Sept. 10, 1940. L. H. HAYWARD ET AL 2,214,555

APPARATUS FOR CEMENTING WELLS

Filed March 22, 1938 2 Sheets-Sheet 1

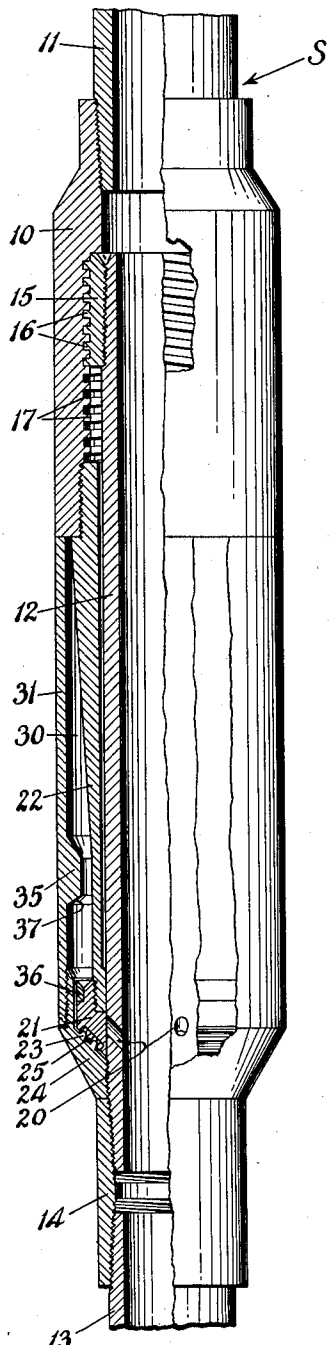


Fig. 1

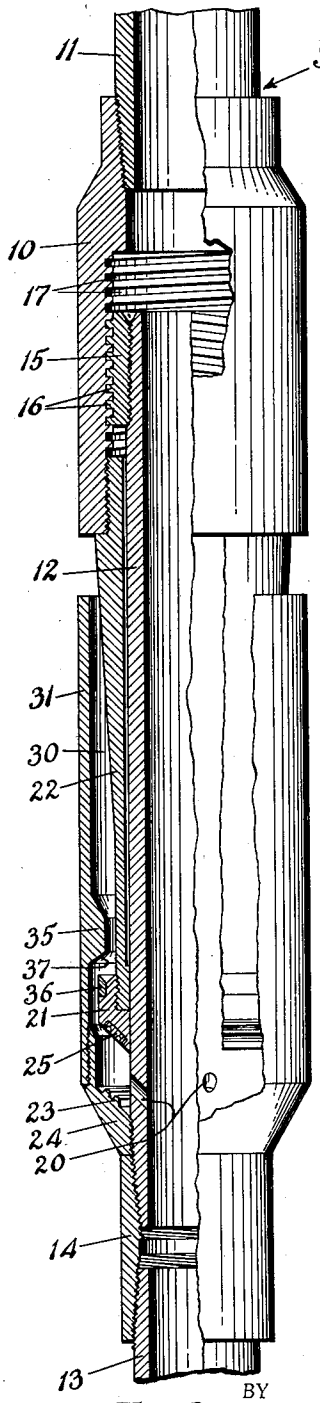


Fig. 2

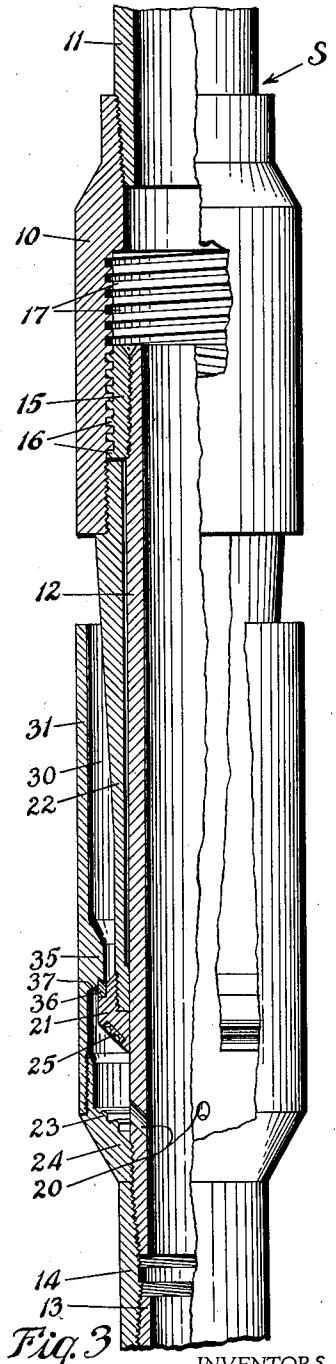


Fig. 3

