Dec. 5, 1961 C. B. HOLT 3,011,548

APPARATUS AND METHOD FOR TREATING WELLS

Filed July 28, 1958 2 Sheets-Sheet 1

Fig. 1.

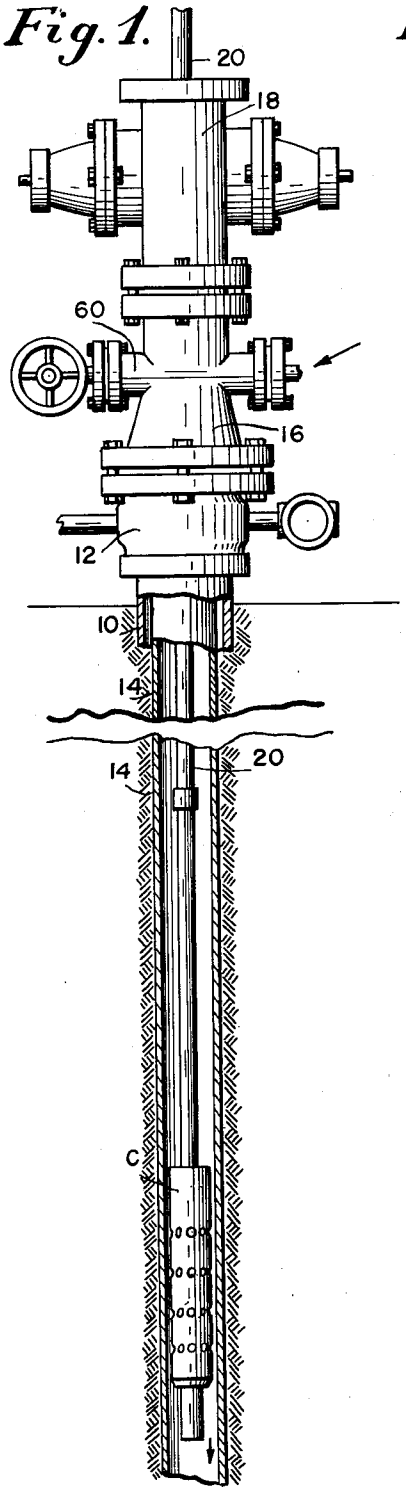
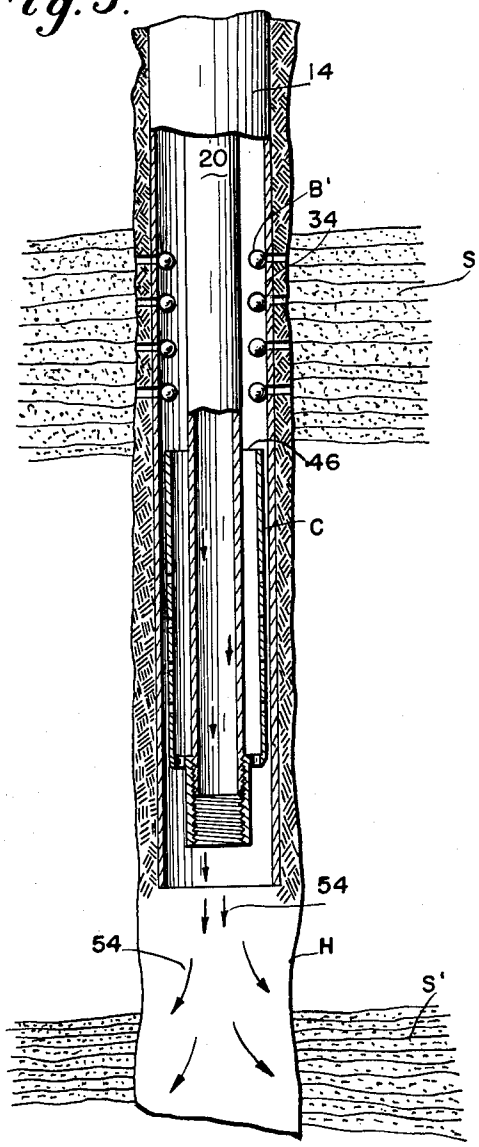


Fig. 3.



