Feb. 27, 1940. L. L. BROWN 2,191,750

WELL CEMENTING APPARATUS

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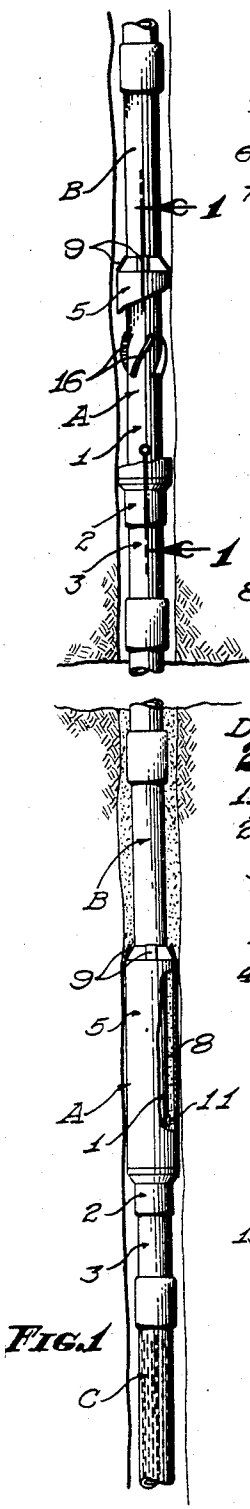


