

[54] **WELL METHODS FOR SAND BRIDGE REMOVAL USING SMALL DIAMETER TUBING**

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Related U.S. Application Data

[62] Division of Ser. No. 873,932, Nov. 4, 1969, abandoned.

[52] U.S. Cl. **166/311, 166/315**

[51] Int. Cl. **E21b 21/00, E21b 37/00**

[58] Field of Search **166/305, 311, 314, 315; 171/134, 137**

References Cited

UNITED STATES PATENTS

3,722,594 3/1973 Smith et al. 166/305 R

3,346,045 10/1967 Knapp et al. 166/315
3,100,528 8/1963 Plummer et al. 166/305

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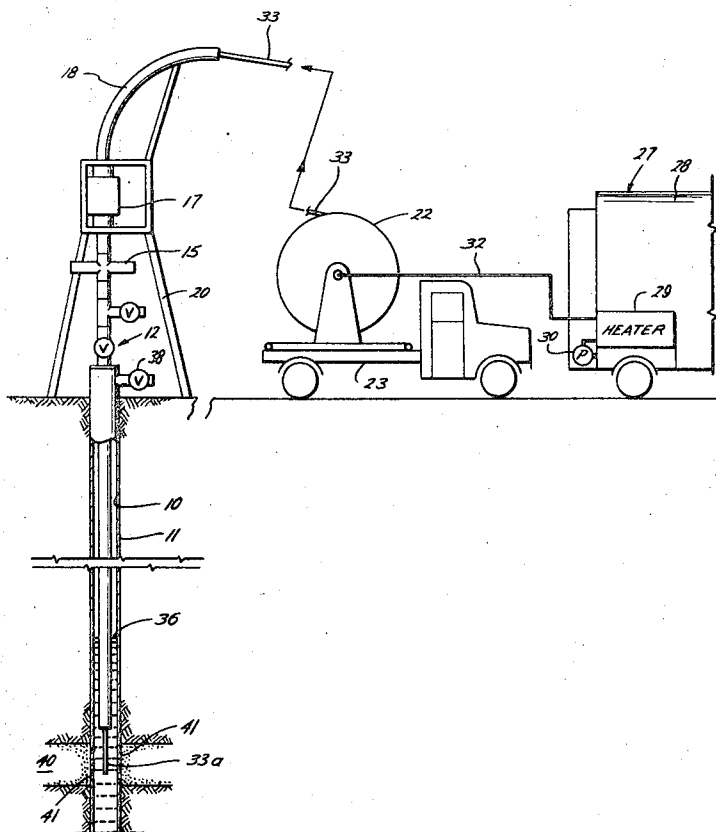
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[57]

ABSTRACT

Well methods using small diameter tubing introduced into and withdrawn from the well by an injector apparatus, for removing sand bridges from wells. The tubing is introduced into and withdrawn from the well by the injector from a tubing-holding reel and introduction of an inert gas such as nitrogen through the small diameter tubing breaks up the sand bridge and carries the sand out of the well in gasified suspension. Other gases may also be introduced through the small diameter tubing for sand bridge removal. The methods are especially suitable for use in petroleum wells, but may if suitable be used in water wells.

4 Claims, 4 Drawing Figures



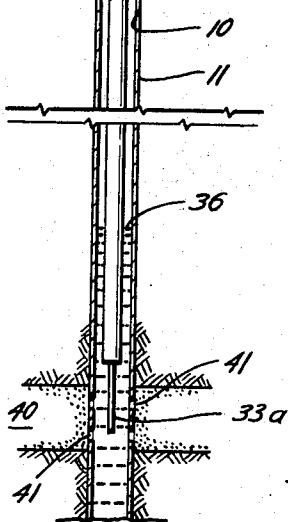
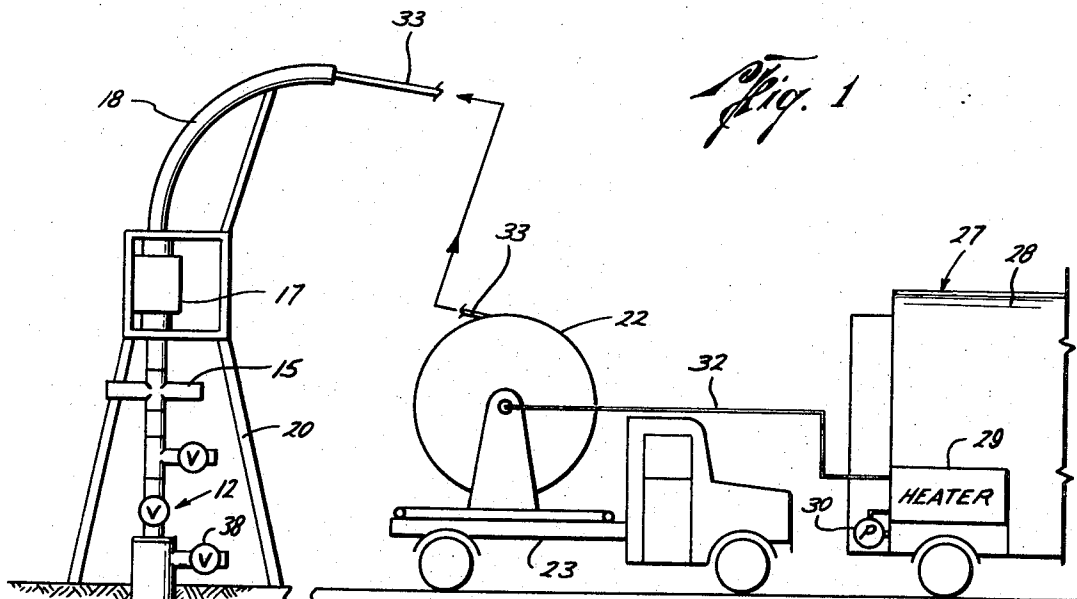


