April 9, 1940. R. C. BAKER 2,196,652

APPARATUS FOR CEMENTING WELL BORES

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Fig. 1.

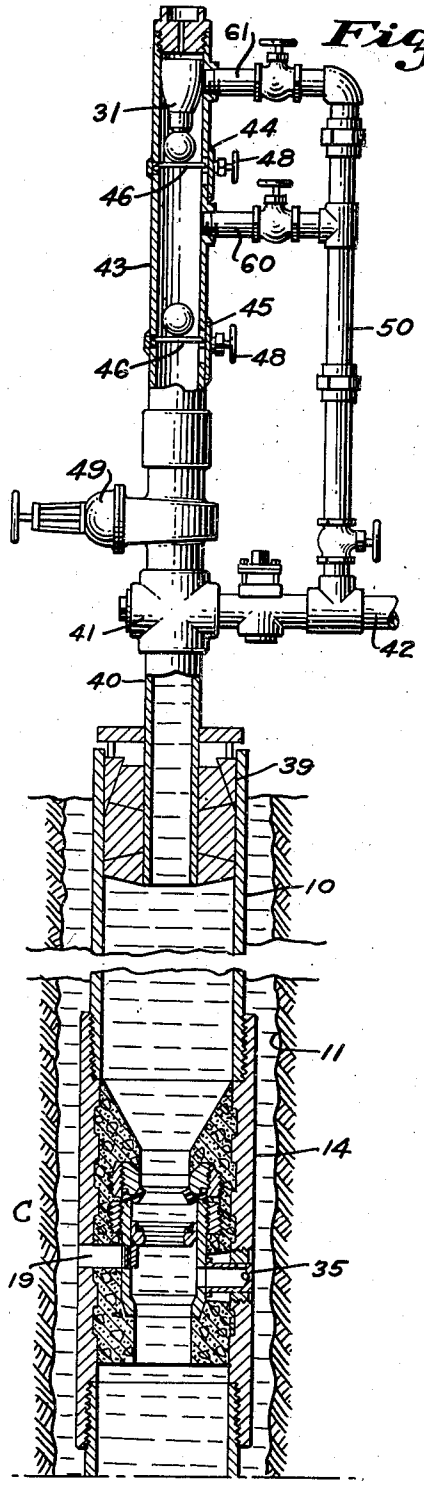
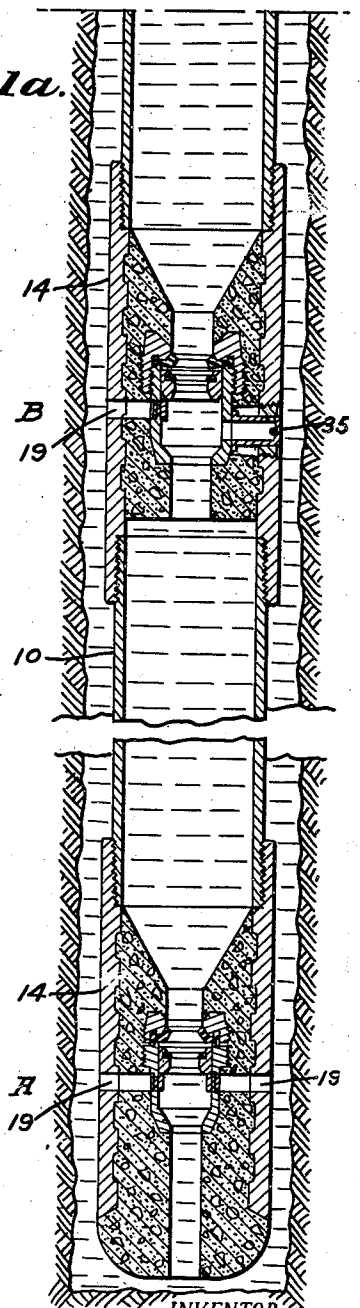


Fig. 1a.



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Fig. 2.

