April 6, 1948. R. O. CHILDERS 2,438,992

WELL CEMENTING APPARATUS

Filed April 3, 1942 2 Sheets-Sheet 1

Fig. 1.

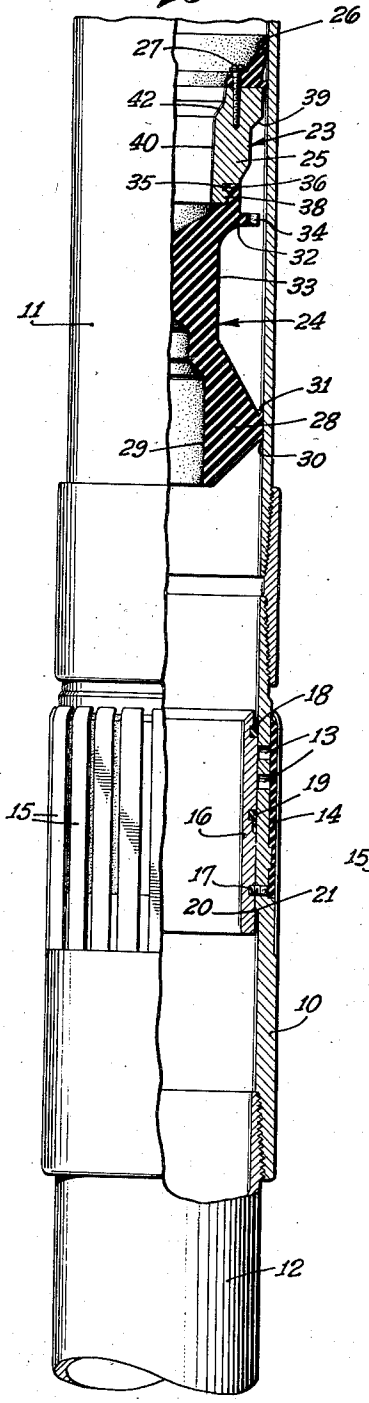


Fig. 2.

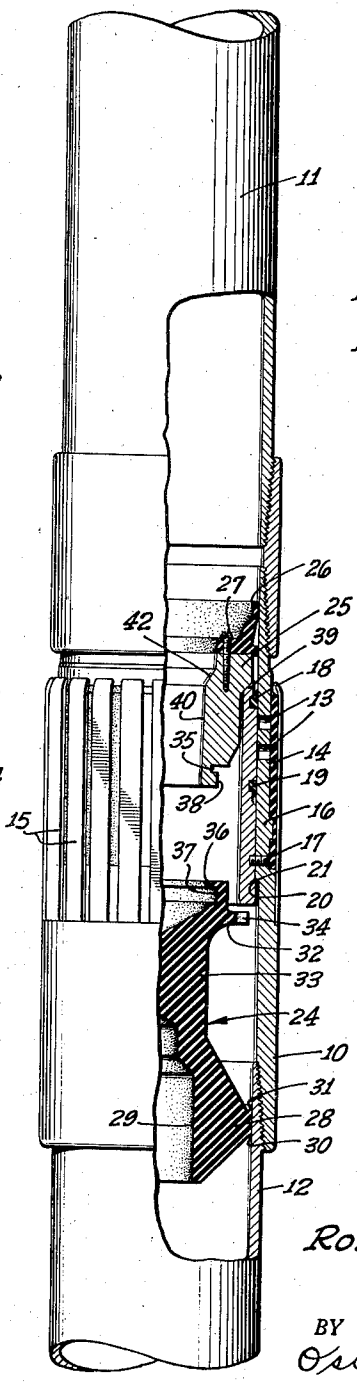
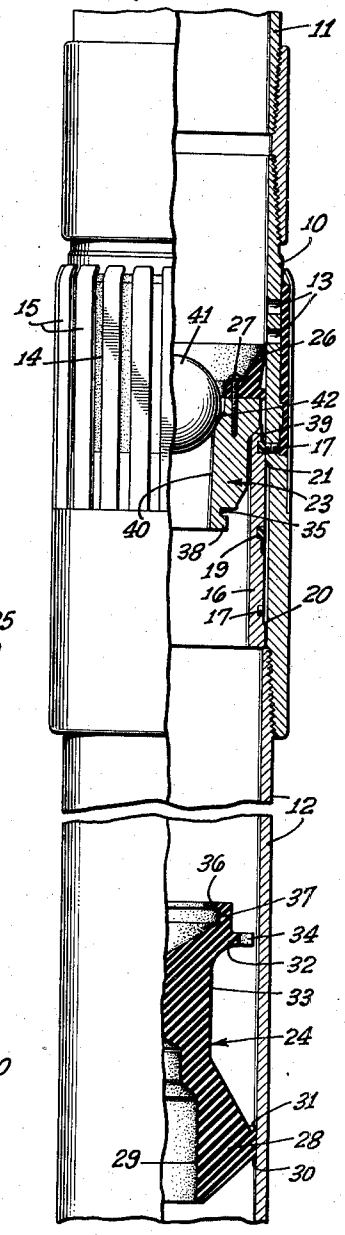