FIG. 1

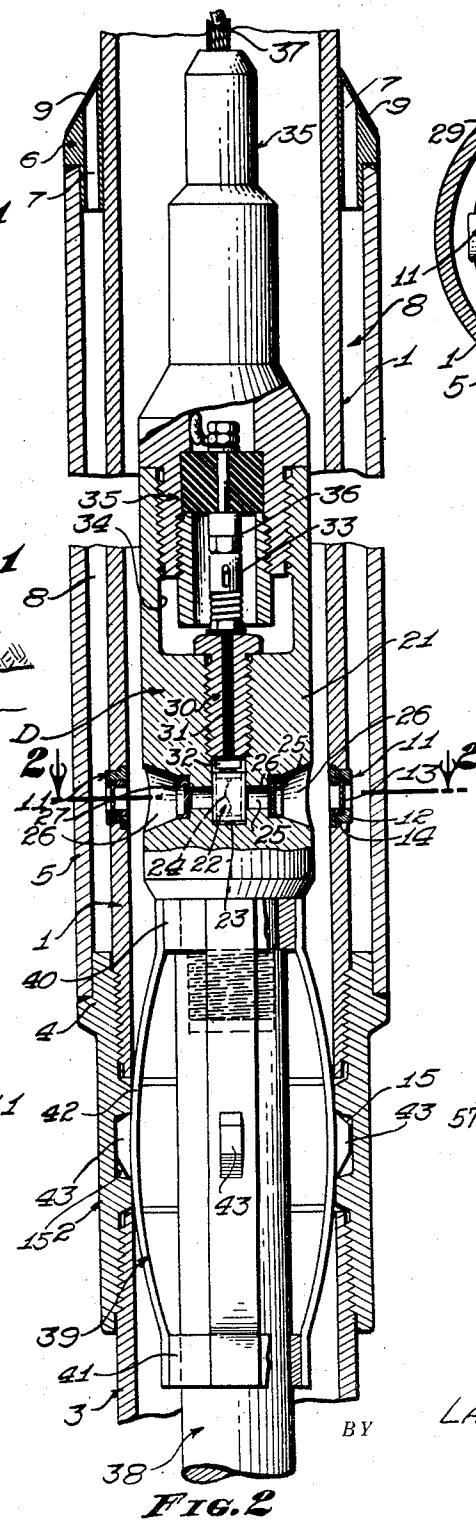


FIG. 2

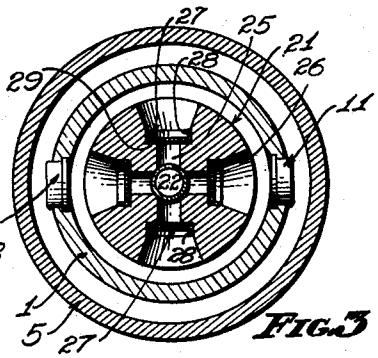


FIG. 3

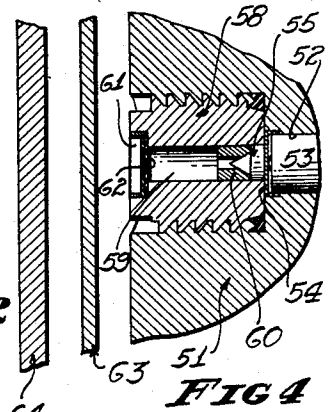


FIG. 4

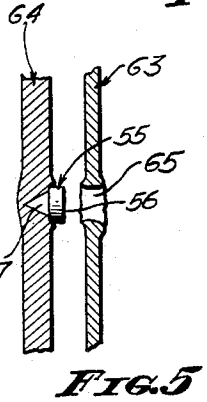


FIG. 5

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WELL CEMENTING APPARATUS

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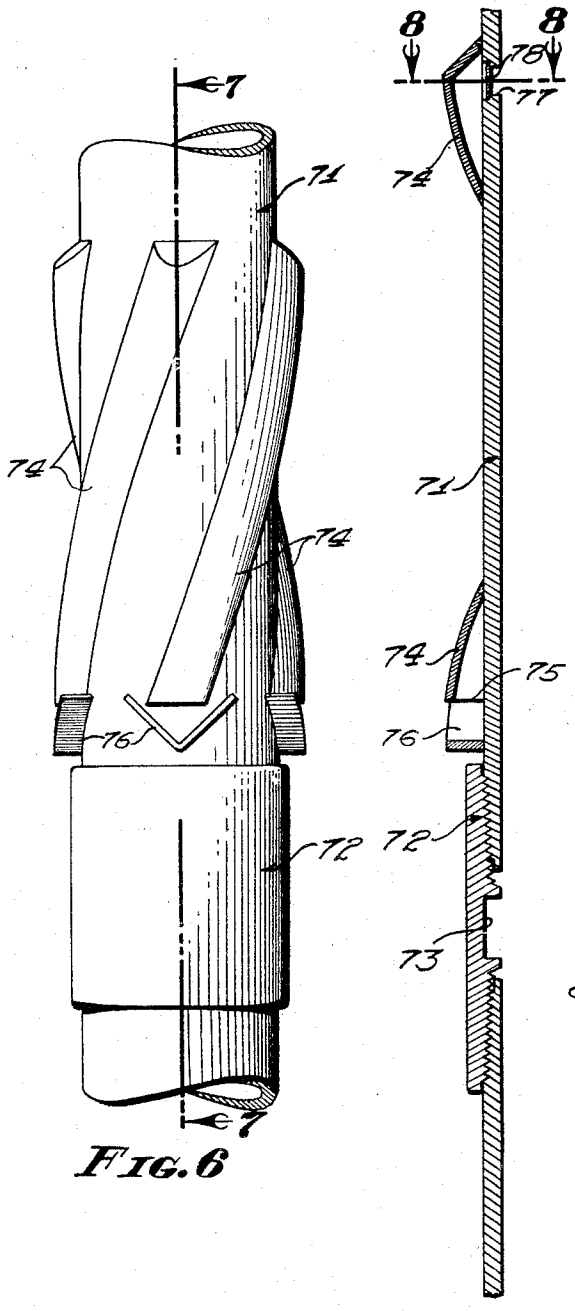


FIG. 6

FIG. 7

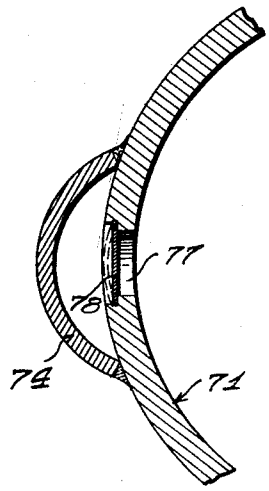


FIG. 8

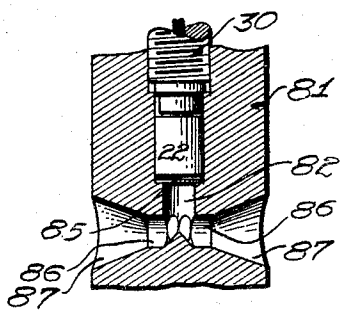


FIG. 9

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2,191,750

WELL CEMENTING APPARATUS

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Application March 14, 1938, Serial No. 195,856

12 Claims. (Cl. 166—1)

My invention relates to well cementing apparatus and process which is particularly designed for use in conjunction with oil wells. A material problem in drilling for oil is the prevention of transfer of liquid from one zone to another through the annular space between a well casing and the well bore. Unless a seal is provided between the formation and the casing, below various saturated zones, there is danger of transfer and contamination of the various liquids. For instance, a cement seal is required below the surface water sands, both to prevent drainage of the surface water into a lower strata or contamination of the surface water by up-welling of salt water or oil. Also it is highly desirable to separate the oil and the salt water sands, one from the other, as well as producing sands of different formation pressure.

