United States Patent

[11] 3,583,489

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[21] Appl. No. **838,083**
[22] Filed **July 1, 1969**
[45] Patented **June 8, 1971**

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[54] **WELL CLEANING METHOD USING FOAM CONTAINING ABRASIVES**
6 Claims, 3 Drawing Figs.

[52] U.S. Cl. 166/312, 134/7
[51] Int. Cl. E21b 21/00
[50] Field of Search ..... 166/311, 312, 309; 175/69, 71; 134/7, 8, 22—24; 51/317, 318, 319, 320

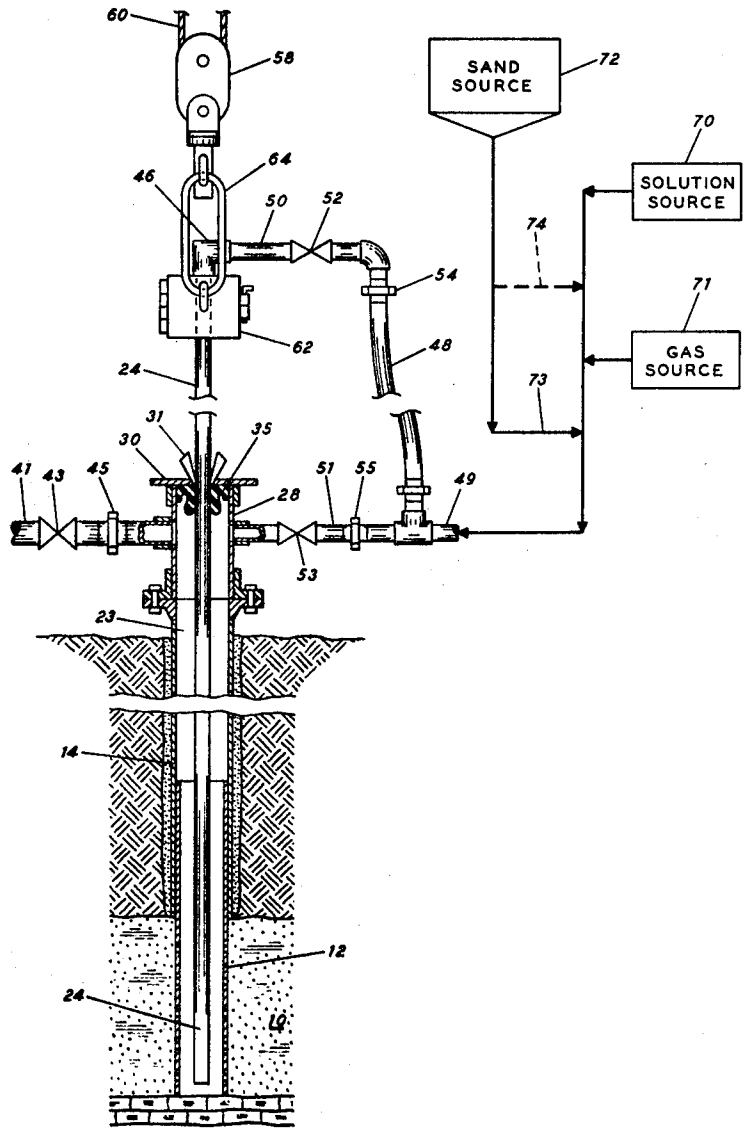
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ABSTRACT: A method of cleaning a well liner by contacting the well liner with a gas-liquid foam having entrained therein a quantity of abrasive particles so as to remove scale and other undesirable material from such liner.