Fig. 3.



ROSCOE O. CHILDERS,
INVENTOR.

BY
Oscar A. Mellin
ATTORNEY

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Filed April 3, 1942 2 Sheets-Sheet 2

Fig. 4.

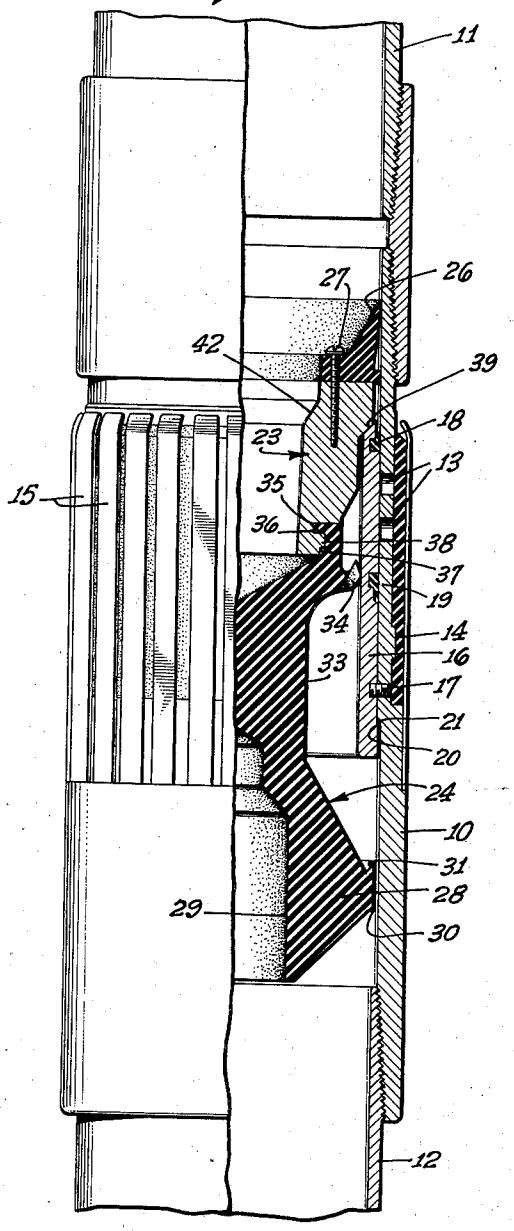
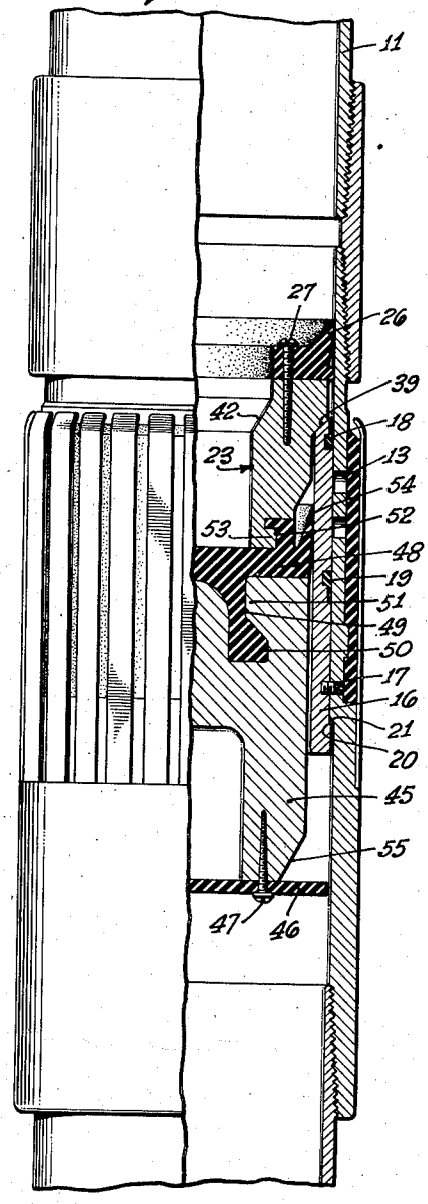