INVENTOR

CLARENCE B. HOLT

BY Cushman, Darby & Cushman
ATTORNEYS

Dec. 5, 1961 C. B. HOLT 3,011,548

APPARATUS AND METHOD FOR TREATING WELLS

Filed July 28, 1958 2 Sheets-Sheet 2

Fig. 2.

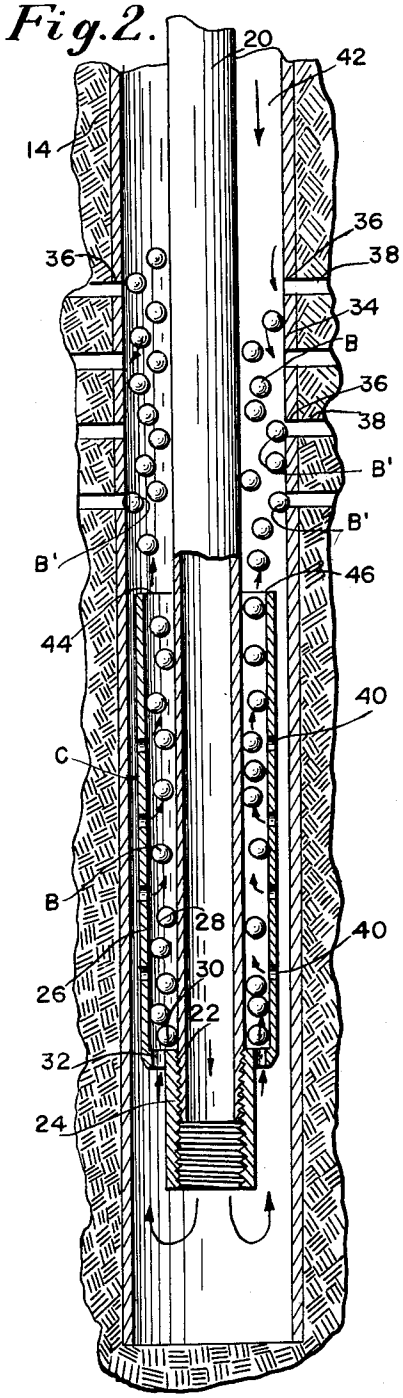


Fig. 4.

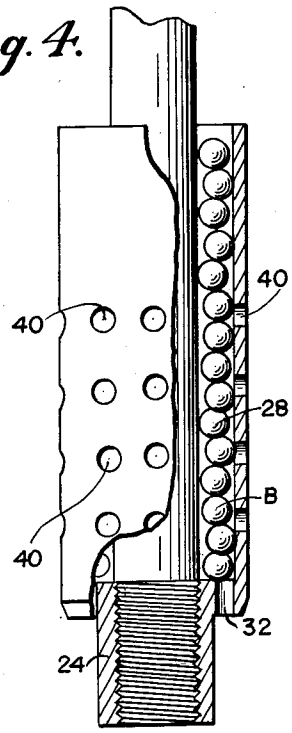
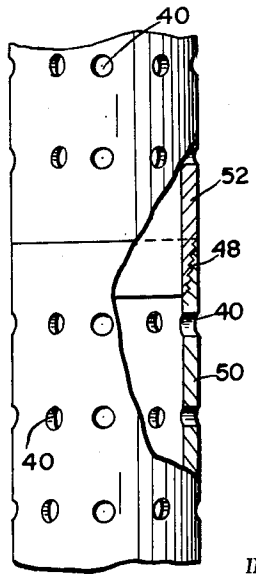


Fig. 5.



INVENTOR

CLARENCE B. HOLT

BY Cushman, Darby & Cushman ATTORNEYS

United States Patent Office 3,011,548 Patented Dec. 5, 1961

3,011,548
APPARATUS AND METHOD FOR TREATING WELLS

Clarence B. Holt, 621 Austin, Borger, Tex.
Filed July 28, 1958, Ser. No. 751,417
7 Claims. (Cl. 166—42)

The present invention is an improved means and method for treating wells, and more specifically, a method and means involving selectively closing the perforations in an oil well casing, by small balls or spheres of appropriate size, which are lowered to position for application to the perforations, by a structure which forms an important part of the invention.

