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WELL REPAIR

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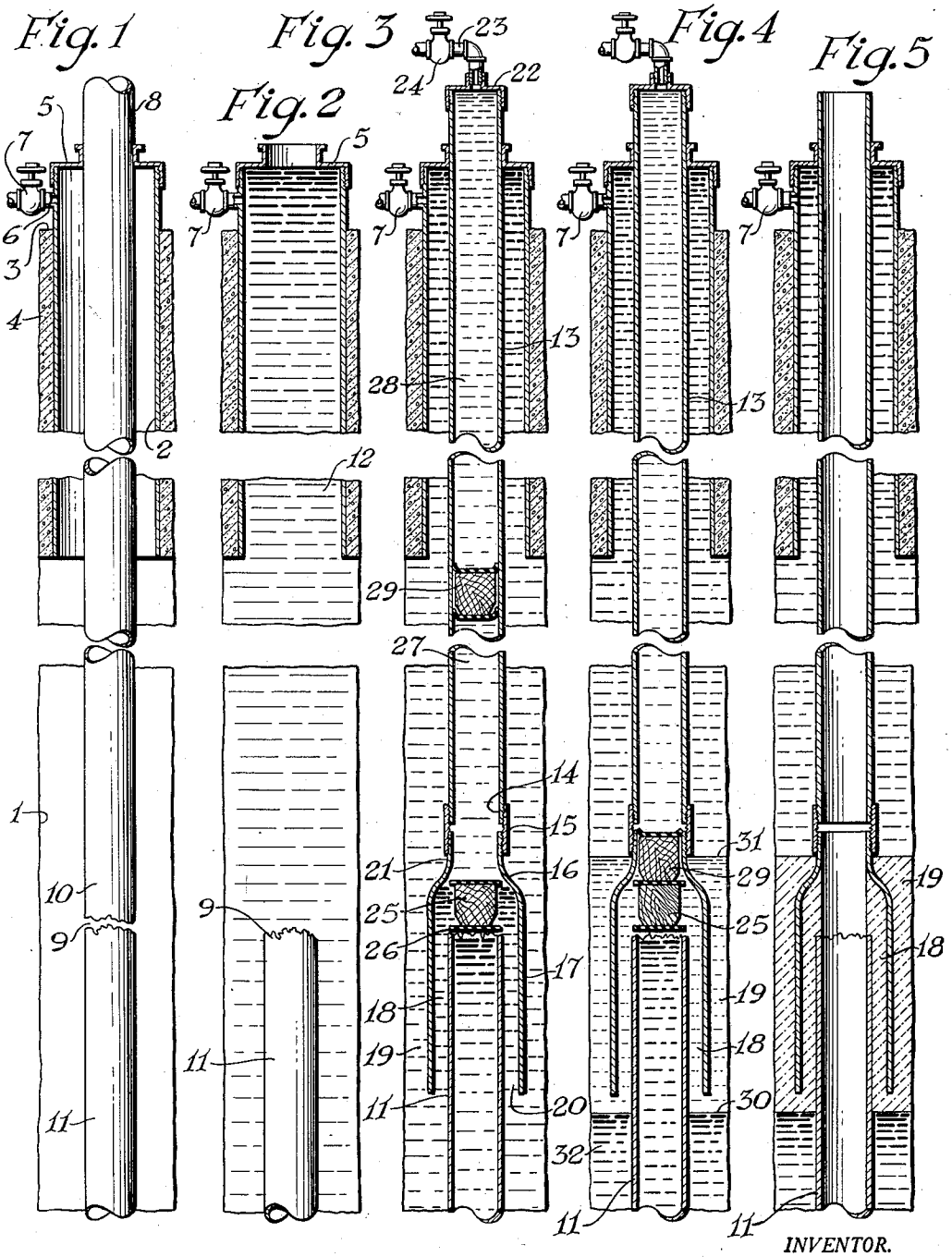
Fig. 1 Fig. 3 Fig. 4 Fig. 5

Fig. 2



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WELL REPAIR

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1

The invention relates to methods of repairing well structures. It more particularly concerns a method of making repairs to a well liner or casing.

In the construction of deep wells, it is usual to case the bore with pipe which extends from the top of the well to a rock or other dense consolidated formation not requiring support to prevent caving or sloughing. An inner casing or liner is then run into the well through the cased bore to the production stratum. Opposite the production stratum, the casing or liner is usually perforated to permit passage of oil into the well. These inner casings or liners sometimes become damaged, the damage being confined, oftentimes, to only a small portion leaving most of the liner intact. Such damage may result from the application of an excessive longitudinal tension or compression stress, as in pulling a liner for example, which may cause the liner to part at some point in the well. Liners are sometimes damaged in treating wells with chemical solutions introduced under pressure through the liner as when excessive treating pressures are used which causes the liner to burst. Liners or casings thus damaged present a difficult problem of repair.