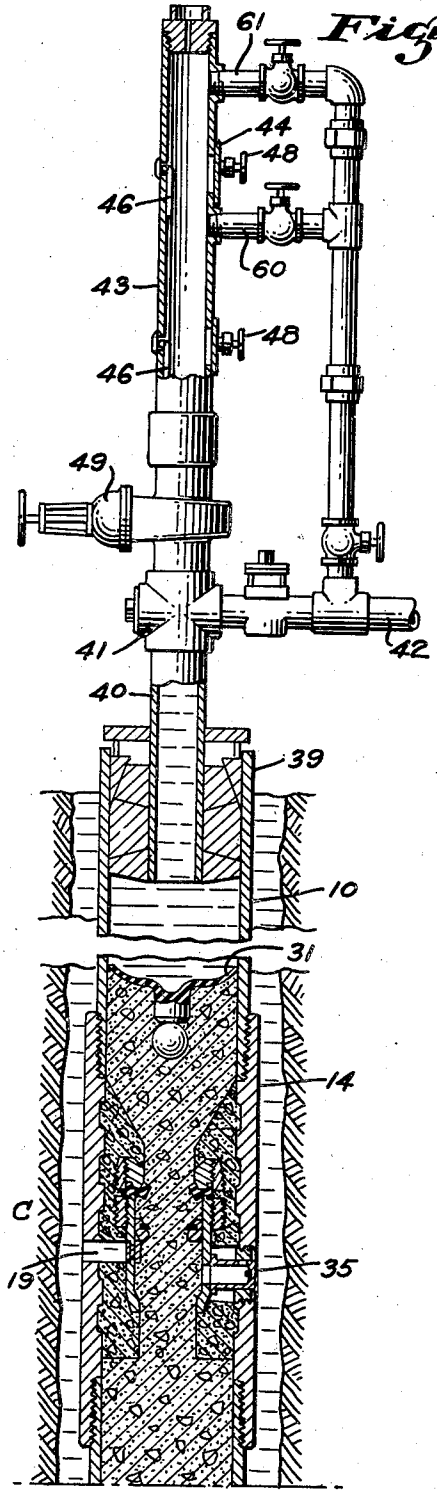
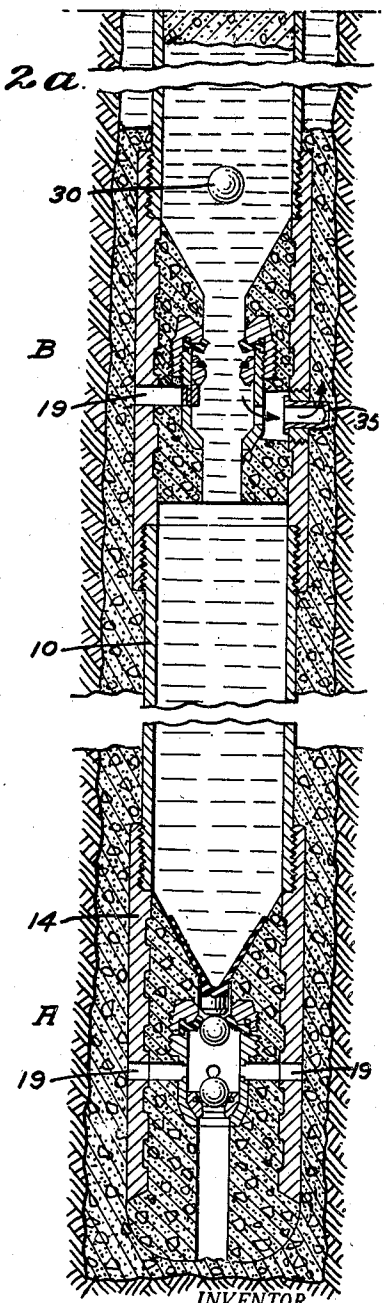


Fig. 2a.



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APPARATUS FOR CEMENTING WELL BORES

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Fig. 3.

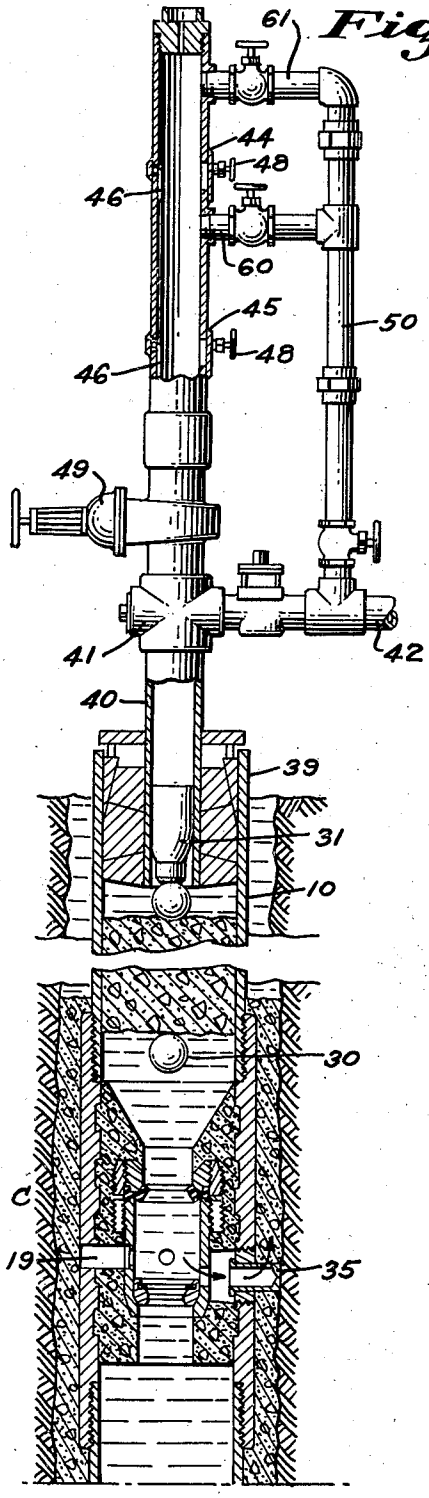
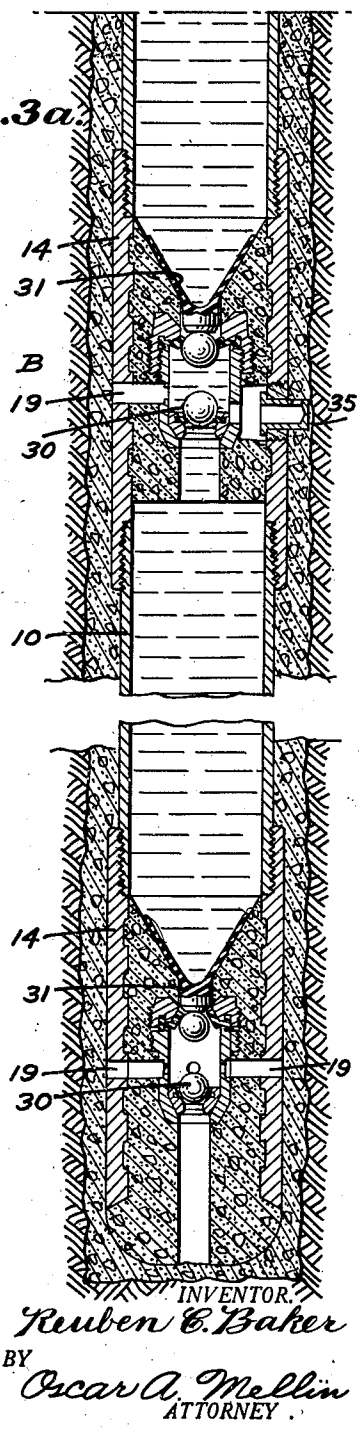


Fig. 3a.



