

Oct. 13, 1953

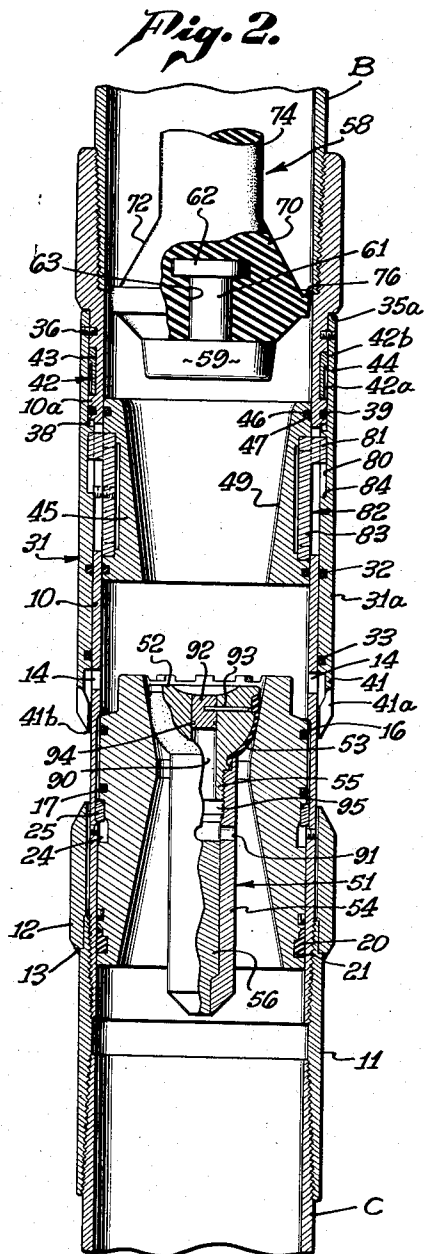
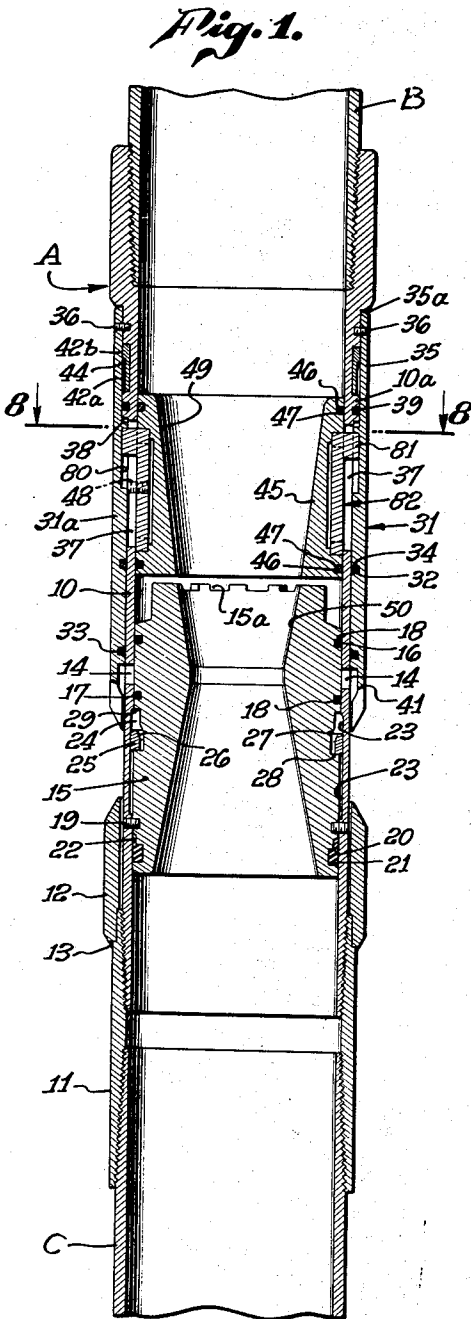
R. C. BAKER ET AL

2,655,216

POSITIVE SHUTOFF PORTED CASING APPARATUS

Filed April 23, 1948

3 Sheets-Sheet 1



REUBEN C. BAKER,
BENJAMIN L. AUSTIN,
INVENTORS.