An important object of the invention is to provide mechanical means for retrieving all of the balls or spheres which have been applied to the perforations to close same, so that they may be examined upon removal from the well, to detect as by scratches, ridiging and marking on the balls or spheres, such information as the number of such balls or spheres which were seated in the perforations and thus to determine how many of the perforations were closed off during the formation treating operations which were carried out.

A principal object of the invention is to introduce the balls for closing the perforations, in a basket or cage which is mechanically lowered to position adjacent the perforations in the casing, as distinguished from previous practices where such balls have been added to the stream of treating fluid which is introduced into the casing. In these prior practices, where the balls have been introduced into the well in the casing head along with and into the formation-treating liquid or material, there is no adequate control of the delivery of the balls to the perforations which it is desired to close off, nor was there any adequate provision for removing the balls from the perforations in order that they might be examined to determine effectiveness of the formation-treating operations which were being carried out.

In order to carry out the purposes of the invention, I have devised a structure comprising a basket to be attached to the lower end of an oil well tubing or the like, which is of a size to carry a multitude of the perforation-closing balls. This basket is of such construction that fluid may be introduced downwardly through the tubing, to remove the balls from the basket at the proper location. These operations, involving proper positioning of the balls adjacent to and below the perforations, and their removal from the basket and delivery to the perforations to be closed, may be carried out substantially independently of the introduction of the treating fluid into the well, the latter being introduced at the well head into the space between the casing and the tubing, and passing downwardly in this annulus and outwardly through the perforations being treated.

Modern methods for completing oil and gas wells frequently demand treatments of the producing formations by forcing into the same under high pressure, certain acid or fracturing fluid, and this fluid is forced into the formation through the perforations which have been provided in the producing casing, in a manner which is well known in the art. In carrying out these procedures, it has been

the practice to force spheres or balls of metal or the like, downwardly into the well with the treating fluid, to close off certain of the perforations incident to the carrying out of the process. The known methods of introducing the balls into the well have been inadequate, mainly because of the uncertainty as to the closure of the desired number of perforations in the casing. It has not been possible to retrieve all of the balls which have been used for the above purpose in order that they may be examined to determine the number of perforations which have been treated by entry into same of the treating fluid. Furthermore, when employing previous practices, it has not been possible to introduce a sufficient number of balls for complete closure of all perforations in an oil well casing, and to thereafter treat by fluid injection into the open uncased hole which may lie beneath the casing, at least with any certainty, and without excess use of and waste of the treating fluid. In past practices, no provision was made for the use of a conduit for the treating fluid, which would pass below the casing perforations closed by the balls, in order to introduce this fluid into an uncased and lower portion of the drilled hole.

In the drawings, which illustrate the preferred embodiments of apparatus for practicing the invention:

FIGURE 1 illustrates conventional well head equipment, and shows the ball cage of the invention positioned on a tubing string being lowered into the casing of the well.

FIGURE 2 is an enlarged partial vertical sectional view through the casing of the well, at the perforated zone thereof, and which shows the ball cage positioned below the perforations and the manner of elevating the balls into position to enter the perforations in the casing.

FIGURE 3 is a similar vertical sectional view, showing how the balls close off the casing perforations, and further illustrating the manner of treating an open hole below the casing.

FIGURE 4 is a partial vertical sectional view of the cage, showing the manner in which the balls are carried in the cage.

FIGURE 5 is a side elevational view, partly in section, of a modification of the invention, showing how an additional section may be added to the cage, to increase its capacity.

Referring to FIGURE 1, the usual oil well outer or surface casing is shown at **10**, and mounted on top of the same is the customary casing head **12**. Suspended from the casing head **12** as by the conventional hanger is the inner casing **14**, and mounted at the upper end of this casing is a further casing or tubing head **16**. A blow-out preventer **18** or other item of control equipment may be mounted on the casing head **16**, and a string of tubing **20** passes through the control equipment and down into the casing of the well, as shown in FIGURE 1. It is at the lower end of the tubing string **20**, that the ball cage C which forms an important part of the invention may be mounted.

