April 28, 1959 A. J. TEPLITZ ET AL 2,884,066

APPARATUS FOR APPLYING OUTWARDLY DIRECTED FORCES TO TUBING

Filed July 26, 1954 2 Sheets-Sheet 1

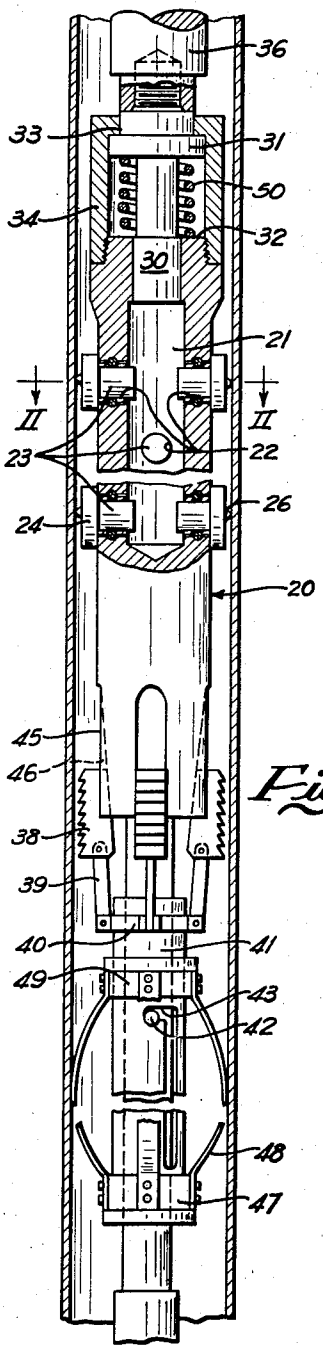


Fig. 1

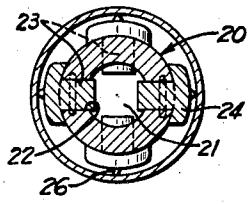


Fig. 2

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Fig. 3

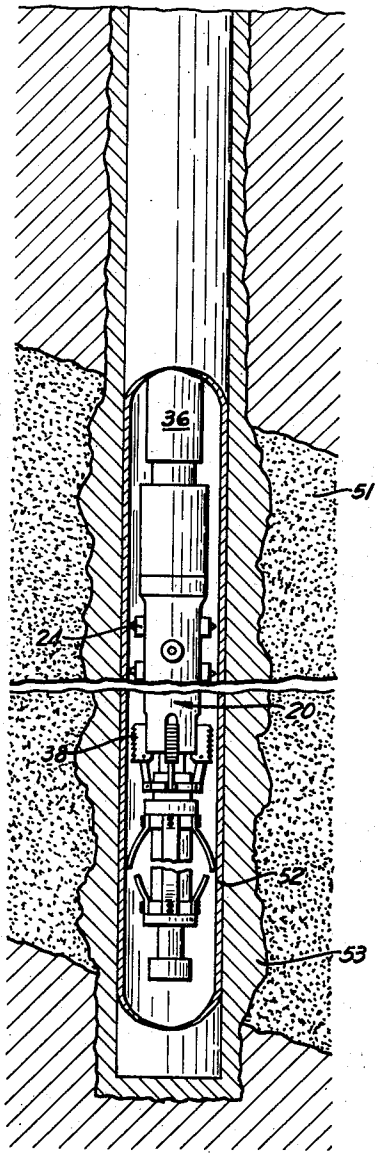
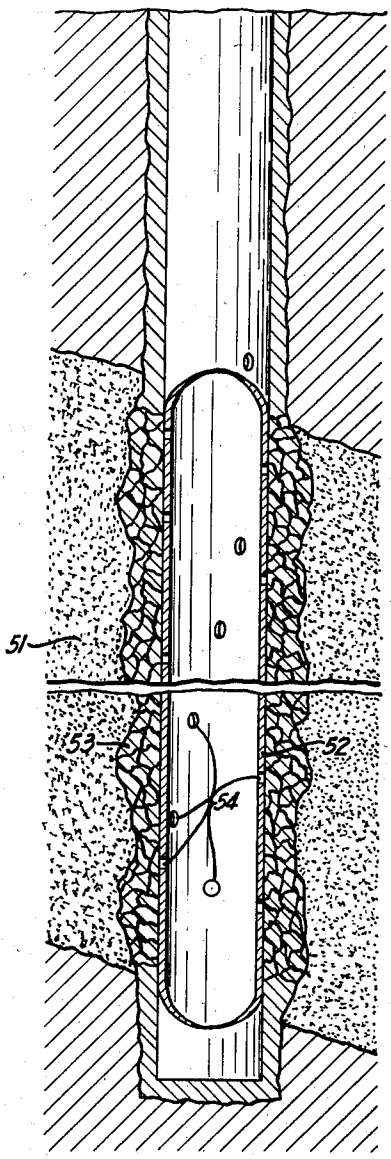