BY

Mellin and Hanson
ATTORNEY.

Oct. 13, 1953

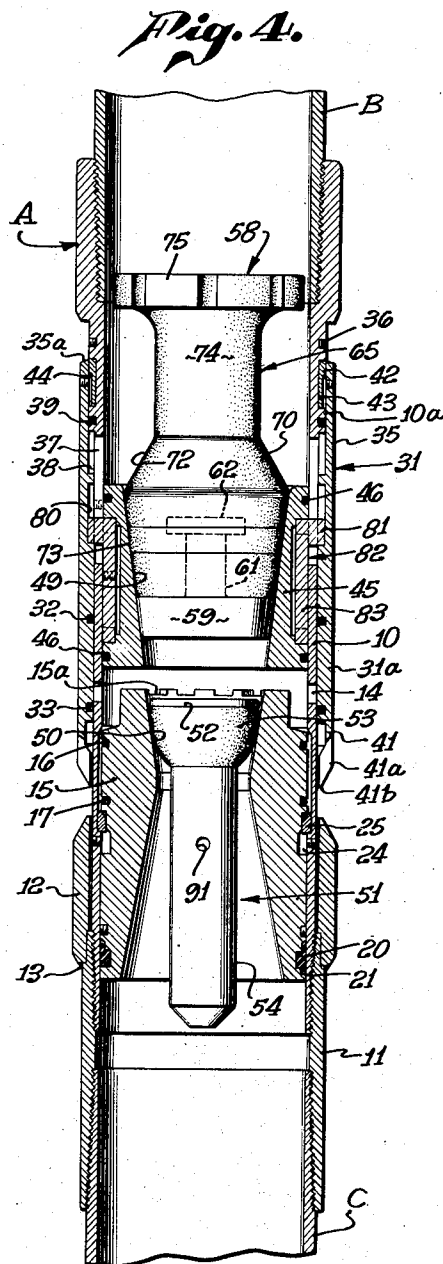
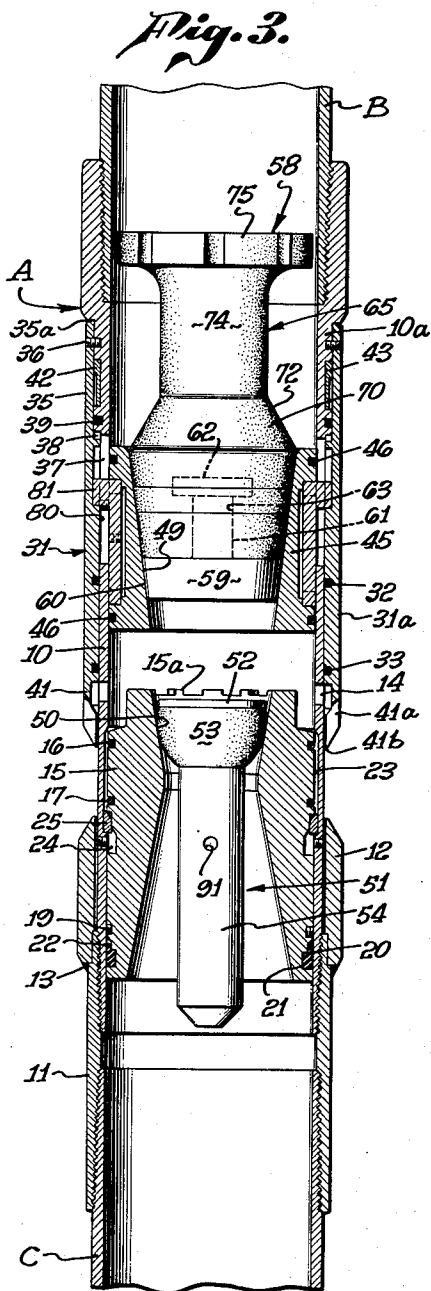
R. C. BAKER ET AL

2,655,216

POSITIVE SHUTOFF PORTED CASING APPARATUS

Filed April 23, 1948

3 Sheets-Sheet 2



REUBEN C. BAKER,
BENJAMIN L. AUSTIN,
INVENTORS.