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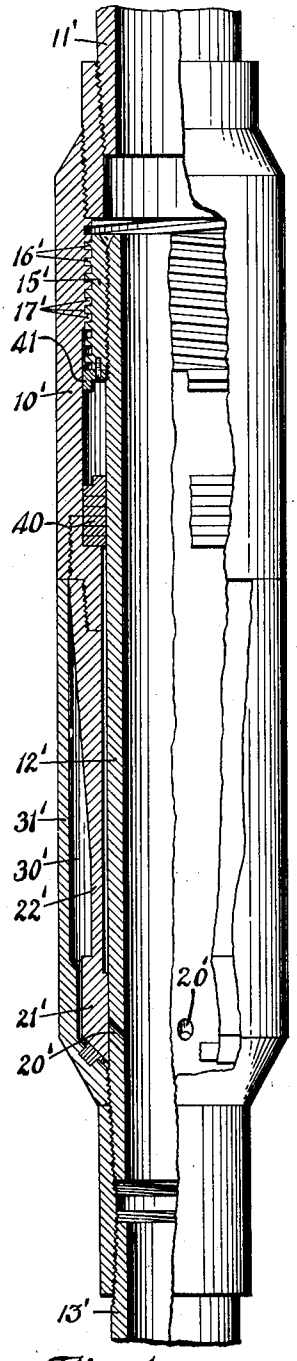


Fig. 4

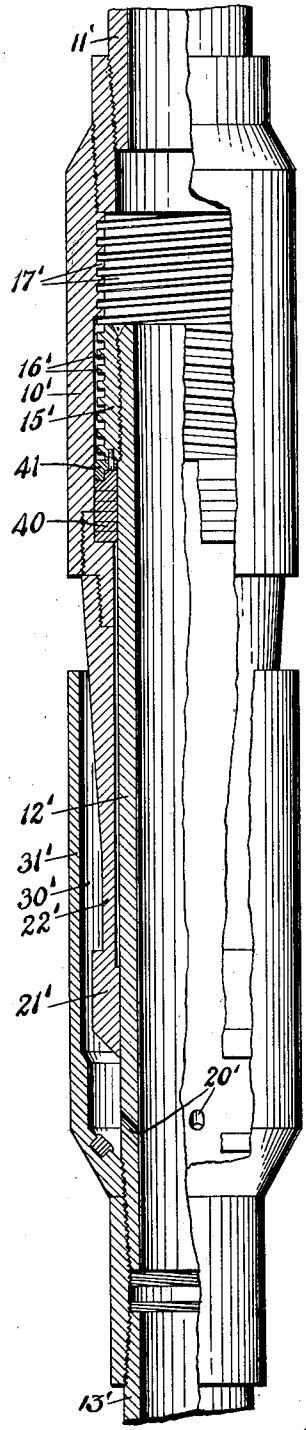


Fig. 5

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APPARATUS FOR CEMENTING WELLS

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Application March 22, 1938, Serial No. 197,392