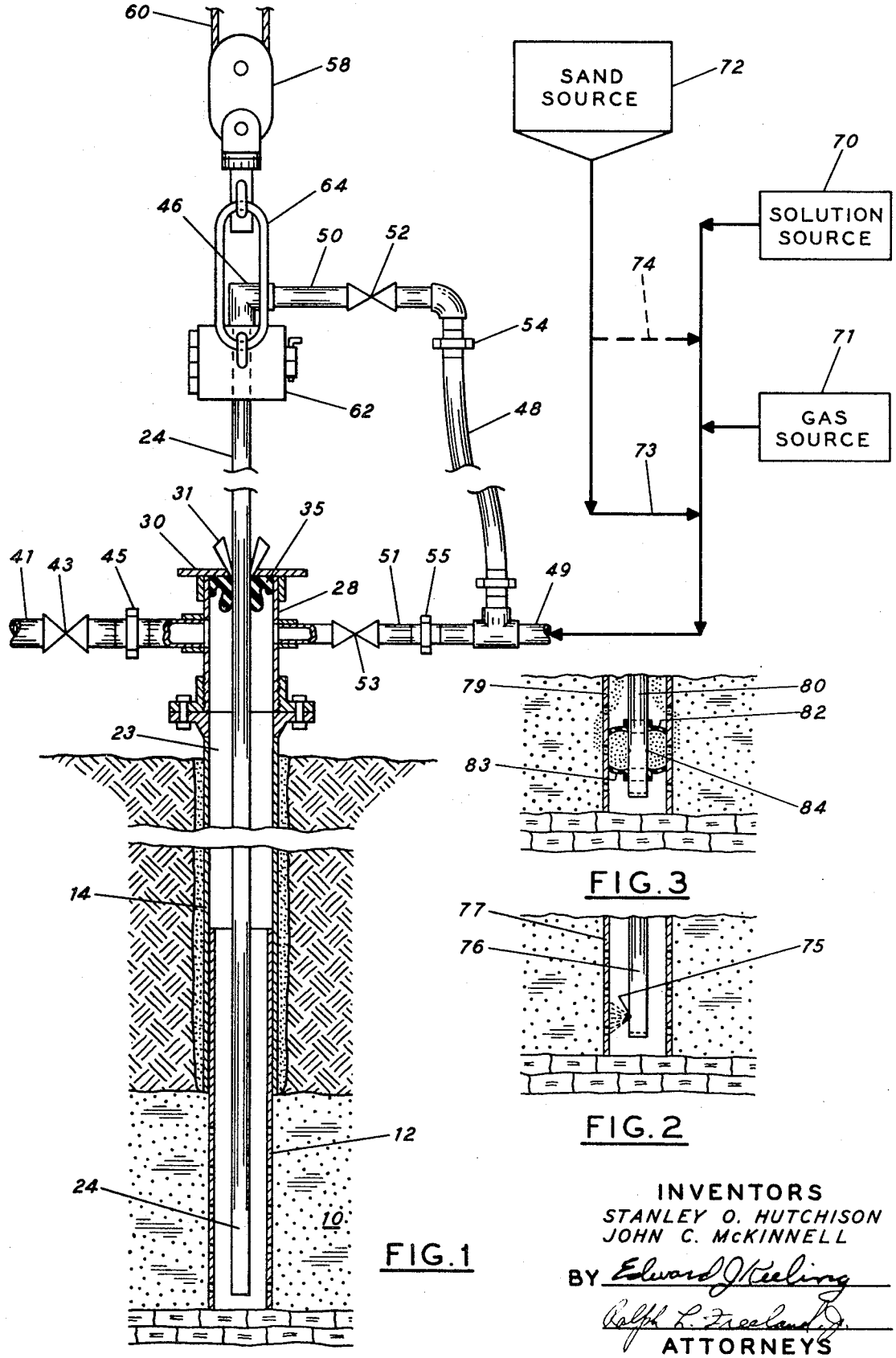


FIG. 1

FIG. 3

FIG. 2

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WELL CLEANING METHOD USING FOAM CONTAINING ABRASIVES

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention is related to the field of inventions disclosed and claimed in copending U.S. applications Ser. No. 704,832, filed Feb. 12, 1968; Ser. No. 720,977, filed Apr. 12, 1968 and Ser. No. 807,766, filed Mar. 13, 1969.

