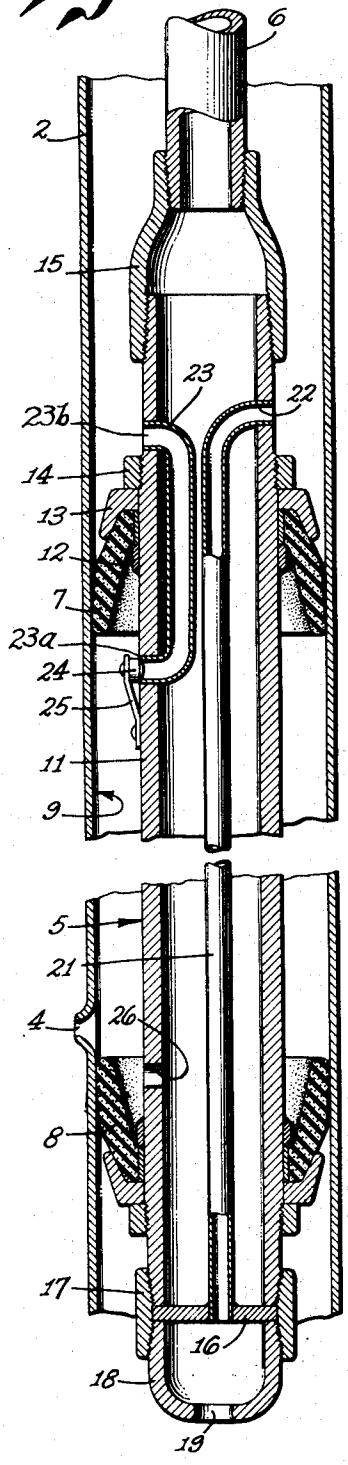
Jan. 12, 1943. P. H. GRANGER 2,308,072

METHOD OF CEMENTING OIL WELLS

Filed May 27, 1941

Fig. 2.



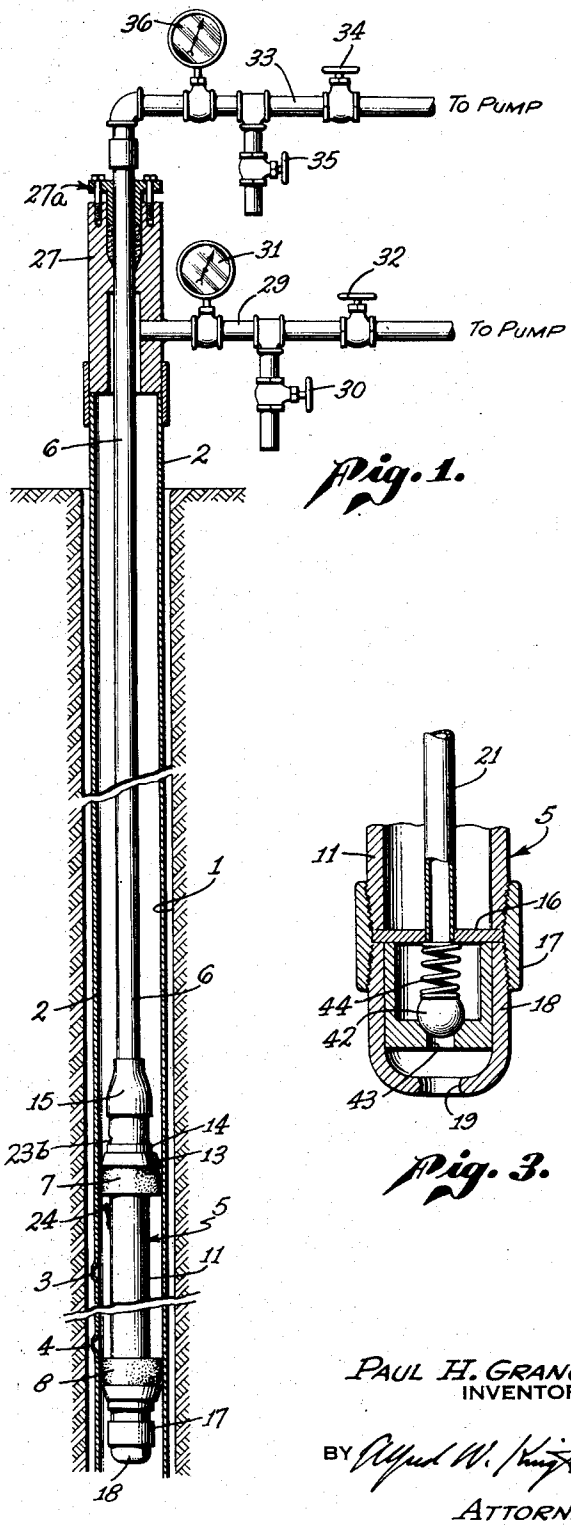


Fig. 1.

