

March 6, 1945.

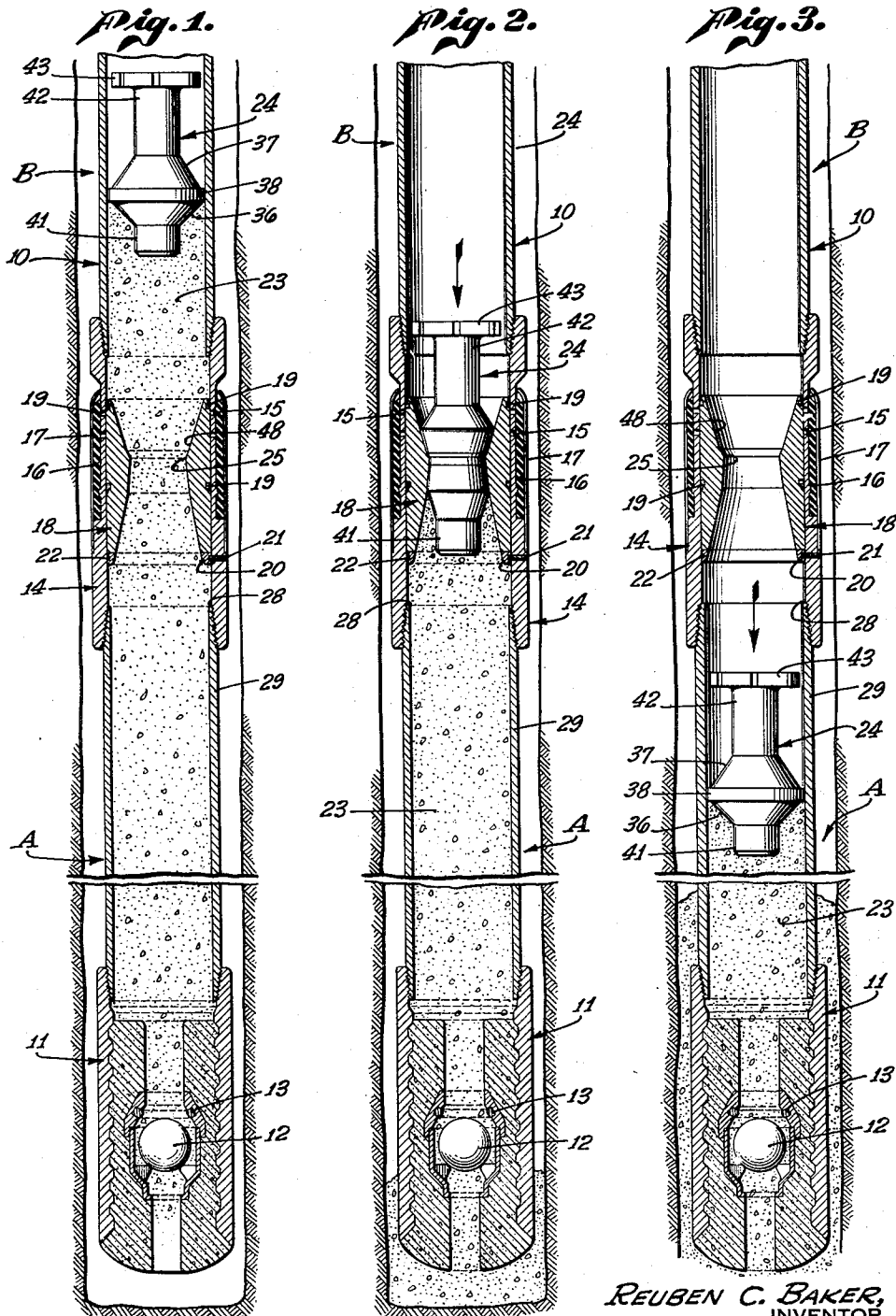
R. C. BAKER

2,370,833

APPARATUS FOR CEMENTING WELL BORES

Filed March 16, 1942

4 Sheets-Sheet 1



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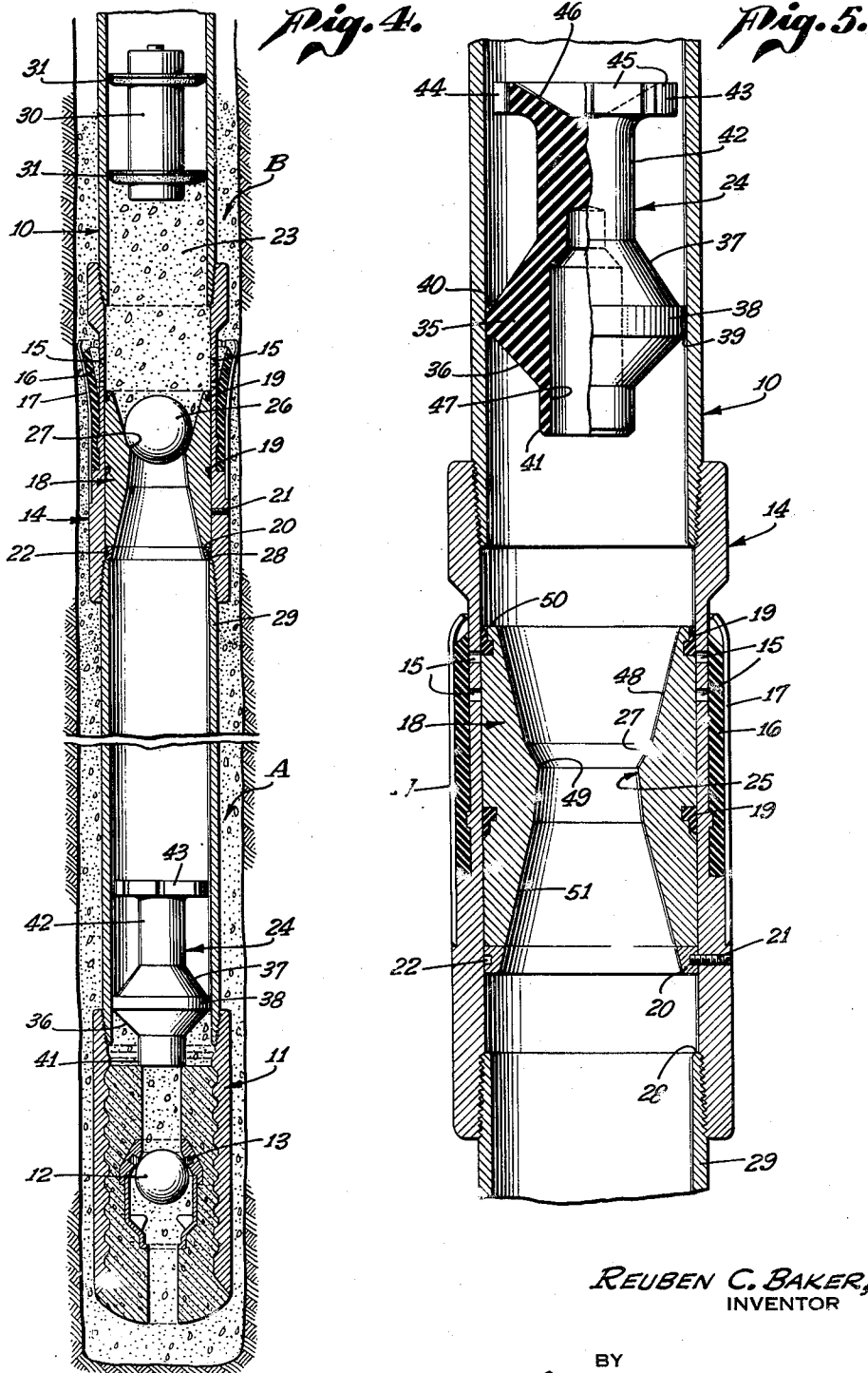