Accordingly, it is the principal object of the invention to provide a simple and effective method of making repairs to casings or liners in a deep well.

Other objects and advantages will appear from the accompanying drawing and following description setting forth a preferred mode of carrying out the invention, such mode illustrating, however, but one of the various ways in which the principle of the invention may be practiced.

In the said drawing:

Fig. 1 is a longitudinal section through a portion of a well bore partly cased and having a liner therein with a break below the casing;

Fig. 2 is a similar view of the well with the portion of the liner above the break removed, and showing the well prepared for the repair operation;

Fig. 3 is a similar view of the well showing initial stages of making a liner repair according to the invention;

Fig. 4 is a similar view of the well showing subsequent stages in the liner repair operation;

Fig. 5 is a similar view of the well showing a completed repair.

As shown in the drawing, wherein like numerals refer to like parts in the several figures, the upper portion of the well bore 1 is cased

2

with pipe 2 which extends above the ground level 3, the space between the pipe and the well bore being filled with cement 4. The casing is equipped with a head 5 and a pipe connection 6 having a valve 7 for controlling the flow of fluid into or out of the casing. Passing through the casing head 5 into the well is a liner 8, which is shown as having been damaged, the damage being indicated by a parting at 9 disconnecting the upper portion 10 from the lower portion 11.

In Fig. 2, the well has been put under hydrostatic control by a column of drilling mud 12 and the upper portion of the liner string above the break 9 has been removed.

In Fig. 3, an upper portion 13 of liner is shown in the well, the liner being provided with a removable head 22, and a pipe connection 23 with a valve 24. The lower end 14 of the liner is joined by a collar 15 to a cylindrical member 16, larger than the liner, the big end 17 of which is adapted to slip over the upstanding end 11 of the lower portion of the original liner.

In carrying out a repair operation, according to the invention, the portion 10 of the liner above the break 9 is removed from the well. This may be accomplished in the usual way, as by withdrawal through the casing head. In order to retain hydrostatic control of the well, it may be filled, if necessary, with drilling mud 12 or other suitable fluid which does not readily seep into the surrounding earth, as shown in Fig. 2.

The cylindrical member 16 is secured to the lower end 14 of a liner string by means of a collar 15 (the withdrawn portion of the liner being used if desired), the cylindrical member being adapted to slip over the upstanding end 11 of the lower portion of the liner in the well, and the assembly is lowered into the well until the cylindrical member receives the upstanding end of the liner. A cylindrical member may be used which leaves annular spaces 18 and 19 between the cylindrical member 16, the liner 11 in the well hole and the well hole 1, respectively.

A fluid sealing compound which adheres to and makes a tight seal with the surface of the metal pipe when set is then introduced into the annular spaces 18 and 19 in amount sufficient to fill the bore from about the lower end 20 of the cylindrical member to the upper end 21 thereof and the annular space 18. The tightness of the seal produced between the inside of the cylindrical member and the outside of the upper end of the lower portion of the liner de-

pends largely upon the choice of sealing material. I have found that by using partially condensed mixtures of phenol and formaldehyde or other resin-forming liquids capable of transformation into solid resins without significant contraction in volume are suitable. An example of a resin-forming liquid is the following:

Mix 40 parts by weight of phenol with 50 parts by weight of an aqueous solution of formaldehyde containing 37 per cent by volume of formaldehyde and add thereto 1.35 parts by weight of sodium hydroxide. The resulting solution is then heated for 6 hours at a temperature of between 75° to 80° C. and becomes a clear amber liquid. This clear liquid is then mixed with 15 per cent by volume of a catalyst consisting of 40 per cent by volume of 95 per cent ethyl alcohol and 60 per cent by volume of concentrated (36 per cent by volume) hydrochloric acid. The resin-forming liquid mixture so formed remains a pumpable fluid for about 40 minutes but gradually changes so that it becomes a solid resin insoluble in oil or water within about 12 hours. The mixture so prepared is introduced into the well while in the pumpable state.