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APPARATUS FOR CEMENTING WELL BORES

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Fig. 4.

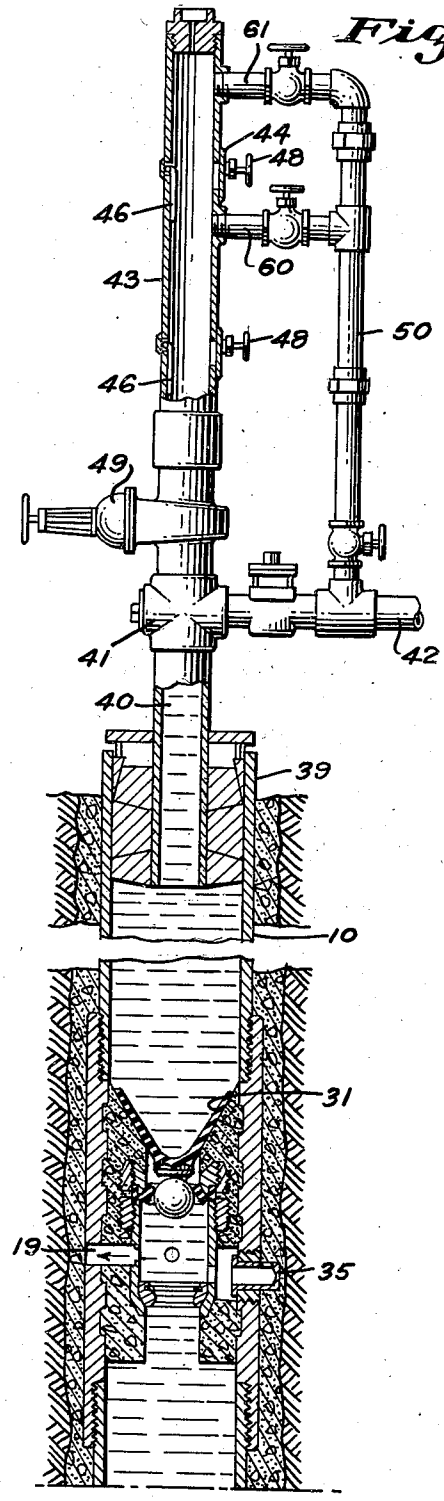
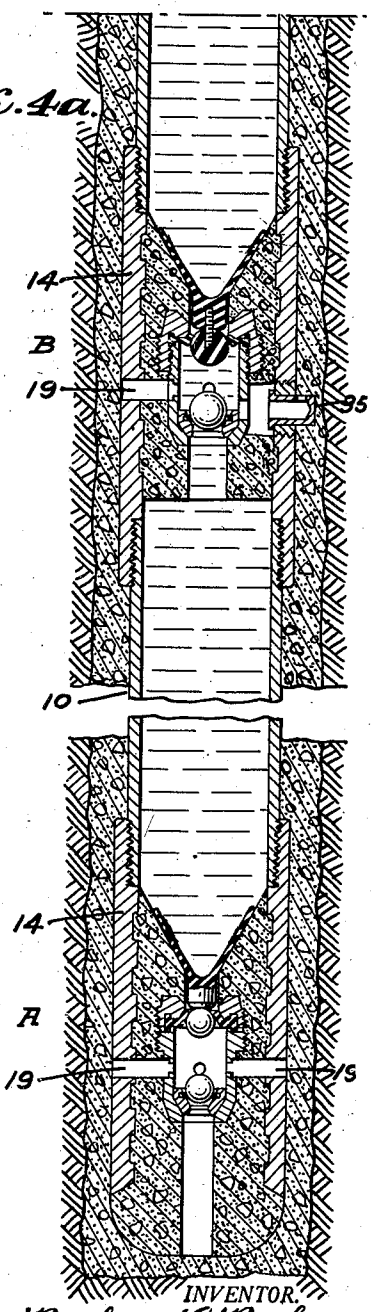


Fig. 4a.



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APPARATUS FOR CEMENTING WELL BORES

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Fig. 5.

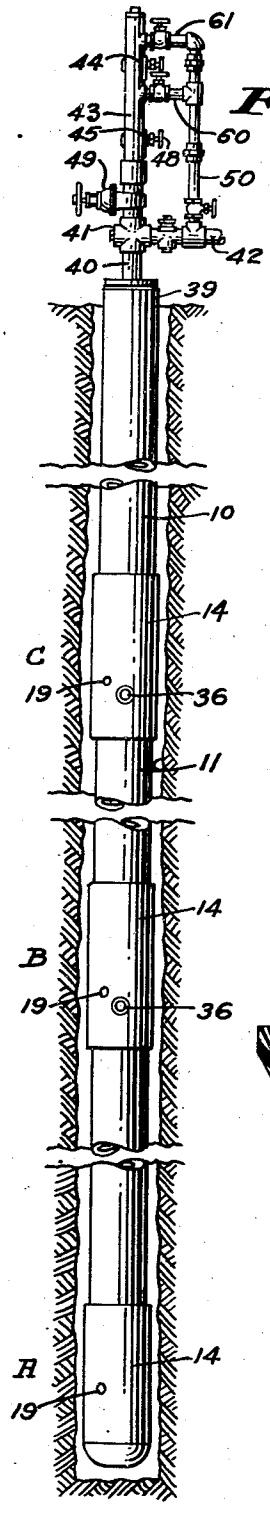


Fig. 10.

