated. Although the method has been described with reference to fluid reagents generally it will be understood that the method is particularly useful wherein it is desired to direct a charge of an acid such as hydrochloric, nitric or mixtures of these acids into a selected stratum or even into a portion of such a stratum.

It will be noted that although the method has been described with particular reference to oil or gas wells, it need not be limited thereto, but may equally well be applied in treating other types of wells, such as those producing water or brine.

Other modes of applying the principle of our invention may be employed instead of the one explained, change being made as regards the method herein disclosed, provided the step or steps stated by any of the following claims or the equivalent of such stated step or steps be employed.

We therefore particularly point out and distinctly claim as our invention:

1. In a method of treating with an acid a mineral fluid bearing stratum of a well provided with the usual casing and tubing, the uncased portion of the well bore penetrating a relatively permeable formation overlying the stratum to be treated, the steps which consist in introducing an aqueous dispersion of an organic jellifying material into the well in such amount as to fill the well to above the relatively permeable formation, locating the lower open end of the tubing in the aqueous dispersion of the organic jellifying material opposite the stratum to be treated, introducing the acid into the uncased portion of the well through the tubing, whereby the aqueous dispersion of an organic jellifying material above the lower end of the tubing is displaced upwardly in the well bore exposing the said stratum, while the overlying permeable formation remains sealed by said mixture, and applying a pressure both on the aqueous dispersion of the organic jellifying material and on the acid so as to force the acid into the said stratum without causing further upward displacement of the aqueous dispersion of the organic jellifying material in the well bore.

2. In a method of treating with an acid a mineral fluid bearing stratum of a well provided with the usual casing and tubing, the uncased portion of the well bore penetrating a relatively permeable formation overlying the stratum to be treated, the steps which consist in introducing an aqueous dispersion of bentonite into the well in such amount as to fill the well above the relatively permeable formation, locating the lower open end of the tubing in the aqueous dispersion of bentonite opposite the stratum to be treated, introducing the acid into the uncased portion of the well through the tubing, whereby the aqueous dispersion of the bentonite above the lower open end of the tubing is displaced upwardly in the well bore exposing the said stratum,

while the overlying permeable formation remains sealed by said mixture, and applying a pressure both on the aqueous dispersion of bentonite and on the acid so as to force the acid into the said stratum without causing further upward displacement of the aqueous dispersion of bentonite in the well bore.

3. In a method of treating with an acid a mineral fluid bearing stratum of a well provided with the usual casing and tubing, the uncased portion of the well bore penetrating a relatively permeable formation overlying the stratum to be treated, the steps which consist in introducing a substantially non-penetrating emulsion into the well in such amount as to fill the well to above the relatively permeable formation, locating the lower open end of the tubing in the said emulsion opposite the stratum to be treated, introducing the acid into the uncased portion of the well through the tubing, whereby the said emulsion above the lower open end of the tubing is displaced upwardly into the well bore, exposing the said stratum while the overlying permeable stratum remains sealed by said mixture, and applying a pressure both on the said emulsion and on the acid so as to force the acid into the said stratum without causing further upward displacement of the substantially non-penetrating emulsion in the well bore.

4. In a method of treating with hydrochloric acid a mineral fluid bearing stratum of a well provided with the usual casing and tubing, the uncased portion of the bore penetrating a relatively permeable formation overlying the stratum to be treated, the steps which consist in introducing a substantially non-penetrating liquid mixture into the well in amount sufficient to fill the well bore to above the relatively permeable formation excluding that portion of the well bore adjacent to the stratum to be treated, locating the lower open end of the tubing in the said mixture opposite the said stratum, introducing the hydrochloric acid into the well through the tubing whereby the said mixture is displaced upwardly in the well bore covering the relatively permeable formation and exposing the said stratum, while the overlying permeable formation remains sealed by said mixture, and applying a pressure both on the said mixture and on the hydrochloric acid so as to force the hydrochloric acid into the said stratum without causing further upward displacement of the said liquid mixture in the well bore.

5. In a method of treating with a fluid reagent a mineral fluid bearing stratum of a well provided with the usual casing and tubing, the uncased portion of the bore penetrating a relatively permeable formation overlying the stratum to be treated, the steps which consist in introducing a substantially non-penetrating liquid mixture into the well in amount sufficient to fill the well bore to above the relatively permeable formation, introducing the fluid reagent into the uncased portion of the well bore at a point opposite the stratum to be treated, whereby the said mixture is displaced upwardly in the well bore covering the relatively permeable formation and exposing said stratum, while the overlying permeable formation remains sealed by said mixture, and applying a pressure both on said mixture and on the fluid reagent so as to force the fluid reagent into said stratum without causing further upward displacement of said mixture in the well bore.

6. In a method of treating with aqueous hy-

drochloric acid a mineral fluid bearing stratum of a well provided with the usual casing and tubing, and with the uncased portion of the well bore penetrating a relatively permeable formation overlying the stratum to be treated, the steps which consist in introducing a substantially non-penetrating liquid mixture into the well in such an amount as to fill the well to a level above the relatively permeable formation, locating the lower open end of the tubing in the non-penetrating liquid mixture opposite the stratum to be treated, introducing a quantity of a separating liquid into the uncased portion of the well through the tubing, said separating liquid having approximately the same specific gravity as that of the hydrochloric acid, whereby said acid

is separated from the non-penetrating liquid mixture during its introduction into the well, then introducing the hydrochloric acid into the tubing, whereby the non-penetrating liquid mixture above the level of the lower end of the tubing is displaced upwardly in the well bore exposing the said stratum, while the overlying permeable formation remains sealed by said mixture, and applying pressure both on the said liquid mixture and on the aqueous hydrochloric acid so as to force the acid solution into said stratum without causing further upward displacement of the said liquid mixture in the well bore.

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