The general practice has been to drill to a point below a saturated sand, or group of sands, cement a string of casing in place, then proceed with the drilling through the casing to the next zone. It is customary to run each string of tubing the full length of the well bore so that at the top there are concentric strings of casing which, except for the sealing off of fluid, only one casing serves any useful function. Attempts have been made to eliminate or reduce the number of casing strings by interposing in the casing string special valves which, when the casing string is landed, are opposite the proper locations for the introduction of cement into the well bore. These valves are operated by special plugs or triggers and require a complicated and expensive cementing program in order to cement at the desired point. Another procedure is to lower a blank casing and gun-perforate the same opposite the desired zone. Both arrangements are open to the objection that the cementing operations conducted intermediate the ends of the casing are often unsatisfactory. This is due, primarily, to channeling of the cement, that is, by reason of the fact that the casing leans against the side of the well bore the cement is prevented from completely encircling the casing. A further difficulty is that the cement, in leaving such special valve or passing through the gun perforations, flows upwardly so that there is little or no cement below the opening through the casing. As a result, particularly, if there is gas pressure below, there is a tendency for fluids to come in through such perforations or valve.

Accordingly, among the objects of my invention are:

First, to provide a well cementing apparatus and process whereby a positive seal of cement may be provided at any predetermined point intermediate the ends of a well casing which not only serves to prevent transfer of fluid along the well bore but also insures against leakage between the well bore and the interior of the casing;

Second, to provide an apparatus of this character which insures adequate spacing of that portion of the well casing to be encased in cement, so that free flow of the cement may be had and channeling is avoided;

Third, to provide an apparatus and process of this character which may or may not, as desired, be used in conjunction with a conventional cementing program, that is, the bottom of a casing string may be cemented in the usual manner and thereafter my apparatus and process may be used to accomplish a cementing operation intermediate the ends of the casing;

Fourth, to provide an apparatus of this character wherein as many devices may be interposed in a tubing string as there are regions in the well bore requiring cement seals, and wherein any one of such apparatus may be opened to accomplish a cementing operation without affecting or interfering with the other, so that the various regions may be cemented in stages and in any order desired;

Fifth, to provide an apparatus of this character wherein an intermediate chamber is provided between the casing and the well bore, and the points of communication between the casing and chamber, and between the chamber and the well bore are offset axially, or otherwise, whereby such cement as remains in the chamber forms adequate seal to prevent any communication between the well bore and the interior of the casing string;

Sixth, to provide an apparatus of this character which incorporates special pressure responsive closure devices and a special gun designed to create sufficient pressure to open the closure devices, such devices being so constructed that they are capable of resisting the hydrostatic heads of fluid in the well bore and casing, as well as any pump pressure that may be applied so that the said closure devices will not be accidentally opened;

Seventh, to provide an apparatus of this character which provides a simple, yet effective, means for registering the pressure exerting gun in approximate relation with the pressure responsive closure devices;

Eighth, to provide an apparatus of this char-

acter which may incorporate a special gun designed to pierce openings into an intermediate chamber, but which will not penetrate the outer walls of said chamber.

With the above and other objects in view, as may appear hereinafter, reference is made to the accompanying drawings, in which:

Figure 1 is a fragmentary sectional view of a well bore with a casing incorporating two of my cementing units shown in position and in partial section, the lower apparatus being shown as it appears when cemented in the well, and the upper apparatus being shown as it appears before use;

Figure 2 is an enlarged longitudinal sectional view through 2—2 of Figure 1, with my special partition rupturing gun shown in position;

Figure 3 is a transverse sectional view thereof through 3—3 of Figure 2;

Figure 4 is a fragmentary sectional view on an enlarged scale, showing a modified form of my apparatus wherein a special projectile is used to penetrate into one wall only of my apparatus;

Figure 5 is a similar sectional view showing the bullet after it has penetrated;

Figure 6 is an elevational view of a modified form of my cementing unit, wherein hollow spiral ribs are provided to introduce the cement into the well bore with a rotary motion;

Figure 7 is an enlarged longitudinal sectional view thereof taken through 7—7 of Figure 6;

Figure 8 is a fragmentary cross sectional view through 8—8 of Figure 7, illustrating one of the outlet ports and its sealing disc; and

Figure 9 is a fragmentary longitudinal sectional view of a modified form of my gun.