BACKGROUND OF THE INVENTION

This invention relates to a method of utilizing abrasive particles entrained in foam for cleaning an oil well liner or the like and, more particularly, this invention provides for contacting a well liner including the slots thereof with a foam having entrained therein a plurality of small angular particles at a velocity sufficient to abrade scale and other undesirable material from such a well liner.

As is known in the art, oil is produced from underground formations penetrated by a well. A well liner is usually placed adjacent a producing formation and oil is produced through slots or perforations in the well liner. Such liners are almost always used when the oil-bearing formation tends to be unconsolidated. The well liner holds back the unconsolidated material and allows oil to be produced through the slots or perforations. As time goes by and such production occurs, however, the well liner often becomes plugged by organic and inorganic material such as asphaltene deposits and scale. As plugging occurs, the amount of oil which can enter the well through the liner for production therefrom is drastically reduced. Many methods have been used heretofore to alleviate this problem. Thus many mechanical scratching devices have been used to scratch or scrape off the scale and other deposits. In addition, many washing techniques using solvents have also been used to attempt to clean up a well liner. For a number of reasons, none of these methods have been entirely satisfactory.

SUMMARY OF THE INVENTION

The present invention is directed to providing a method for cleaning well liners utilizing a foam circulating material having abrasive particles entrained therein. The liner is contacted by the particle-containing foam at a velocity sufficient to abrade and remove undesirable material from such liner and to open the slots or perforations in it. After contacting the liner with such particles, the particles and any scale or other material are circulated from the well and the well is ready for additional production through the cleaned liner.

BRIEF DESCRIPTION OF THE INVENTION

The present invention provides a method for removing undesirable material such as scale or asphaltene deposits from a well liner by forming a foam having entrained therein a quantity of abrasive particles and injecting such foam containing the particles down a well and contacting a well liner with the foam and particles at a velocity sufficient to remove the undesirable materials from the well liner. In accordance with the invention, a liquid-gas foam is formed by contacting a suitable liquid, such as an aqueous surfactant solution, with a gas, such as air, to form a foam suitable for use in a well. Abrasive particles are added to the foam and the foam having the particles entrained therein is injected by suitable means, such as a tubing string, down a well to a position adjacent a well liner located therein. The foam is then directed against the well liner and the particles contained in the foam assist in abrading undesirable materials from the liner to open the slots or perforations of the liner. Such undesirable material and used particles are circulated up the well annulus by additional foam which is injected down the tubing and circulated up the well annulus. When the foam having the particles entrained therein has cleaned the liner to a desired degree, the foam is circulated out of the well and the well is ready for additional production.

OBJECTS OF THE INVENTION

A particular object of the present invention is to provide for cleaning a well liner by contacting such liner with foam having abrasive particles contained therein at a velocity sufficient to abrade and remove undesirable material from such liner and from the well. Further objects and advantages of the present invention will become apparent from the following detailed description read in light of the accompanying drawing which is made a part of this specification.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view of the preferred embodiment of apparatus assembled in accordance with the invention for use in circulating an abrasive foam through a tubing string to a well liner located in a well, FIG. 2 is a view of an alternative embodiment of apparatus for directing foam from a tubing string to a well liner, and FIG. 3 is a view of another alternative embodiment of apparatus for directing foam through the slots of a well liner.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Refer now to the drawing and to FIG. 1 in particular where the preferred embodiment of apparatus assembled in accordance with the present invention is illustrated. FIG. 1 shows an elevation view, partially in section, of a well penetrating an oil-producing formation **10**. The portion of the well adjacent the producing formation **10** contains a perforated or otherwise suitably slotted well liner **12**. The well liner **12** is connected by suitable means to a string or casing **14** which extends from the upper portion of the producing formation through the earth to the surface. The well liner is placed during completion of the well and oil from the producing formation **10** enters the well through the slots in well liner **12**. The oil is moved to the surface by suitable means such as an oil well pump. After many years of such production, the well liner tends to accumulate scale and other undesirable deposits, and often the slots or perforations of the liner become partially or completely plugged. This results in drastically reducing the amount of oil which can enter the well through the liner. When such plugging occurs, the method of the present invention may be utilized to assist in cleaning the liner so that additional production may be obtained from the well.