Fig. 3.

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METHOD OF CEMENTING OIL WELLS

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2 Claims. (Cl. 166—22)

This invention relates to a method of placing cement through openings in oil well casings.

It has been common practice for some time to place cement through an opening in the casing by means of a tool suspended from a tubing and provided with spaced packers adapted to seal off a zone in the casing in which the opening is located. The term "tubing" is used herein to denote a conduit such as a string of pump tubing or drill pipe. Such a cementing operation may be carried out, for example, for the purpose of sealing off around an opening caused by failure of the casing. In other cases, an opening or a plurality of openings may be purposely made in the casing adjacent a water-bearing stratum so that cement may be forced through the opening or openings into the well around the casing and into the structure to effect a water seal. Cement is forced down the tubing and into the tool so as to flow through the localized zone and out through the opening or openings in the casing into the well and the surrounding formation so as to seal the formation and close the openings.

It has been common practice to remove the tool from the position of the opening or openings immediately after the cementing operation has been performed, usually by moving the tool upwardly in the casing, in order to prevent the tool from becoming stuck due to formation of a bond between cement remaining in the localized zone and the cement outside the casing at said position. Under such circumstances there is a decided tendency for cement to flow back through the opening into the casing, sometimes to such an extent that the cementing job is ineffective.

Usually some cement remains in the tool, particularly in the localized zone of the casing sealed off between the packers after the required amount of cement has been forced through the opening. According to some practices the cement remaining in the tool is not forced out or is not perfectly flushed out before the tool is brought to the surface on the tubing string. There is, therefore, a decided tendency for the tool to become jammed in the casing due to the setting of the cement remaining in the tool and particularly in the zone of the casing sealed off between the packers.

The term "cement" is used herein in a broad sense, to include Portland cement, special types of "oil well" cement such as are in common use in well-cementing operations, and other hydraulic cement materials, and, in general, any material which is adapted to be placed while in fluent or plastic condition and to set or harden to a relatively solid or rigid condition upon standing for a suitable period of time.

A particular object of the invention is to provide a cementing method which prevents the back flow of cement into the casing after the cement has been forced out through the opening in the casing into the surrounding formation.

Another object of the invention is to provide for the flushing out of excess cement from the tool while preventing the back flow of cement into the casing through the opening which has been cemented.

A further object of the invention is to provide for the substantially complete removal of cement from the zone in the casing between the spaced packing means after the desired amount of cement has been forced through the opening in the casing.

Further objects and advantages of the invention will become apparent as the description proceeds.

In the placing of cement through an opening in the casing of a well with a tool suspended within the casing from a tubing and provided with vertically spaced packing means for sealing off a portion of the casing therebetween, the tool is first brought into position to seal off between the packing means a localized zone of the casing containing the opening. The tool is preferably positioned with the lowermost packing means adjacent the opening.

Tools of this type are provided with one or more cement ports providing communication between the space between the packing means and the tubing string. For reasons that will be brought out subsequently, the cement port or ports are preferably located adjacent the lowermost packing means.

Cement is then forced down the tubing into the localized zone and through the opening. According to one practice of the invention, especially in situations where considerable cement is liable to accumulate in the localized zone, liquid is then forced down the casing around the tubing, through the localized zone, and out through the tubing to substantially completely remove cement from the localized zone. It is preferable that the tool be maintained in the same position during the cementing and flushing operations.

In some situations, especially when using a tool which has a cementing port closely adjacent the lower packing means and when such tool is located with the lower packing means adjacent

the opening in the casing, it is not necessary to carry out the above flushing operation. However, it is preferable in any case to retain the tool in position after the cementing operation, while maintaining the tubing full of liquid to maintain in the zone between the packing means a fluid pressure at least equal to the hydrostatic head produced by the liquid in the tubing, until the cement around the opening has taken at least an initial set. This substantially prevents any back flow of cement through the opening into the casing.