Referring now to FIGURE 2, the lowermost section of the tubing string **20** is exteriorly threaded as at **22**, and these threads engage and secure to interior threads on a depending collar **24** which forms the lower end of the ball cage C. The upper portion **26** of the ball cage is

enlarged, and is cylindrical in form, and is of diameter only slightly less than the interior diameter of the casing 14. This enlarged part 26 of the cage, with the outside wall of the tubing 20, from which it is spaced, forms a chamber 28 to carry any number of balls or spheres which are used to close the perforations in the casing. The enlarged part 26 of the cage has a bottom wall 30, where it connects with the collar-like extension 24, and there are a number of vertical openings 32 in this bottom wall, which openings are of diameter somewhat smaller than the balls or spheres B, which are disposed in the cage, as hereinafter described.

In FIGURE 2, the casing 14 is shown lowered to the bottom of the drilled hole, and it may be cemented off at its lower end, in accordance with known practice. At a selected distance upwardly from the lower end of the casing, there is a perforated area 34 formed by shooting or otherwise providing a number of openings or perforations 36, which extend through the casing and outwardly into the producing formation, as at 38, passing through any cement which may surround the casing at this point, or passing outwardly through the formation to the desired distance, if no cement is present. It is through these perforations that the oil or gas, under its natural pressure, is permitted to enter the casing, during the period when the well is producing, and this oil or gas may be taken from the well through appropriate outlets from the casing 14, at the well head, or through a flow tubing, with the assistance of whatever conventional equipment as may be required for the efficient flowing of the well.

As is well known in the art, the perforations in the casing may become partially or completely clogged, due to the accumulation of materials therein, and the channels of flow from the formation outwardly of the perforations may likewise become clogged. It is for this reason, that various methods have been employed, to treat the perforations in the casing and the passages in the formation, with acid or other fracturing fluid in order to facilitate the flow of oil and gas from the formation.

The cage C has, in addition to the bottom openings 32, a plurality of openings 40 in its side wall, so that when the cage has been lowered to the desired position adjacent to and below the perforations in the casing, any fluid, such as water or treating fluid, may be pumped downwardly through the tubing 20 and out the lower end thereof as shown by the arrows in FIGURE 2. When this is done, there is created an upward circulation of fluid, from the lower end of the tubing, and it passes through the openings 32 and 40 in the cage, and as it moves upwardly, thence to elevate the balls B from the cage, to a position adjacent the perforations in the casing. At the same time, by appropriate pumping means at the surface of the well, the treating fluid may be forced downwardly in the space 42 between the casing and the tubing, and this treating fluid will be forced outwardly through the perforations in the casing and in the formation when the pumping pressure is greater than the natural pressure in the formation. The balls B which have been elevated from the cage, will be carried by this outwardly moving flow of the treating fluid, into the inner ends of the perforations in the casing, to close off these perforations as it is illustrated by the balls B_1 in FIGURE 2.

As is well known in the art, the balls so positioned and delivered will tend to close the more active of the perforations, thus increasing pressure on the perforations which are less active, or substantially entirely clogged, and the tendency of the treating fluid under pressure in the casing area 42 will be to open the less active perforations, by the intensified pressure thereon. Of course, various procedures and manipulations of the equipment may be carried out, as desired, in order to treat the formation as desired.

In FIGURE 2, I have shown only a relatively few of the balls B in the cage, and disposed above same, merely for purposes of clarity, but it will be understood that a relatively great number of such balls or spheres may be carried in the cage, as is better illustrated in FIGURE 4. With reference to FIGURE 4, it will be noted that the bottom openings 32 are offset outwardly toward the outer wall of the basket compartment 28, so that it is not possible for the balls to close off the bottom openings 32.

When using an oil well casing of 5½ inches outside diameter, and a 2-inch tubing, the basket should be of sufficient size to hold up to 200 balls of a diameter of approximately ⅞ inch. It will be understood that the balls will be of diameter sufficiently greater than the openings or perforations in the casing, so that they will not actually enter these perforations, and will not become so embedded therein, that they cannot be removed, as hereinafter mentioned.

Referring again to FIGURE 2, the cage C is open at its upper end, as indicated at 44, and the ledge 46 at its upper end is of such diameter with relation to the interior diameter of the casing, that when the cage is elevated on the tubing, after the treating operation has been completed, this ledge 46 will tend to strip the balls from the perforations in the casing, and they will drop into the open end of the cage and can then be elevated from the well, in order that the balls may be examined to determine the success or degree of treatment of the well, with the treating fluid.