BY

Mellin and Hanson
ATTORNEY.

Oct. 13, 1953

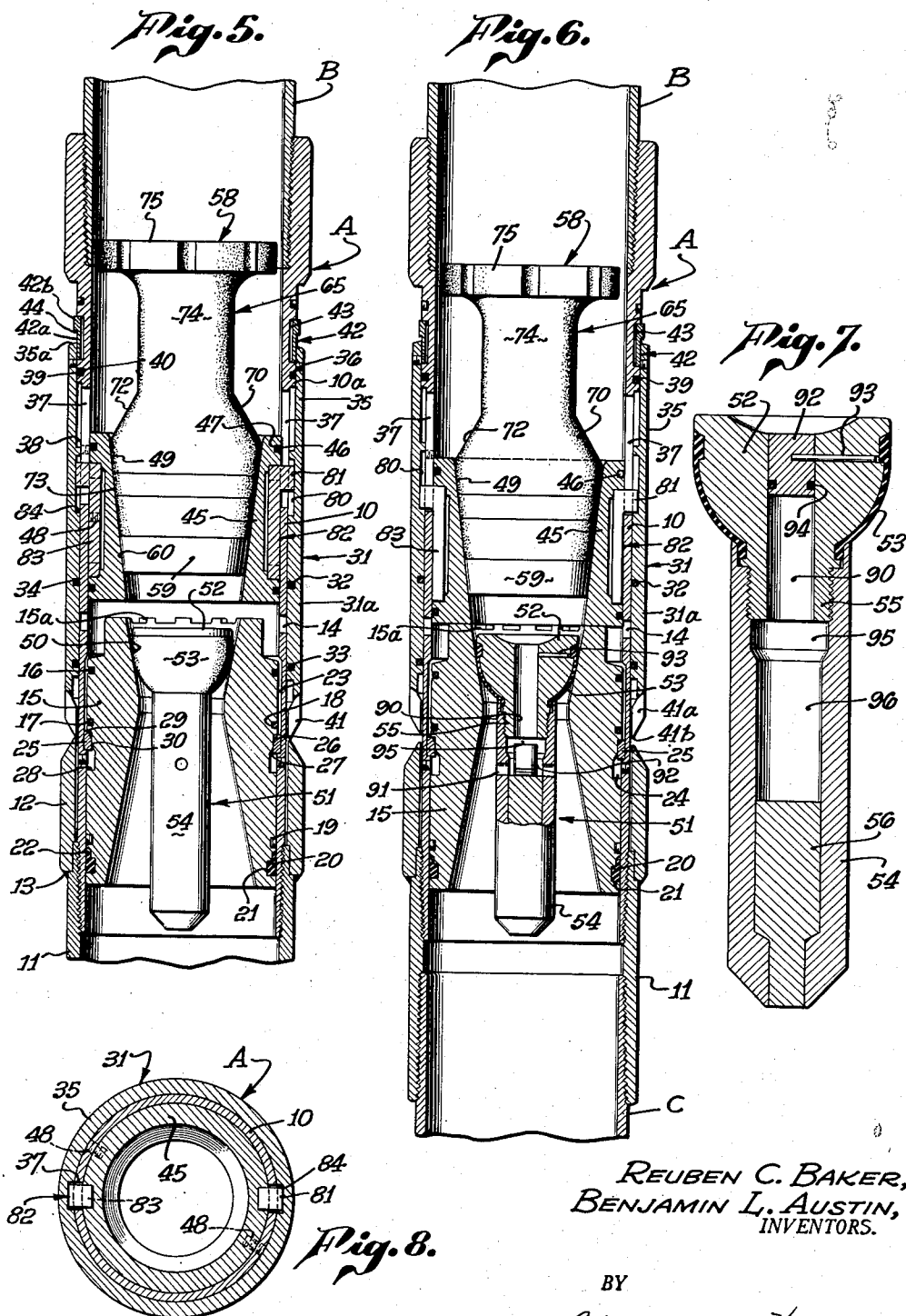
R. C. BAKER ET AL

2,655,216

POSITIVE SHUTOFF PORTED CASING APPARATUS

Filed April 23, 1948

3 Sheets-Sheet 3



REUBEN C. BAKER,
BENJAMIN L. AUSTIN,
INVENTORS.

BY

Mellin and Hanscom
ATTORNEY.

UNITED STATES PATENT OFFICE

2,655,216

POSITIVE SHUTOFF PORTED CASING
APPARATUS

Reuben C. Baker, Coalinga, and Benjamin Lewis
Austin, Long Beach, Calif., assignors to Baker
Oil Tools, Inc., Vernon, Calif., a corporation of
California

Application April 23, 1948, Serial No. 22,886

17 Claims. (Cl. 166—1)

1

The present invention relates to devices adapted to form parts of casings, liners, and similar conduits located in well bores, and more particularly to side-ported cementing devices for use in cementing conduits in well bores.

It has been proposed to close a side port in a casing string by shifting a sleeve valve hydraulically across the port. The effective area of the sleeve valve, or parts connected to the sleeve valve, subject to pressure, has been relatively small, which imposes limitations upon the total hydraulic force that can be applied to it. If considerable resistance to movement of the sleeve valve is encountered, it may be difficult, or impossible, to shift the valve to port closing position.

Accordingly, it is an object of the invention to effect a substantial increase in the hydraulic force applicable to the sleeve valve, in shifting it to a desired position, without increasing the unit pressure of the fluid. In fact, a greater total force is available with a lesser unit pressure than heretofore necessary.

Another object of the invention is to provide an improved side ported apparatus having ports that can be opened and then closed positively against passage of fluids in both directions between the interior and exterior of the apparatus.

Certain types of side ported casing cementing apparatus embody a lower sleeve valve initially closing the ports, and also an upper sleeve valve which is capable of determining the closing of the ports. In moving the upper sleeve valve toward the lower sleeve valve, fluid may be trapped therebetween, which might preclude downward movement of the upper valve to the desired extent.