Fig. 4



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APPARATUS FOR APPLYING OUTWARDLY DIRECTED FORCES TO TUBING

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Application July 26, 1954, Serial No. 445,842

2 Claims. (Cl. 166—55)

This invention relates to an apparatus for applying outwardly directed forces to the inner surfaces of tubular means and more particularly to such an apparatus which is adapted to deform and/or perforate a section of well casing.

The apparatus of our invention is particularly adapted for use in applying deforming forces to a well casing in a newly-developed method for completing wells in poorly consolidated formations which is described in the patent application of Abraham J. Teplitz, Serial Number 424,862, filed April 22, 1954, now abandoned. In the Teplitz method a well is drilled through a poorly consolidated producing formation, such as an unconsolidated oil sand, and casing is cemented in the well. Thereafter a stress is applied to the casing opposite the sand formation so as to crack the surrounding cement and form a system of fluid-permeable fractures in the cement sheath. Perforations are formed in the casing, in any convenient manner, before, after or simultaneously with the cracking of the cement. The resulting well structure comprises a perforated tubular casing extending into the unconsolidated producing formation and a surrounding fractured cement sheath. The fractured cement sheath provides support for the sand formation. The fractures in the cement exclude sand but permit fluids to pass from the producing formation into the borehole through the perforations in the casing.

The above-mentioned Teplitz patent application describes a number of methods of applying stress to the cement sheath to form the desired fractures. These include the use of an explosive charge, the use of a device for hammering the inner wall of the casing, the use of a gun perforator firing non-penetrating bullets, etc. The present invention provides an apparatus which is particularly advantageous for use in applying stress to such a cement sheath by applying outwardly directed deforming forces to the inner walls of the well casing. The advantages of our apparatus in this usage include simplicity of construction and of operation, the ability to transform a vertical force into controllable lateral forces by hydraulic pressure, and the ability to use the weight of drill pipe by which the device is lowered into the well for producing the outwardly directed deforming forces.

The apparatus of the invention in general comprises an elongated body member or mandrel which is provided with an interior vertical chamber and a plurality of horizontal cylinders extending radially from the interior chamber through the walls of the mandrel. A vertical piston is slidably mounted in the upper portion of the interior longitudinal chamber and a horizontally slidable piston is mounted in each of the horizontal cylinders. The vertical piston is provided at its upper end with means for connection to a string of drill pipe. It is also provided with means for limiting its vertical displacement. When the vertical piston is raised to its upper limit the limiting means makes a supporting engagement with an element of the mandrel so that the entire apparatus is supported by the string of drill pipe to which the vertical piston is connected. The mandrel or body member is provided with anchoring means such as serrated slips which can be forced into gripping engagement with the inner walls of the tubular means into which the apparatus is lowered so as to hold the apparatus at any desired level within the tubular means which is to be deformed or perforated. This arrangement of the elements of the apparatus is such that when the anchoring means is engaged with the walls of the tubular means and the weight of the supporting drill pipe is released, the vertical piston is forced downwardly and applies a hydraulic pressure to a fluid within the longitudinal chamber of the mandrel which is transformed into horizontal forces acting outwardly against the horizontal pistons.

The invention can best be described in detail with reference to the drawings in which:

Figure 1 is a view partially in cross-section of a particular embodiment of the apparatus of the invention positioned within a tubular means;

Figure 2 is a cross-sectional view taken along line II—II of Figure 1;

Figure 3 is a diagrammatic view in vertical section of a producing formation in an oil well with an apparatus of our invention positioned within the cemented casing of the well opposite the producing formation; and

Figure 4 is a similar view of the well after the casing has been perforated and after the cement sheath surrounding the casing has been fractured by an apparatus of our invention.