After the tool has been retained in position the desired length of time, substantially the whole tool, including the packing means is moved vertically to a different position in the casing, as upwardly to the earth's surface.

I have illustrated examples of apparatus which may be used for carrying out my invention in the accompanying drawing, and referring thereto:

Fig. 1 is a partly sectional elevational view of an oil well with apparatus for cementing therein;

Fig. 2 is a longitudinal section of a cementing tool such as illustrated in Fig. 1; and

Fig. 3 is a longitudinal section of a portion of the tool illustrated in Fig. 2, modified by the addition of a check valve.

Referring to Figs. 1 and 2 of the drawing, a bore hole is indicated at 1 and is shown provided with a casing 2, having openings 3 and 4 therein through which cement is to be placed. A cementing tool 5, shown in detail in Fig. 2, is suspended within the casing on a tubing 6 such as a string of drill pipe or pump tubing, and is provided with spaced packing means such as upper and lower packing cups 7 and 8 which are adapted to seal with the inner walls of the casing 2 to seal off a localized zone in the casing therebetween as indicated at 9. The tool 5 is shown as comprising a generally cylindrical body member 11 to which the packers 7 and 8 are suitably attached at vertically spaced positions. For example, the uppermost packer 7 may be held in position between a ring 12 secured to the body 11 and a conical ring 13 forced toward the ring 12 by means of a compression nut 14. The lower packer 8 may be held in position by a similar construction. The body 11 is suspended from the tubing 6 by means of a reducing coupling 15 which threadedly engages the tubing and the body.

The lower end of the tool is closed by means of a partition 16. This partition is shown abutting the lower end of the body member 11 to which a collar 17 is threadedly secured. A cap member 18 is shown threaded to the collar 17 and in contact with the partition 16 to hold it in tight engagement with the lower end of the body member 11. The lower end of the cap member 18 is provided with an opening 19 below the lower packer 8 through which liquids may flow.

The tool is further provided with a by-pass 21 which extends from the partition 16, where it communicates with the opening 19, upwardly within the member 11 and thence outwardly through the wall of the member 11 as at 22 at a position above the upper packer 7. The tube 21 provides for by-passing liquids between the spaces above and below the packing means during vertical movement of the tool in the casing. Such by-passing is generally necessary in view of the tight fit the packing means makes with the casing.

Another tube is indicated at 23 extending within the body 11 and providing communication betwen the localized zone as at 23a and the space in the casing above the uppermost packing means as at 23b. The tube is shown provided with check valve means such as a valve member 24 mounted on a spring arm 25 and adapted to maintain the tube 23 closed when the pressure within the localized zone 9 exceeds the pressure in the space in the casing above the uppermost packing means 7. The valve 24 is adapted to open the passage 23 when the pressure in the space in the casing above the uppermost packing means exceeds the pressure in the localized zone.

The packers 7 and 8 may be of any suitable type adapted to maintain a fluid-tight seal with the walls of the casing against pressure within the localized zone between the packers, so as to prevent flow of cement past the packers in cementing operations such as described hereinafter. If the upper packer 7 is of a type which will also maintain a fluid-tight seal when the pressure within the casing above the packer exceeds the pressure between the packers, and if it is desired to remove excess cement from the localized zone by introduction of a flushing liquid down the casing as described hereinafter, then it is necessary to provide some means such as the passage 23 and check valve 24 for permitting such flushing liquid to flow downward past the position of the upper packer and into the localized zone. However, the tool is shown as provided with packers of the type comprising flexible cups of rubber or the like, facing inwardly toward each other, so as to maintain a tight seal by expansion thereof against the casing when the pressure in the localized zone between the packers exceeds the pressure above and below such localized zone. When using flexible packing cups of this type, it may not be necessary to provide means such as passage 23 for permitting downward flow of flushing liquid past the upper packer, because the upper packer may be constructed so as to yield sufficiently upon excess pressure from above to permit the flushing liquid to flow down between the packer and the casing.

The tool is further provided with a cement port 26 which provides communication between the inside of the member 11 and the localized zone between the packers. Although more than one port may be employed, I prefer that any cement port providing such communication be located closely adjacent the lowermost packing means and preferably at a position below the uppermost edge of such packing means.