In accordance with the preferred embodiment of the invention, a tubing string **24** is positioned in the well through a suitable wellhead **28**. The particular size and type of tubing string will depend on the particular well being serviced. Both segmented tubing strings and continuous tubing strings are suitable for use in the present invention. When using a segmented tubing string, slips **31** are positioned on a slip base plate **30** which is connected to the top of the wellhead **28**. The slips **31** are used to hold the tubing string during make up of the string. Stripper rubber **35** is used in the wellhead **28** to prevent leakage of foam past the tubing string where it enters the wellhead. The lower end of the tubing string **24** is positioned adjacent the well liner **12** which is to be cleaned. The tubing string **24** and the well liner **12**—well casing **14** form a well annulus **23**. Thus a path for circulating foam through the well is provided in the interior or tubing string **24** and well annulus **23**. A blooie line **41** is connected through valve **43** and connection **45** to the well annulus **23** for exhausting foam therefrom. The tubing string may be raised or lowered in the well during foam circulation by hoist means which include a traveling block **58** which is moved by suitable cable **60**. A conventional hoist means or derrick, not shown, is used to move the traveling block up and down. The elbow joint **46** which is connected to the upper end of the tubing string **24** is held in an elevator **62** which is connected by suitable links **64** to the traveling block **58**. Thus when the traveling block **58** moves up or down the tubing string and the apparatus connected thereto are also raised or lowered.

Foam is formed by mixing together a surfactant solution and a gas. The foam must be a relatively stable foam capable of holding the abrasive particles. Thus a suitable foamable solution source 70 and a gas source, such as an air compressor 71, are located on the surface. Suitable piping extends from these sources to a common conduit. This conduit 49 is connected to both the tubing string 24 and the well annulus 23. The conduit is connected to the tubing string 24 through flexible conduit 48, hammer connection 54, conduit 50 and elbow joint 46. Valve 52 is used to control flow to the tubing string. The conduit 49 is connected to the well annulus 23 by means of conduit 51 and connection 55 via wellhead 28. Valve 53 controls flow to the well annulus. Thus foam may be circulated in a normal manner, i.e., down the tubing and up the annulus, or foam circulation may be reversed, i.e., down the annulus and up the tubing. Operating conditions may occasionally dictate that the abrasive foam be reciprocated up and down past the liner to obtain best results. This is accomplished by reversing foam injection sequentially from tubing to liner.

An abrasive material, such as sand, is provided from sand source 72. The sand is preferably added to the foam after it has been formed through line 73. Alternatively, the sand may be added to the liquid prior to forming the foam by alternative sand line 74. The preferred abrasive material is sand. However, other particulate abrasive material such as angular steel shot may be used. The material should be of the type used in sand blasting operations to obtain maximum descaling results. The size of the particles may vary. However, sizes in excess of one-eighth inch are not normally used.

The foam is formed by bringing a foamable mixture of a surfactant solution and gas together. The preferred foam is an aqueous-air foam. Water and a detergent and if desired suitable stabilizing agents are mixed to produce a foamable mixture. Suitable foam and the specific surfactants which go into the foamable mixtures that make them are described in detail in the above-noted application Ser. No. 704,832, filed Feb. 12, 1968 and now U.S. Pat. No. 3,463,231. The disclosure of such application is incorporated herein by reference. A preferred foam for use in the present invention is a C_{11}—C_{14} alkylbenzene sulfonate (ABS) preferably the ammonium salt. The ABS should be added to water to foam a foamable solution in an amount of between 0.5 to 1.0 parts by weight per 100 parts water. The foamable solution is mixed with air in a gas to liquid volume ratio of between 3 to 50 SCF to 1 gallon. Superior results are obtained when the foam is carrying abrasive particles when the gas/liquid volume ratio is between 10 to 20 SCF to 1 gallon.