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

Fig. 6.

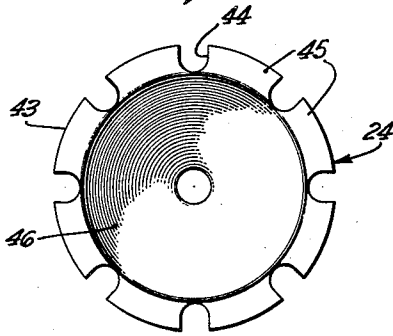


Fig. 8.

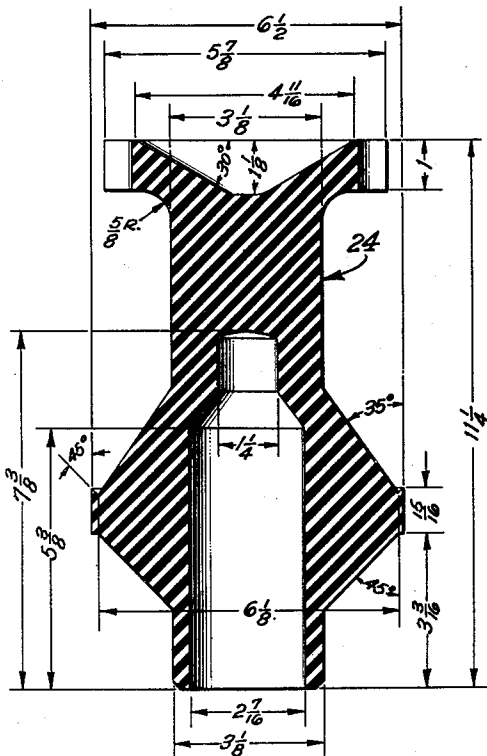
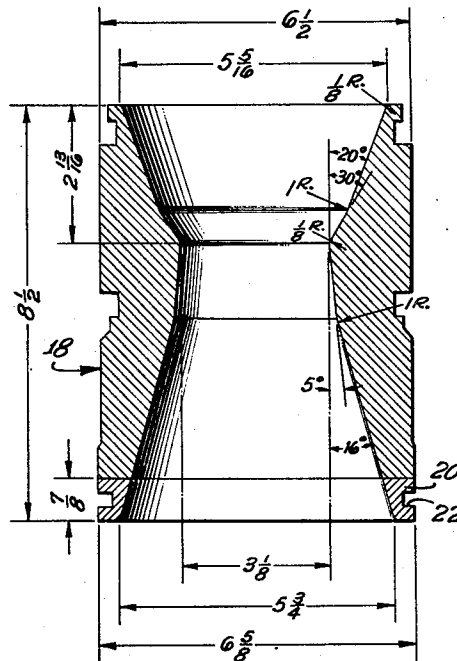


Fig. 7.