16 Claims. (Cl. 166—1)

In substantially all of the known multiple stage cementing devices, the cementitious material is forced through radial discharge openings directly into the space between the cementing device or casing and the walls of the hole. Instead of being distributed uniformly around the device or casing in the region of the discharge openings, the cementitious material tends to channel through the drilling fluid contained in the well bore, leaving intermediate bodies of said drilling fluid which subsequently hardens. The presence of such solidified drilling fluid will permit seepage of waters or other undesirable materials back into the casing through the radial openings to contaminate the oil flowing in the well and also permit the passage of fluids from the interior of the casing outwardly through the discharge openings and solidified drilling fluid. The extent of seepage will be enhanced by the inability of the presently used multiple stage cementing devices to distribute the cementitious material below the radial discharge openings due to the tendency of the material to move in a path of least resistance upwardly therefrom, caused by the progressively decreasing fluid pressure from the discharge openings to the surface. Such lack of cementitious material will permit seepage of water into the casing from points below the position of the cementing device.

Attempts have heretofore been made to prevent reverse flow of the cementitious material and of the waters, by associating one way pressure actuated valve devices with the discharge openings. These expedients have proved unsatisfactory, since the presence of foreign matter, or the cement itself, tends to prevent their closing or the valve devices themselves may be entirely cut away.

Among the features of the present invention is to obviate the foregoing disadvantages of the prior art devices. It therefore becomes an object of the invention to provide a well cementing device which will ensure a complete cementitious seal between the openings for discharging cementitious material into the space between the casing and walls of the bore, or another casing within which the device is confined.

A further object of the invention lies in the provision of a well cementing device capable of producing a circumferentially uniform discharge of cementitious material from the outlet end of the device to the space between the casing and walls of the bore, or another casing within which the device is confined.

Another object of the invention is the provision of a well cementing device which will ensure a circumferentially uniform discharge of cementitious material from the outlet end of the device by effecting a uniform circumferential dispersion of the material within the device prior to its discharge.

Still another object of the invention resides in the provision of a valve mechanism positively operable from the surface of the bore for controlling the discharge of material from the cementing device into the bore or other confining casing.

A further object of the invention is to provide a valve mechanism positively operable from the surface of the bore for controlling the discharge of material from the cementing device into the bore, said control being assisted by the action of gravity and/or friction on the well casing to which the device is attached.

A further object of the invention is to provide a sealing mechanism positively operable from the surface of the bore for preventing reverse flow of fluid cementitious material through the cementing device.

A still further object of the invention resides in the provision of a sealing mechanism positively controllable from the surface of the bore for preventing reverse flow of fluid cementitious material through the cementing device, said sealing being assisted by the action of gravity on the well casing to which the device is attached.

Still another object of the invention contemplates a well cementing device capable of performing its functions both in upright and inverted positions.

This invention possesses many other advantages and has other objects which will be made more easily apparent from a consideration of the embodiments thereof shown in the accompanying drawings and forming a part of the present specification. We shall now proceed to describe these forms in detail which illustrate the general principles of our invention; but it is to be understood that this description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Figure 1 is a longitudinal sectional view of the device, portions of which are shown in elevation.

Figure 2 is a view similar to Figure 1 showing parts of the device in a different position of adjustment.

Figure 3 is a view similar to Figure 1 showing parts of the device in still another position of adjustment.

Figure 4 is a longitudinal sectional view par-

tially in elevation, of a modified form of the device; and

Figure 5 is a view similar to Figure 4, showing parts of the device in a different position of adjustment.

In the drawings, the cementing device is shown as being positioned in and forming part of a casing string S. Said device includes an upper hanger sleeve 10 threaded onto a casing section 11 and a tubing 12 connected to a lower casing section 13 through a coupling 14 into which the tube and casing ends are threaded. The tubing carries a ring 15 threaded onto its upper end which serves to adjustably connect it with the hanger sleeve 10 by means of the square threads 16 on the exterior of the ring 15 interfitting with the complementary internal threads 17 formed in the hanger sleeve 15. Relative rotation between the hanger sleeve and tubing 12 will produce movement of the tubing longitudinally of the axis of a well bore within which the casing and cementing device is contained, to accomplish a purpose hereinafter described.