Fig. 1A

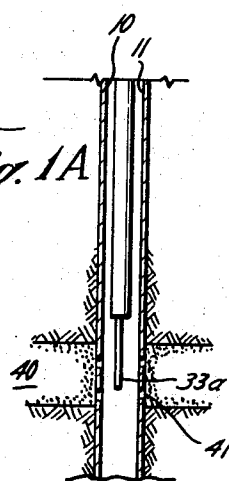


Fig. 1B

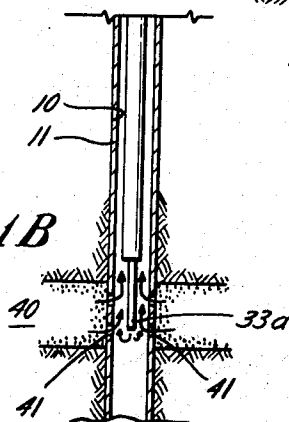


Fig. 2

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WELL METHODS FOR SAND BRIDGE REMOVAL USING SMALL DIAMETER TUBING

This application is a division of application Ser. No. 873,932, filed Nov. 4, 1969 and now abandoned, and entitled "Well Methods Using Small Diameter Tubing."

BACKGROUND OF THE INVENTION

Injection equipment has relatively recently become available through use of which tubing strings may be introduced into and withdrawn from wells. Such equipment has been developed for use with tubings of three-fourths to 1 inch diameter size. Apparatus has not been available for introduction of steel tubing of smaller than three-fourths inch diameter. However, the equipment which is available may be converted for introduction of the smaller size tubing. According to this invention, one-half to three-fourths inch outside diameter steel tubing is the preferred size for use, although larger or smaller sizes may be used. According to this invention, use of smaller inexpensive tubing is feasible for introduction of gases into wells for various treatment purposes.

Exemplary of the types of tubing injection apparatuses which are available are those disclosed in Patent Nos. 3,182,877, 3,285,485, 3,258,110, 3,330,531, and 3,379,393. Such apparatuses have not been developed or used in connection with methods such as those herein described.

A primary object of the invention is to provide methods for performing well operations using small diameter tubings injectable and withdrawable from a well. Other objects of the invention are to provide methods for sand bridge removals.

The methods afforded according to the invention are very economical. The small diameter tubing used is of relatively low cost and may be used for long periods of time in a single well or may be used over and over in the same or different wells, as the apparatus employed in connection with the methods is entirely portable. The methods avoid the use of workover rigs and tools where the same would otherwise be required. The methods may be performed very rapidly without lengthy shut downs or delays being necessary.

Other objects and advantages of the invention will appear from the detailed descriptions of preferred embodiments of the invention and from the accompanying drawings illustrating the methods.

BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. 1 is a schematic showing of a displacement method of preferred form according to the invention, and an apparatus useful therewith.

FIGS. 1A - 1B are partial schematic showings illustrating, respectively, progressive fluid displacement and backwash steps of the method of FIG. 1.

FIG. 2 is a partial schematic showing illustrating sand bridge removal according to the invention.

DESCRIPTIONS OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1 of the drawings, a well 10 has therein one or more casings 11 lining the well hole, and may have other pipes, casings, or tubings therein as required for the purposes of the well, all as well known in the art. Above the well, there is provided a well head

12 which may be of any form employed in the art, the well head including devices for suspending pipes in the well, valves for controlling well pressures, and valve-controlled outlets for providing for flow to and from the pipes in the well. Above the well head, there is a blowout preventer 15, or other device through which a pipe string may be run without leakage of pressures from within the well. The blowout preventer, or seal, about the small diameter tubing may take the form of a hydraulically activated rubber or elastomeric pack-off.