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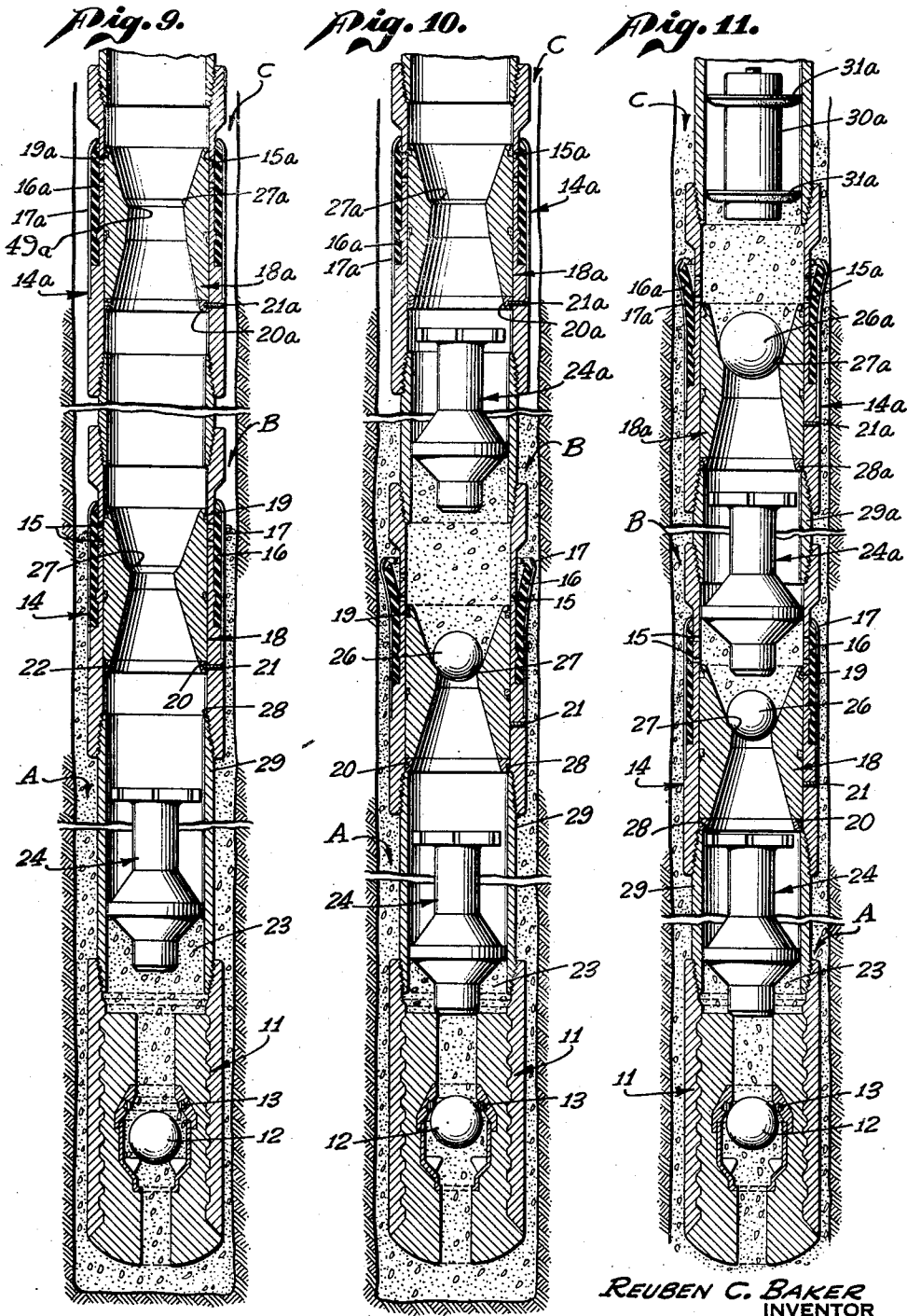
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APPARATUS FOR CEMENTING WELL BORES

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,370,833

APPARATUS FOR CEMENTING WELL BORES

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Application March 16, 1942, Serial No. 434,913

16 Claims. (Cl. 166—1)

This invention relates to the cementing of well bores, and is more particularly concerned with the cementing of long strings of casing by ejecting separate charges of cementitious material from the casing at predetermined spaced points along the well bore.

In drilling a well, it is usual practice to cement the casing in the well bore along its entire length for the purpose of preventing migrant waters from contaminating the well fluid. Where the well is deep, it is difficult to perform this operation with a single charge of slurry ejected from the lower end of the casing, because of the high pressures required to elevate the cement in the annulus around the casing to the desired level, and the time consumed, which might allow quick acting cements to set prematurely.

It has been proposed to avoid these difficulties by cementing the casing in the well bore by stages. That is, separate charges of cement are ejected from spaced predetermined points along the casing in upward sequence until the entire length of the casing is surrounded with the desired sheath of cement. The casing outlets above the lowermost of these predetermined points are initially closed, usually by a slidable sleeve valve, and plug devices are employed for opening them at the proper time and sequence. The plug devices not only serve to open the sleeve valves, but also as separating elements between each charge of cement slurry and mud, to prevent their commingling and consequent contamination of the slurry. The plug and sleeve valve arrangements heretofore used have been of such character and cooperate in such manner as to prevent circulation of washing fluid through the outlets of a particular stage prior to cementing of that stage, or they effect shifting of the sleeve valve of that particular stage to open position before a lower stage cementing operation has been completed.

It is an object of the present invention to provide an improved multiple stage cementing apparatus which enables separate charges of cement to be displaced from the casing at vertically spaced stations along the casing, and which permits circulation to take place through the outlets of any stage for as long as desired prior to ejection of cement therethrough. By virtue of the present invention, it is only necessary to place one charge of cement in the casing at any time for ejection from the particular station.