Fig. 5.



ROSCOE O. CHILDERS,
INVENTOR.

BY
Oscar A. Mellin.
ATTORNEY

Patented Apr. 6, 1948

2,438,992

UNITED STATES PATENT OFFICE

2,438,992

WELL CEMENTING APPARATUS

Roscoe O. Childers, Olney, Ill., assignor to Baker Oil Tools, Inc., Vernon, Calif., a corporation of California

Application April 3, 1942, Serial No. 437,545

12 Claims. (Cl. 166—1)

1

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

In drilling and completing many wells, it is usual practice to cement the casing in the well bore along its entire length in order to prevent migrant waters from contaminating the well fluids. In deep wells, it is difficult to perform this operation with a single charge of cement slurry ejected from the lower end of the casing, because of the high pressures required to elevate the slurry in the annulus around the casing to the desired level, and the time consumed, which might allow quick acting cement 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, as by an internal slidable sleeve valve, and plug devices are employed for opening them at the proper time and sequence. These plug devices not only function to open the sleeve valves, but they also operate as separting 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 require the introduction of all plugs and charges of cement slurry separated by predetermined quantities of drilling mud in a single continuous operation in the well casing. If errors are made in the extent of the mud column intervening between separate charges of slurry, an upper sleeve valve would be opened by a plug prematurely, or it would be impossible to open it at all, precluding ejection of the cement slurry in the casing above the mud column. In addition to this difficulty, such plug and sleeve valve arrangements do not permit washing fluid to be circulated through the outlets of a particular stage prior to the cementing of that stage.

The aforementioned difficulties have been overcome by an apparatus described and claimed in the application of Reuben C. Baker, Serial No. 434,913, filed March 16, 1942, now Patent #2,370,-

2

833, dated March 6, 1945, for "Apparatus for cementing well bores," in which the cement slurry and following mud column of fluid are introduced in the well bore with an intervening flexible top cementing plug. This plug is made of a material which permits its slidable engagement with the well casing and radial compression and passage through a sleeve valve bore of materially restricted diameter as compared to the inside diameter of the casing string. After passing through the sleeve valve, the plug expands to its initial shape so as to continue functioning as a top cementing plug in forcing the cement slurry ahead of it down through the casing for ejection therefrom at a predetermined lower point. Following completion of the cementing operation at the lower stage, a bridging member is allowed to gravitate through the mud fluid in the casing into engagement with a companion seat in the sleeve valve to close its central passage, allowing the sleeve valve to be shifted downwardly by hydraulic actilon to a position opening lateral ports through an upper cementing stage. This upper stage could then be washed thoroughly by circulating fluid and placed in condition for the reception of the requisite quantity of cement slurry pumped down the casing string for ejection through the open ports.

