Jan. 10, 1939. C. W. SAVITZ 2,143,251

METHOD OF AND EQUIPMENT FOR ACIDIZING WELLS

Filed June 21, 1938

166/42

Fig. 1

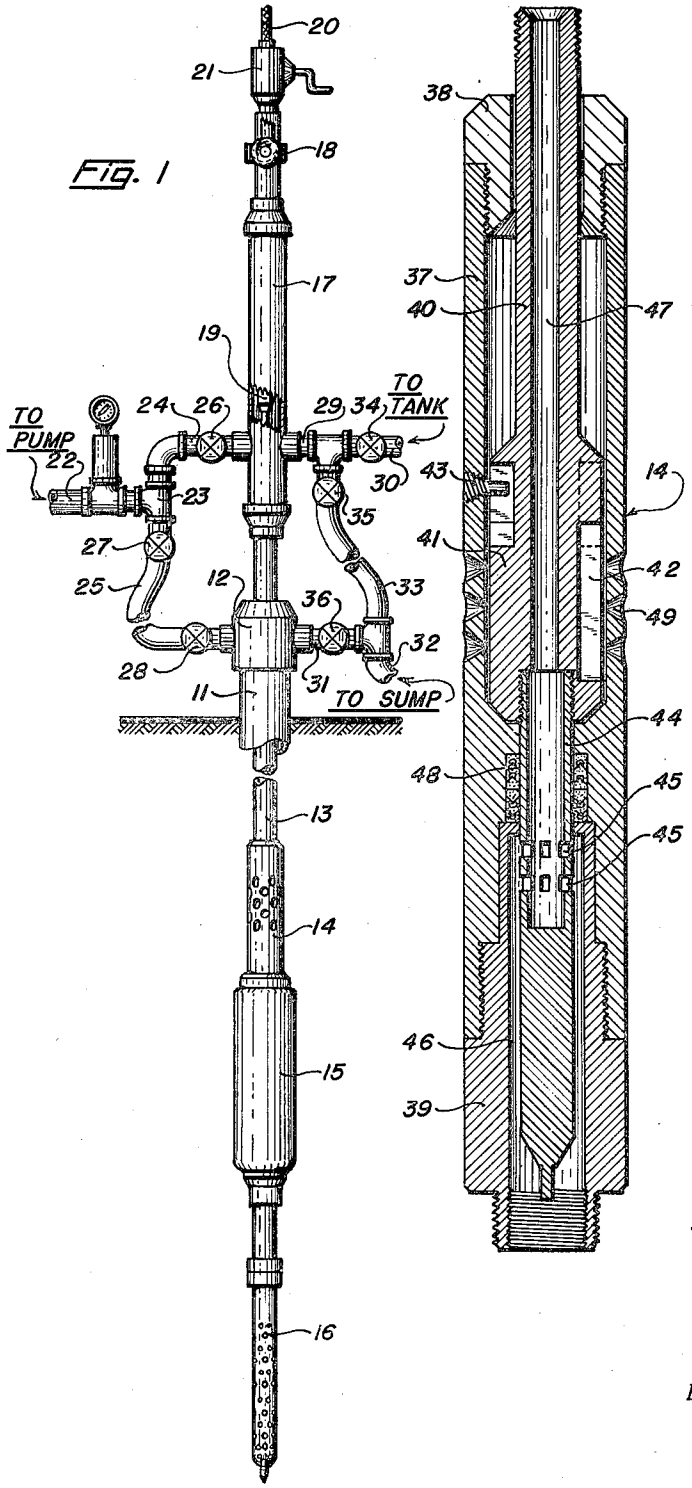

Fig. 2

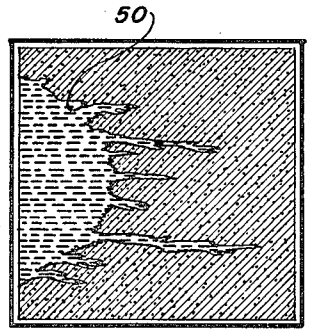

Fig. 3

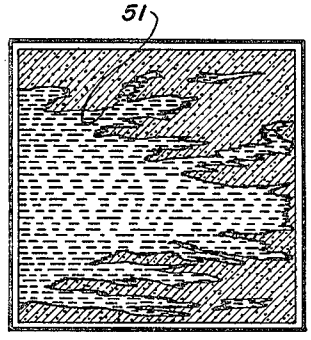

Fig. 4

103.