The invention further contemplates an improved multiple stage cementing apparatus having outlets at predetermined points or stations along the casing normally closed by sleeve valves

which are shiftable to open position after the cement slurry for a lower stage has been fully displaced to the desired extent around the casing, in which opening of the sleeve valve is independent of the displacement operation for the lower stage.

Another object of the invention is to provide an improved multiple stage cementing apparatus embodying a plug for preventing commingling between columns of cement slurry and mud, which is capable of readily passing through a materially restricted bore of a casing sleeve valve without shifting it to outlet opening position; so as to enable the valve to be opened later independently of the cementing operation in which the plug was employed.

The invention is also concerned with an improved top cementing plug capable of being forced without damage and at comparatively low pressures through a sleeve bore of much lesser diameter than the inside diameter of a casing with whose wall the plug slidably seals.

In its general aspects, the invention contemplates a casing string or conduit provided with a sleeve valve initially closing lateral ports or outlets through an upper cementing station of the casing. A charge of cement slurry is pumped down the casing with a flexible plug at its upper end to prevent commingling between the cement and the following mud column. The plug is so designed as to have slidably sealing contact with the wall of the casing and be pumped through the bore of the sleeve valve without shifting the latter to a position opening its associated ports, despite the fact that the sleeve valve bore has a relatively small diameter. As soon as the plug is forced through the sleeve it expands to its initial shape in order to continue its slidably engagement with the casing in a downward direction on top of the cement column, until the desired quantity of slurry has been ejected from the casing at a predetermined exit point below the sleeve valve, to complete cementing of the lower stage.

The sleeve valve has a bore of much lesser diameter than the inside diameter of the casing, which allows a comparatively small diameter or size bridging member to gravitate or be otherwise lowered freely through the standing column of fluid in the casing above the sleeve, until it seats on the sleeve valve to close its bore. Thereafter, the pressure of the standing fluid column in the casing can be increased to shift the sleeve downwardly to a position opening its associated ports or outlets, so as to permit establishment of

free circulation down through the casing, the outlets, and up through the annulus around the casing. After sufficient circulation or washing has taken place, the next charge of cement can be sent down the casing for ejection through the open outlets of the upper cementing station and for upward passage around the casing.

This invention has other objects which will become apparent from a consideration of the apparatus shown in the drawings accompanying and forming part of the present specification. This apparatus will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Figure 1 is a longitudinal section through a well bore with a casing string therein including the apparatus of the present invention, disclosed with a top cementing plug of the present invention positioned above a stage collar through which the plug is to pass;

Figure 2 is a view similar to Figure 1, with the plug passing through the stage collar;

Figure 3 is a view similar to Figure 1, disclosing the plug after it has passed through the stage collar;

Figure 4 is a view similar to Figure 1, disclosing the lower stage cemented and the upper stage in process of being cemented;

Figure 5 is a view of part of the apparatus shown in Figure 1 on an enlarged scale;

Figure 6 is a top plane view of a top cementing plug disclosed in Figure 7;

Figure 7 is a longitudinal section containing dimensions of an actual plug made and operated in accordance with the invention;

Figure 8 is a longitudinal section showing the dimensions of an actual sleeve valve made and used in conjunction with the plug disclosed in Figure 7;

Figure 9 is a view similar to Figure 3, but disclosing the casing string as having more than one upper cementing stations;

Figure 10 is a view similar to Figure 9, illustrating the lowermost stage cemented and the intermediate stage being cemented; and

Figure 11 is a view similar to Figure 9, disclosing the uppermost stage being cemented.

By referring to the drawings, it is to be noted that the casing string 10 is shown with the usual float shoe 11 at its lower end incorporating a back pressure ball 12 capable of engaging the valve seat 13 to prevent return flow of fluids through the shoe into the casing. A stage collar 14 is included in the casing string at a predetermined point above the shoe, and this collar is provided with a plurality of outlets or ports 15 through which fluids can be ejected. It is preferred to prevent return flow of such fluids by any suitable means, such as a flexible sleeve valve 16 fixed at one end to the collar, but otherwise radially expandable to permit fluid passage from the interior of the casing to its surrounding annulus. This flexible or rubber sleeve valve 16 may be protected by a plurality of closely spaced leaf springs 17 whose lower ends are welded to the collar 14 and whose upper ends are free to flex outwardly and permit opening of the valve member. The flexibility of the leaf springs 17 also assists in closing the rubber valve member 16 and keeping it in sealing engagement with collar in the region of the outlets 15.

Passage of fluid through the outlets 15 is initially prevented by a slidable sleeve valve 18 disposed over the outlet area of the casing string. Leakage between this sleeve valve 18 and the collar 14 is prevented by opposed seals 19 on the sleeve engageable with the collar on opposite sides of its outlets 15. Downward movement of the sleeve 18 is initially prevented by its seating upon a drillable, cast iron shear ring 20 attached to the collar by shear screws 21 threaded through the collar into an external groove 22 on the ring. The shear ring and screw arrangement 20-22 prevents downward shifting of the slidable sleeve valve 18 and opening of the ports 15 until desired. Any other suitable frangible arrangement for preventing movement of the sleeve valve to port opening position can be employed.