It is an object of the present invention to provide an improved multiple stage cementing apparatus in which charges of cement slurry can be ejected from the well casing at predetermined points independently of one another, and in which the outlets at such points are closed by sleeve valves having a larger central bore than heretofore employed, to permit easier passage of cementing plugs therethrough, and diminishing the danger of inadvertent shifting of the sleeve valves by the plugs to port opening positions. Despite the employment of a sleeve valve having a central passage that is not much smaller than the inside diameter of the casing string, the apparatus still permits the use of a bridging member capable of gravitating to a companion seat on a device associated with the sleeve valve, so that the latter may be hydraulically shifted to open position after the cementing operation through a lower stage has been completed.

The invention is also concerned with an improved top cementing plug capable of separating charges of cement slurry and following drilling mud during their entire passage through the casing string, and of passing through a sleeve valve closing upper stage ports without shifting such sleeve to open position.

Another object of the invention is to provide an improved top cementing plug of a composite construction, in which the lower portion or member of the plug is effective to separate cement slurry and a following column of mud or other fluids throughout the entire travel of the cement slurry through the casing, and in which an upper portion of the plug travels only part way through the casing string until it reaches a sleeve valve, where it becomes separated from the lower plug portion.

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 casing string embodying the apparatus of the present invention, with a top cementing plug above a stage collar with which it is to cooperate;

Figure 2 is a view similar to Figure 1, with the lower part of the plug shown below the stage collar;

Figure 3 is a view similar to Figure 1, disclosing the upper part of the plug after it has effected opening of the stage collar;

Figure 4 is a longitudinal view on an enlarged scale of the plug portion of the apparatus within the stage collar; and

Figure 5 is a view similar to Figure 4 of another embodiment of the invention.

The same reference numerals refer to like parts throughout the several views and embodiments of the invention.

In its general aspects, the invention is directed to a well cementing apparatus including a top cementing plug capable of separating cement slurry and a following mud column throughout the entire length of travel of the slurry through a well casing string, and which is also capable of opening an upper sleeve valve in the casing string after completion of a cementing operation at a lower stage.

The plug is of such character as to permit the stages to be cemented separately and independently of one another, and it also permits the use of a sleeve valve having a central bore almost as large as the inside diameter of the casing. The cementing plug is made of two main parts with the lower portion capable of passing readily through the sleeve valve, which arrests the upper portion, whereupon the pressure of the fluid above the plug disconnects the lower portion from the upper portion and permits its continued downward travel through the casing below the sleeve valve as an efficient top cementing plug in preventing contamination between the cement slurry and mud in the well casing. The two plug members are disconnected at the sleeve valve with the exertion of a separating force that is too low to shift the sleeve valve to port opening position.

The upper plug portion is provided with a central passage of much less diameter than the internal diameter of the casing string, to permit use of a bridging member that is small enough to gravitate readily through the fluid in the casing above the sleeve and close its bore, allowing an increase in the pressure of fluid above the upper plug portion to shift the sleeve downwardly to port opening position, and permit the upper stage to be cemented.

The form of invention disclosed in Figures 1 to 4, inclusive, consists of a tubular collar 10 adapted to form part of a casing string by being threaded at its opposite ends to upper and lower casing sections 11, 12, or to an intervening coupling. This collar is provided with lateral ports or outlets 13 through which fluids may pass from the interior of the casing string into the annulus between its exterior and wall of the bore hole. Although not essential to the present invention, if desired, return flow of such fluids is preventable by any suitable back pressure valve device, which in the present instance consists of a flexible sleeve valve 14 of rubber or similar material whose lower end is fixed to the exterior of the collar and whose remaining upper portion is free to flex outwardly away from the ports 13 under the influence of fluids passing therethrough. Any tendency for such fluids to flow back through the ports is prevented by the rubber sleeve 14 snugly embracing the ported collar area.