It may be assumed that the position of the openings 3 and 4 is known, as from casing records or as the result of forming said openings at a known depth, or has been located by well-known leak-locating procedures. The tool is brought into position to seal off between the packers 7 and 8 the localized zone 9 in the portion of the casing containing the openings 3 and 4. The tool is preferably so positioned as to place the lower packer 8 as close to the lowermost opening 4 as is possible. While lowering or raising the tool into the hole on the tubing the liquid in the casing is by-passed through the tool through the tube 21.

For cementing operations, the casing 2 is usually provided at its upper end with a cementing head 27. This head may be held in place by a collar 28 threadedly engaging the upper end of the casing. A conduit 29 is shown connected to

the cementing head for providing communication between the interior of the casing and a pump not shown. A shut-off valve is indicated at **32** in the conduit **29** for cutting off communication between the pump and the casing. The conduit **29** is shown with a discharge valve **30** connected thereto between the valve **32** and the head **27**, and with a pressure gauge **31** located between the valve **30** and the head, for indicating the pressure in the casing. A conduit **33** is shown connected to the upper end of the tubing string **6** and leading to a suitable pump not shown. A shut-off valve is shown at **34** in the conduit **33** and a discharge valve **35** is connected to said conduit between the valve **34** and the tubing string. The conduit **33** is further provided with a pressure gauge **36** located between the tubing string and the valve **35**. The cementing head includes a packing gland **27***a* for preventing leakage around the outside of the tubing.

To place cement through the openings **3** and **4**, a suitable cementing material in fluent form, such as a Portland cement slurry, is introduced into the conduit **33** and pumped down the tubing string **6** where it enters the body **11** of the tool **5** and is discharged therefrom through the cement port **26**. The cement then flows over the lowermost packer **8** and out through the opening **4**, or through both openings **3** and **4**, into the space around the outside of the casing and into the formation, at the position of the openings and for some distance below and above the openings.

The total amount of cement to be forced down the tubing is determined before the cementing operation is begun, the amount being dictated by knowledge of the situation and experience. When the desired amount of cement has been pumped into the tubing, water or other fluid is introduced and pumped down the tubing to force the remaining cement down to the tool. Suitable well-known means is employed for indicating the arrival of the last of the cement at the tool. Usually a certain amount of liquid is forced down the tubing after this to clear the tool and place as much of the cement as possible through the opening or openings.

Generally when cementing a plurality of vertically spaced openings such as the openings **3** and **4**, there will be considerable cement left in the tool at the end of the cementing operation. This cement may be flushed from the tool by pumping liquid into the casing through the conduit **29** while the tool is maintained in position with the packers on opposite sides of the openings in the casing.

Under ordinary circumstances the pressure in the localized zone produced during the cementing operation is somewhat greater than can be withstood by the casing at positions adjacent the surface. Hence, if an attempt is made to force liquid down the casing from the conduit **29** at a pressure in excess of the pressure which has been established in the localized zone during the cementing operation, there is a good possibility that the upper portions of the casing will rupture. Before starting such circulation, it is therefore preferable to bring the pressure in the localized zone to a level which the casing can withstand. This may be accomplished by opening the valve **35** and reducing the pressure to a desired value as indicated by the pressure gauge **36**. Since the tool is maintained at the localized cementing zone and the tubing is full of liquid remaining therein at the completion of the cementing operation, the fluid pressure in the localized zone is maintained at least equal to the hydrostatic head of the column of liquid in the entire length of tubing above the tool, and the maintenance of this pressure at the position of the openings **3** and **4** serves to prevent back flow of the cement through the openings into the localized zone. By opening valve **35**, the pressure in the localized zone may be reduced to any desire pressure equal to or greater than such hydrostatic head.

The liquid forced down the casing passes into the localized zone past the position of the upper packing means **7**, either directly between the packer and casing, or through the tube **23**, since excess pressure from above opens the valve **24**. This liquid flows downwardly through the localized zone and flushes any excess cement out of the zone through the cement port **26** and upwardly through the body **11** and the tubing **6** from which it is discharged through the conduit **33**. Since there is no communication between the interior of the tubing **6** and the space within the casing around the tubing, except through the above described path leading through the localized zone between the packing means and thence through the tool body, the flow of the flushing liquid from the casing into the tubing takes place substantially wholly through the localized zone, thus ensuring removal of cement from said localized zone while maintaining in said zone a fluid pressure at least equal to the hydrostatic head of the column of liquid in the entire length of the tubing above the tool. By using a tool in which the cement ports are located closely adjacent the lowermost packing means, such reverse circulation will substantially completely remove from the localized zone all cement remaining therein at the completion of the cementing operation. Any cement in this zone will flow or be carried by the flushing liquid to the lower end of the zone, and since the flushing liquid is forced to flow downwardly to the position of port **26** in order to leave the zone, a thorough scavenging action is ensured. If cement is left between the tool and the casing it will normally be located within the lowermost cup and just below the cement port **26**. Such cement, even if allowed to set, will not prevent subsequent movement of the tool.