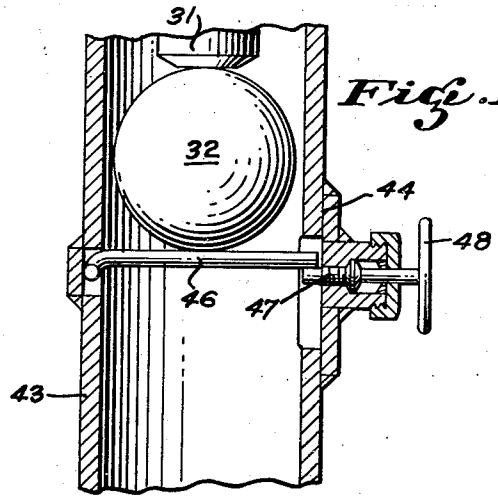


Fig. 11.

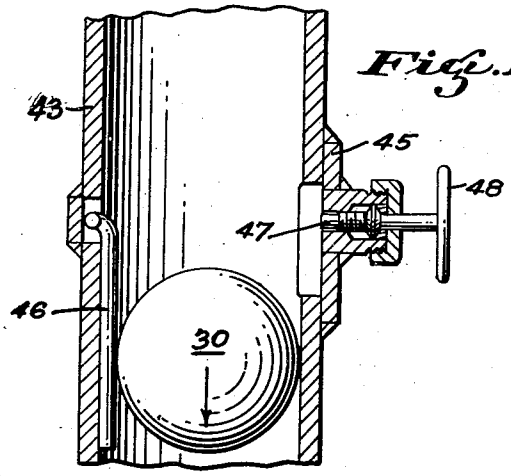
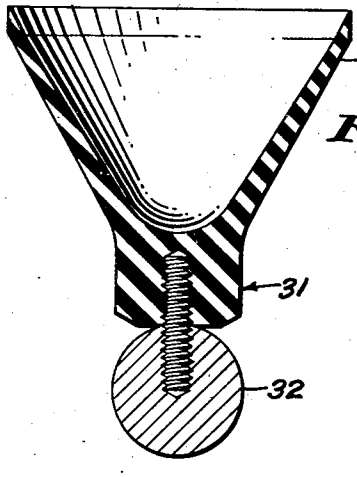


Fig. 12.



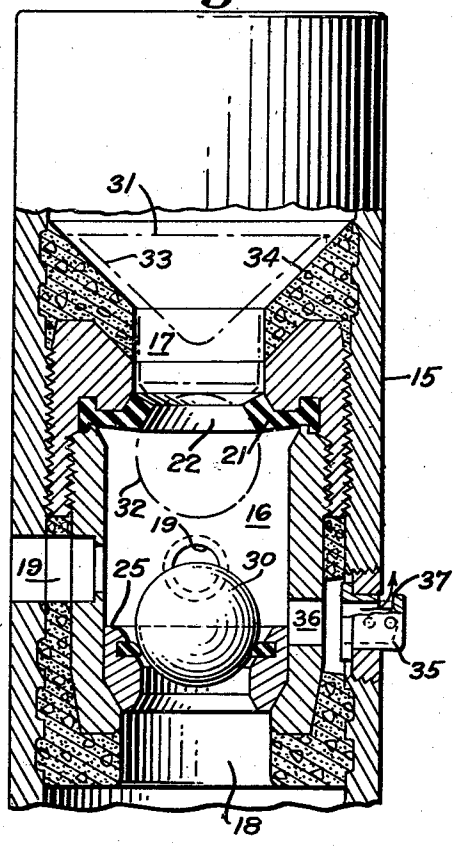
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APPARATUS FOR CEMENTING WELL BORES

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Fig. 7.



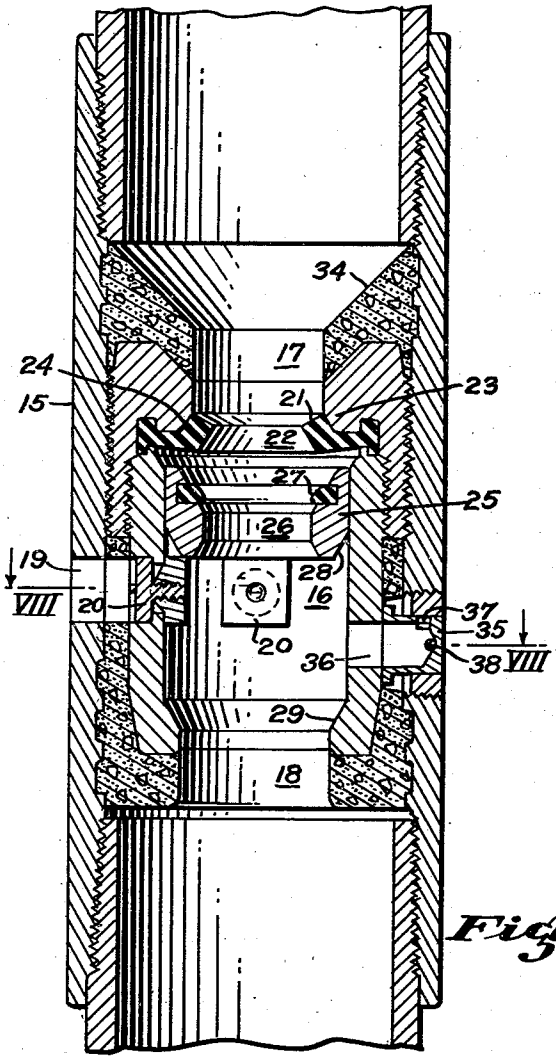
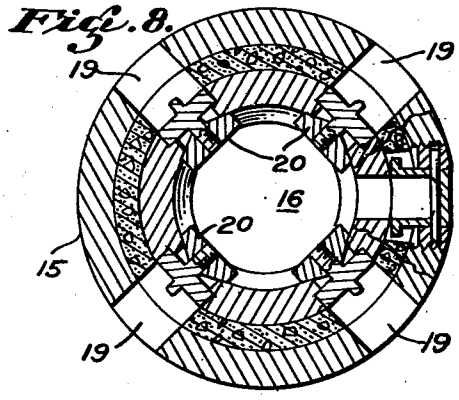


Fig. 6.