The action of the flexible sleeve valve 14 can be supplemented by a plurality of closely spaced longitudinal leaf springs 15 extending circumferentially therearound. The lower ends of these springs are welded to the collar below the lower end of the flexible sleeve 14, and the spring portions extending upwardly from this point of attachment to the collar project over and engage the flexible sleeve valve to add its spring action to the inherent elasticity of the flexible sleeve tending to hold it in closed position over the ports 13. It is therefore necessary for the fluid under pressure within the casing string to overcome both the elasticity of the rubber sleeve valve 14 and leaf springs 15 in opening the ports. Not only do the leaf springs assist in the functioning of the rubber sleeve as a back pressure valve, but they also serve to protect it against damage during lowering of the casing string in the well bore.

Passage of fluids through the ports 13 is controlled by a sleeve valve 16 slidable within the collar. This valve is initially held over the ports by frangible means, such as shear screws 17, which position its upper and lower side seals 18, 19 on opposite sides of the ports to prevent flow of fluids in either direction between the exterior of the sleeve 16 and wall of the collar 10 for passage outwardly through the ports 13. The sleeve valve 16 is incapable of moving upwardly from the position in which it is held by the shear screws by engagement of its external shoulder 20 with a companion shoulder 21 in the interior of the collar. When the screws 17 are sheared, in a manner hereafter described, the sleeve valve 16 is shifted downwardly to a position below the ports 13, limited by engagement of the lower end of the sleeve with a suitable stop, which is disclosed in the drawings as being constituted by the upper end of the lower casing section 12.

The collar and sleeve valve construction are incorporated in the casing string at a predetermined point along its length for operation as a multiple stage cementing device. That is, it is first desired to eject cement from a particular point in the casing below this stage collar, and after this lower cementing operation has been completed, to shift the sleeve valve 16 downwardly to open its cooperable ports 13 and permit the cementing operation to occur through them. It is also desired to eject the different charges of cement slurry separately and inde-

pendently of one another with the use of separating cementing plugs.

In cementing the lower stage, a cementing plug is placed at the top of the charge of slurry and this combination is pumped down through the casing by means of a following column of mud or other suitable fluid. The top cementing plug is of composite character, consisting of an upper member 23 and a lower member 24 detachably secured together. The body 25 of the upper member is made of a suitable rigid drillable material, such as wood, aluminum, or synthetic resin, and has an annular upper packing cup 26 secured to it, as by the screws 27, for slidable sealing with the wall of the casing as the plug moves downwardly therewithin.

The lower plug member 24 is similar to the flexible cementing plug described in the above referred to patent application. Essentially this lower member consists of a tapered body 28 made of rubber or similar material adapted to be compressed inwardly as it is forced through the sleeve valve 16 at a sufficiently low pressure as not to shear the screws 17 holding the sleeve valve in closed position over the ports 13. Such inward compression is assisted by providing a central bore 29 in the plug. The plug body 28 includes a leading wiper edge 30 designed to slidably engage the wall of the casing, and a trailing lip 31 adapted to be acted on by fluid under pressure to maintain the plug in engagement with the casing. Tilting of the plug in the casing is limited by a flange 32 extending outwardly from the trailing tail piece 33 of the plug. This flange is preferably notched to provide fingers 34 that flex upwardly and inwardly more readily as the plug passes through the sleeve valve 16.

The upper and lower plug members 23, 24 are connected to one another by providing a groove 35 adjacent the lower end of the upper member in which is receieved an inturned flange 36 at the upper end of the lower member. The lower member also has an internal groove 37 receiving an external flange 38 on the upper member. These cooperable flanges 36, 38 provide an interlock normally coupling the upper and lower members 23, 24 together for movement through the casing, but nevertheless permitting their disconnection upon exertion of sufficient force on the lower plug to pull its rubber flange 36 out of the upper member groove 35.

