

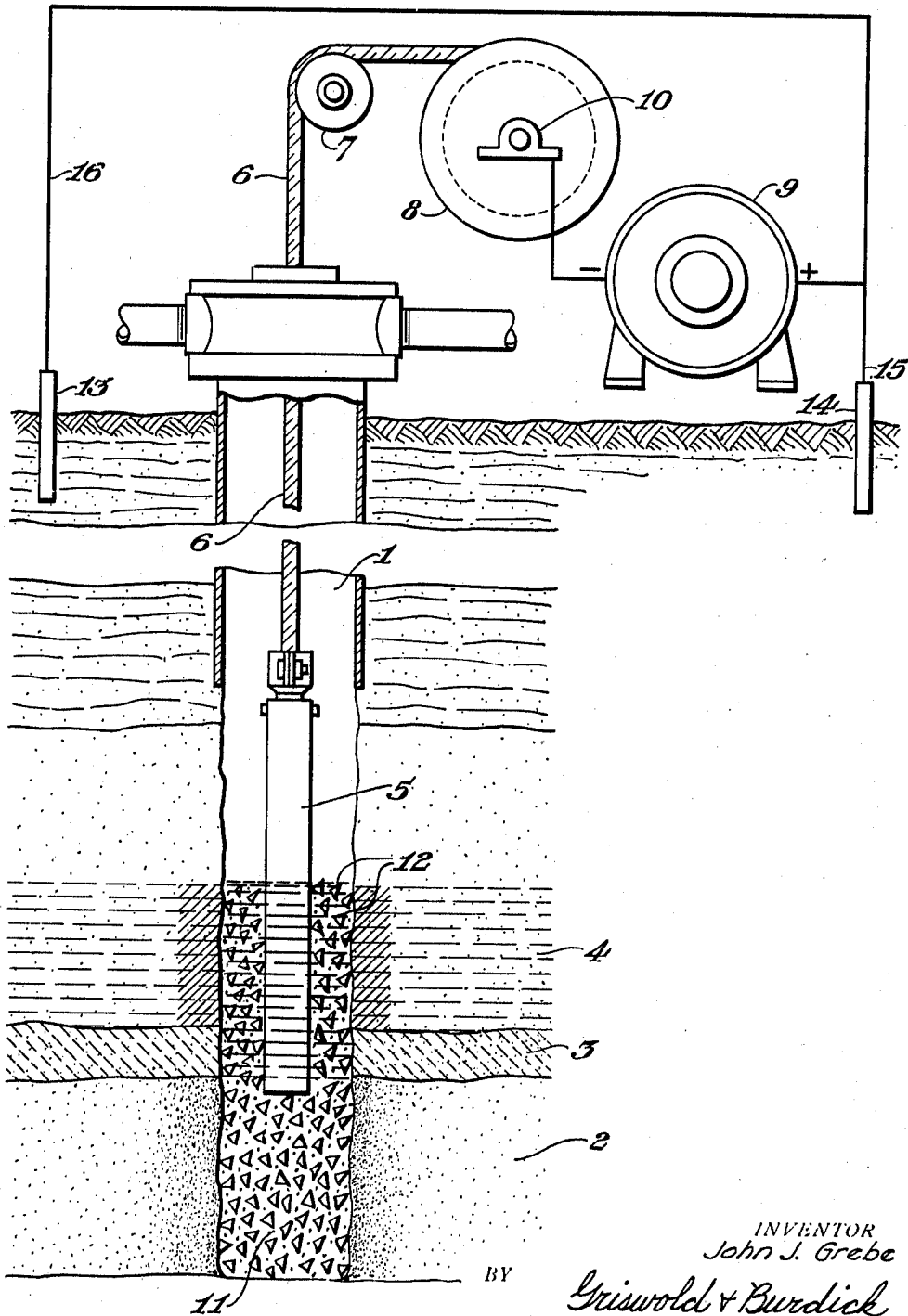
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METHOD OF TREATING WELLS

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METHOD OF TREATING WELLS

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The invention relates to the treatment of wells. It more particularly concerns an improved method of consolidating and rendering impermeable certain portions of the formation penetrated or traversed by the bore of a well.

The principal object of the invention is to provide a method of rendering substantially impermeable to fluids any permeable portion of an earth formation penetrated by a well bore.

Another object is to provide a method of treating an oil or gas well penetrating a hard water or brine bearing stratum to selectively shut off infiltration of brine or hard water without affecting the flow of oil or gas to the well.