Above the blowout preventer or packoff there is disposed a tubing injector device 17 which may be of any of the forms available in the art, but usually modified for use with smaller than conventional size tubing, and capable of rapidly running the tubing into a well and withdrawing the tubing from the well. Injector 17 may be modified for use with, for example, one-half inch steel tubing. The tubing lengths are welded together at their ends and have no exterior projections. Above the injector 17 there is provided a curved tubing guide 18. The tubing guides are usually provided with a plurality of rollers rotatable between side guide elements to guide the tubing through a curve or bend when moved longitudinally. Apparatus of the type shown and described in the drawings, of Bowen Tools, Inc., is shown and described in *THE OIL AND GAS JOURNAL*, Jan. 13, 1964, at pages 72-73. Other equipment for the same purposes is produced by Brown Oil Tools, Inc.

The tubing injector is supported by a frame 20 which has legs resting upon the ground about the well head. The tubing is stored on a reel 22, and the reel is equipped so that introductions of fluid to and from the tubing may be made through the reel hub, while all or part of the length of the tubing is wound on the reel or unwound from the reel and injected into a well. The reel 22 is customarily mounted upon a skid unit which may be set on the ground and may be carried on a truck 23 so as to be movable from job to job. As shown in FIG. 1, a liquid nitrogen and a heater 29 to which liquid nitrogen is pumped by a pump 30, pressured nitrogen gas being obtained by this cryogenic operation. Liquid nitrogen is first pressured by pump or compressor 30 and is then passed to heater 29 for vaporization whereupon high pressure nitrogen gas is delivered through conduit 32 to the tubing 33 by way of the hub flow connections of reel 22. Pressured gas exceeding 10,000 pounds per square inch may be obtained in this manner. Other gas may be used for some methods, but nitrogen is safer because of its non-combustible, inert, nature.

In most cases the well 10 will contain a liquid which extends to a level 36 in the well. For displacement of the liquid from the well, the end 33a of tubing 33 is injected into the well by injector 17 to a position somewhat below liquid surface 36. The liquid in the well may be of any form, such as drilling fluid, oil, water, or the like. As the lower end 33a of tubing 33 moves downwardly in the well gaseous nitrogen is continuously introduced at a rate so as to purge and circulate incremental portions of the liquid upwardly from the well through the annulus of a well pipe such as casing 11, through which the tubing 33 is shown introduced. The liquid in the well may be circulated upwardly through any flow passage in the well through which the gas introduced has access. The liquid circulated out of the well is evacuated through an outlet 38 of the well

head. Once the lower end of tubing 33 reaches the bottom of the well, substantially all liquid in the well will have been circulated from the well by the procedure described. Gas introduction may be continuous or discontinuous. It may at times be found beneficial to introduce gas non-continuously and to circulate liquid from the well intermittently when the gas is being introduced. The pressure of gas introduced is adjusted to be sufficient to efficiently force the fluid from the well.

After the fluid has been removed from the well, a pressure draw down exists on the reservoir at the lower portion of the well, the reservoir being denoted by reference numeral 40. Suitable casing perforations 41 are provided at the area of formation or reservoir 40 so that fluid communication from the well may exist. By pressure draw down as mentioned above, it is meant that the pressure within the well is reduced so as to be lower than the reservoir pressure.

The nitrogen gas introduced through tubing 33 may be made to flow outwardly from the well through perforations 41 into the reservoir by closing the upward flow path at the top of the well. When the inert gas pressure within the well is released, the nitrogen which has penetrated the reservoir formation returns to the well and cleans materials such as formation fines, precipitates, scale, shale, contaminants, sand, drilling fluids, filtrates, reservoir fluids, fluid loss control agents, or any chemical, fluid or solid that may be present in the reservoir through the perforations to be carried to the surface and out of the well.

A pressure differential is created with the aid of nitrogen and is essential for removing the hydrostatic column of fluid that restricts reservoir fluid entry to the formation face or well bore perforations. If necessary or desired, nitrogen may be continuously or intermittently introduced through tubing 33 as the tubing is withdrawn upwardly out of the well so that continual evacuation of fluids above the lower end of the tubing from the well is performed. FIG. 1A illustrates progressive fluid removal from a well, and FIG. 1B illustrates the backwash step with return of nitrogen from the formation and up through the well.