Fig. 8.



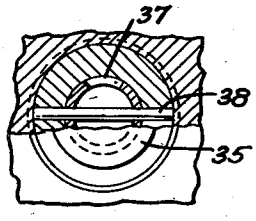


Fig. 9.

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UNITED STATES PATENT OFFICE

2,196,652

APPARATUS FOR CEMENTING WELL BORES

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Application October 10, 1936, Serial No. 105,044

3 Claims. (Cl. 166—1)

This invention relates to the cementing of deep well bores.

It is common practice in drilling a deep well bore to place cement in the annular space between the water string of casing and the bore to fill such space, both to reenforce the casing and to prevent migratory waters from traveling along the casing. It has become highly desirable that this annular space be filled with cement entirely from the lower end of the water string of casing to the top of the bore. This is known as "full hole" cementing. To accomplish this where the casing string is lengthy, several difficulties must be overcome. One is the high pressure necessary to eject the cement and displace the mud, and another is the setting effect of the pressure and high temperatures in the bore on the cement, which, of course, requires that the cement be introduced in the casing and positioned in a comparatively short time period.

It has been attempted to accomplish such a "full hole" cementing job in stages by ejecting separate charges of cement at spaced points along the casing in successive upward steps. In this practice alternately arranged charges of mud and cement slurry of predetermined volume are pumped into the casing at properly spaced intervals and the whole column is continuously moved down the casing. As the spaced charges of cement slurry successively reach their points of discharge, bridging is effected in the casing and side ports are opened to enable the ejection of the cement. In a long string of casing, it is obvious that there may be a number of spaced cement charges in the casing at one time, and during which time but one charge is being ejected, the remaining being enroute to their points of discharge. Should circulation be shut off by failure of one of the cementing devices in the casing or by plugging, by failure of the pumps, or for any other reason, the cement charges are trapped in the casing and are likely to cause loss of the well. At the very least, it will necessitate the drilling out of all of this excessive cement from the casing, which drilling out is an extremely costly and difficult operation.

It is the principal object of my present invention to provide an improved multiple stage method and apparatus for cementing deep well bores which enables circulation to be maintained at all times, but which enables separate charges of cement to be discharged from the casing at vertically spaced points along the casing in upward sequence and without the necessity of having more than one charge of cement in the casing at the same time.

In practicing my invention, I fit the casing with a plurality of cementing devices spaced apart along the length of the well casing and constituting the stations at which cement is to be ejected. Circulation is established through the lower end of the casing or at a point thereabouts, and thereafter a charge of cement is pumped into the casing and ejected therefrom at the first station, which charge is sufficient to cement the annular space between the first and second stations. Thereafter the casing is bridged at the first station and circulation established at the second station by increasing the pressure within the casing. The casing is then bridged below the second station and cementing ports are opened thereabove and a second batch of cement is introduced into the casing and discharged through these latter ports. The casing is then bridged above the cementing ports at the second station. If cementing is to be accomplished in more than two stages, the remaining stage or stages are successively accomplished in the same sequence of steps as just set out.

The invention is exemplified in the following description and illustrated by way of example in the accompanying drawings, in which:

Figs. 1 and 1*a* illustrate, in two sections, a deep well bore with a casing fitted thereto constructed and equipped in accordance with my invention, and disclosing the condition of the casing when it is first positioned in the well bore.

Figs. 2 and 2*a* constitute the same view but disclosing the first stage of cementing completed and the second stage of the cementing about to commence.

Figs. 3 and 3*a* constitute the same view as Figs. 1 and 1*a* with the exception that they disclose the second stage of cementing completed.

Figs. 4 and 4*a* constitute the same view as Figs. 1 and 1*a* but showing all three stages of cementing completed.

Fig. 5 is a diagrammatic view of the casing in the well bore indicating the relative positions of the cementing stations.

Fig. 6 is an enlarged view in central vertical section through one of the cementing devices employed, showing the parts thereof in the position they assume prior to the cementing operation.

Fig. 7 is a similar view with the exception that the parts are shown in the position they assume just prior to and during the cementing operation.

Fig. 8 is a transverse sectional view taken on line VIII—VIII of Fig. 6.

Fig. 9 is a fragmentary view in elevation and section through the pressure actuated circulation valve.

Fig. 10 is an enlarged view of the trip mechanism of the ball magazine.

Fig. 11 is a similar view showing the same released to enable a ball from the magazine to enter the casing.

Fig. 12 is a view in central vertical section through one of the bridging members utilized in connection with the devices shown in Figs. 6 and 7.

Referring more particularly to the accompanying drawings, in Fig. 5 I have there diagrammatically illustrated a casing 10 positioned in a well bore 11. The casing 10 in this instance is illustrated as a water string which it is desired to cement off from the lower end of the casing to the top of the well bore. I desire to point out here, however, that in place of cementing off the entire annular space between the casing and the well bore, that my apparatus and method may be employed in spotting cement along the well bore at spaced points, as, for example, when it is desired to cement off between spaced oil bearing strata.