My cementing apparatus may be utilized in a variety of ways. One possible installation is illustrated in Figure 1, wherein two cementing units A are interposed in a casing string B. The lowermost cementing unit may be placed immediately above the liner C and the other below the surface water stands.

Each cementing unit includes an inner shell 1, the upper end of which is provided with a conventional pipe thread for connection to a collar of the casing string. The lower end of the inner shell 1 is screw-threaded into a special collar 2 which, in turn, is screw-threaded to a stem 3 equal in diameter to the inner shell 1 and the casing string B. The lower end of the stem 3 fits into a collar of the casing string.

The upper end of the collar 2 is enlarged to form a shoulder 4 for receiving the lower end of an outer shell 5 and to facilitate a welded connection therewith. The outer shell 5 encases the lower portion of the inner shell 1 and its upper end is welded to a spacer ring 6 filling the space between the shell, and which may or may not be welded to the inner shell. The spacer ring 6 is provided with ports 7 therethrough which communicate between the chamber 8 formed between the two shells and the exterior of the casing string. The outer end of each port 7 is adapted to be closed by a flap 9 in the form of a thin sheet of metal such as sheet iron, spot-welded to the spacer ring. The purpose of the flap 9 is merely to prevent plugging of the port 7 by material which may fall down the well bore.

Near its lower end the inner shell 1 is provided with apertures adapted to receive plugs 11. Each plug 11 includes a suitable mounting ring 12. The mounting ring is provided with an internal shoulder, against which rests a rupturable disc 13 held in place by a retainer ring 14. The plug 11 may be press-fitted or welded in the shell 1. The rupturable discs 13 are designed to withstand the hydraulic pressure of any fluid within the casing or well bore and, in addition, any pump pressure that may be applied. They are designed, however, to give way to the momentary percussive pressure built up when a small charge of explosive is set off in close proximity. This is accomplished by a special gun structure designated generally by D.

A cylindrical gun body 21 is provided, having a centrally disposed chamber in which fits a cylindrical cartridge 22. The cartridge 22 comprises a fibre shell containing an explosive powder. The ends of the cartridge 22 are provided with contacts 23, and a filament wire 24 extends therebetween so that upon application of electrical energy the filament wire is heated to incandescence and ignites the powder.

A plurality of lateral bores 25 radiate from the cartridge chamber. Their outer ends terminate in conical muzzles 26 which form, with the bores 25, shoulders adapted to receive sealing discs 27. Each sealing disc is in the form of a flat metal plate with a skirt 28 around the margin, which is directed outwardly so that the pressure of liquid thereagainst tends to force the sealing disc. A gasket 29 may be provided behind each sealing disc 27.

Access to the cartridge chamber is afforded through an axially extending bore provided in the gun body, which receives a screw plug 30. The screw plug 30 receives a small insulated stem 31 which terminates in a contact at one end in a contact head 32, engageable with one of the contacts 23. The upper end of the stem 31 is connected to a yieldable terminal 33.

The yieldable terminal 33 and the head of the screw plug 30 are positioned within a socket 34 formed at the upper end of the gun body, which socket is internally threaded to receive the lower end of a cable head 35. The cable head carries a terminal 36 which, when the cable head is screwed into the socket 34, engages the yieldable terminal 33. The cable head is secured to a supporting and conducting cable 37 having a single conductor therein, whereby electric current may be furnished to the cartridge.

The lower end of the gun body 21 is secured to a weight bar 38 on which is mounted a cage 39 comprising a fixed collar 40 and sliding collar 41 connected by bow springs 42. The bow springs 42 are adapted to ride against the inside walls of the casing and inner shell. Each bow spring is provided with a shoe 43 which is adapted to fit into a channel 15 formed in the collar 2. The distance between the channel 15 and plugs 11 is approximately the same as the distance between the shoes 43 and the lateral bores 25 of the gun, so that when the shoes fit into the channel 15 the muzzles of the gun are approximately opposite the rupturable discs 13.