The tubing 12 is provided near its lower end with generally radial discharge ports 20 normally closed by an annular valve head 21 whose inner surface slidably engages the tubing. The valve head 21 is threaded onto the lower end of a valve sleeve 22 surrounding the tubing 12 and having its upper end threaded into the hanger sleeve 10. When the valve head 21 is in its closed position as shown in Figure 1, fluid will be prevented from passing between the interior and exterior of the casing string through the discharge openings 20. Assurance against such passage of fluid is provided by the engagement of the lower tapered portion of the valve head 21 with the annular seats 23 formed on the frusto-conical coupler 24 threadedly attached to the lower end of the tubing 12 below the discharge openings 20. The valve head 21 is preferably provided with a lead or other suitable insert 25 which will provide an efficient fluid tight seal upon application of pressure between it and the seats 23 on said frusto-conical coupler 24.

The discharge ports 20 can be opened by effecting relative rotation between the hanger sleeve 10 and the tubing 12. By reason of such relative motion the interengaging square threaded portions of the hanger sleeve and ring 15 will produce longitudinal movement of the tubing 12 with respect to the valve head 21, valve sleeve 22, and hanger sleeve 10, all of which are rigidly interconnected as heretofore described, until the parts become positioned as shown in Figure 2, with the valve head removed from the sealing seats 23 and disposed above the discharge ports 20 to permit passage of fluid therethrough. Cementitious material forced downwardly through the casing string S is thus permitted passage through the discharge ports, but instead of being permitted to flow directly therefrom into the space between the casing string and the walls of the bore or confining casing (not shown), it is directed through an annular passage 30 defined by a discharge tube 31 threadedly connected to the frusto-conical coupler 24 and spaced with respect to the outer surface of the valve sleeve 22.

The cementitious material is caused to flow through the passage 30 to obviate the defects associated with the aforementioned channeling of the material resulting in seepage of waters or other undesirable elements back into the casing through the discharge ports 20. Due to the extended annular passage 30, the cementitious material, prior to its emission from the outlet end of the discharge tube 31, will become uniformly dispersed between the valve sleeve 22 and said discharge tube, to provide a circumferentially continuous mass of sealing material in said passage. Such continuity will insure against the aforementioned undesirable seepage upon hardening of the material. It also results in the emission of the fluid cementitious material from the discharge tube 31 in a circumferentially continuous stream to provide a complete filling of the space between the casing string and walls of the bore, particularly in the region of the discharge end of the tube.

In furtherance of obtaining a circumferentially continuous mass of sealing material in the passage, the outer surface of the valve sleeve can be tapered outwardly towards the discharge end of the tube, to cause the cementitious material to spread circumferentially during its movement through the passage, because of the gradual restriction to longitudinal flow of the material.

After the proper quantity of fluid cementitious material has been discharged through the radial openings 20 and from the outlet end of the tube 31, its reverse flow is prevented by effecting a seal between an annulus 35 secured to the interior of the discharge tube 31 and an upper portion of the valve head 21, preferably consisting of a hardened ring insert 36 having an upper edge adapted to be pressed against the lower tapered face 37 on the annulus for effecting a positive seal. The seal is produced by a continued rotary movement of the hanger sleeve 10 with respect to the tubing 12, which will cause the latter element and the discharge tube 31 connected therewith to move longitudinally of the valve head 21 until the tapered seat 37 on the annulus engages with the upper edge of the hardened ring insert 36 as disclosed in Figure 3. After the seal is established, the fluid cementitious material is prevented from flowing reversely past the upper portion of the valve head 21. Upon hardening, a solid cementitious seal will be obtained in the passage 30 between the discharge tube 31 and valve sleeve 22 to prevent leakage into the casing string, which leakage is further prevented by the sealing engagement between the ring insert 36 and the tapered seat 37 on the annulus 35.