The embodiment of the apparatus of our invention illustrated in Figure 1 will be discussed in detail. The device comprises an elongated body member or mandrel **20** provided with an interior longitudinal chamber **21** and a plurality of horizontal cylinders **22** extending radially from the longitudinal chamber through the walls of the mandrel.

Slidably mounted in said horizontal cylinders **22** are pistons or plungers **23**. The horizontal pistons **23** have enlarged, stress-applying, outer faces **24** which are adapted to be forced against the inner walls of tubular casing to apply stress to the casing. The stress-applying faces **24**, in the preferred embodiment shown in Figures 1 and 2, are provided with pointed projections **26** which can pierce the steel casing when the outwardly directed force applied against the pistons **23** is sufficient. Pistons **23** preferably are also provided with pins (not shown in the drawing) which limit their outward displacement so that the stress applied to the steel casing will not exceed its elastic limit.

Slidably mounted at the upper end of the chamber **21** of the mandrel **20** is a vertical piston **30** which is provided at its upper end with a threaded connection for attachment to drill pipe or tubing **36**. Piston **30** is also provided with a flange or collar **31** which is adapted to limit the extent of vertical movement of the piston, the collar **31** being confined in movement between the upper end **32** of the mandrel **20** and the inwardly turned flange **33** of a cylindrical sleeve **34** which is threadedly connected to the upper end of mandrel **20**.

At its lower end the mandrel **20** is provided with means for anchoring the assembly within a tubular means, such as a well casing, at any desired level. The anchoring means is of conventional design. In the preferred embodiment of the drawing it comprises serrated slips **38** pivotally attached by slip reins **39** to a ring or collar **40** at the upper end of a slip cage sleeve **41**. The slip cage sleeve **41** is free to rotate and slide longitudinally upon the mandrel **20** except as limited by a pin **42** which projects outwardly from the mandrel through a J-slot **43** in the slip cage sleeve **41**.

Rigidly mounted on the mandrel above the slip cage sleeve **41** is a tapered member or slip cone **45** which has

inclined guide slots 46 for the inner faces of the serrated slips 38. Rigidly attached to the lower end of slip cage sleeve 41 is a ring 47 to which are attached the lower ends of a plurality of outwardly-bowed friction springs 48. Springs 48 are attached at their upper ends to a ring or collar 49 which is mounted slidably on the upper portion of the sleeve 41 to permit contraction and expansion of the bow springs 48.

To fracture a cement sheath surrounding a well casing using the apparatus of Figure 1 the procedure is as follows. The apparatus is lowered through the well casing 52 to a level opposite an unconsolidated producing formation 51 as shown in Figure 3 of the drawing. Then, to anchor the apparatus at the desired level, the drill pipe 36 is raised slightly and rotated to the left. The bowed springs 48 provide sufficient friction so that the pin 42 attached to mandrel 20 can move to the limit of the lateral slot at the top of J-slot 43 in the slip cage sleeve 41. The drill pipe is then further lowered, resulting in downward movement of the mandrel 20 with respect to sleeve 41 which remains in position because of the frictional engagement of the springs 48 with the inner walls of casing 52. As the mandrel 20 moves downwardly relative to the cage sleeve 41 and the slips 38 mounted thereon the cone 45 slides downwardly and forces the slips outwardly into a gripping engagement with the walls of the casing.

By the gripping engagement of slips 38 with the inner walls of casing 52 obtained by the above-described manipulation of the mandrel, the entire apparatus is anchored in the casing at the desired level. As the weight of drill pipe 36 is further released to bear against the vertical piston 30, the piston is forced downwardly in chamber 21. The pressure on the hydraulic fluid, such as oil, in chamber 21 is transferred to the horizontal pistons 23, causing the pistons to apply outwardly directed forces against the walls of the casing 52. The casing 52 is thus stressed and deformed or bulged outwardly. As a result of the deforming of the casing the relatively inelastic cement sheath 53 surrounding the casing is fractured.

Depending upon the thickness of the unconsolidated producing formation, it may be desirable or necessary to deform the casing at two or more levels in order to crack the cement sheath throughout the producing interval. If so, after the casing has been expanded or deformed at one level the anchoring means of the deforming apparatus is disengaged by raising the drill pipe and rotating to the right to re-engage pin 42 with the lateral slot at the top of J-slot 43 in the slip cage sleeve 41. The slip cone 45 is thus raised and the slips 38 are disengaged from the casing walls. The raising of vertical piston 30 creates a partial vacuum in the longitudinal chamber 21 and causes the horizontal pistons 23 to be withdrawn inwardly so that they cannot impede the lowering or raising of the deforming apparatus.