As was described above, the composite top cementing plug is pumped down the casing on top of the cement slurry. Due to its ability to compress inwardly, the lower plug member 24 passes into the sleeve valve 16 without shearing the screws 17, but the upper plug member comes to rest upon engagement of its outwardly extending shoulder 39 with the upper end of the sleeve 16, with its depending body portion 25 extending into the sleeve. The comparatively rigid material from which the upper body 25 is made prevents its moving any further with respect to the sleeve. It is to be noted that the packing cup 26 on the upper plug body and the body itself have a central passage 40 therethrough, and that this passage is initially closed by the lower plug member 24 through the cooperation between the interlocking flanges 36, 38 which prevent leakage of fluids through the passage 40 and between the plug members.

After engagement of the upper body shoulder 39 with the sleeve 16, an increase in pressure of the casing fluid above the plug combination exerts a force on the upper end of the lower member 24 of a sufficient degree to pull its flange 36 out of the upper member 23 and separate the two. Such separating force is well below the shear value of the screws 17, allowing the sleeve valve 16 to remain in its closed position. A continuation of the pumping action thereafter moves the lower plug member 24 only down through the casing to force the cement slurry ahead of it and eject it from the casing at the predetermined lower point. This lower member continues to make an efficient seal with the casing as it moves downwardly through it.

After the lower stage has been cemented, it is desired to shift the sleeve valve 16 to open position and permit the ejection of fluids through the ports 13 of the upper stage collar 10. A bridging member in the form of a ball 41 is allowed to gravitate through the fluid in the casing until it engages a companion seat 42 in the upper plug body to close its passage 40. An increase in the fluid pressure to a sufficient degree then causes the bridging member 41 and plug 23 to exert a sufficient force on the sleeve valve 16 to shear the screws 17 and move the sleeve downwardly to a sufficient extent in which the plug packing cup 26 is below the ports 13; that is, until the ports are open. Circulating fluid may now be pumped through the casing string for movement through the ports and passage upwardly through the casing annulus, conditioning it for reception of a following charge of cement slurry. Movement of fluid through the casing below the ports is precluded by the upper plug member 23 and ball 41. After the well bore has been properly conditioned, the required cement slurry is pumped through the casing for ejection through the ports 13 and upward passage through the annulus between the exterior of the casing and wall of the bore. Return flow of the slurry is prevented by the back pressure valve device 14, 15.

The inside diameter of the sleeve valve 16 is not much smaller than that of the casing string, which permits the lower plug member 24 to pass through it much more readily than if the sleeve bore or passage were restricted to a much greater extent. However, the provision of a sleeve bore of such large diameter makes it difficult for a bridging member to gravitate through the fluid in a well casing to a companion seat on the sleeve, since the bridging member would have to be almost the same diameter as the inside diameter of the casing and would not permit fluid to bypass around it readily. There is danger that this large bridging member could not be moved through the casing at all unless it forced the fluid ahead of it, and such movement could not occur in the apparatus described because the casing string is at that time imperforate, due to the closing of the collar ports 13 by the sleeve valve and the engagement of the lower plug member 24 with a lower shoe or collar to close the lower end of the casing. The upper member 23 of the cementing plug therefore serves not only to effect opening of the sleeve valve 16 when desired, but it also provides the requisite restricted bore 40 in the sleeve after the lower plug member has passed through it for reception of a bridging member 41 of much lesser diameter than the inside diameter of the casing, which obviously can gravitate easily through the casing fluids, and does not tend to force fluid ahead of it.

The form of invention disclosed in Figure 5 is similar in most respects to the one previously described. The difference resides in an alteration in the construction of the lower plug member 24.