When used for cementing at an intermediate stage in a bore, the device is lowered thereinto as part of the casing string, with the discharge ports 20 closed by the valve head 21, as shown in Figure 1. This will permit circulation of drilling mud and fluid cementitious material to a lower stage without any leakage of these materials through the discharge openings. When it is desired to cement at the stage at which the device is positioned, the casing string 11 thereabove and the hanger sleeve 10 attached to it will be rotated from the surface preferably in a clockwise direction. Due to its inertia and resistance to turning offered by the drilling mud, and also possibly by its engagement with the walls of the bore, the casing depending from the cementing device will be restrained from rotation, resulting in relative longitudinal movement between the rotating hanger sleeve 10 and the tubing 12 occasioned by the interconnected helical threads on the hanger sleeve and ring 15 secured to said tubing. Such longitudinal movement will open the valve to the position in Figure 2, permitting the flow of fluid through the dis-

charge openings 20 and tube 31 as heretofore described. After a proper quantity of cementitious material has passed through the device, continued rotation of the hanger sleeve 10 and upper casing string 11 will position the parts to effect a final and permanent seal as hereinbefore described in connection with Figure 3.

Under certain conditions, such as the use of the cementing device as an intermediate part of the casing string, the weight of the string 13 below the device will assist in the aforementioned longitudinal movements of the tubing 12 and associated parts with respect to the hanger sleeve 10 and its associated valve sleeve 22 and valve head 21. The action of gravity and/or friction upon the lower casing string 13 will reduce the effort required in obtaining the necessary relative rotation between the hanger sleeve and tubing; and additionally, it will assist in the maintenance of the sealing engagement between the annulus 35 and the hardened ring insert 36.

The modified form of the invention disclosed in Figures 4 and 5 possesses the same general constructional features and mode of operation as the embodiment heretofore described. For that reason the same reference numerals have been applied to similar parts with a prime mark added in each instance. The essential difference resides in the elimination of the annulus and hardened ring insert for preventing retrograde flow of the fluid cementitious material through the discharge openings. Figure 4 shows the parts of the device in a position similar to Figure 1 with the valve 21' closed, and the square threads 16' on the ring 15' in uppermost intergaging position in the hanger sleeve 10'. Rotary motion of the hanger sleeve will move the discharge openings 20' out of registry with the valve head 21', allowing the drilling fluid and cementitious material to pass through the passage 30' between the discharge tube 31' and the valve sleeve 22', into the space between the casing string and the walls of a confining bore or casing. The fluid cementitious material will normally be prevented from unwarranted reverse movement through the discharge openings 20' by maintaining suitable pressure upon the fluid within the casing until the cementitious material becomes set. The cementitious material will harden within the discharge tube 31' and the discharge openings 20'. However, should leakage develop within the discharge tube and fail to materialize through the discharge openings and the hard cement surrounding them in their vicinity, the seepage of waters or other fluids between the valve sleeve 22' and the tubing 12', and between the cooperating square threads to the interior of the casing string will be prevented by the packing 40 positioned between the inner surface of the hanger sleeve 10' and the outer surface of the tubing 12'.

The packing is in an uncompressed state so long as the valve 21' is closed. But upon movement of the tubing 12' longitudinally with respect to the hanger sleeve 10' to effect an opening of the valve, the packing will be compressed by reason of disengagement and uncoupling occuring between the square threads in the hanger sleeve and the threads on the ring affixed to the tubing. This will permit the weight of the tubing 12' and lower casing attached thereto, to apply a compressive effort to the packing through the agency of a clamping ring 41, attached to the square threaded ring 15, to expand the packing 40 into sealing engagement with the inner surface of the hanger sleeve 10' and the outer surface of the tubing 12'.