The shoes 43 may be so formed that they will readily ride downwardly past the channel 15 of an upper cementing unit, but may have relatively abrupt upper ends so that increased resistance is encountered when attempting to pull upwardly on the gun after the shoes engage the channel. Thus the operator can readily detect, by the increased tension on the cable, the engagement of the shoes with the channel of the desired cementing unit. If, however, only one cementing unit is provided the shoes may be so arranged that they do not ride past the channel, but tend to engage therein. While it is preferred to provide a spe-

cial channel 15 for engagement with the shoes, which channel has a greater width than the recesses formed between adjacent casing ends screwed into the conventional coupling or collar, in order that such recesses will not interfere with the movement of the gun, it should be borne in mind that such conventional recesses may be utilized. In such case, reliance is had on the weight indicator and measuring device associated with the cable. These structures are conventional and are not illustrated herein.

Operation of my cementing apparatus is as follows: In making up the casing string one or more of the cementing units are interposed so that when the casing is landed they occur opposite the desired points in the well bore. For example, the lowermost unit may be positioned above the producing zone and the uppermost unit positioned below the surface water sand.

When it is desired to conduct a cementing operation through one of the cementing units the gun D is lowered to a position opposite the cementing unit, as shown in Figure 2. It should be understood that the casing is full of fluid. Consequently, when the gun is discharged a material surge of pressure is built up, which is ample to rupture the discs 13 if the gun is in any proximity thereto. As a matter of fact, it is unnecessary for the muzzles of the gun to be directly opposite the rupturable discs, but the position of the gun may vary an appreciable distance above or below the rupturable discs. The pressures so generated are materially higher than any pump pressure plus hydrostatic pressure that may be exerted against the discs. Consequently, all operations within the well bore may be conducted without danger that the discs may rupture accidentally.

After the discs are ruptured the gun is withdrawn and a conventional cementing operation is undertaken. A cementing job of this type is commonly referred to as a "squeeze" job, and the procedure is well established in the industry. By such process cement is forced outwardly through the plugs 11 into the chamber 8 formed between the two shells and out of the ports 7. The flaps 9 readily give way or break off so that the cement is free to flow upwardly around the casing. Inasmuch as the cement is introduced by flow down the interior of the casing and outwardly through the openings in the cementing unit, and thereupon upwardly along the outside of the casing, little or no cement is deposited below the discharge port 7. However, the chamber 8 remains full of cement so that a complete seal is provided between the plugs 11 and the discharge port. It should be noted here that in conducting a conventional "squeeze" job through open perforations in the casing, or through a special valve, that because little or no cement accumulates below the perforations a very inadequate seal is formed between the well bore and casing below the cement. Furthermore, the outer shell serves to center the casing thereabove in order to insure the distribution of cement around all sides. If desired, baffle vanes 16 may be provided in the chamber 8 to insure complete distribution of cement around the inner shell between the plugs 11 and the port 7.

Reference is now directed to Figures 4 and 5: The structure here illustrated fragmentarily is in most respects similar to the structure hereinbefore described. The essential different is that instead of the plugs 11 a special projectile is provided, adapted to penetrate the inner shell and imbed itself without penetrating the outer shell. In Figures 4 and 5 a gun body 51 is provided having a cartridge chamber 52 adapted to receive a cartridge 53 similar to the cartridge 22. The cartridge 53 is covered at the discharge end of the chamber with an expansion delaying disc 54 which is spot-welded to a projectile 55. The projectile 55 comprises a head 56 and a point 57. The head is relatively thin, and the point 57 is relatively abrupt and preferably forms a shoulder at its intersection with the head 56. The gun body 51 is counterbored outwardly from the cartridge chamber 52 to receive a gun barrel 58 adapted to be screw-threaded into position. The gun barrel 58 is provided with a bore 59 in which the projectile 55 extends. Fitted over the pointed end of the projectile is a guide plug 60 which serves to maintain the projectile in proper position within the gun barrel until it is discharged therefrom. The guide plug 60 is formed of relatively fragile material so that it readily breaks apart or disintegrates as soon as the bullet, or projectile, leaves the gun barrel.

The outer end of the gun barrel 58 may be closed by a sealing disc 61 and gasket 62 to prevent the entrance of liquids.