In cementing the lowermost stage around the casing, a quantity of cement slurry 23 at least sufficient to fill the annular space A between the shoe 11 and collar outlets 15 is introduced in the casing. This column of cement slurry and a flexible plug 24 forming part of the present invention placed at its top end are then pumped down the casing string with the aid of a following column of mud, water or other fluid. The plug 24 makes slidable sealing contact with the wall of the casing to prevent contamination between the slurry and the following fluid column. However, when the plug reaches the slidable sleeve 18, the force of the fluid above it and its coaction with the sleeve reduces its radial size and pushes it through the restricted bore 25 of the sleeve at a pressure that is too low to shear the screws 21 and shift the sleeve 18 downwardly to outlet opening position. After having been forced through the slidable sleeve valve, the plug 24 again expands to its original size and shape to continue its function as a normal top cementing plug in preventing admixture between the cement slurry and the following column of fluid.

The top cementing plug 24 is pumped down the casing until sufficient cement slurry has been ejected through the shoe 11 (first cementing station), or until the plug 24 contacts the shoe (as disclosed in Figure 4), whereupon no further movement can occur. Thereafter, a bridging member in the form of a ball 26 is placed in the casing and allowed to gravitate to its seat 27 on the slidable sleeve valve 18 to close its central restricted bore 25. Pressure built up in the fluid column above the sleeve can then shear the screws 21 and shift the sleeve 18 downwardly to open the ports or outlets 15. Downward movement of the sleeve is limited by its engagement with a suitable stop, which in the present instance is disclosed as consisting of the end 28 of a lower casing section 29 threaded into the collar 14.

Upon opening of the outlets 15, circulating fluid can be pumped down the casing for passage through the outlets and upwardly through the annular space B around the casing. Any cement slurry from the lower stage above the collar 14 is removed by the circulating fluid, and this washing action is preferably continued until the well bore has been properly conditioned for receipt of the second charge of cement slurry. This charge is sent down the casing in a conventional manner, preferably with a top cementing plug 30 at its upper end, which has the usual flexible cups 31 slidable along the wall of the casing to prevent commingling between the cement slurry and the fluid above the plug 30. This cement slurry is ejected through the outlets 15 and passes up-

wardly around the casing to form an annular seal at the second cementing stage. Reverse flow of the slurry in the casing is prevented by the flexible rubber sleeve valve 16 and spring elements 17.

After the cement has set and hardened, the interior of the casing is drilled out to provide an unobstructed bore therethrough. For this reason, the slidable sleeve valve 18, its shear ring 20, cementing plugs 24, 30, and interior of the casing shoe 11 are all preferably made of readily drillable material.

The passage or bore 25 through the slidable sleeve valve 18 is of much lesser diameter than the inside diameter of the casing, in order to permit employment of a bridging member 26 small enough in diameter to gravitate readily through the fluid in the casing to its companion seat 27. The flexible plug 24 is designed to function as an efficient top plug in forcing cement down through the casing, when positioned both above and below the sleeve valve 18, and still be capable of being forced through this latter member at a pressure sufficiently low as to be incapable of disrupting the shear screws 21 holding the sleeve valve 18 in closed position across its outlets 15.

The flexible plug 24 is made of rubber or similar pliant, elastic material, and consists of a head or body 35 having a tapered front or leading external surface 36 inclined downwardly toward the axis of the casing, and a rear or trailing tapered external surface 37 inclined upwardly toward the axis of the casing. These opposed, generally conical, conoidal, or similar shaped portions 36, 37 of the plug head or body 35 are separated by or merged into a comparatively narrow casing engaging portion 38 of the body, having a leading wiper edge 39 for removing cement slurry from the wall of the casing, and a trailing, relatively short annular lip 40 adapted to be acted on by fluid under pressure above the plug to keep it expanded against the wall of the casing and prevent leakage between the casing and plug.

The plug 24 is also provided with a generally cylindrical nose 41 extending in advance of the body 35 and of much smaller diameter than that of the casing, and also with a generally cylindrical stem or tail piece 42 extending from the tapered trailing portion 37 of the plug body. This tail piece 42 terminates in a guiding flange 43 having a plurality of notches 44 forming intervening fingers 45 capable of upward deflection as the plug 24 passes through the sleeve 18. As further assistance to the flexing of the guide flange 43, the upper end 46 of the cylindrical stem or tail piece is relieved in concave fashion. Similarly, the nose 41 and body 35 of the plug are relieved by a comparatively large central bore 47, which will permit compression of the plug body 35 inwardly more readily upon passing through the slidable sleeve valve 18.

The leading face 48 of the sleeve valve bore 25 diverges upwardly from its valve seat 27 or smallest diameter 49, to leave a comparatively small shoulder 50 at its upper end. The smallest diameter central portion 49 of the sleeve bore may be cylindrical or tapering slightly in an outward and downward direction, while the lower or trailing face 51 of the sleeve bore may diverge downwardly.

As the flexible plug 24 reaches the slidable sleeve valve 18, the inclined leading surface 36 of its body engages the inclined leading face 48 of the sleeve bore to compress the body member 35

inwardly. This compressive action is assisted by the fluids under pressure acting on the inclined trailing portion 37 of the body, which have radial thrust components exerted inwardly to decrease the diameter of the plug body 35 and enable the downward components of pressure to force the body and plug through the sleeve valve. Upon passing through the most restricted portion 49 of the sleeve bore, the plug body 35 again expands to its initial shape. The inclined, trailing face 51 of the sleeve bore allows such expansion to occur gradually rather than suddenly, which might be the case were the minimum bore 49 through the sleeve to extend cylindrically throughout its remaining length.