It is to be understood that it is not essential to rotate the hanger sleeve 10' to an extent sufficient to disengage the cooperating square threads 16' and 17' on the hanger sleeve and ring 15'. Opening of the valve can be effected with the square threads still remaining in engagement. Thereafter, if deemed essential to compress the packing, the hanger sleeve can be rotated to a further extent, resulting in thread disengagement and compressing of the packing in the manner aforementioned. If not deemed essential, the valve could be reclosed by the reverse rotation of the hanger sleeve producing an upward longitudinal movement of the tubing until the valve head closes the discharge openings, which will prevent reverse flow of any matter therethrough. Instead of permitting disengagement between the cooperative square threaded portions, the threads in the hanger sleeve could extend sufficiently to maintain engagement throughout the entire range of movement of the tubing. With this arrangement of parts, the packing could be compressed through the advancement of the packing ring occasioned by relative turning of the hanger sleeve and tubing. Such compression could be released by reverse rotation of the hanger sleeve, which could continue to the point of reclosing the valve, as aforementioned.

We claim:

1. A well cementing device comprising, means defining a passage for conducting cementitious material, means providing a second passage having a circumferentially continuous outlet, one or more openings in said device providing intercommunication between said passages, said last mentioned means being of rigid material to withstand forces tending to deform it and restrict said second passage.

2. A well cementing device comprising, a tubing for conducting cementitious material, a discharge tube providing a passage for said material having a circumferentially continuous outlet, one or more openings in said device providing intercommunication between said tubing and discharge tube, said discharge tube being of rigid material to withstand forces tending to deform it and restrict said second passage.

3. A well cementing device comprising, a tubing for conducting cementitious material, a discharge tube providing a passage for said material having a circumferentially continuous outlet, one or more openings in said device providing intercommunication between said tubing and discharge tube, means within said passage and positioned between said one or more openings and the outlet end of said tube for restricting the flow of material therethrough, said discharge tube being of rigid material to withstand forces tending to deform it and restrict said passage.

4. A well cementing device comprising, means defining a passage for conducting cementitious material, means providing a circumferentially continuous and convergent passage, means providing intercommunication between said passages, said second-mentioned means being of rigid material to withstand forces tending to deform it and restrict its passage.

5. A well cementing device comprising a tubing for conducting cementitious material, a discharge tube providing a passage for said material, means providing inter-communication between said tubing and discharge tube, separate means

intermediate said tubing and discharge tube defining a circumferentially continuous and convergent passage between said inter-communicating means and the outlet end of said discharge tube, said discharge tube being of rigid material to withstand forces tending to deform it and restrict its passage.

6. A well cementing device comprising, means defining a passage for conducting cementitious material, one or more openings in said device through which said material can flow, valve means for controlling the passage of material through said one or more openings, and means permanently secured to said valve means and positively operable from the surface of a bore for producing relative movement between said valve means and one or more openings, whereby to open or close said openings to control the passage of material therethrough.

7. A well cementing device comprising a tubing for conducting cementitious material, the side walls of said tubing being provided with one or more openings for the passage of said material, valve means slideable over said one or more openings for controlling the passage of material therethrough, and means permanently secured to said valve means and positively operable from the surface of a bore for producing relative movement between said valve means and one or more openings, whereby to open or close said openings to control the passage of material therethrough.

8. A well cementing device comprising, a tubing for conducting cementitious material, said tubing being provided with one or more openings for the passage of said material, valve means for controlling the passage of material through said one or more openings said means including sealing instrumentalities for preventing leakage of fluid when said valve is in closed position, and means permanently secured to said valve means and positively operable from the surface of a bore for producing relative movement between said valve means and one or more openings, whereby to open or close said openings to control the passage of material therethrough and the sealing of said instrumentalities.