INVENTOR.
Christian W. Savitz.
BY Earl Babcock.
ATTORNEYS.

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METHOD OF AND EQUIPMENT FOR ACIDIZING WELLS

Christian W. Savitz, Los Angeles, Calif., assignor to Halliburton Oil Well Cementing Company, Duncan, Okla.

Application June 21, 1938, Serial No. 214,897

6 Claims. (Cl. 166—21)

This invention relates to the acidizing of oil wells and more particularly to a method of subjecting the formation of a well to a multiple cycle method of acidizing and to equipment suitable for use in such a method.

It is sometimes desirable in the acidizing of an oil well to withdraw the acid and pump in a new supply. When the acid is traveling at too slow a rate of speed into the formation, regardless of the pressure thereon, the formation is not effectively treated. The portion of the acid which is in contact with the formation has become partially or wholly spent and it forms a separating liquid between the unspent portion of the acid and the formation. With a faster rate of travel it may correctly be assumed that a tapered channel is being formed with the larger end of the channel nearest to the well bore. It is of course desirable to have the acid penetrate as far as possible from the well bore and if the acid is not traveling at a fairly fast rate of speed the bore created by reaction of the acid with the formation has a large taper but short length and the acid penetrates less distance. If this acid can be removed from the formation and new acid supplied thereto it will have a chance to start working quickly at the point where the old or spent acid ceased reacting. In some cases it may be desirable to remove the spent acid and supply new acid several times before obtaining great penetration. Where a chemical agent is added to the acid which tends to increase its penetrating properties, as is well known in the art, this problem is not so pronounced but in some cases does nevertheless exist.

It is difficult and dangerous and practically impossible to remove unspent acid from a tubing in an oil well by swabbing. Therefore, unless the acid can be brought out of the well due to natural pressures in the formation it is very difficult to remove it by ordinary means. In accordance with the present invention a special apparatus has been devised for removing acid which has been pumped into a formation through tubing.

Accordingly, it is one object of the invention to devise a novel method of acidizing an oil well by a multiple cycle process in which fresh acid may be supplied to the formation to be treated as many times as desired.

It is a further object of the invention to devise a method of multiple cycle acidizing of the formation of a well which is safe in operation and which permits the cycles of the process to be carried out rapidly and effectively.

It is still a further object of the invention to devise equipment for use in the acidizing of oil wells by means of which the acid can be conveyed into and out of the formation safely and expediently.

One element of the equipment forming a part of the present invention is a circulating valve which may be used for other purposes. This circulating valve per se is disclosed and claimed in the co-pending application of Christian W. Savitz, Serial No. 212,054, filed June 6, 1938, for "Circulating valves".

Other objects and advantages of the invention reside in certain novel features of the method and apparatus as will be apparent from the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a view in side elevation of a well head and apparatus adapted to be lowered into a well and illustrating preferred equipment for carrying out the principles of the present invention;

Figure 2 is a view in vertical cross-section of a circulating valve used in the arrangement of Figure 1;

Figure 3 is an imaginary view of the formation of a well during the process of acidizing same; and

Figure 4 is an imaginary view of the formation after it has been subjected to several cycles of fresh acid in accordance with the present invention.

Referring to the drawing in detail and first to the showing of Figure 1, it will be seen that the casing of a well is there shown at 11, the casing being provided with a head 12. Within the casing, tubing 13 is placed, this tubing extending down into the well to some point beneath the casing shoe (not shown in the drawing) and being provided at its lower end with a circulating valve assembly 14, a packer 15 of any suitable type and a perforated anchor pipe 16 through which acid may be supplied to the formation of the well which is to be treated.

In the drawing the packer 15 is illustrated as of the wall type. If the packer is to be set in the lower portion of the casing a hook-wall packer may be employed, and if the packer is to be set into a rat hole or into a hole of smaller diameter than the casing a cone packer may be employed.

The upper end of the tubing 13 above the casing-head 12 is connected to an enlarged section of pipe 17 which is called a lubricator, and this section of pipe is in turn connected to the elevators 18 of the drilling rig so that the tubing may

be raised and lowered through the casing 11 and casinghead 12. It will be understood that the casinghead 12 is of such type that a seal is maintained between the casing and the tubing therein.