As the plug 24 is passing through the sleeve valve 18, the fingers 45 of the guide flange 43 engage the inclined leading face 48 of the sleeve bore 25 and are deflected or stretched upwardly, while the fluid under pressure above the plug is pushing it through the sleeve. However, upon leaving the sleeve, the guide flange 43 returns to its initial outward shape and position to continue its function of preventing material tilting of the plug as it moves through the casing string.

The nose 41 of the plug has an external diameter substantially equal to that of the minimum bore diameter 49. This nose fits within the minimum bore portion of the sleeve to center the plug and prevent its tilting or twisting as its inclined leading face 36 contacts the inclined leading face 48 of the sleeve bore. It should be noticed that the small shoulder 50 at the top of the sleeve is insufficient in extent to prevent passage of the plug into the sleeve bore. As a matter of fact, this shoulder could be eliminated entirely by continuing the bore taper 48 upwardly to a further extent, but this is not essential. The cylindrical tail piece or stem 42 of the plug also has a diameter substantially equal to that of the minimum bore portion 49 so as to function as a piston after the body 35 of the plug has passed through the minimum bore section and has begun to expand to its initial position. The pressure of fluid acts on top of the tail piece 42 and pushes the entire plug through the sleeve. Of course, as the guide flange 43 engages the inclined face 48 of the sleeve bore it is deflected upwardly and inwardly until it passes through the sleeve, whereupon it expands to its initial position, as was previously described.

After leaving the sleeve 18, the rubber plug 24 regains its initial shape to continue forcing the cement slurry down through the casing in as efficient a manner as conventional top cementing plugs.

Figures 7 and 8 are longitudinal sections through a flexible plug 24 and a sleeve valve 18, respectively, designed to operate in 7", 24 pound casing, with all essential dimensions placed on the figures to enable an operable apparatus to be made from the data given. The plug 24 shown in Figure 7 is of a composite character. Its neck 41 is molded from a rubber having a 64 Shore hardness number, its body 35 from a rubber having a 32 Shore hardness number, and its cylindrical tail piece or stem 42 and flange 43 from a rubber having a 64 Shore hardness number. These hardnesses of rubber were found to operate satisfactorily in pumping the rubber plug 24 at low pressures through the sleeve 18 whose dimensions appear in Figure 8. This latter sleeve was made from a phenolic casting resin, known as "Baker" casting resin, to obtain readily drillable characteristics.

The collar device incorporating the sleeve valve and frangible connection is described and claimed in the application of Clarence E. Burt and William S. Althouse, Jr., Serial No. 437,548, filed April 3, 1942, entitled Well cementing apparatus, now Patent No. 2,330,267, granted Sept. 28, 1943.

In actual operations of the cementing apparatus in a well bore employing the plug and sleeve combination shown in Figures 7 and 8, the plug 24 was pumped slowly through the sleeve 18 with a rise in pump pressure of only about 100 p. s. i. When pumped rapidly through the sleeve, no rise in pressure was noticed on the pump gauge. Such low pressures required to move the plug through the sleeve are far below the shear values of the screws 21 holding the sleeve valve in closed position over its outlets 15. This last mentioned value can be of the order of 800 to 1000 p. s. i., which leaves a very large margin between the pressure necessary to pump the plug through the sleeve and that required to shear the screws after the bridging ball 26 has engaged the sleeve seat 27, thus offering assurance that the sleeve will not be shifted prematurely or inadvertently as the flexible plug is forced through it in cementing the lower stage.

Figures 9, 10 and 11 disclose apparatus for performing more than two stages of cementing. In these figures, another stage cementing collar 14a, substantially the same as the lower collar device 14, has been incorporated in the casing string at a predetermined point above the lower collar device heretofore described. The minimum diameter 49a of the bore through the sleeve valve 18a of this upper device is greater than through the lower sleeve valve. As a matter of fact, it is large enough to permit the bridging ball 26 for the lower collar to pass through it freely, but this ball, of course, is larger than the minimum bore 49 through the lower collar sleeve 18 so as to engage its seat 27 and allow shifting of the sleeve to a position clear of its outlets 15.

The lowermost stage cementing operation is performed in exactly the same manner as previously described in connection with Figures 1 to 4. The flexible cementing plug 24 employed on top of the charge of cement passes more readily through the upper cementing collar 14a than through the lower one 14 since it does not have to compress radially to as great an extent. After the lowermost stage has been cemented, the lower bridging ball 26 dropped, and the lower sleeve valve 18 moved to open position, circulation is established through the lower collar, and a second, upper flexible cementing plug 24a is employed in forcing the second charge of cement through the lower collar 18 to perform the second stage of cementing. This second flexible cementing plug 24a can be a duplicate of the first cementing plug 24, and it passes readily through the upper sleeve valve 18a without causing its shifting to open position.

After the upper plug 24a has moved downwardly sufficiently to eject its charge of cement from the casing, a second bridging ball 26a of larger diameter than the minimum bore portion 49a through the upper sleeve is allowed to gravitate through the fluid in the casing until it engages its companion seat 27a on the upper sleeve, whereupon an increase in the pressure of the fluid above the sleeve and ball to a sufficient degree shears the second set of screws 21a and forces the second sleeve 18a downwardly to a position opening its associated outlets or ports 15a. (The second set of shear screws 21a may have about

the same shear value as the lower set). Circulation can then be established through these open ports 15a to wash the annulus C around the casing above the lower two stages; and a third charge of cement slurry ejected through the outlets of the second collar 14a by pumping it downwardly through the casing, preferably by use of any top cementing plug 30a. It is preferred that this upper collar 14a also be provided with a back pressure valve 16a, 17a to prevent return flow of ejected cement slurry through the outlets 15a into the casing.