In the present instance I have shown the casing of a length that it may be cemented off in three stages although I desire to point out that with my method and apparatus the casing may be cemented off in two or more stages, depending upon the length of the casing and the judgment of the operator. For this purpose the well casing is fitted with three cementing devices 14, one of which is positioned at the lower extremity of the casing and the other two of which are positioned at spaced points apart above the lower end of the casing. These three cementing devices are positioned at the three stations A, B and C, from which cement is to be ejected from the casing. The first stage of the cementing is accomplished at the lowermost station A, the second stage of cementing being accomplished at the intermediate station B, and the third stage being accomplished at the uppermost station C. The cementing devices are all of the same construction and are clearly illustrated in Figs. 6 and 7, and are described and claimed in my U. S. Letters Patent entitled "Well cementing device," dated May 17, 1938, bearing Number 2,117,534.

It will be noticed that the cementing devices each comprise a cylindrical member 15 which is connected between casing lengths or at the lower extremity in the case of the lowermost one, and therefore forms a rigid part of the casing. Formed coaxially within the cylindrical member 15 is a cylindrical valve chamber 16 which is here illustrated as of a diameter considerably less than the interior diameter of the cylindrical member 15. Extending from the upper end of the valve chamber 16 is an upper passageway 17 which is disposed coaxially of the valve chamber 16 and is of a diameter considerably less than the same. Extending coaxially from the lower end of the valve chamber 16 is a lower passageway 18 which is of a diameter less than the diameter of the valve chamber 16.

Intermediate the ends of the valve chamber are radial cementing ports which extend from the valve chamber through the cylindrical member 15 so that when these ports 19 are unobstructed, fluid may flow from the valve chamber 16 outwardly through the ports 19 into the annular space between the exterior of the casing and the wall bore. In the present instance I have shown normally fixed closures 20 for the cementing ports 19 to maintain the same closed during the period prior to the ejection of cement through the ports 19. The plugs or closures 20 are, however, releasable as will be hereinafter described so that they may be released and the ports 19 opened just prior to the forcing of cement therethrough.

At the junction between the upper end of the valve chamber 16 and the upper passageway 17 I provide a yielding valve seat member 21 of the type described and claimed in U. S. Letters Patent entitled "Valve structure for well casings and tubing," dated May 17, 1938, bearing Number 2,117,536. The yielding valve seat member is preferably formed of such yielding or pliable material as rubber and is disk like and is anchored at its outer periphery adjacent the perimeter of the valve chamber as illustrated. The yielding valve seat member 21 is formed with a central valve port 22 arranged coaxially of the passageway 17 and of a diameter less than the same. The valve port 22 is surrounded by an upturned conical flange 23 which abuts at its upper and outer surface against a conical shoulder face 24 formed at the junction between the valve chamber 16 and the upper passageway 17.

Reciprocably mounted within the chamber 16 for movement axially thereof is an annular piston 25 formed with a central port 26 extending coaxially therethrough as illustrated. Surrounding the upper end of the port 26 is a valve seat 27 and surrounding the lower end of the annular piston 25 at its perimeter is a conical seating face 28 adapted to cooperate with a conical seating face 29 at the junction between the lower end of the chamber 16 and the lower passageway 18. The annular piston is normally disposed intermediate the radial cementing ports 19 and the valve seat member 21, and it should be stated that when in this position, it is free to move downwardly of the valve chamber except for the projecting portions of the closure members 20 of the radial cementing ports 19. These projecting portions of the closures 20 project inwardly of the valve chamber so that in attempting to move downwardly, the annular piston 25 will abut thereagainst. This annular piston is utilized as a means for removing these projections of the closures 20 and thereby releasing the closures so that fluid may be ejected outwardly through the ports 19.

For cooperation with the device is a tripping ball 30 which is less in diameter than the upper passageway 17 and greater in diameter than the port 26 through the piston 25. The tripping ball 30 is likewise greater in diameter than the port 22 in the valve seat member 21. It should be explained that when the tripping ball 30 is pumped downwardly through the casing and passes through the passageway 17 that it will expand the port 22 of the yielding seat member 21 and will pass therethrough into the valve chamber 16 and seat on the seat 27 of the annular piston 25. However, when the ball 30 attempts to pass upwardly through the port 22, the latter will not expand and therefore the ball will cooperate with the seat therearound in closing the upper passageway. This is obvious when it is noticed that the conical flange 23 which surrounds the port 22 will be prevented from expansion when the ball attempts to pass upwardly through the port

22 due to its engagement or abutment with the tapered annular shoulder face 24.

The closures 20 for the cementing ports 19 are so constructed as illustrated that when the lower end of the piston 25 engages the inner projections thereon, and sufficient pressure is applied downwardly to said piston, the latter will shear said projections and thereby release the plugs or closures 20 so that the latter may pass outwardly through the ports 19 and enable fluid to be pumped outwardly through said ports. Upon the removal of the closures 20, the annular piston 25 will travel downwardly and the face 28 thereon will seat on the face 29 at the junction between the lower passageway 18 and the valve chamber 16 and the annular piston 25 together with the tripping ball 30 will form a closure for the lower passageway 18 and thereby bridge the casing at a point below the cementing ports 19.

It should be pointed out, however, that the passageway 17, port 22 and port 26 in the annular piston and lower passageway 18 in each of the cementing devices are progressively decreased in diameter in the three cementing devices 14. That is to say, the larger ports and passageways are in the uppermost device, the next larger in the second device 14 and the smaller in the lowermost device 14. That is so that the tripping ball 30 for the lowermost device may pass freely through the uppermost two cementing devices 14 and the tripping ball for the intermediate device 14 may pass through the uppermost one.