A further object of the invention is to prevent the entrapped fluid from interfering with full movement of the upper sleeve valve, whenever such movement is necessary.

Another object of the invention is to dissipate automatically the entrapped fluid from the region between the two sleeve valves.

Still another object of the invention is to provide an improved plug, or trip device, particularly useful in closing the central passage through a sleeve valve, which enables the fluid trapped between the upper and lower valve to be dissipated.

Yet a further object of the invention is to provide an improved cementing plug especially useful at the upper end of a charge of cementitious material.

Another object of the invention is to provide a cementing plug that is slidable along the wall

2

of a casing string and capable of cooperating with a sleeve valve to effect its hydraulic shifting from port closing position, without interfering with the passage of fluid through the ports.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it is embodied. This form is shown in the drawings accompanying and forming part of the present specification, and will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a longitudinal section through a ported well apparatus, with the ports closed and the parts arranged for running the apparatus in a well bore;

Fig. 2 is a view similar to Fig. 1, with the ports open;

Fig. 3 is a view similar to Fig. 1, with the parts occupying another position;

Fig. 4 is a view similar to Fig. 1, with the outer sleeve valve moved partially downward to a position closing the ports;

Fig. 5 is a view similar to Fig. 1, disclosing one manner of closing the ports;

Fig. 6 is a view similar to Fig. 1, disclosing another manner of closing the ports;

Fig. 7 is an enlarged longitudinal section through the tripping device for the lower inner sleeve valve member; and

Fig. 8 is a cross-section taken along the line 8—8 on Fig. 1.