The tool is preferably maintained in the cementing position until the cement around the openings in the casing has taken at least an initial set and the above-mentioned fluid pressure is preferably maintained in the localized zone throughout that period. During at least part of that period, and preferably during the first part thereof, the above-mentioned flushing procedure is conducted while maintaining the tool in said cementing position in order to maintain pressure on the cement and give it a chance to set without back flow or channeling.

As illustrated in Fig. 3, the tool may, if desired, be provided with means for preventing down flow through the tube **21** during a flushing operation such as described above. In Fig. 3 the tool is shown modified by the provision of a valve cage **41** suitably secured in the member **18** and containing a ball **42** held seated in an opening **43** by means of a compression spring **44**. The ball **42** is raised from the opening **43** by upward pressure against it, upon downward movement of the tool, to provide for the upward flow of liquid through the tool from the opening **19** to the opening **22**. An excess of fluid pressure from above as communicated from the opening **22** will force the ball down and close the passage **43**,

preventing the downward flow of liquid through the tube 21.

In some cases the tool may be left in position for several hours after the cement has taken an initial set. The tool, including the spaced packers, after being maintained in position for the desired interval, is then moved vertically in the casing either to the surface or to a position to cement other openings. It is not necessary to disintegrate the packers, as by reaming, in order to move the tool at the completion of the cementing operation.

It will be assumed that general good practice will be followed in placing the cement in the openings to be cemented. Other tools which are suitable for practicing the method of this invention are disclosed and claimed in my copending applications Serial Nos. 347,697 (Patent No. 2,248,169) and 383,589, filed July 26, 1940, and March 15, 1941, respectively.

My invention is subject to considerable modification, hence I do not choose to be strictly limited to the above illustrative examples, but rather to the scope of the appended claims.

I claim:

1. In the placing of cement through an opening in the casing of a well with a tool suspended within the casing from a tubing and provided with vertically spaced packing means for sealing off a localized zone in the casing therebetween, said tubing being adapted to communicate with the localized zone, the steps which comprise: bringing the tool into position in the casing with the packing means located at opposite sides of the opening in the casing to seal off a localized zone in the portion of the casing containing the opening; forcing cement down the tubing into the localized zone and through the opening; and thereafter, while maintaining the tool positioned with the packing means located at opposite sides of the opening, forcing liquid down the casing around the tubing, through the localized zone, and up through the tubing, the flow of said liquid from the casing into the tubing being substantially wholly through said localized zone between the packing means, whereby cement is substantially completely removed from said zone by the flushing action of said liquid while maintaining in said zone a fluid pressure at least equal to the hydrostatic head of the liquid in the entire length of the tubing above the tool.

2. In the placing of cement through an opening in the casing of a well with a cementing tool of the type suspended within the casing from a tubing and provided with upper and lower packers sealing with the interior of the casing at vertically spaced positions to seal off a portion of the casing therebetween, and having a cementing port providing communication between the tubing and the portion of the casing between the packers, the steps which comprise: bringing the tool into a cementing position to seal off a localized zone in the portion of the casing containing the opening; forcing cement down the tubing through the cementing port and through the localized zone into and through the opening; and thereafter retaining the tool in said cementing position until the cement around the opening has taken at least an initial set, while maintaining the tubing full of liquid to maintain in said zone a fluid pressure at least equal to the hydrostatic head produced by the liquid in the tubing; and during at least part of the time said tool is so retained in said cementing position, forcing liquid down the casing around the tubing and into the localized zone, and thence through the cementing port and up through the tubing, the flow of said liquid from the casing into the tubing being substantially wholly through said localized zone between the packing means, whereby cement is substantially completely removed from said zone by the flushing action of said liquid while maintaining such fluid pressure in said zone.

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