9. A well cementing device comprising, a tubing for conducting cementitious material, a discharge tube providing a passage for said material, said tubing having one or more openings providing intercommunication between it and said discharge tube, valve means within said passage for controlling the passage of material through said one or more openings, means positively connected with said valve means and positively controllable from the surface of a bore for producing relative movement between said valve means and one or more openings, whereby to control the passage of material therethrough, and cooperable sealing instrumentalities on said valve means and discharge tube for preventing reverse flow of fluids through said one or more openings.

10. A well cementing device comprising a tubing for conducting cementitious material a discharge tube surrounding said tubing and providing a passage for said material the side walls of said tubing having one or more openings providing inter-communication between it and said discharge tube, valve means within said discharge tube slideable over said one or more openings for controlling the passage of material therethrough, means positively connected with said valve means and positively controllable from the surface of a bore for producing relative movement between said valve means and one or more openings, and cooperable sealing instrumentalities on said valve means and discharge tube for preventing reverse flow of fluids through said one or more openings.

11. A well cementing device comprising, a tubing for conducting cementitious material, a discharge tube providing a passage for said material, said tubing having one or more openings providing intercommunication between it and said discharge tube, a valve head within said discharge tube for controlling the passage of material through said one or more openings, means including a valve sleeve positively connected with said valve head and positively controllable from the surface of a bore for producing relative movement between said valve head and said one or more openings, whereby to control the passage of material therethrough, said valve sleeve being positioned within said discharge tube in spaced relation with respect thereto to define a convergent path through which said material can flow.

12. A well cementing device adapted to be attached in a casing string as a part thereof comprising, a tubing for conducting cementitious material, one or more openings in said tubing through which said material can flow, valve means for controlling the passage of material through said one or more openings, and means fixedly connecting said valve means and casing string and causing relative movement between said valve means and one or more openings upon movement of the casing from the surface, to open or close said openings to control the passage of material therethrough.

13. A well cementing device adapted to be attached in a casing string as a part thereof comprising, a tubing for conducting cementitious material, a discharge tube providing a passage for said material, said tubing having one or more openings providing intercommunication between it and said discharge tube, valve means within said discharge tube for controlling the passage of material through said openings, means positively connected with said valve means and operable through motion of the casing string for producing relative movement between said valve means and openings, whereby to control the passage of material therethrough, and cooperable sealing instrumentalities on said valve means and discharge tube for preventing reverse flow of fluids through said openings.

14. A well cementing device comprising a tubing for conducting cementitious material, said tubing having one or more discharge openings therein, a valve for controlling the passage of material through said one or more openings, means connected with said valve and adjustably connected with said tubing for effecting relative movement between said valve and one or more openings, cooperable sealing means between said first mentioned means and tubing, and means positively controllable from the surface of a bore for effecting relative movement between said first mentioned means and tubing to open said valve and actuate said sealing means to effect a fluid tight seal between said first mentioned means and tubing.

15. A well cementing device comprising a tubing for conducting cementitious material, said tubing having one or more discharge openings therein, a valve head for controlling the passage of material through said openings, means connected with said valve head and positively controllable from the surface of a bore for provid-

ing relative movement between said valve head and said one or more openings whereby to control the passage of material therethrough, packing means between said means and tubing, and means compressing said packing means into sealing engagement with the sides of said tubing upon relative movement between said tubing and said valve head.

16. A well cementing device comprising a tubing for conducting cementitious material, said tubing having one or more discharge openings therein, a valve head slidable with respect to said one or more openings longitudinally of said tubing, means including valve and hanger sleeves interconnecting said valve head with means positively controllable from the surface of a bore for effecting relative movement between the valve head and one or more discharge openings, and means for threadedly interconnecting said hanger sleeve and tubing, whereby to effect relative movement between said valve head and one or more openings longitudinally of said tubing upon relative rotative movement between said hanger sleeve and tubing, to control the passage of material through said one or more discharge openings.

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