It is preferred, in conjunction with this embodiment of my invention, to substitute an inner shell 63 for the inner shell 1, and an outer shell 64 for the outer shell 5, the difference being that the inner shell 63 is made as thin as possible and the outer shell 64 is designed to carry the tensional load of the casing string. The purpose for doing this is to insure penetration of the inner shell 63, as shown in Figure 5, without penetration through the outer shell 64. As shown in Figure 5, the projectile makes a hole 65 in the inner shell 63, but merely embeds itself without penetrating the outer shell 64.

Reference is now made to Figures 6, 7 and 8: In the structure herein illustrated a shell 71 is provided, which is threaded for connection at its upper end to a conventional collar and at its lower end to a special collar 72. The collar 72 is similar to the collar 2 in that provision is made for a channel 73 between the ends of the pipe connected by the collar for the purpose of receiving the shoes 43 of the collar locating cage 39.

Welded to the shell 71 are a plurality of hollow helical ribs 74 which are preferably semi-cylindrical in cross section, closed at their upper ends and provided with openings 75 at their lower ends. Immediately below each hollow rib 74 is mounted a V shaped baffle 76 which protects the opening 75 as well as serving as a deflector for cement discharged through the opening 75.

The upper end of each hollow rib 74 covers a port 77. Each port 77 is enlarged at its outer end to form a shoulder against which fits a sealing disc 78. Each sealing disc is initially cupped, as indicated by dotted lines in Figure 8, whereby, when forced into position, the margins form a fluid-tight seal capable of withstanding the required pressure. The particular sealing disc here contemplated is known to the trade as a "Welch" disc.

The modified structure shown in Figures 6 to 8 is installed in the casing string as in the first described structure, and a gun such as shown in Figure 2 is employed, with the distance between the gun muzzles and the shoes 43 increased to correspond to the distance between the ports 77 and the channel 73. After the discs 78 are ruptured, or blown from the ports 77, the cement is introduced through these ports and flows down-

wardly through the several hollow ribs 74 to discharge into the baffles 76 and be deflected backwardly and upwardly between the ribs 74. By reason of the helical form of the ribs the cement is given a whirling action which tends to distribute it evenly around the shell 71 and the casing string thereabove. The ribs also serve to space the casing string from the walls of the well bore so as to insure complete distribution of the cement.

Reference is now made to Figure 9, wherein a further modified form of the gun is illustrated. In this construction the gun body 81 receives the cartridge 22 as in the first described structure. However, in place of the laterally directed bores intersecting the cartridge chamber a single downwardly directed bore 82 continues from the chamber. A sealing disc 85 is pressed into position above the bore 82, said bore being slightly smaller in diameter than the cartridge chamber to form a shoulder for the sealing disc 85. The lower end of the bore 82 intersects a plurality of radiating bores 86 having flared muzzles 87. With this construction only one sealing disc is required. Furthermore, the disc is so arranged that it must rupture before the effect of the explosive may be obtained, with the result that a higher pressure is built up than is the case where the several discs are merely frictionally held in place, as in Figure 2. Also that portion of the gun body surrounding the chamber is relatively massive so that there is little or no danger of the gun body rupturing by reason of the pressure. Except for the above noted differences, the gun structure shown in Figure 9 is similar to the gun structure shown in Figure 2.

My process of cementing well casing consists essentially of the following steps:

1. Interposing in the casing string a cementing unit having a chamber ported to the well bore but sealed from the casing.

2. Establishing by gun fire, avenues of communication between the casing and the chamber, such avenues being out of registry with the ports of the chamber.

3. Introducing cement through said avenues of communication and chamber to the well bore.

Though I have shown and described certain embodiments of my invention, I do not wish to be limited thereto, but desire to include in the scope of my invention the constructions, combinations and arrangements substantially as set forth in the appended claims:

I claim:

1. In an apparatus for introducing cement into a well bore around a well casing for the purpose of effecting a seal against transfer of fluid along the well bore externally of the casing, of: a shield incorporated on the casing string opposite the region to be cemented, said shield defining with the casing string a chamber having an inlet communicating with the interior of the casing and an outlet communicating with the well bore, said inlet and outlet being offset with respect to each other to form a passage therebetween adapted, when filled with cement, to form a pressure-tight seal against exchange of fluids between the well bore and interior of the casing; a sealing means within and initially closing said inlet, said sealing means being capable of withstanding the hydrostatic and pump pressures exerted by fluid in the casing; and an explosively operated device adapted to create a localized surge pressure materially exceeding such hydrostatic and pump pressure for opening said sealing means.

