Dec. 16, 1958 G. H. TAUSCH 2,864,449

APPARATUS FOR FLOWING FLUID MATERIAL IN A WELL

Filed Jan. 29, 1954

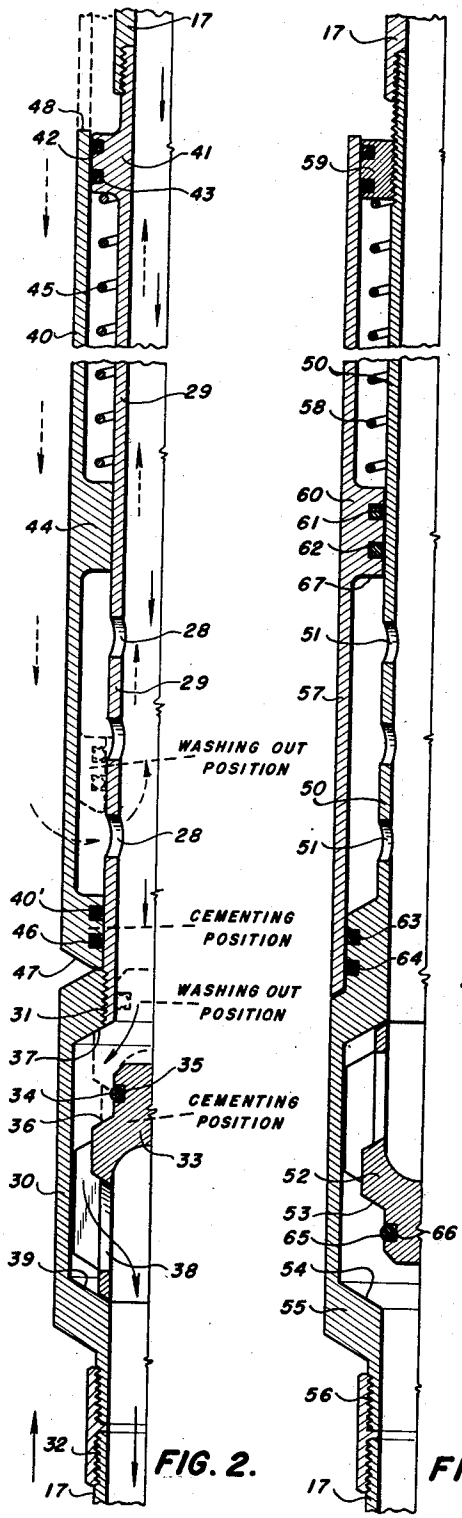


FIG. 2.

FIG. 3.

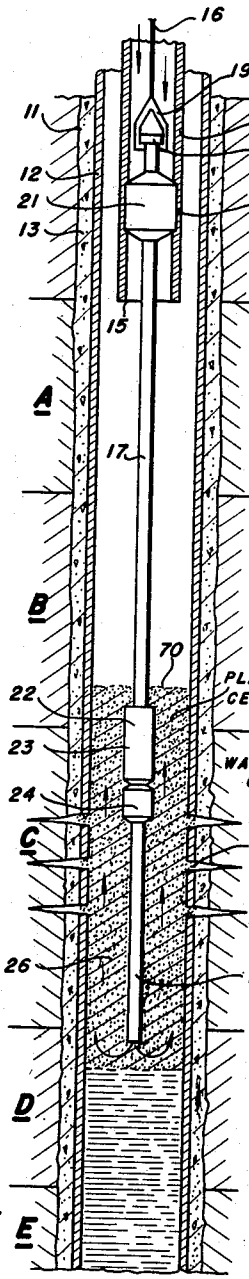


FIG. 1a.