Another object is to provide a method of treating the formation adjacent to a well bore to produce therein a consolidating solid deposit or sheath preventing caving, sloughing, or shifting of the earth or rock. Other objects and advantages will be apparent as the description of the invention proceeds.

According to my invention I introduce into the well bore and the formation to be treated an aqueous electrolyte containing a heavy metal ion, which can be deposited out when subjected to electrolysis, and then pass an electric current through such electrolyte in the formation between a cathode in the well bore adjacent to the formation to a suitable ground connection, whereby the metal ion builds up a deposit of metal in the pores and interstices of the formation. By using a suitable cathode, or one the surface of which conforms more or less to the configuration of the portion of the well bore penetrating the formation to be treated, the electrolysis results in producing a deposit of metal first at the cathode face next to the earth formation, and as the electrolysis proceeds, the deposit increases in amount, gradually extending into the pores and interstices of the formation plugging them and consolidating the formation.

The invention, then, consists of the method hereinafter fully described and particularly pointed out in the claims, the accompanying drawing and the following description setting forth in detail one mode of carrying out the invention, such mode illustrating, however, but one of various ways in which the principle of the invention may be used.

The accompanying drawing is a diagrammatic view in vertical section of an oil well drilled into an oil bearing stratum overlaid by an impervious stratum and a water bearing stratum, said well being provided with a casing and also with equip-

ment for treating the well according to my invention.

As shown, the upper portion 1 of a well is cased and passes through non-productive earth and rock, while its lower portion ends in an oil producing stratum 2, separated from a water producing stratum 4, by an impervious stratum 3. A suitable electrode 5, such as a copper tube, is shown surrounded by a granular electrical conducting material, such as coke 12, forming the cathode which extends to the top of the water bearing stratum 4. The electrode 5 is connected to an insulated cable 6 which can be lowered into the well over the pulley 7 from the reel 8. The negative terminal of a generator 9 to furnish the electric current is shown connected to the cable on the reel 8 by suitable means at the reel shaft 10. Suitable electrodes, such as iron bars 13 and 14, are driven into the earth at a suitable distance from the well, and are connected by suitable electrical leads 15 and 16 to the positive terminal of the generator 9.

In carrying out the invention in an oil well to shut off infiltration from the brine stratum 4, for example, the eductor tube, not shown, is first withdrawn from the well. A granular conducting material is introduced into the lower portion 11 of the well until it is filled up to about the bottom of the brine stratum. The electrode 5 is lowered into the well by means of the insulated cable 6 to which it is connected until its lower end rests upon the granular material. Then the remaining space between the electrode and the well bore, is filled with a further quantity of granular conducting material 12 up to the top of the brine stratum 4. The granular material and the electrode in combination form the cathode, having a shape conforming to the configuration of the well bore.

An electrolyte is then introduced into the well bore and pressure, if necessary, is applied to it to force any brine standing in the well back into the formation. Since aqueous solutions enter brine-bearing formations more readily than oil bearing formations, there is but slight risk of forcing the electrolyte into the oil bearing stratum 2.

The amount of electrolyte to be employed depends upon a number of variables, such as the thickness of the brine stratum, its permeability, and the extent to which it is desired to bring about consolidation or sealing. A penetration of several inches to many feet may be employed, and the volume of electrolyte required for such penetration may be estimated from a knowledge of the porosity of the formation and its thickness. As

an example, I have found that good results were obtained in a well having a brine bearing stratum about 10 feet thick by introducing about 2,000 gallons of electrolyte.

- 5 After the electrolyte is introduced into the well so as to impregnate the portion of the brine stratum surrounding the well bore and the granular material, it is electrolyzed, pressure being maintained upon the electrolyte, if necessary, to prevent it returning to the well while the electrolysis is in progress. Electrolysis is accomplished by applying a suitable potential from the generator 9 between the electrode 5, which makes contact with the granular material in the well bore, and the electrodes 13 and 14 which act as ground connections completing the circuit.

- The voltage, which should be applied to effect electrolysis, depends upon the conductivity of the surrounding earth and the resistance of the ground connections. A sufficient potential is applied to produce a current density in the order of about 15 to 150 amperes per square foot of area of the face of the formation being treated. This area may be calculated from a knowledge of the thickness of the brine stratum and the diameter of the well bore. Other current densities can be used according to the composition of the electrolyte being employed. It has been found that a potential of from about 25 to 200 volts may be required, but these values are merely illustrative.

- The ground connection may be made through metal rods or the like driven into the ground in the vicinity of the well, preferably in moist earth and about half as far from the well head as the depth of the stratum to be treated.

The following are examples of the composition of suitable electrolytes and the current density which ensures the deposition of the metal.