In the preferred embodiment of the apparatus a resilient means such as spring 50 is positioned between the collar 31 on vertical piston 30 and the upper end of mandrel 20 to assist in maintaining the vertical piston in the raised position shown in the drawing.

After disengagement of the anchoring means and the horizontal pistons, the apparatus is raised or lowered opposite the portion of the cement sheath which is not yet fractured. The anchoring means is re-engaged as explained above and the weight of the drill pipe is released to bear against the vertical piston and force the horizontal pistons by hydraulic pressure outwardly against the casing wall. This procedure is repeated as many times as is necessary to fracture the cement sheath throughout the producing formation.

It is necessary, of course, to form perforations in the well casing so that fluids can pass from the fractures in the cement sheath into the well bore. These perforations can be formed in the casing before or after it is placed in the well. As already mentioned, the horizontal pistons 23, in the embodiment of our apparatus illustrated in the drawing, are provided with perforating points or projections of hardened steel on their outer faces. These points are capable of piercing holes in the casing when the pistons are forced outwardly to deform the casing and crack the cement sheath. The apparatus can thus be used to deform and perforate the casing simultaneously. It should be understood, however, that the invention also includes apparatus which is intended only to deform casing or other tubular means without perforating. In such apparatus the perforating points are omitted and the pistons have rounded or flat stress-applying faces, preferably of a larger cross-sectional area than the pistons.

The structure of the well which results from the operation of our apparatus is shown in Figure 4 of the drawing. As the drawing shows, the casing 52 extends through the unconsolidated producing zone 51 and is surrounded by a cement sheath 53 having a network of fractures therein. These fractures permit fluids to pass from the producing formation into perforations 54 in the casing but prevent the production of sand of any substantial particle size.

Although the apparatus of the invention is particularly adapted for use in the Teplitz method of well completion for applying stress to a casing to fracture the surrounding cement, apparatus embodying the principles of the invention can also be used simply as a tubing or casing perforator. In such an embodiment of the apparatus the outer ends of the horizontal pistons terminate in casing perforating means such as hardened points or blades adapted to perforate without otherwise deforming the tubing or casing to any substantial extent.

The particular anchoring means shown in the drawing, with its slips 38 and slip cone 45, is largely of conventional design and is only one convenient form of anchoring means. Our apparatus can employ any other suitable means capable of holding the apparatus at a fixed level within a well casing or other tubular structure while a downward force is applied to the longitudinal piston 30 by the weight of the string of pipe to which the apparatus is attached.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. Apparatus for deforming well casing which comprises a drill pipe adapted to be lowered into a well casing and means carried adjacent to the lower end of said drill pipe for transforming the downward force developed by the weight of said drill pipe into horizontal forces acting outwardly against said well casing, said means comprising a mandrel having a longitudinal interior chamber, a plurality of horizontal cylinders extending radially from said interior chamber through the walls of said mandrel, horizontal pistons slidably mounted in said cylinders, the outer faces of said horizontal pistons being adapted to press against the inner walls of a well casing which is to be deformed, a vertical piston slidably mounted in said longitudinal chamber, said chamber, pistons and cylinders being adapted to contain a liquid as a hydraulic working medium, said vertical piston having a collar attached near its upper end, a cylindrical sleeve attached to the upper end of said mandrel, said sleeve having an inturned flange at its upper end, said inturned flange and the upper end of said mandrel limiting the extent of vertical displacement of the collar of said vertical piston, resilient means disposed between the upper end of said mandrel and the collar of said vertical piston, anchoring means comprising serrated slips adapted to be forced outwardly for anchoring said mandrel within a well casing to be deformed, said anchoring means being operable while said apparatus is suspended within said well casing, said vertical piston being connected at its upper end with said string of drill pipe

adjacent the lower end thereof whereby the entire apparatus is supported by said drill pipe when the collar of said vertical piston is in supporting engagement with the inturned flange of the cylindrical sleeve of said mandrel and whereby the weight of said drill pipe can apply a downward force to said vertical piston when said serrated slips are in anchoring engagement with the inner walls of the well casing so as to force said horizontal pistons outwardly by hydraulic pressure.

2. The apparatus of claim 1 in which said horizontal pistons are provided at their outer faces with perforating points.

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