In FIGURE 5, a modified construction of the cage is illustrated, wherein the upper end 48 of a cage section 50 is threaded, and secured thereto a further section 52 of the cage, to increase the overall-capacity thereof, in order that a greater number of balls may be carried, in instances where it may be desired to close off sections of a casing, having a relatively great number of perforations therein.

In FIGURE 3, the casing well is shown as having an open hole H extending below the lower end of the casing 14, which has the perforated area 34 in alignment with the oil-bearing stratum S, there being another oil-bearing stratum S_1 below the lower end of the casing 14. In the arrangement of the equipment shown in FIGURE 3, by continued introduction of the balls into the area of the casing perforations, as described, while treating fluid is being forced downwardly through the casing around the tubing, all of the perforations in the casing may be sealed off, and thereafter, the open hole below the casing can be treated by the injection therein of acid or fracturing fluid through the lower end of the tubing, as is indicated by the arrows 54. With this arrangement, positive treatment of the open hole below a casing which has been partially set through a producing formation, is provided for.

In the embodiments described, when the treatment of the producing formations has been accomplished, the cage is removed from the well as the tubing is elevated therefrom, and the upper end of the cage will engage the balls and retrieve all of them, the balls being again received in the cage and elevated thereby to the surface of the well. By the scratches, ridges and markings on the balls, it is possible to determine how many of same were seated in the perforations and thus determine how many of the perforations were blocked off or closed by the balls or spheres. It will be understood that the balls may be removed from the perforations mechanically, and without depending on a pressure differential between the formation and the interior of the casing, to secure their removal. The balls may be made of a material which will not be destroyed by the treating fluids or acids, but a material may be selected which will to some extent be reacted upon by the fluids, in order to show how many of the balls were present in the perforations, during a treating operation. Those skilled in the art will understand that it may be of importance to determine if all of the perforations were closed off, or to determine just

how many of the perforations were closed during a formation-treating operation. The material from which the balls may be made, will be a matter of selection. They may be made of appropriate metals, such as steel, aluminum, or appropriate alloys of these or other metals, of plastic, or of hard rubber, and the like. They should be of such weight that when the basket is positioned adjacent the perforations, as illustrated in FIGURE 2, a circulation of fluid downwardly through the tubing will elevate them to positions adjacent the perforations, in order that they may enter the open perforations under the influence of the treating fluid passing into the perforations, as illustrated. Of course, the balls should be of a material heavy enough to cause them to remain in the cage, by gravity, as the equipment is being lowered into the well, possibly through accumulated fluid in the well. The cage or basket C may be made of steel or steel alloy, or it may be made of plastic, aluminum, or other material capable of being drilled out, or dissolved by acid, in case it should become necessary to leave the cage in the well, such as in the event that it should become stuck in the casing.

The operation of the embodiments referred to above will be clear from the description which has been given, but it is briefly summarized below. The basket is screwed onto the bottom of a conventional oil well tubing and then filled with the desired number of balls or pellets, at the surface of the well. Thereafter, the tubing is lowered through whatever equipment may be provided on the well, and down through the casing to a point adjacent the lower end thereof, and preferably just below the perforations through which the treatment is to be made. If any of the balls are dislodged from the basket during the descent, no harm will result, for they will soon settle into the cage when its descent has been arrested, and before treatment commences. The upper end of the tubing is connected to any appropriate hydraulic pump, as commonly used on oil wells, and this pump may be operated to force the ball seating fluid downwardly through the tubing, and thence upwardly from the lower end thereof through the openings in the basket, to dislodge the balls therefrom and elevate them to positions adjacent the perforations, and into the range of the treating fluid. It will be understood that the treating fluid may be forced downwardly in the space between the casing and the tubing. This fluid may be admitted into this space through any of the appropriate outlets from the casing head equipment, such as through the side outlet **60** in the casing or tubing head **16**, and it is pumped downwardly under the desired pressure, with available pumping equipment and in a manner well known in the art. The treating fluid passes through the open perforations and accomplishes acidifying or fracturing of the formation opposite these perforations, as is well understood by those skilled in the art. The introduction of the fracturing fluid or acid through the casing perforations creates a flow pattern or current which causes the balls which have been elevated to proper position to enter the casing perforations and seal them off. As some of the casing perforations are sealed off, the treating fluid is forced by the pump pressure at the surface into the other perforations which have not been closed by the balls. Further fluid may be pumped through the tubing to move more of the balls into position to close off the perforations. It will be understood that the method referred to may be repeated or varied, within the skill or knowledge of the operator, to cause all of the casing perforations to be sealed off by the ball material. In general, when all of the perforations have been closed, it is established that all of the perforations and adjacent openings in the formation have received the treating fluid, so as to improve the character of the formation adjacent to the perforations, for the production of oil and gas. Thereafter, the basket may be elevated to remove the balls from the perforations, in order that the well may flow or produce, under pressure of the formation, as is well understood in the art. As previously stated, the equipment is so designed with relation to the diameter of the casing in which it is used, that all of the balls can be removed with the basket, and subjected to inspection, in order to determine the effectiveness of the formation treatment which has been carried out.