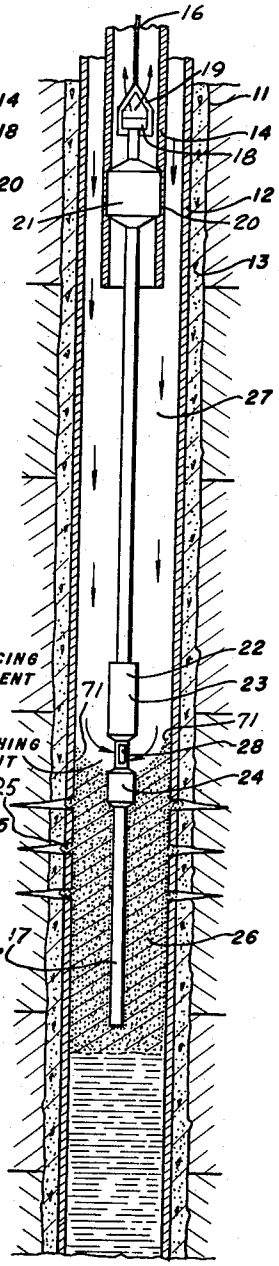


FIG. 1b.

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United States Patent Office 2,864,449
Patented Dec. 16, 1958

2,864,449

APPARATUS FOR FLOWING FLUID MATERIAL IN A WELL

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Application January 29, 1954, Serial No. 407,023

11 Claims. (Cl. 166—115)

The present invention is directed to an apparatus and method for flowing or introducing a fluid material in a cased and tubed well. More particularly, the invention is directed to apparatus for introducing fluid cement into a cased and tubed well. In its more specific aspects, the invention is directed to apparatus and method for cementing in a cased and tubed well in which the tubing is arranged with its lower end above a plurality of productive strata.

The invention may be briefly described as apparatus for use in flowing a fluid material in a cased and tubed well in which the tubing is arranged with its lower end above a plurality of productive strata. The apparatus comprises a tubular member adapted to be lowered through the tubing to project a substantial distance below the lower end of the tubing to increase the effective length of the tubing. The tubular member is provided with at least one port communicating the interior with the exterior of the tubular member at a point intermediate the first and second ends of the tubular member. A valve means is arranged in the tubular member below the port and is adapted to close off the tubular member. A slidable sleeve is mounted on the tubular member and is normally urged into a position to close the port by means of a biasing means or spring arranged on the tubular member under the sleeve. The closing of the valve and the opening of the port by fluid pressure applied in the well serves to shorten the effective length of the tubular member.

The invention also contemplates a method for cementing in a cased and tubed well in which the tubing is arranged at its lower end above a plurality of productive strata. In the practice of the method a body of a low water loss fluid cement is introduced into the well at a point substantially below the lower end of the tubing adjacent perforations in the casing to be sealed with the cement. The cement is in the form of a plug which extends above the perforations. At least a portion of the plug is then removed from the well by circulating out cement from the plug above the perforations. The circulation may be performed by removing the fluid cement by circulation out of the annulus between the tubing and casing or by circulating out through the tubing.

The low water loss fluid cement employed in the practice of the present invention may be any low water loss cement but preferably is a low water loss cement, such as described by Salathiel in U. S. Patent 2,482,459. Other low water loss cements, such as oil-emulsion cements and other modified low water loss cements available on the market, may be used.

The invention will be further described by reference to the drawing in which:

Fig. 1A is a view of the apparatus lowered through a tubing string in a cased well bore;

Fig. 1B illustrated the removal of cement;

Fig. 2 is a sectional view of one modification of the apparatus of the present invention; and

Fig. 3 is a sectional view of another embodiment of the present invention.

Referring now to the drawing in which identical numerals will be employed to designate identical parts, numeral 11 designates a well bore which has penetrated a plurality of subsurface strata or formations A, B, C, D, and E in which is arranged a casing 12 which has been cemented in place with primary cement 13. Arranged from the earth's surface, not shown, is a tubing string 14 having its lower open end 15 arranged above the strata A.

Lowered through the tubing string 14 by means of a wire line 16 is a tubular member 17 which is open at both ends and is provided with a fishing neck 18 for attachment by clamping means 19 to wire line 16, as shown.

The upper end of the tubular member 17 has been landed in a landing nipple 20, such as described in the Composite Catalogue of Oil Field and Pipe Line Equipment, vol. 2, page 4063, Fig. 38, 19th edition, 1952–1953. The landing nipple engages with the upper end of the tubular member 17 and a sealing means, such as chevron packing 21, may be employed to seal off between the tubing 14 and the tubular member 17.