If required, one or more additional stage cementing collars can be placed in the casing string at predetermined points above the two collars 14, 14a specifically disclosed and described, and the flexible cementing plugs 24, 24a employed as top plug members for all lower stages. The only limitation is that the minimum diameter of the bores through the sleeve valves increase in upward sequence so as to permit free passage of bridging members adapted to seat upon lower sleeves.

It is therefore apparent that a multiple stage well cementing apparatus has been described which permits circulation through and around the casing prior to the cementing of each stage, while employing top cementing plugs which prevent contamination between the charge of cement slurry and the fluid following it. Such top cementing plug is made of such material and is so designed as to pass through the sleeve valve without moving it to open position, and this is true even though the minimum bore through the sleeve valve is much less in diameter than the inside diameter of the casing, so as to permit use of a bridging member to close the bore of the sleeve valve, which bridging member can gravitate to its companion seat without displacing the fluid above the sleeve valve and independently of the downward movement of the preceding flexible plug. It is after the top cementing plug has passed through the sleeve valve and continued on therebelow to complete the cementing of a lower stage that the bridging member is dropped to permit hydraulic opening of the ports or outlets through the upper stage collar.

I claim:

1. In combination, a string of well casing adapted to be positioned in a well bore, said casing string having lateral outlet means above its lower end, a sleeve valve in said casing string for closing said outlet means and provided with a central bore materially less in diameter than the inside diameter of said casing string, frangible means for preventing movement of said sleeve valve to outlet opening position, and a plug slidably engageable with the wall of said casing string and having a pliant, elastic central body portion normally larger than said central bore but adapted to compress inwardly to enable its complete passage through said central bore of said sleeve valve without disrupting said frangible means and moving said sleeve valve to outlet opening position, said plug having a diameter when uncompressed substantially equal to the inside diameter of said casing.

2. In combination, a string of well casing adapted to be positioned in a well bore, said casing string having lateral outlet means above its lower end, a sleeve valve in said casing string disposed over said outlet means to close the same and provided with a central bore materially less in diameter than the inside diameter of said casing string, frangible means for resisting movement of

said sleeve valve to outlet opening position, a plug having a normal unrestrained diameter of such size as to have slidable sealing contact with the wall of said casing string and having a pliant, elastic central body portion normally larger than said central bore but adapted to compress inwardly to enable its complete passage through said central bore of said sleeve valve without disrupting said frangible means and moving said sleeve valve to outlet opening position, and means movable downwardly through said casing string without displacing the column of fluid above said sleeve valve for closing said central bore, to enable said sleeve valve to be subjected to the pressure of the fluid column thereabove to disrupt said frangible means and shift said sleeve to outlet opening position.

3. In combination, a string of well casing adapted to be positioned in a well bore and provided with lateral outlet means above its lower end, a sleeve valve in said casing string for closing said outlet means and provided with a central bore of materially less diameter than the inside diameter of said casing string, a cementing plug having a normal unrestrained diameter substantially equal to the inside diameter of said casing string and adapted to pass through said central bore of said sleeve valve without shifting it to outlet opening position, and means adapted to be introduced in said casing string and movable downwardly therethrough without displacing the column of fluid above said sleeve valve for closing said central bore, to enable said sleeve valve to be shifted hydraulically to outlet opening position.

4. In combination, a string of well casing adapted to be positioned in a well bore and provided with lateral outlet means at spaced points therealong above its lower end, sleeve valves slidable along the inner wall of said casing string and adapted to close said outlet means, each of said sleeve valves being provided with a central bore of materially less diameter than the inside diameter of said casing string, with the bore through a lower sleeve valve having a lesser diameter than the bore through an upper sleeve valve, a cementing plug slidably engageable with the wall of said casing string and adapted to pass through the central bores of said sleeve valves without shifting them to outlet opening positions, means movable downwardly through said casing string and upper sleeve valve without displacing the column of fluid above said lower sleeve valve for closing its central bore, to enable said lower sleeve valve to be shifted hydraulically to outlet opening position, a second cementing plug slidably engageable with the wall of said casing string and adapted to pass through the central bore of said upper sleeve valve without shifting it to outlet opening position, and means movable downwardly through said casing string without displacing the column of fluid above said upper sleeve for closing its central bore, to enable said upper sleeve valve to be shifted hydraulically to outlet opening position, said plugs having normal unrestrained diameters of such size as to have slidable sealing contact with the wall of the casing.

5. In combination, a string of well casing adapted to be positioned in a well bore and provided with lateral outlet means at spaced points therealong above its lower end, sleeve valves in said casing string for closing said outlet means, each of said sleeve valves being provided with a central bore of materially less diameter than the inside diameter of said casing string, with the bore through a lower sleeve valve having a lesser

diameter than the bore through an upper sleeve valve, a top cementing plug slidably engageable with the wall of said casing string and having a pliant, elastic central body portion normally larger than the bore through said lower sleeve valve but adapted to compress inwardly to enable its complete passage through the bores of said sleeve valves without moving them to outlet opening positions, a bridging ball of lesser diameter than said upper sleeve valve bore adapted to be sent down said casing string to close the central bore of said lower sleeve valve, to enable said lower sleeve valve to be shifted hydraulically to outlet opening position, a second top cementing plug slidably engageable with the wall of said casing string and having a pliant, elastic central body portion normally larger than the bore through said upper sleeve valve but adapted to compress inwardly to enable its complete passage through said central bore of said upper sleeve valve without moving said upper sleeve valve to outlet opening position, and a larger ball than said first mentioned ball adapted to be sent down said casing string for closing the bore of said upper sleeve, to enable said upper sleeve to be shifted hydraulically to outlet opening position, said plugs having a diameter when uncompressed substantially equal to the inside diameter of said casing.