As partially shown in Figure 1 a swab 19 may be run through the tubing, this swab being pulled up into the lubricator 17 when not in use. The swab may be of any known type and is supported by means of a wire line or cable 20 which passes through a wire line oil saver 21 of known type mounted on top of the lubricator 17.

To carry out the multiple cycle acidizing process conduits are connected both to the tubing and to the casing as illustrated in Figure 1. The connections illustrated show the preferred arrangement but the method can of course be carried out with connections other than those illustrated. It is preferable to connect the pump of the truck in such a way that fluid may be forced into the well therefrom either into the casing 11 or into the tubing 13. Thus, the conduit 22 which is connected to the pump on the truck is connected by T-connection 23 to conduits 24 and 25. Conduit 24 which contains the valve 26 is connected to the lubricator 17 and hence to the interior of the tubing 13. Conduit 25 contains the valves 27 and 28 and is connected to the casinghead 12 so as to supply fluid to the annular space between the tubing 13 and the casing 11. Due to the fact that in certain operations the tubing 13 must rotate within the casing 11, the conduit 25 must be flexible and of such length to permit the desired amount of rotation.

It is also desirable at certain phases of the operation of the equipment to discharge fluids from either the casing 11 or the tubing 13 either into the acid tank or to the sump of the well. Connections for this purpose may be illustrated, there being a conduit 29 connecting the tubing 13 to the conduit 30 which is connected to the tank and a conduit 31 connecting the casinghead 12 to the conduit 32 which leads to the sump. The conduits 30 and 32 are connected to each other by means of a flexible conduit 33 similar to the conduit 25 mentioned above, and valves are placed in the discharge arrangement as shown at 34, 35, and 36.

With the connections at the well head as illustrated it will be seen that any desirable circulation can be effected. Fluid can be pumped either into the tubing or into the casing and can be discharged from either the tubing or the casing into the acid tank or into the slush pit or sump merely by manipulation of the valves.

The circulating valve 14 of Figure 1 is shown in detail in cross section in Figure 2.

The circulating valve assembly includes an outer cylindrical member or sleeve 37 to which a guiding and lifting member 38 is screw threaded at the upper end and to which a coupling and packing member 39 is connected at the lower end. Within this sleeve 37 a mandrel 40 is mounted, this mandrel being screw threaded at its upper end and connected to the tubing 13 as illustrated in Figure 1.

At its lower end the mandrel 40 is provided with an enlargement 41 which provides means for transmitting force from the tubing to the sleeve 37. This enlargement also provides means for controlling relative movement between the mandrel 40 and the sleeve 37. The enlargement 41 is provided with a number of J-slots 42 and the sleeve 37 is provided with a number of pins 43 which project into the slots 42. The pins 43 normally occupy the horizontal portions of the J-slots 42, but upon the mandrel 40 being lifted and rotated to the left as viewed from the top in Figure 2, the slots travel relative to the pins and the pins are in the longitudinally extending portions of the J-slots, at which time the mandrel may be raised and lowered with respect to the sleeve 37.

Beneath the enlargement 41 and the control means just described the mandrel has a depending portion or sleeve 44 which is provided with openings 45 substantially midway of its length, the sleeve 44 being closed at its lower end. With the parts in the position shown in Figure 2 the sleeve 44 extends into the bore 46 of the member 39, and since this bore is of a larger diameter than the diameter of the sleeve 44 fluid may flow from the tubing through the bore 47 of the mandrel 40 and through the sleeve 44 and ports 45 into the bore 46 and on downwardly and outwardly through the perforations in the anchor pipe 16 shown in Figure 1. Upon the mandrel 40 being raised with respect to the sleeve 37 the ports 45 in the sleeve 44 move upwardly through the packing 48 and prevent the flow of fluid as just described, since the lower portion of the sleeve 44 seals off the top of the bore 46. At this time, however, the ports 45, being above the packing 48, connect the bore 47 of the mandrel 40, and hence the tubing 13 to the exterior of the sleeve 37 flow in this manner being through openings 49 provided in the sleeve 37.

It will thus be seen that the circulating valve provides means for either opening or closing the tubing at a point near the anchor pipe 16 and the packer 15 when desired, and that whenever this tubing is closed for longitudinal flow to a point beneath the packer, it is open for flow to or from the annular space between the tubing and the casing at a point above the packer 15.