Spotting the sealing compound at the desired places may be accomplished by opening the valve 7 and introducing first a quantity of water, if desired, into the upper end of the liner 13 through valve 24 so as to flush off mud from the surface of the pipe and then a travelling plug, such as a conventional cementing plug, making a sliding sealing fit with the inside of the liner, the liner head 22 being removed to admit the plug and then replaced. The requisite volume of fluid sealing compound, prepared as above or otherwise, is then introduced into the liner behind the first plug and after the charge of sealing compound is in the liner a second cementing plug is inserted in the liner in the same manner as the first plug just behind the sealing compound. A pressuring liquid, such as water, is next introduced behind the second plug so as to force the two plugs and the charge of sealing compound contained between them down the liner to the cylindrical member while a corresponding volume of mud fluid, thereby displaced, is permitted to escape from the valve 7 as shown in Fig. 3. In this view, the spotting operation is shown as having reached the stage where the first plug 25 has come to rest against the upstanding end 26 of the liner 11 and the charge of sealing fluid 27, which is about to enter the annular space 18, is separated from the pressuring fluid 28 by the second plug 29.

The introduction of pressuring fluid is continued until the second plug 29 comes to rest on the first plug 25, as shown in Fig. 4, and the sealing compound is displaced into the annular spaces 18 and 19 between the levels 30 and 31. Passage of the sealing compound into the lower portion of the well below the cylindrical member is prevented by the fluid (mud) column 32 therein as shown. A corresponding volume of fluid escapes through valve 7 as the sealing fluid is displaced into the aforesaid spaces, and when the displacement is complete, the valve 7 is closed and the well maintained under pressure, if necessary, to keep the sealing compound in place while it sets to a solid mass.

After the sealing compound has set, the head 22 is removed from the top of the liner and the bore cleared by drilling a passage from the upper portion 13 to the lower portion 11 of the liner, leaving the bore of the liner unobstructed as in Fig. 5 and the annular spaces 18 and 19 sealed with solid set sealing compound.

Although the preferred mode of operation, just described, employs two travelling or cementing plugs, one above and the other below the column of sealing compound, it will be apparent that in some instances the use of either the upper or the lower, or both, plugs may be dispensed with, as when the distance to be travelled by the sealing compound is relatively short, i. e. when the cylindrical member is not far below ground, or when some mixing of the sealing compound with the fluid displaced by it and with the pressuring fluid is not objectionable. In dispensing with both plugs, the mode of operation is as follows: After filling, if necessary, the liner and casing with some liquid, such as oil, water, or drilling mud, as previously described, the requisite quantity of sealing compound may be introduced into the liner string 13 and then the pressuring fluid which is introduced behind the sealing compound. The introduction of pressuring fluid is continued while venting the casing through valve 7 until a sufficient volume has been introduced to fill the liner string to the top of the cylindrical member 16, thereby moving the sealing compound into the cylindrical member and the annular space 19 around the overshot. The sealing compound is then maintained in position until set, as by closing the casing and the liner string valves 7 and 24, respectively. After the sealing compound has had time to harden, the head 22 is removed and the liner string cleared, if necessary, of set sealing compound, by boring a passage from the upper to the lower section of the string, leaving an annulus 18 of set sealing compound between the outside of the upstanding end 11 of the liner and the inside of the cylindrical member. In carrying out the process with but one plug, the operation is the same as that just described without plugs, except that one plug is introduced into the liner string either ahead of or behind the charge of sealing compound.

In its broader aspects, then, the invention contemplates the repair of a casing or liner either with or without the use of travelling plugs to separate the sealing compound from the fluid above and below it as the sealing compound is moved into position in the well.

In actual use of this method in a deep well in making a repair of a 5½ inch liner, which split at a depth of 2750 feet due to the application of an excessive pressure (4200 p. s. i.), a strong pressure tight seal was obtained which withstood a water pressure test of 1900 p. s. i. between the inside and outside of the liner at the depth of the repair.

I claim:

1. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, introducing into the annular spaces between the cylindrical member, the liner in the well and the well hole a fluid sealing compound capable of setting to a solid, and after the sealing com-

pound has set forming an axial passage from the upper to the lower portion of the liner.

2. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, introducing into the liner string in the order named a quantity of a fluid sealing compound in amount at least sufficient to fill the well hole for a depth equal to the length of the cylindrical member and then a pressuring liquid, continuing the introduction of the pressuring liquid until an amount has been introduced sufficient to fill the liner to the top of the cylindrical member, thereby displacing the sealing compound from the liner string above the cylindrical member into the annular spaces between the cylindrical member, the liner in the well and the well hole, permitting the sealing compound to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the well, and after the sealing compound has set forming an axial passage from the upper to the lower portion of the liner.

3. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, introducing into the liner string in the order named a travelling plug, a quantity of a fluid sealing compound in amount at least sufficient to fill the well hole for a depth equal to the length of the cylindrical member, and a pressuring fluid, continuing the introduction of the pressuring fluid until an amount has been introduced sufficient to fill the liner to the top of the cylindrical member, thereby displacing the sealing compound from the liner string above the cylindrical member into the annular spaces between the cylindrical member, the liner in the well hole and the well hole permitting the sealing compound to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the well, and after the sealing compound has set forming an axial passage from the upper to the lower portion of the liner.

4. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, introducing into the liner string in the order named a quantity of a fluid sealing compound in amount at least sufficient to fill the well hole for a depth equal to the length of the cylindrical member, a travelling plug, and a pressuring fluid, continuing the introduction of the pressuring fluid until an amount has been introduced sufficient to fill the liner to the top of the cylindrical member, thereby displacing the sealing compound from the liner string above the cylindrical member into the annular spaces between the cylindrical member, the liner in the well hole and the well hole, permitting the sealing compound to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the well, and then making an axial passage from the upper to the lower portion of the liner.

5. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, introducing into the liner string in the order named a first travelling plug, a quantity of a fluid sealing compound in amount sufficient to fill the well hole for a depth at least equal to the length of the cylindrical member, a second travelling plug, and a pressuring liquid, continuing the introduction of pressuring liquid until the second travelling plug reaches the cylindrical member so as to displace the fluid sealing compound from the liner string into the annular spaces between the cylindrical member, the liner in the well and the well hole, permitting the fluid sealing compound to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the well, and then making an axial passage from the upper to the lower portion of the liner.

6. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, filling the well and liner with a drilling mud so as to render the well hydrostatically controllable, introducing into the liner string in the order named a quantity of water, a first travelling plug, a quantity of a fluid sealing compound in amount sufficient to fill the well hole for a depth at least equal to the length of the cylindrical member, a second travelling plug, and a pressuring liquid, continuing the introduction of pressuring liquid until the second travelling plug reaches the cylindrical member so as to displace the fluid sealing compound from the liner string into the annular spaces between the cylindrical member, the liner in the well hole and the well hole, permitting the fluid sealing compound to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the

well, and then making an axial passage from the upper to the lower portion of the liner.

7. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering the said liner string with cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, filling the well and liner with a drilling mud so as to render the well hydrostatically controllable, introducing into the liner string in the order named a quantity of water, a first travelling plug, a quantity of a resin-forming liquid capable of setting to a solid resin in amount sufficient to fill the well hole for a depth at least equal to the length of the cylindrical member, a second travelling plug, and a pressuring liquid, continuing the introduction of pressuring liquid until the second travelling plug reaches the cylindrical member so as to displace the resin-forming liquid from the liner string into the annular spaces between the cylindrical member, the liner in the well and the well hole, permitting the resin-forming liquid to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the well, and then making an axial passage from the upper to the lower portion of the liner.

8. The method of repairing a break in a liner in a deep well which comprises withdrawing from the well the portion of the liner above the break so as to leave the remainder of the liner with severed end upstanding in the well, attaching a cylindrical member larger than the liner to the lower end of a liner string, said cylindrical member being adapted to slip over the upstanding end of the liner in the well, lowering

the said liner string with the attached cylindrical member into the well so as to place the cylindrical member over the upstanding end of the liner, introducing into the liner string in the order named a first travelling plug, a quantity of a resin-forming liquid capable of setting to a solid resin in amount sufficient to fill the well hole for a depth at least equal to the length of the cylindrical member, a second travelling plug, and a pressuring liquid, continuing the introduction of pressuring liquid until the second travelling plug reaches the cylindrical member so as to displace the resin-forming liquid from the liner string into the annular spaces between the cylindrical member, the liner in the well hole and the well hole, permitting the resin-forming liquid to set in situ so as to form a seal between the cylindrical member and the upstanding end of the liner in the well, and then making an axial passage from the upper to the lower portion of the liner.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,269,090	Kistler	June 11, 1918
1,369,891	Halliburton	Mar. 1, 1921
1,404,353	Ellis	Jan. 24, 1922
1,567,109	Boynton	Dec. 29, 1925
2,164,266	Armentrout et al.	June 27, 1939
2,219,319	Irons	Oct. 29, 1940
2,312,862	Bermingham, Jr.	Mar. 2, 1943
2,372,461	Uren	Mar. 27, 1945
2,447,629	Beissinger et al.	Aug. 24, 1948

FOREIGN PATENTS

Number	Country	Date
6,507	Great Britain	1904