6. In combination, a well conduit provided with lateral outlet means, a sleeve valve in said conduit adapted to close said outlet means and provided with a central bore of materially less diameter than the inside diameter of said conduit, and a plug having a pliant, elastic body portion engageable with the surface of the central bore of said sleeve valve to be compressed thereby inwardly to an extent sufficient to enable passage of the plug through said valve, said plug having a diameter when uncompressed substantially equal to the inside diameter of said conduit.

7. In combination, a well conduit provided with lateral outlet means, a sleeve valve slidable along the inner wall of said conduit and adapted to close said outlet means, said sleeve valve having a central bore portion of materially less diameter than the inside diameter of said conduit and a leading bore surface diverging in an upward direction from said portion, and a plug having a pliant, elastic body portion engageable with said diverging surface to be compressed thereby inwardly to an extent sufficient to enable downward passage of the plug through the less diameter portion of said sleeve valve, said plug having a diameter when uncompressed substantially equal to the inside diameter of said conduit.

8. In combination, a well conduit provided with lateral outlet means, a sleeve valve in said conduit for closing said outlet means, said sleeve valve having a central bore diverging in an upward direction from a sleeve bore portion of materially less diameter than the inside diameter of said conduit, and a plug having an upwardly diverging, pliant, elastic body portion engageable with said diverging bore to be compressed thereby inwardly to an extent sufficient to enable downward passage of the plug through the less diameter portion of said sleeve valve, said plug having a diameter when uncompressed substantially equal to the inside diameter of said conduit.

9. In combination, a well conduit provided with lateral outlet means, a sleeve valve slidable along the inner wall of said conduit and adapted to close said outlet means, said sleeve valve having

a central bore diverging in an upward direction from a sleeve bore portion of materially less diameter than the inside diameter of said conduit, and a plug having a pliant, elastic body of a diameter when uncompressed substantially equal to the inside diameter of said conduit, said body having an upwardly diverging leading surface and an upwardly converging trailing surface, whereby said leading surface is engageable with said diverging bore and said trailing surface is acted on by fluid under pressure in said conduit above said plug to effect compression of said body inwardly to an extent sufficient to enable downward pumping of the plug through said sleeve valve.

10. In combination, a well conduit provided with lateral outlet means, a sleeve valve slidable along the inner wall of said conduit, frangible means for preventing shifting of said sleeve valve to outlet opening position, said sleeve valve having a central bore diverging in an upward direction from a sleeve bore portion of materially less diameter than the inside diameter of said conduit, and a top cementing plug having a pliant, elastic body slidably engageable with the inner wall of said conduit, said body having a leading surface converging downwardly and a trailing surface converging upwardly, respectively, from the wall engaging portion of said body, whereby said leading surface is engageable with said diverging bore and said trailing surface is acted on by fluid under pressure in said conduit above said plug to effect compression of said body inwardly to an extent sufficient to enable downward pumping of the plug through said sleeve valve without disrupting said frangible means, and a bridging member adapted to be introduced in said conduit for seating in the bore of said sleeve to close the same and enable said frangible means to be disrupted hydraulically and said sleeve valve shifted to outlet opening position.

11. A plug, including a pliant, elastic and inwardly collapsible body provided with a portion adapted to engage the wall of a well casing, said body having an outer leading surface converging downwardly from said wall engaging portion, and an outer trailing surface converging upwardly from said wall engaging portion.

12. A plug, including a pliant, elastic and in-

wardly compressible body provided with a portion adapted to engage the wall of a well casing, said body having an outer leading surface converging downwardly from said wall engaging portion, an outer trailing surface converging upwardly from said wall engaging portion, and said body being relieved centrally thereof to reduce its resistance to inward compression.

13. A plug, including a pliant, elastic and inwardly collapsible body provided with a portion adapted to engage the wall of a well casing, said body having an outer leading surface converging downwardly from said wall engaging portion, an outer trailing surface converging upwardly from said wall engaging portion, and a tail piece extending upwardly from the trailing surface of said body.

14. A plug, including a pliant, elastic body provided with a portion adapted to engage the wall of a well casing, said body having an outer leading surface converging downwardly from said wall engaging portion, an outer trailing surface converging upwardly from said wall engaging portion, an elastic tail piece extending upwardly from the trailing surface of said body, and an elastic guide flange projecting radially from said tail piece.

15. A plug, including a pliant, elastic and inwardly collapsible body provided with a portion having an upwardly facing lip adapted to engage the wall of a well casing, said body having an outer leading surface converging downwardly from said portion, and an outer trailing surface converging upwardly from said lip.

16. A plug, including a pliant, elastic body provided with a relatively narrow portion adapted to engage the wall of a well casing and having an upwardly facing wall engaging lip, said body having an outer leading surface converging downwardly from the lower end of said narrow portion, an outer trailing surface converging upwardly from said lip, an elastic generally cylindrical tail piece extending upwardly from the trailing surface of said body, and an elastic guide flange projecting radially from said tail piece, said body having a central bore extending upwardly from its lower end.

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