The tubular member 17 is provided with an arrangement generally indicated by the numeral 22 for shortening the effective length of the tubular member 17. The element 22, shown generally in Figs. 1A and 1B, includes a slidable sleeve 23 and a check valve 24 arranged in the tubular member 17. The device of Figs. 1A and 1B is shown more clearly in Fig. 2.

In Fig. 1A the perforations 25 in the casing 12 which have been formed in hydrocarbon productive strata C by lowering a tubing gun down through tubing 14 prior to running in the tubular member 17 are to be sealed and a cement plug, such as plug 26, has been arranged in the casing 12 by flowing same down the tubing 14 and the tubular member 17.

In Fig. 1B the cement plug 26 has been placed and it is desired to remove excess cement from the plug by reversing circulation of fluid. In this particular instance, a fluid, such as water, is flowed down the annulus 27 between the tubing 17 and the casing 12 and the fluid pressure serves to close the check valve 24 and open ports 28 in the tubular member 17 to allow circulation down the annulus 27, through the ports 28, up the tubular member 17 and the tubing 14 to the earth's surface. Opening of port 28 serves to decrease the effective length of the tubular member 17, which increases the effective length of the tubing 14.

Referring now to Fig. 2, it will be seen that the tubing extension 17 is provided with a port section 29 in which the ports 28 are arranged. The section 29 has a check valve section 30 attached to it by mating threads 31 and the port section 29 is connected to a lower portion of the tubular member 17 by mating threads 32. Arranged in the check valve section 30 is a check valve 33 which is provided with a sealing member 34 arranged in a recess 35. The sealing member 34 may suitably be an O-ring. The check valve 33 has an upwardly facing seat 36 which is designed to seat on the downwardly facing seat 37 of the check valve section 30, the O-ring 34 forming a seal with the port section 29.

The check valve 33 has a spider 38 which rests on the upwardly facing shoulder 39 when the valve is open.

Slidably embracing the port section 29 is a sleeve 40 which is in engagement with a shoulder 41 of the port section 29. The shoulder 41 is provided with sealing members, such as O-rings 42, arranged in recesses 43 such that a seal is made with the sleeve 40. Confined by a shoulder 41 of the port section 29 and an inwardly facing shoulder 44 of the sleeve 40 is a biasing

means, such as a helical coil spring 45, which serves to urge the sleeve 40 in a position as shown such that the ports 28 are normally closed. The lower end of the sleeve 40 is provided with sealing means, such as O-rings 40' arranged in recesses 46 to form a seal to insure closing of the ports 28.

The lower end of the sleeve 40 has a surface 47 which is greater in area than the surface 48 of the upper end of the sleeve 40. This surface 47 allows the sleeve 40 to be moved slidably upward to uncover the ports 28 as will be described.

Referring now to Fig. 3 in which another embodiment of my invention is described, the tubular member 17 is provided with a port section 50 in which is arranged ports 51 which serve to communicate the interior of the tubular member 17 with the exterior thereof. Arranged within the tubular member 17 below the ports 51 is a check valve 52 provided with a downwardly facing seat 53 which is designed to seat on the shoulder or seat 54 of the valve section 55 of the tubular member 17. This latter section 55 may be made integrally with the port section 50 and is attached at its lower end by mating threads 56 with the lower end of the tubular member 17.

Slidably embracing the port section 50 is a sleeve 57 which serves to close the ports 51. The sleeve 57 is urged into closing relationship with the port 51 by a biasing means, such as a helical coil spring 58, which is confined by a shoulder 59 of the port section 50 and a shoulder 60 of the sleeve 57. The shoulder 60 is provided with sealing means, such as O-rings 61, arranged in recesses 62.

The lower end of the slidable sleeve 57 is sealed with the port section 50 by sealing means 63 arranged in recesses 64.

It is to be noted that the check valve 52 is provided with a sealing means, such as an O-ring 65, arranged in a recess 66 to form a seal with the lower end of the valve section 55 as will be described.