As previously referred to, the open hole below the casing in certain wells having same, can be treated by the injection therein through the tubing of acid or fracturing fluid, after the casing perforations have been closed off, by practicing the invention as described herein.

It will be understood that the equipment described herein may be used in association with other conventional oil well devices, commonly employed at the surface of the well, or at the lower end thereof, such as packers and the like. The manipulative steps referred to herein may be varied, for purposes which best suit the situation which is encountered in the well being produced, and the placing or removing of the balls may be controlled at will, and from time to time as desired, in order to seal off all or any part of the perforations, as may be required. For instances, the basket may be placed at any point of a perforated zone or area of a casing, in order to close off only the perforations at points above where the basket is positioned. Other manipulative variations will occur to those skilled in the art in order to otherwise control the manner of treatment of the perforations, and the formation.

I claim:

1. Apparatus for separating perforations in the casing of a well comprising: a cage having means for attachment to a tubing or other pipe string above the lower end thereof for sealing an area of the casing having perforations therethrough, said cage being of a size to substantially fill the casing and open at its upper end, a plurality of closure pellets in said cage for upward discharge past the upper end of said cage, said cage have openings adjacent its lower end for upward flow therethrough of fluid discharged from the lower end of the tubing, whereby circulating fluid may pass upwardly through said cage to elevate the pellets therefrom into position to seal said perforations.

2. A construction in accordance with claim 1, in which said pellets comprise spheres made of metal or the like, and of size to close the perforations in the oil well casing without passing into or through said perforations.

3. A construction in accordance with claim 1, wherein the upper end of said cage removes the pellets from the perforations in the casing and receives them into the interior of the cage when the cage is moved upwardly in the casing.

4. A construction in accordance with claim 1, in which the upper end of said cage is provided with means to attach an additional section thereto to increase the pellet-carrying capacity of the cage.

5. A construction in accordance with claim 1, in which the side walls of the cage have openings therein to permit flow of fluid inwardly through the wall of the cage to assist in elevating the pellets therefrom.

6. The method of treating the formation of a well below a perforated area of the casing which comprises, lowering under positive control a plurality of closure pellets of size to close the perforations without passing into or thru same to a level adjacent to and below the perforations to be sealed, elevating the pellets by forcing a fluid upwardly past the same, pumping the fluid outwardly thru the perforations to treat the formation and carry the pellets into the perforations to close same, and forcing fluid downwardly in the well and outwardly into the formation at an elevation below the area where the per-

forations have been closed by the pellets, and thereafter elevating the pellets under positive control and raising the same to the surface.

7. The method of sealing perforations in a well casing comprising the steps of lowering a cage carrying a plurality of closure pellets of a size to close the perforations without passing into or through the same, to a level adjacent to and below the perforations to be sealed; circulating fluid upwardly from below the plurality of pellets and through the cage with sufficient pressure to carry the pellets upwardly into position to seal the perforations in the cage; and raising the cage to positively disengage the pellets from the perforations by engagement of the cage therewith whereby the pellets are collected in said cage; and raising the cage and collected pellets to the surface whereby the same may be inspected.

References Cited in the file of this patent

UNITED STATES PATENTS

2,698,582	Vincent	Jan. 4, 1955
2,699,212	Dismukes	Jan. 11, 1955
2,754,910	Derrick et al.	July 17, 1956
2,809,013	Ledgerwood et al.	Oct. 8, 1957
2,868,509	Williams	Jan. 13, 1959