Instead of forming this member entirely of a readily compressible material, it is formed of a body 45 having a flexible wiper disc 46 at its lower end secured to the body by screws 47 or the like. The upper portion of the body has a packing member 48 molded to it which extends across its upper end and has a depending skirt 49 terminating in a flange 50 cooperating with an inturned flange 51 on the body to lock the packing member thereto. This packing member 48 is also furnished with an upwardly projecting flange portion 52 interlocking with the flange 53 at the lower end of the upper body member, in the same manner as was described in connection with the other form of invention. A peripheral packing member lip 54 extends outwardly for slidable sealing engagement with the wall of the casing as the plug 24 passes through it.

The plug is used in exactly the same manner as the one previously described. The lower body 45 is small enough to pass freely through the sleeve valve 16. This is also true of the wiper disc 46 whose outer margins are deflectable upwardly by the sleeve valve as permitted by the relieved bevel portion 55 at the lower end of the body; and the lip member 54 is also forced inwardly by the sleeve valve for passage therethrough.

When the shoulder 39 on the upper plug member 23 engages the sleeve valve 16, its downward movement is stopped, and the pressure of the fluid in its passage 40 disengages the interlocking flanges 52, 53 and forces the lower member 23 completely through the sleeve valve, whereupon the wiper disc 46 and packing lip 54 may again expand outwardly into slidable sealing engagement with the casing and continue to function as a top cementing plug in forcing the charge of cement slurry ahead of it through the casing.

It is therefore apparent that the present invention provides an improved apparatus for cementing each stage separately and independently of any other stage. The ports through an upper stage need not be opened until after the cementing operation through a lower stage has been completed, whereupon the upper stage can be thoroughly washed or otherwise fully conditioned prior to receiving its charge of cement slurry.

I claim:

1. Apparatus of the character described, including a tubular member adapted to form part of a well casing and having a lateral outlet, valve means initially closing said outlet, an upper member having a passage therethrough and adapted to operate said valve means to open said outlet, a lower member, means releasably securing said upper and lower members together for joint movement downwardly through said casing until said upper member engages said valve means to arrest downward movement of said upper member, said releasable means being releasable to disconnect said lower member from said upper member after the latter engages said valve means to allow continued downward movement of said lower member below said sleeve valve in slidable sealing engagement with said casing, and means for closing said upper member passage to allow hydraulic pressure to be exerted on said upper member to move said valve means to outlet opening position.

2. Apparatus of the character described, including a tubular member adapted to form part of a well casing and having a lateral outlet, a sleeve valve within said member initially closing said outlet, a cementing plug movable downwardly through said casing and comprising an upper member having a passage therethrough and a lower member, means releasably securing said upper and lower members together during their downward movement through said casing toward said sleeve valve, said upper member being engageable with said sleeve valve, said means being releasable to disconnect said lower member from said upper member after engagement of the latter with said sleeve valve to permit said lower member to be moved through said sleeve valve and slidably engage said casing below said sleeve valve, and means adapted to be sent down said well casing to close said upper member passage and allow hydraulic pressure to be exerted on said upper member and sleeve valve to move said sleeve valve to outlet opening position.

3. Apparatus of the character described, including a tubular member adapted to form part of a well casing and having a lateral outlet, a sleeve valve within said member for closing said outlet, a plug device comprising upper and lower members initially secured together and movable downwardly through said casing, said upper member having a fluid passage therethrough and being arrested upon engagement with said sleeve valve, said lower member being disengageable from said upper member by hydraulic pressure exerted through said fluid passage and said lower member being adapted for slidable engagement with said casing as it moves downwardly therethrough below said sleeve valve.