For cooperation with each of these cementing devices I also provide a bridging member 31 most clearly illustrated in Fig. 12. This device constitutes a ball 32 having projecting upwardly therefrom a conical pliable packing member 33. The ball 32, as illustrated in dotted lines in Fig. 7, is capable of passing downwardly through the passageway 17 and through the valve port 22 in the flexible valve seat member 21, but its downward movement therein is limited by the tripping ball 30, leaving the hollow conical packing member 33 disposed in the upper passageway 17 so that downward pressure against the same will expand it against the conical upper shoulder 34 at the upper end of the passageway 17, effectively forming a bridge in the casing above the cementing ports 19 so that further downward flow through the cementing device will be terminated.

It should be stated that like the tripping balls 30, the bridging member for the lowermost cementing device is adapted to pass through the upper two cementing devices at stations C and B, and the packing 31 for the intermediate cementing device at station B is adapted to pass through the uppermost cementing device at station C.

As illustrated in the drawings, particularly Figs. 6 and 7, each cementing device is provided with a normally closed pressure actuated circulation valve 35. This valve 35 is interposed in a radial port 36 formed through the cylindrical member 14 from the chamber 16. This valve member is hollow and cylindrical and has an open port 37 formed in one side thereof. The valve member is secured in position in the port 36 by means of a shear pin 38. As the outer end of the cylindrical valve member is closed, when the shear pin 38 is in position, the port 37 will be closed and no fluid can pass from the chamber 16 through the cylindrical port 36. The shear pin 38, however, is adapted to be sheared by pressure of a predetermined value from within the casing and chamber 16 to enable the valve member 35 to move outwardly and uncover the port 37, by which means circulation can then be established from within the casing through the chamber 16 and outwardly through the port 37.

It is unnecessary to provide the lowermost cementing device with a circulating valve just described but it is necessary that the subsequent or uppermost cementing devices be so equipped. The shear pin of the cementing device at station B is adapted to be sheared by pressures less than that required to shear the shear pin of the cementing device at station C.

In practicing my method and in operation of the apparatus here disclosed, the casing is fitted with the cementing devices 14 as illustrated in Figs. 1 and 1*a*, and the casing is lowered into the well bore, and if desired, may be suspended therein slightly above bottom as is the practice in some instances. It may, however, be lowered right to bottom if desired. A cementing head 39 is then connected with the top of the casing as in usual practice and the casing is connected through piping to the pumps. A circulation is established downwardly through the casing and through the bottom thereof as in usual practice, this being permitted due to the fact that there is nothing in the casing to obstruct the downward flow of fluid therethrough. In fact, fluid may be pumped downwardly through the casing and through the lower end thereof to wash down any bridges or for any other purpose during the lowering of the casing into the hole.

When the casing has been properly positioned and the cementing head assembled thereon, the tripping ball 30 of the lowermost cementing device at station A is placed into the casing and thereafter a sufficient quantity of cement slurry is placed in the casing under pressure, the said quantity being sufficient to cement from the station A up to the station B, as illustrated in Figs. 2 and 2*a*.

It is very desirable that the tripping balls 30 and the bridging members 31 be introduced into the casing without letting an unnecessary amount of air into the casing. For this reason the cementing tube 40, which extends into the casing through the cementing head 39, is fitted at its upper end with a cross 41, one horizontal leg of which is connected to the pumps by the connection 42. The leg of the cross in vertical alignment with the cementing tube 40 is fitted with a vertically extending cylinder 43 in which are spaced two release devices 44 and 45, these devices being disclosed most clearly in Figs. 10 and 11. It will be seen that they constitute a flapper type of barrier 46 and a screw latching member 47. By releasing this latching member 47 through the medium of the hand wheel 48, the flapper member 46 may drop, releasing the ball above it and permitting the same to drop into the casing. However, intermediate the lowermost release device 45 and the cementing tube 40 is a gate valve 49 which is normally closed. From the pressure line 42 is a by-pass line 50 connected as at 60 to the cylinder 43 between the devices 44 and 45. A second connection 61 between the line 50 and the cylinder 43 is provided above the uppermost tripping device 44. The upper end of the cylinder 43 is plugged as illustrated.

It will be noticed that a valve is provided in each of the connections 60 and 61 as well as in the line 50 which leads from the pressure line 42. For example, when it is desired to drop the tripping ball 30 without letting an excessive amount of air into the casing, the gate valve

49 is opened and the tripping device 45 is released to enable the ball to drop. Pressure above the ball is then created by opening the valve in the line 60 and the valve in the line 50. After the ball has been dropped into the casing, the gate 49 is closed as well as the valves in the lines 50 and 60.

When it is desired to release the bridging member 31, the release device 45 has been already released so that it is then only necessary to trip the releasing device 44. The valves in the lines 50 and 61 are then opened and the gate valve 49 is opened, causing the bridging member 31 to pass downwardly into the casing.

Intermediate cementing operations, to charge the cylinder for the second stage, it is only necessary to close the valves 49 and the two valves in the lines 60 and 61 and remove the plug from the upper end of the cylinder, reset the tripping device 45 and drop the proper ball 30 into the cylinder. The tripping device 44 is then set and a bridging member 31 is similarly positioned thereabove and thereafter the upper end of the cylinder 43 is again plugged and ready for a successive operation.

The tripping ball 30 for the lowermost cementing device will pass through the upper two cementing devices and will seat on the annular piston 25 on the lowermost cementing device, and the fluid pressure above it will force the ball and the annular piston 25 downwardly in the valve chamber 16 until the piston seats on the lower end of said chamber. During this movement, the closures 20 of the ports 19 in the lowermost cementing device will be released, opening the ports 19. When the piston 25 and ball seat at the lower end of the chamber 16, the casing will be effectively bridged below the ports 19 and the cement following the tripping ball will be ejected through the ports 19 and upwardly into the annular space surrounding the casing to a point preferably, but not necessarily, above the second cementing station B.