The opening and the closing of the circulating valve may be controlled from the surface of the well.

To carry out the acidizing process in accordance with the invention the equipment illustrated is first run into the well. While it is being run the parts of the circulating valve occupy the position shown in Figure 2, and since it may be assumed that the well is full of oil or other fluid it will be filled with oil as it is lowered into the well. The packer 15 is then set and seals off the tubing from the wall of the well.

In accordance with the invention the next step in the process is to open the circulating valve and "bleed" the tubing of the oil therein. Acid which is to be forced into the formation is pumped into the tubing through the conduits 22 and 24, all the valves except 26 and 36 being closed at this time. As the acid moves downwardly within the tubing 13 the oil which is below it is forced out of the tubing above the packer through the circulating valve and flows upwardly through the casing and out into the sump through the conduits 31 and 32. This "bleeding" process is continued until the acid is down in the tubing to a point some slight distance above the circulating valve, at which time the circulating valve is closed and the parts occupy the position shown in Figure 2. Pumping of the acid is then continued and the acid is forced into the formation below the packer 15.

Before continuing with the description of the additional steps in the process it should be noted here that the "bleeding" action just described is different from that which takes place where acid is ordinarily pumped into a well through tubing

which is provided with a packer. In the ordinary process the tubing is filled with oil and this oil is "bled" out of the tubing at the bottom below the packer. The result is that during the "bleeding" operation the seat for the packer is often partially washed away, especially in soft formations, and this makes it difficult to maintain a proper seal with the packer. A further advantage of the present arrangement results from the fact that during the "bleeding" operation the formation and all of the well beneath the packer is sealed off and is not subjected to any variations in pressure due to the difference in density between the acid and the oil which in some cases tend to contaminate the formation or force oil into the formation. It it were not for the fact that when the circulating valve is open the ports **45** in the sleeve **44** move above the packing **48** to seal off the lower portion of the tubing as described above, there would be some tendency for the oil in the tubing to flow on downwardly and into the formation as acid is supplied to the tubing and the oil removed therefrom.

Continuing with the process, let us assume that after the initial quantity of acid has been forced into the formation the reaction has slowed down and that it is desirable to remove this acid and supply a fresh quantity to the formation. It may be assumed that the smaller bores or capillaries of the formation have been eaten away until they have the appearance shown at **50** in Figure 3. It is obvious that merely increasing the pressure on the acid will not tend to make the acid penetrate any farther but that it is necessary to remove the spent or partially spent acid and subject the formation to a fresh quanity in order to enlarge the bore and make it take the shape shown at **51** in Figure 4.

Now it may be that the formation pressure is not very great and is insufficient to remove the acid from the well. One skilled in the art would immediately suggest that the well should be swabbed in order to remove this acid, but this is extremely dangerous and expensive. It is impossible in any swabbing operation to prevent the fluid being swabbed from passing up with the wire line which operates the swab, splattering around the drilling rig, and on the driller or other workmen thereon. If an attempt were made to swab acid, it is obvious therefore that it would be hazardous for the workmen and also very destructive on the equipment.

In accordance with the present invention swabbing is employed but steps are first carried out so that only oil or other harmless fluid is lifted by the swab. The conditions encountered when it is first decided that the acid should be removed from the well and replaced are such that the entire tubing is filled with fresh unspent acid and the lower portion of the well beneath the packer is filled with spent or partially spent acid. In accordance with the present invention the unspent acid in the tubing **13** is first removed from the well. This is accomplished simply by opening the circulating valve and forcing oil or other fluid downwardly within the casing. The pump is connected to a supply of oil, and this is forced inwardly through the conduit **22** and into the casing **11**, the valves **27** and **28** in the conduit **25** being open and the valve **26** closed. On the discharge side of the connections at the well head the valves **35** and **36** are closed and the valve **34** open. Since the bottom of the tubing is then closed off, the oil forced downwardly in the annular space between the casing **11** and the tubing **13** causes the unspent acid in the tubing **13** to flow back into the acid tank through the conduit **30**. When all of this unspent acid has been removed from the tubing the tubing will be full of oil. The circulating valve is then closed and the oil in this tubing is swabbed by the swab **19** until the unspent or partially spent acid has been brought to the tubing from the formation and from the well beneath the packer **15**. It will be noted, however, that only the oil and not the acid is swabbed, although the swabbing action causes the acid to leave the formation. After this swabbing operation the circulating valve may again be opened and the spent or partially spent acid which is then in the tubing **13** may be circulated out of the tubing by again forcing downwardly through the annular space between the tubing and the casing, the tubing again filling with oil. If the acid then in the tubing is spent or nearly spent, this particular step may not be necessary, however.