2. In an apparatus for introducing cement into a well bore around a well casing for the purpose of effecting a seal against transfer of fluid along the well bore externally of the casing, of: a shield incorporated on the casing string opposite the region to be cemented, said shield defining with the casing string a chamber having an inlet communicating with the well bore, said inlet and outlet being offset with respect to each other to form a passage therebetween adapted, when filled with cement, to form a pressure-tight seal against exchange of fluids between the well bore and interior of the casing; a sealing means initially closing said inlet, said sealing means being capable of withstanding the hydrostatic and pump pressures exerted by fluid in the casing; an explosively operated device adapted to create a localized surge pressure materially exceeding such hydrostatic and pump pressure for opening said sealing means; and means for locating said device in approximate registry with said sealing means.

3. A cementing apparatus comprising: a hollow double walled casing section interposed in the casing string and defining a cylindrical chamber having a relatively thin imperforate inner wall and a relatively thick outer wall; outlet ports from said chamber into the well bore; and gun means including a projectile adapted, when fired, to pierce the inner wall only.

4. A cementing apparatus comprising: a hollow double walled casing section interposed in the casing string and defining a cylindrical chamber having a relatively thin imperforate inner wall and a relatively thick outer wall; outlet ports from said chamber into the well bore; a gun adapted to be lowered into said casing string and including a projectile adapted, when fired, to perforate the inner wall only; and a locating means for positioning said gun to fire said projectile in longitudinal offset relation with the outlet port, whereby a passage is established between the gun perforation and outlet port, adapted, when filled with cement, to form a pressure-tight seal against exchange of fluids between the well bore and interior of the casing.

5. A cementing apparatus comprising: a hollow, double-walled casing section interposed in a casing string and having an unobstructed passage therethrough approximating the internal diameter of said casing string; outlet ports from the outer wall of said casing section to the well-bore; inlet ports in the interior wall of said casing section; sealing means for said inlet ports set within the walls of the casing section clear of the passage therethrough; and pressure-producing means for opening said sealing means.

6. A cementing apparatus comprising: a hollow, double-walled casing section interposed in a casing string, including an inner wall initially free of ports and defining an unobstructed passage approximating the internal diameter of the casing string in which it is interposed, an outer wall forming, with the inner wall, a chamber, and having outlet ports communicating between said chamber and the well-bore; and means for perforating the inner wall only.

7. A cementing apparatus comprising: a hollow, double-walled casing section interposed in a casing string, including an inner wall initially free of ports and defining an unobstructed passage approximating the internal diameter of the casing string in which it is interposed, an outer wall forming, with the inner wall, a chamber, and having outlet ports communicating between said

chamber and the well-bore; and means operable subsequent to landing of said casing string, for establishing inlet openings in said inner wall.

8. A structure as specified in claim 6 wherein said means comprises an explosive-operated device adapted to be lowered into the casing string after said casing string is landed, and operated to establish inlet openings in the inner wall only.

9. A well casing cementing apparatus comprising: an unobstructed casing section interposed in a casing string and having an internal diameter equal to the nominal internal diameter of said casing string whereby tools may pass freely therethrough; a shell positioned on said casing section forming therewith an elongated chamber in communication with the well bore but initially sealed from the interior of the casing; and a tool adapted to be lowered into said casing for establishing a port through said casing section into said chamber.

10. A well casing cementing apparatus comprising: a casing string adapted to be lowered into a well bore; a plurality of cementing units interposed in said casing string, each unit including means defining a chamber having an outlet port in communication with the well bore but sealed from communication with the interior of said casing; and a tool adapted to be lowered to any of said units for establishing communication between the interior of said casing string and the chamber of the selected unit, said units having an internal diameter equal to the nominal internal diameter of the casing string and being free of obstruction or constriction, whereby said tool may pass freely to the selected unit.

11. In an apparatus for establishing communication through a casing: a casing section having preformed openings therein; pressure responsive discs initially sealing said openings, whereby said string may be lowered into a well bore in an initially imperforate condition; and pressure generating means for forcing said discs through said openings.

12. In an apparatus for establishing communication through a casing string subsequent to landing said string within a well bore; a casing section incorporated in said string and having preformed openings therethrough; pressure responsive sealing means for said openings adapted to withstand the normal pressure of fluid in said well bore; and an explosive operated tool for generating surge pressures capable of opening said sealing means.

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