Example 1

Iron plating solution	Concentration, grams per liter
FeSO ₄ (NH ₄) ₂ SO ₄ ·6H ₂ O.....	350
H ₂ SO ₄	0.25
Glue.....	0.5
Current density: 30 amperes.....	

Example 2

Copper plating solution	Concentration, grams per liter
CuSO ₄ ·5H ₂ O.....	200
H ₂ SO ₄	50
Current density: 40-115 amperes.....	

Example 3

Copper plating solution	Concentration, grams per liter
CuSO ₄ ·5H ₂ O.....	200
CH ₃ COOH.....	60
Glue.....	0.5
Current density: 15-40 amperes.....	

Example 4

Copper plating solution	Concentration, grams per liter
CuCN.....	22.5
NaCN.....	34.0
Na ₂ CO ₃	15
Current density: 15 amperes.....	

While it is generally suitable to introduce the electrolyte illustrated above directly into the well and thence into the formation and proceed at once with the electrolysis, in some instances it may be desirable to clear the well bore and force back into the formation any well liquids that may excessively dilute or react with the electrolyte containing the metal ion to be deposited. This can be accomplished by first introducing into the well a neutral aqueous solution of an inorganic salt, such as sodium chloride, which is substantially unreactive with the electrolyte, and then introducing the electrolyte.

The duration of the electrolysis may be varied according to the extent to which it is desired to bring about deposition of the metal ion and may be estimated from the volume and the composition of the electrolyte employed when the magnitude of the electrolyzing current is known.

Ordinarily the solution employed is electrolyzed until the greater portion of the metal ion in the electrolyte has been deposited in the pores of the formation, sealing them and bringing about consolidation. Upon completion of the electrolysis, the electrode is withdrawn from the well and the granular conducting material removed in any convenient manner, as by bailing, before putting the well into production.

In some instances, the well casing may be used as the cathode, as for example, where it is desirable to produce a deposit of metal in the vicinity of the casing in which case it is unnecessary to remove the cathode from the well after the treatment is completed.

By the foregoing method fluid permeable earth and rock, loose or unconsolidated formations not containing oil, can be rendered substantially fluid tight and mechanically strong so that sloughing, shifting, or caving of the formation does not occur. The method has particular advantage in the treatment of oil or gas wells yielding water or brine from a stratum closely adjacent to one yielding oil or gas, because the comparatively high electrical resistance of such formations prevents electrolysis from occurring therein. As a result the water or brine bearing earth is consolidated or plugged without substantially affecting the flow of oil or gas, even though by chance some of the electrolyte used enters these portions of the formation.

Other modes of applying the principle of my invention may be employed instead of those 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.

I therefore particularly point out and distinctly claim as my invention:—

1. In a method of treating an earth or rock formation penetrated by a well bore, the steps which consist in introducing into the well bore and thence into the formation to be treated an aqueous electrolyte comprising a heavy metal ion, and electrolyzing the solution in situ, to deposit the metal from the solution.

2. In a method of treating an earth or rock formation penetrated by a well bore, the steps which consist in introducing into the well bore and thence into the formation to be treated an aqueous electrolyte containing a heavy metal ion, and electrolyzing the solution in situ by passing a direct current between a cathode located in the well bore and a ground connection in the vicinity of the well.

3. In a method of treating an earth or rock formation penetrated by a well bore, the steps which consist in introducing into the well bore and thence into the formation a neutral aqueous solution of an inorganic salt, thereafter introducing into the well bore and thence into the formation an aqueous electrolyte containing a heavy metal ion, and then electrolyzing the solutions in situ to deposit the metal.

- 10 4. In a method of treating an earth or rock formation penetrated by the bore of a well, the steps which consist in introducing into the well bore and thence into the formation to be treated an aqueous solution containing copper cation, 15 and electrolyzing the solution in situ by passing an electric current between a cathode located in the well bore and a ground connection located in the vicinity of the well.

5. In a method of treating an earth or rock formation penetrated by the bore of a well, the

steps which consist in introducing into the well bore and thence into the formation to be treated an aqueous solution containing copper sulphate, and electrolyzing the solution in situ by passing an electric current between a cathode located in the well bore and a ground connection located in the vicinity of the well. 5

6. In a method of treating an earth or rock formation penetrated by a well bore, the steps which consist in introducing into the well bore and thence into the formation to be treated an aqueous solution containing copper sulphate, and applying a potential between a cathode in the well bore and an anode in the surrounding formation sufficient to produce a current having a density at the cathode of from 15 to 150 amperes per sq. ft. of area of the face of the well bore treated. 10 15

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