After this operation has been completed the entire cycle of supplying acid to the formation and removing it therefrom may be repeated as many times as desired or until the formation begins to take the acid at a more rapid rate.

While the method and equipment have been described above in some detail, it is obvious that both the method and the equipment may be used in various ways without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. Apparatus for the multiple cycle acidizing of a formation of a well including tubing adapted to be run in the well, a packer near the lower end of said tubing, a circulating valve in the tubing above the packer and adapted to be opened or closed by manipulation of said tubing, and connections at the surface of the well for circulating fluid downwardly or upwardly through said tubing as desired.

2. Apparatus for the multiple cycle acidizing of a formation of a well including tubing adapted to be run in the well, a packer near the lower end of said tubing, a circulating valve in the tubing above the packer and adapted to be opened or closed by manipulation of said tubing, and connections at the surface of the well for circulating fluid downwardly or upwardly through said tubing as desired, said circulating valve having means therein for preventing the flow of fluid through said tubing to a point beneath the packer when said circulating valve is open to permit circulation above said packer.

3. The method of multiple cycle acidizing of a formation of a well which includes lowering a valved tubing into the well, packing off the tubing near the bottom thereof, opening the valve and pumping acid down the tubing to bleed off fluid in the tubing through the valve, closing the valve, forcing some of the acid in the tubing into the formation to be treated, allowing this portion of acid to react wholly or partially with the formation, removing the unspent acid from the tubing by opening the valve and forcing the acid upwardly by reverse circulation with oil or other inert fluid passing downwardly outside of the tubing and displacing the acid therein, closing the valve and swabbing the inert fluid then in the tubing, to draw the spent or partially spent acid out of the formation into the tubing,

removing the spent or partially spent acid from the tubing and repeating the cycle recited as many times as necessary or desirable to repeatedly subject the formation to fresh unspent acid.

4. The method of multiple cycle acidizing of a formation of a well which includes lowering a valved tubing into the well, packing off the tubing near the bottom thereof, opening the valve and pumping acid down the tubing to bleed off fluid in the tubing through the valve, closing the valve, forcing some of the acid in the tubing into the formation to be treated, allowing this portion of acid to react wholly or partially with the formation, removing the unspent acid from the tubing by opening the valve and forcing the acid upwardly by reverse circulation with oil or other inert fluid passing downwardly outside of the tubing and displacing the acid therein, closing the valve and swabbing the inert fluid then in the tubing to draw the spent or partially spent acid out of the formation into the tubing, removing the spent or partially spent acid from the tubing by again opening the valve and again forcing the acid in the tubing upwardly by reverse circulation with oil or other inert fluid and then repeating the cycle recited as many times as necessary or desirable to repeatedly subject the formation to fresh unspent acid.

5. In the acidizing of the formation of a well by the use of a tubing lowered into the well and packed off at the bottom, the method of safely removing the acid from the well should it become necessary or desirable to do so, which includes opening the tubing at a point above the place where it is packed off and forcing an inert fluid downwardly outside of the tubing to force the acid out of the tubing by reverse circulation until the inert fluid has displaced the acid, then closing the tubing at the point where it was opened and swabbing the inert fluid to draw the acid out of the formation into the tubing and then removing the acid thus drawn into the tubing.

6. In the acidizing of the formation of a well by the use of a tubing lowered into the well and packed off at the bottom, the method of safely removing the acid from the well should it become necessary or desirable to do so, which includes opening the tubing at a point above the place where it is packed off and forcing an inert fluid downwardly outside of the tubing to force the acid out of the tubing by reverse circulation until the inert fluid has displaced the acid, then closing the tubing at the point where it was opened and swabbing the inert fluid to draw the acid out of the formation into the tubing and then removing the acid thus drawn into the tubing by again opening the tubing and forcing an inert fluid downwardly outside of the tubing to force the acid upwardly therein by reverse circulation.

CHRISTIAN W. SAVITZ.