The apparatus and method of the present invention operates as follows:

In this particular instance, it is desired to seal off at least a portion of the strata or formation C in which the perforations 25 have been made, prior to perforating in a vertically displaced strata such as A. To this end a body of cement 26 is flowed down the tubing 14 and the tubular member 17 providing an upper level of cement 70. After the cement has been located, as shown in Fig. 1A, and it is desired to circulate out the cement to reduce its level to a level 71 as shown in Fig. 1B, water or other fluid is circulated down the annulus 27 and pressure is thus exerted on the cement and against the check valve 33 causing it to rise into sealing engagement with the seat 36 against the shoulder or seat 37 and the O-ring 34 forming a seal with the port section 29.

Since the area 47 of the sleeve 40 is greater than the area 48, pressure exerted against the area 47 causes the sleeve 40 to move upwardly overcoming the spring 45 and uncovering the ports 28 which allows the cement in the casing above ports 28 to be reversed out through the ports 28, up the tubular member 17 and up the tubing 14 to the earth's surface. Thus, it will be seen that with the device of Figs. 1A, 1B and Fig. 2, it is possible to increase the effective length of the tubing and then to decrease or shorten the effective length of the tubular member. The effective length of the tubing is increased by positioning the tubular member 17 in the landing nipple 20 while the effective length of the tubular member is shortened by opening the ports 28 on imposing pressure on the sleeve 40.

The apparatus of Fig. 3 works in an opposite manner to that of Figs. 1A, 1B and Fig. 2 in that in the apparatus of Fig. 3 the cement would be flowed down the annulus 27 and located at the particular point to be desired below the open end 15 of the tubing 14. Thereafter fluid, such as water or the like, will be flowed down the tubular member 17 causing the valve 52 to be forced into seating engagement with the seat 53 against the shoulder 54, a seal being formed with the O-ring 65. After the valve 52 has closed, fluid pressure is then exerted through the ports 51 against the surface 67 of the shoulder 60 which pressure would overcome the downward force of the spring 58 causing the sleeve 57 to move upward uncovering the ports 51. By virtue of the circulation through the ports 51, it is then possible to shorten the effective length of the tubular member and to remove the cement from a body, such as 26.

The present invention is particularly useful in plugging off a non-commercial or non-productive interval or strata in a well in which a tubular member of the type described is employed. The present invention allows water in a particular strata or formation or producing interval to be squeezed off without moving the tubing extension or without moving the tubing. Thus, small volumes of cement may be correctly placed without the necessity of moving either the tubular member or the tubing. In other words, the present invention allows a displacement plug of cement to be cut or removed at a selected point as may be desired. The invention is particularly useful in well cementing operations but may be used in other operations employing the introduction or removal of chemicals or other materials which will readily flow from a well.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and to secure by Letters Patent is:

1. Apparatus for use in flowing a fluid material in a cased and tubed well while maintaining the tubing in place in which the tubing is arranged with its lower open end above a plurality of productive strata which comprises a retrievable tubular member lowerable on a flexible line through said tubing and sealingly seatable with its upper end in the lower end of said tubing to project a substantial distance below said lower end to increase the effective length of said tubing, said tubular member being provided with at least one port communicating its interior with the exterior of said tubular member at a point intermediate first and second ends of said tubular member, a valve means arranged in said tubular member below said port adapted to close said tubular member and prevent flow in one direction by fluid pressure exerted against said valve means, a slidable sleeve mounted exteriorly on said tubular member, and a biasing means arranged exteriorly on said tubular member to urge said sleeve to a position normally closing said port, closing of said valve and opening of said port by said fluid pressure exerted against a surface of said sleeve in said one direction serving to provide fluid passage through said opened port between the interior and exterior of the tubular member intermediate its first and second ends on overcoming said biasing means.