4. Apparatus of the character described, including a tubular member adapted to form part of a well casing and having a lateral outlet, a sleeve valve within said member, frangible means initially holding said sleeve valve in closed position over said outlet, a plug device comprising upper and lower members secured to one another and movable downwardly through said casing in slidable engagement therewith, said upper member being arrested upon its engagement with said sleeve valve, said plug device being so constructed and arranged that said lower member is hydraulically disconnectable from said upper member after its engagement with said sleeve valve in order that said lower member may move through said sleeve valve without disrupting said frangible means, and means adapted to be sent down said well casing for cooperation with said upper member to enable said frangible means to be disrupted hydraulically and said sleeve valve moved to outlet opening position.

5. Apparatus of the character described, including a tubular member adapted to form part of a well casing and having a lateral outlet, a sleeve valve within said member, frangible means initially holding said sleeve valve in closed position over said outlet, a plug device movable downwardly through said casing in slidable engagement therewith comprising an upper member having a passage therethrough and a lower member secured to said upper member to close one end of said passage, said upper member being arrested upon its engagement with said sleeve valve and said lower member being hydraulically disconnectable from said upper member after such engagement so as to be hydraulically movable through said sleeve valve without disrupting said frangible means, and means adapted to be sent down said well casing to close said upper member passage whereby hydraulic pressure may be exerted on said upper member and sleeve valve to disrupt said frangible means and move said sleeve valve to outlet opening position.

6. Apparatus of the character described, in-

cluding a tubular member adapted to form part of a well casing and having a lateral outlet, a sleeve valve within said member, means initially holding said sleeve valve in closed position over said outlet, a plug device comprising an upper member having a passage therethrough and a lower member slidably engageable with said casing and secured to said upper member to close one end of said passage, said upper member being arrested upon its engagement with said sleeve valve and said lower member being hydraulically disconnectable from said upper member after such engagement so as to be hydraulically movable through said casing below said sleeve valve, and a bridging ball adapted to be sent down said casing to close said passage whereby said holding means may be rendered ineffective hydraulically and said sleeve valve shifted to outlet opening position.

7. A plug device adapted for use in well casing, including an upper member having a fluid passage therethrough and a lower member, means releasably securing said lower member to a body portion of said upper member, said lower member having means thereon adapted for slidable sealing engagement with the wall of such well casing, said lower member having a body portion so constructed and arranged as to be passable through a bore of less diameter than the body portion of said upper member.

8. Apparatus of the character described, including a tubular member having a lateral outlet and adapted to form part of a well casing positioned in a well bore, a sleeve valve slidable within said member for controlling flow of fluid from within said member through said outlet, means adapted to be sent down said tubular member from the surface of said well bore for restricting the bore through said sleeve valve, and means adapted to be sent down said tubular member for closing the bore through said first-mentioned means.

9. Apparatus of the character described, including a tubular member having a lateral outlet and adapted to form part of a well casing positioned in a well bore, a sleeve valve slidable within said member for controlling flow of fluid from within said member through said outlet, a plug device having a fluid passage and adapted to be sent down said tubular member from the surface of said well bore into engagement with said sleeve valve to restrict the bore of the latter, and means adapted to be sent down said tubular member into engagement with said plug device to close its passage.

10. A plug device adapted for use in well casing, including upper and lower members disconnectably secured together, said upper member having a body portion provided with a central passage normally closed by said lower member, and said lower member having a body portion passable through a bore of less diameter than the diameter of said upper body portion.

11. A plug device adapted for use in well casing, including upper and lower members disconnectably secured together, said upper member having a body portion provided with a central fluid passage normally closed by said lower member, said lower member having a body portion passable through a bore of less diameter than the diameter of said upper body portion, and said lower member having a packing thereon adapted for slidable sealing with the wall of such casing.

12. A plug device adapted for use in well casing, including upper and lower members disconnectably secured together, said upper member having a body portion provided with a central fluid passage normally closed by said lower member, packing means secured to said body portion for slidable sealing with the wall of such casing, said lower member having a body portion passable through a bore of less diameter than the diameter of said upper body portion, and said lower member having packing means thereon adapted for slidable sealing with the wall of such casing.

ROSCOE O. CHILDERS.

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