As has been stated, use of small diameter tubing strings, smaller than heretofore contemplated in connection with tubing injection equipment, has been found to be advantageous. The tubing lengths are welded together end to end so that the tubing is smooth and uniform inside and outside. The tubing sizes contemplated are sizes up to three-fourths inch nominal tubing sizes, or larger. While one-half inch tubing or smaller tubing is not usually practical for use in conveying liquids into and out of wells because of the poor flow rates and high pressure drops encountered, one-half inch tubing or even smaller tubing is adequate for flow of high pressure gases into (and out of) wells for the purposes of this invention. For example, it has been found that the pressure drop through 10,500 linear feet of one-half inch tubing at a flow rate of 485 cubic feet of gas (N₂) per minute is about 6,350 pounds per square inch. But since gas pressures upwards of 10,000 pounds per square inch are available, this pressure drop is not excessive. If water were used instead of gas, pressure drops of the order of 15,000 psi would be encountered. For the methods herein described, gas input rates exceeding 200 cubic feet per minute will not normally be required, but gas input rates as high as 600 cubic feet per minute may be employed with one-half

inch tubing without excessive pressure drops as would occur if water were used.

The cost of one-half inch tubing is considerably smaller than the costs of three-fourths and 1 inch tubing heretofore used with tubing injection apparatuses, and the tubing reels for one-half inch tubing are smaller and less costly.

Referring now to FIG. 2 of the drawings, there is shown the method for removal of sand bridges, and the like, from well. The tubing 33 is lowered into the well 10 by injector 17 to adjacent the upper level of the sand bridge 43. Nitrogen introduction through tubing 33, with lowering of the tubing further down into the well, agitates and fluidizes the sand of the sand bridge formation and circulates it from the well with the nitrogen gas which passes upwardly through the annulus between the well wall 44 and pipe 33. The tubing 33 is injected to the obstruction and with the aid of the nitrogen passed downwardly through the tubing, the sand is washed from the static level and is circulated up the annulus to the surface of the ground and removed from the well. Expansion of the gas from the lower end of the small diameter tubing 33 agitates the sand and initiates the breaking up of the sand obstruction, thereby eliminating the need for a drill bit or other tool specifically designed to remove sand from the well. The sand is removed progressively from the upper end of the sand obstruction downwardly.

As will be realized, various combinations of the described procedures may be practiced in order to achieve the desired treatment of the well, and the exact procedural combinations are exemplary of the various combinations of procedure steps which may be used to gain the benefits of use of the small diameter tubing strings. It will of course be realized that the one-half inch tubing strings may be injected, withdrawn, and re-injected, as necessary to the object at hand.

While preferred embodiments of the invention have been shown in the drawings, and described, many modifications thereof may be made by a person skilled in the art without departing from the spirit of the invention, and it is intended to protect by Letters Patent all forms of the invention falling within the scope of the following claims:

We claim:

1. Method for sand bridge removal from wells, comprising running a small diameter tubing down a well by means of a tubing injector apparatus, said tubing injector apparatus including a reel for storing the tubing wound thereon and having gas entrance means to said tubing at the hub of said reel, said tubing being run to adjacent the upper end of a sand bridge in the well and lowered through the thickness of the sand bridge while continuously introducing said pressured gas therethrough whereby said gas agitates and fluidizes the sand of the said bridge to break up the sand bridge and circulate the sand from the well.

2. Method according to claim 1, said pressured gas being nitrogen.

3. Method according to claim 1, said well having liquid material therein above the upper end of the sand bridge, and including introducing pressured gas through said tubing while said tubing is being run to adjacent the upper end of the sand bridge to gasify the liquid material and circulate same from the well prior to said sand bridge removal.

4. Method according to claim 3, said pressured gas being nitrogen.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,791,447

Dated February 12, 1974

Inventor(s) ARTHUR W. SMITH, ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 40, cancel "and" and insert -- tank truck 27 has --
Column 3, line 25, change "precipitats" to -- precipitates --
Column, 3, line 62, change "istead" to -- instead --
Column 4, line 10, change "well" (first occurrence) to -- wells--
Column 4, lines 35-36, cancel "one-half inch".

Signed and sealed this 13th day of August 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

Disclaimer

3,791,447.—*Arthur W. Smith, Ray A. Plummer, and Charles Wayne Johnson*, Houston, Tex. WELL METHODS FOR SAND BRIDGE REMOVAL USING SMALL DIAMETER TUBING. Patent dated Feb. 12, 1974. Disclaimer filed Jan. 2, 1976, by the assignee, *Big Three Industries, Inc.*

Hereby enters this disclaimer to claim 1 of said patent.

[*Official Gazette February 1, 1977.*]