2. Apparatus for use in flowing a fluid material in a cased and tubed well while maintaining the tubing in place in which the tubing is arranged with its lower open end above a plurality of productive strata which comprises a retrievable tubular member lowerable on a flexible line through said tubing and sealingly seatable in said tubing to project a substantial distance below said lower end to increase the effective length of said tubing, said tubular member being provided with at least one port communicating its interior with the exterior of said tubular member at a point intermediate first and second ends of said tubular member, means for suspending said tubular member in said tubing, a check valve arranged in said tubular member below said port adapted to close said tubular member and prevent flow in one direction by fluid pressure exerted against said check valve, a slidable sleeve mounted exteriorly on said tubular member, and a coil spring mounted exteriorly on said tubular member to urge said sleeve to a position normally closing said port, closing of said valve and opening of said port by said

fluid pressure exerted against a surface of said sleeve serving to provide fluid passage through said opened port between the interior and exterior of the tubular member intermediate its first and second ends on overcoming said coil spring.

3. Apparatus for use in flowing a fluid material in a cased and tubed well while maintaining the tubing in place in which the tubing is arranged with its lower open end above a plurality of productive strata which comprises a retrievable tubular member lowerable on a flexible line through said tubing and sealingly seatable with its upper end in the lower end of said tubing to project a substantial distance below said lower end to increase the effective length of said tubing, said tubular member being provided with at least one port communicating its interior with the exterior of said tubular member at a point intermediate first and second ends of said tubular member, means for suspending said tubular member in said tubing, a check valve arranged in said tubular member below said port adapted to close said tubular member and prevent flow in one direction by fluid pressure exerted against said check valve, a slidable sleeve mounted exteriorly on said tubular member, and a coil spring mounted exteriorly on said tubular member under said sleeve to urge said sleeve to a position normally closing said port, closing of said valve and opening of said port by said fluid pressure exerted against a surface of said sleeve serving to provide fluid passage through said opened port between the interior and exterior of the tubular member intermediate its first and second ends on overcoming said coil spring.

4. Apparatus for use in cementing a cased and tubed well while miantaining the tubing in place in which the tubing is arranged with its lower open end above a plurality of productive strata which comprises a retrievable tubular member lowerable on a flexible line through said tubing and sealingly seatable with its upper end in the lower end of said tubing to project a substantial distance below said lower end to increase the effective length of said tubing, said tubular member being provided with a plurality of ports communicating its interior with the exterior of said tubular member at a point intermediate first and second ends of said tubular member, means for suspending said tubular member in said tubing, a check valve provided with an upwardly facing seat arranged in said tubular member below said ports adapted to close said tubular member and prevent flow upwardly through said tubular member by fluid pressure exerted against said check valve, a slidable sleeve mounted exteriorly on said tubular member, a helical coil spring mounted exteriorly on said tubular member under said sleeve to urge said sleeve to a position normally closing said port, closing of said valve and opening of said ports by said fluid pressure applied exteriorly to said tubular member against a surface of said sleeve serving to provide fluid passage through said opened port between the interior and exterior of the tubular member intermediate its first and second ends on overcoming said coil spring.

5. Apparatus for use in cementing a cased and tubed well while maintaining the tubing in place in which the tubing is arranged with its lower open end above a plurality of productive strata which comprises a retrievable tubular member lowerable on a flexible line through said tubing and sealingly seatable with its upper end in the lower end of said tubing to project a substantial distance below said lower end to increase the effective length of said tubing, said tubular member being provided with a plurality of ports communicating its interior with the exterior of said tubular member at a point intermediate first and second ends of said tubular member, means for suspending said tubular member in said tubing, a check valve provided with a downwardly facing seat arranged in said tubular member below said ports adapted to close said tubular member, and prevent flow downwardly through said tubular member by fluid pressure exerted

against said check valve, a slidable sleeve mounted exteriorly on said tubular member, a helical coil spring mounted exteriorly on said tubular member under said sleeve to urge said sleeve to a position normally closing said port, closing of said valve and opening of said ports by fluid pressure applied interiorly in said tubular member against a surface of said sleeve in fluid communication with the interior of said tubular member serving to provide fluid passage through said opened port between the interior and exterior of the tubular member intermediate its first and second ends on overcoming said coil spring.