As noted above, the abrasive material which in the preferred embodiment is sand, is preferably added to the foam after it has been formed through line 73. Suitable means for introducing the sand into the foam conduit are well known in the art. A screw extruder for introducing the particulate material into the pressurized foam conduit is one such suitable means. If it is desired to add the sand to the foamable solution prior to forming the foam, the sand may be carried in a liquid slurry and injected into the solution line using a pressure vessel such as is used in sand and gravel packing. Although particular local conditions of a well may dictate otherwise, it is usually preferred to entrain in the foam between one-half to 6 pounds of sand per gallon of foam solution. A range 2 to 4 pounds of sand per gallon of foam solution is most preferred.

In the preferred form of the invention, the foam having the abrading sand entrained therein is injected down the well through tubing string 24. Thus valve 52 on line 50 is opened to admit foam to the tubing and valve 53 on line 51 is closed to prevent foam from entering the well annulus. Valve 43 on blooie line 41 is opened so that foam may be exhausted from the well annulus at the surface. The abrasive foam is directed out the end of tubing string 24 and is circulated up the well against well liner 12 to remove scale and undesirable material therefrom. Then foam is circulated at a velocity sufficient to abrade the scale and the other undesirable material from the well liner and to open the slots or perforations in the liner. In most applications a velocity of at least 25 feet per minute is required to provide a minimum abrasive action. It is highly preferred to circulate the foam at a velocity of at least 300 feet per minute to obtain improved results. The sand and the scale which is removed from the well liner and the slots thereof are circulated up the well annulus 23 and dumped at the surface through blooie line 41.

DESCRIPTION OF ALTERNATIVE EMBODIMENTS

FIG. 2 shows an alternative form of directing the abrasive foam against the well liner. Thus a small opening 75 is formed in the lower end of a tubing string 76 and the foam containing the abrasive sand particles is directed through one or more such openings against the well liner at substantially right angles thereto to abrade and clean it. The foam and any material removed from the liner 77 are circulated up the well annulus as described above.

In FIG. 3 another alternative embodiment of apparatus for use in the method of the invention is shown. In this embodiment wash cups 82 and 83 are utilized to isolate one or more perforations in a liner from the rest of the well annulus. Foam is then injected into this isolated portion of the annulus through a suitable opening 84 in the tubing string 80. The wash cups 82 and 83 cause the foam to be forced through the perforations in the liner 79 adjacent thereto and to move behind the liner and back into the well annulus through the slots above the uppermost wash cup 82. This has the effect of cleaning and abrading the slots or perforations and provides a beneficial cleaning action. It is evident that the method of the present invention may be utilized in combination with other types of washing devices and scratching devices. Such use is, of course, within the scope of the invention.

While preferred embodiments of the invention have been shown and described, it is evident that modifications thereof can be made by one skilled in the art without departing from the scope of the invention.

I claim:

1. A method of cleaning a well liner comprising the steps of forming a foam having entrained therein a quantity of abrasive particles, injecting said foam containing said particles down a well and contacting a well liner with said foam and said particles at a velocity sufficient to abrade scale and other undesirable materials from said well liner.

2. A method of claim 1 further characterized in that the abrading particles are sand having a diameter of less than one-eighth of an inch.

3. The method of claim 1 further characterized in that the foam containing said particles is circulated past said well liner at a velocity of at least 25 feet per minute.

4. The method of claim 1 further characterized in that at least a portion of the foam containing said particles is jetted against the liner at substantially right angles.

5. The method of claim 1 further characterized in that at least a portion of said foam is directed through slots of the liner.

6. A method according to claim 1 wherein from one-half to 6 pounds of sand per gallon of foam solution is added to said foam.