Immediately that the first charge of cement is introduced into the casing, the bridging member 31 will be placed in the casing through the mechanism previously described. This bridging member 31 will follow the cement down the casing and will pass through the uppermost two cementing devices. When it reaches the lower cementing device, the packing member 33 together with its ball 32 will close the upper passageway 17 in the lower cementing device and effectively bridge the casing above the cementing ports of the lower cementing device. The pressure in the casing will immediately rise to a predetermined point sufficient to shear the pin 38 of the circulation valve 35 of the intermediate cementing device B. This pressure, however, will be insufficient to open the circulation valve of the uppermost cementing device due to the fact that its pin 38 will withstand greater pressure than the pin 38 of the intermediate cementing device.

Immediately following the opening of the circulation valve 35 of the second cementing device, the mud fluid being pumped into the casing will circulate upwardly from the station B and circulation may be continued for as long as desired. I prefer that this circulation be established prior to the introduction of the second batch of cement so that in the event something goes wrong with the lower cementing device, or for some reason circulation is lost or stopped, that a batch of cement will not be trapped in the casing.

After circulation is established at the circulation valve of the intermediate cementing device, the tripping ball 30 of that device is deposited in the casing and following the same cement slurry is pumped into the casing in a sufficient quantity to cement off the space between the stations B and C. When the tripping ball 30 of the intermediate cementing device reaches the same, it will open the ports 19, as previously described, and bridge the casing, and in conjunction with the piston 25 will bridge the casing at a point below the cementing ports 19 of the intermediate cementing device, and the cement will discharge through these ports and upwardly around the casing, at least to or above the station C.

Immediately following the cement a packing member 31 for the intermediate cementing device is placed in the casing and this will travel through the upper cementing device and will cooperate with the intermediate cementing device as described in bridging the casing above the cementing ports 19 of the intermediate cementing device. As soon as this bridging is effected, the pressure in the casing will again immediately rise to a point sufficient to open the circulation valve of the uppermost cementing device. When this valve is opened, circulation is continued and thereafter the tripping ball for the uppermost device is introduced in the casing as described and thereafter the last charge of cement will be introduced into the casing. The tripping ball will, of course, cooperate with the piston 25 in opening the ports 19 of the uppermost cementing device and bridge the casing below those ports so that the cement will discharge outwardly through the ports 19 and upwardly around the casing to the surface. Immediately following the placing of the cement into the casing will be a packing member 31 for the uppermost cementing device, and when this reaches the cementing device and acts to bridge off the casing above the cementing ports, the pump pressure will rise indicating that the job has been completed.

From a description of the cementing devices as previously described, it is obvious that after the positioning of the bridging member 31, that cement cannot back up into the casing due to the fact that the ball 32 of each bridging device 31 will seat upwardly on the seat surrounding the port 22 in the flexible seat member and act as a back pressure valve. It should be stated that like the tripping ball 30, the ball 32 may pass downwardly through the seat member 21 but not in the opposite direction.

It should be pointed out here that when the tripping ball 30 is deposited into the casing to bridge off the casing below the cementing ports at one station, that the cement may be introduced immediately after this ball, or circulation may be continued for as long a period as desired after this ball has been positioned before the cement is introduced in the casing. It is necessary, however, for a proper cementing job that a bridging member 31 be introduced into the casing immediately following the introduction of the cement charge.

It is seen that by my method and with my apparatus, that only a single batch of cement need be in the casing at one time so that in the event that for some reason circulation is discontinued by plugging or failure of one of the cementing devices, or through some other mishap, that but a minimum amount of cement is left in the casing for drilling out. In other

words, only one charge of cement need be in the casing at one time although circulation is continuous which is necessary.

From the foregoing it is obvious that I have provided a very practical and efficient method and apparatus for cementing deep oil wells in stages and so that the same can be cemented from the lowermost end of the casing to the surface, or so that the same can be cemented at any point or points along the casing, and while I have described and illustrated the preferred steps in my method and the preferred apparatus for practicing the same, it is to be understood that various changes may be made in the steps of the method and in the construction of the apparatus without departing from the invention as defined in the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In combination with a string of well casing adapted to be lowered into a well bore, a plurality of normally ineffective circulation means carried by the casing at spaced points therealong above the lower end thereof, said circulation means being capable of being rendered effective successively and in upward sequence by progressively increasing the pressure within the casing, said casing being formed with a set of normally closed cementing ports adjacent each circulation means, and means for opening said ports and bridging the casing below the same subsequent to establishing of circulation at the associated circulation means.

2. In combination with a string of well casing adapted to be lowered into a well bore, a plurality of normally ineffective circulation means carried by the casing at spaced points therealong above the lower end thereof, said circulation means being capable of being rendered effective successively and in upward sequence by progressively increasing the pressure within the casing, said casing being formed with a set of normally closed cementing ports adjacent each circulation means, means for opening said ports and bridging the casing below the same subsequent to establishing of circulation at the associated circulation means, and means for bridging the casing above said cementing ports at any time subsequent to the opening thereof.

3. In combination with a string of well casing adapted to be lowered into a well bore, a plurality of normally ineffective circulation means carried by the casing at spaced points therealong above the lower end thereof, said circulation means being capable of being rendered effective successively and in upward sequence by progressively increasing the pressure within the casing, said casing being formed with a set of normally closed cementing ports adjacent each circulation means, a normally ineffective barrier below each set of cementing ports, a normally ineffective barrier in the casing above each set of cementing ports, bridging means adapted to be introduced into the casing for cooperating with the lower barrier to render the same effective and for simultaneously rendering said cementing ports effective, and a second bridging means capable of being introduced in the casing for cooperation with the second barrier for bridging the casing above said cementing ports, the said bridging means for the lowermost set of cementing ports unaffecting the barriers associated with the set of cementing ports above that selected.

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