6. A well treating tool including: a tubular mandrel having means at its upper end for releasably connecting the mandrel to the lower end of a well tubing after said tubing has been placed in the well, said mandrel having at least one lateral port and open upper and lower ends, said lateral port being intermediate the upper and lower ends, and independently acting valve means for closing said lateral port and said open lower end, one of said valve means closing said lateral port when fluid is forced from the well tubing through the mandrel to the well, and the other of said valve means closing said lower open end when fluid is forced from the well through the lateral port into the mandrel, said valve means closing said lateral port comprising a member carried on the exterior surface of said mandrel, said member and said mandrel being movable relative to each other, said mandrel being lowerable through said tubing on a wire line adapted to be attached releasably to the upper end of said mandrel.

7. A well treating tool including: a main mandrel having at least one lateral port intermediate its upper and lower ends and small enough to be lowered through well tubing in the well; valve means disposed on the exterior of said mandrel for closing said port, said valve means and said mandrel being slidable relative to one another, means yieldably holding said mandrel and said valve means in port closing position, said mandrel having an open lower end and means on an open upper end for releasably connecting said upper end of the mandrel to the lower end of said well tubing to project a substantial distance below said well tubing; and a second valve means for closing said lower open end, said second valve means allowing downward flow of fluid through the lower open end of the mandrel but preventing upward flow of fluid through said lower open end, said mandrel being lowerable through said tubing on a wire line adapted to be attached releasably to the upper end of said mandrel.

8. A well treating tool including: a mandrel having means at an open upper end for releasably connecting the upper end of said mandrel to the lower end of well tubing after said tubing has been placed in the well, said mandrel having at least one lateral port intermediate its upper and lower ends; a tubular valve slidable on an exterior surface of said mandrel for closing said port; means biasing said tubular valve downwardly toward port closing position; said mandrel having an open lower end; and valve means for closing said open lower end, said valve means closing said lower end allowing downward flow of fluid through the lower open end of the mandrel but preventing upward flow of fluid through said lower open end, said mandrel being lowerable through said tubing on a wire line adapted to be attached releasably to the upper end of said mandrel.

9. A well treating tool including: a mandrel having means at an open upper end for releasably connecting the mandrel to the lower end of a well tubing after said tubing has been placed in the well, said mandrel having at least one lateral port intermediate its upper and lower ends; a tubular valve means slidable on an exterior surface of said mandrel for closing said port; said tubular valve means being responsive to the pressure differential between the interior and exterior of the mandrel and movable to open position when the pressure on the exterior of the mandrel exceeds the pressure in the interior

of the mandrel by a predetermined amount; said mandrel having an open lower end; and valve means for closing said open lower end to prevent flow of fluid inwardly through said open end when the pressure exteriorly of the mandrel exceeds that interiorly of said mandrel.

10. A well treating tool including: an elongated body having a flow passage longitudinally therethrough; means at an open upper end of said body for releasably securing it to the lower end of a well tubing after the tubing has been placed in the well to depend therefrom; first valve means at the lower end of said body openable to permit fluid to flow from said well tubing through said body to the exterior thereof and closable to prevent backflow; second valve means between the lower end and the upper end of said body openable under pressure to permit fluid exteriorly of said body to flow into and through said body to said well tubing and closable to prevent backflow therethrough, said second valve means comprising a member carried on the exterior surface of said elongated body, said body and said member being movable relative to each other, said means for supporting said body to said well tubing being releasable whereby said body may be removed from depending connection with said well tubing, said body being lowerable through said tubing on a wire line adapted to be attached releasably to the upper end of said body.

11. A well treating tool including: a body having a flow passage longitudinally therethrough; means on an open upper end of said body for supporting it in the lower end of a well tubing after the tubing has been placed in

the well to depend therefrom; a first valve means carried by said body intermediate its upper and lower ends and below said supporting means and being openable to permit flow in one direction and closable to prevent flow in the opposite direction; second valve means also carried by said body longitudinally spaced apart below the first valve means and openable to permit flow in said opposite direction and closable to permit flow in said one direction; said first valve comprising a member carried on the exterior surface of said body, said member and said body being movable relative to each other; said means for supporting said body to said well tubing being releasable whereby said body and valve means may be removed from depending connection with said well tubing, said body being lowerable through said tubing on a wire line adapted to be attached releasably to the upper end of said body.

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