As disclosed in the drawings, a casing collar A has its upper and lower ends threadedly connected to the ends of upper and lower casing sections B, C forming part of a casing string adapted to be run in a well bore to position the collar at the desired location therein.

The collar A includes a tubular member 10 whose lower end consists of a coupling 11 threaded on to the upper end of the lower casing section C. A stop member 12 is secured to the exterior of the coupling, as by the use of welding material 13, to serve a purpose described below.

The tubular member 10 has a plurality of circularly spaced side ports 14 through which fluids are adapted to pass between the interior and exterior of the collar apparatus. These ports are closed initially by a lower inner sleeve valve member 15 having seal rings 16, 17 disposed in suitable ring grooves 18 on opposite sides of the ports.

These rings may be of rubber and of round cross section to prevent leakage thereby in both longitudinal directions.

The lower inner sleeve valve member 15 is retained in position to locate its seal rings 16, 17 on opposite sides of the ports 14 by one or more frangible devices in the form of shear screws 19 threaded through the tubular member 10 and extending into the valve member. This member 15 also carries a side seal 20 in a groove 21 below the shear screws 19. The seal 20 has an upwardly extending lip 22 for sealing with the wall of the tubular member 10.

It is to be noted that the inside diameter of the tubular member 10, at the region where it is engaged by the lower seal ring 17, is less than the internal diameter of a groove 23 in the member 10 immediately below this region. Also, the sleeve valve member 15 is reduced in external diameter to form a peripheral groove 24 below the lower seal ring 17, in which a split, inherently expandable stop ring 25 is located. The stop ring has an upper inner inclined surface 26 tapering downwardly and inwardly for cooperation with a corresponding tapered surface 27 on the base of the peripheral groove 24. The length of the groove 24 is much greater than the length of the stop ring to permit downward movement of the sleeve valve member 15 relative to the stop ring.

The ring 25 is received within the enlarged diameter portion 23 of the tubular member. This enlarged portion is much longer than the height of the stop ring. The stop ring may rest upon a shoulder 28 provided by the lower end of the peripheral groove 24, the upper end of the stop ring being engageable with an upper shoulder 29 of the peripheral groove 24. Downward movement of the stop ring is limited by its engagement with a shoulder 30 formed by the lower end of the tubular member groove 23.

The shear screws 19 are adapted to be disrupted and the lower inner sleeve valve member 15 moved downwardly to a position in which the upper seal ring 16 is disposed below the ports 14. The ports are then open to the passage of fluid between the interior and exterior of the apparatus.

After the ports have been opened, it is desired to reclose them. To accomplish this purpose, an external sleeve valve member 31 is provided on the tubular member 10. This external member has a plurality of longitudinally spaced seal rings 32, 33 disposed in internal grooves 34 and slidably engageable with the outer surface of the tubular member 10. The outer member 31 has an upwardly extending cylinder 35 integral therewith, or otherwise suitably secured thereto, which is slidable along an enlarged portion 10a of the tubular member.

The outer member 31 is retained initially in an upper position, in which it does not close the ports 14, by one or more shear screws 36 threaded through the cylinder 35 into the enlarged portion 10a of the tubular member. These screws are disruptable hydraulically by fluid pressure, including fluid under pressure entering through one or more elongate ports, slots or openings 37 in the tubular member into a cylinder space 38. This space is formed between the enlarged portion 10a of the tubular member, the cylinder skirt 35 and the part 31a of the sleeve valve member carrying the seal rings 32, 33. Leakage in a downward direction between the sleeve valve member 31 and tubular member 10 is prevented by the seal ring 32. Leakage in an upward di-

rection therebetween is prevented by a seal ring 39 disposed in a peripheral groove 40 in the enlarged portion 10a of the tubular member, which sealingly engages the inner surface of the cylinder 35.

When sufficient hydraulic force is exerted on the outer sleeve valve member 31, the shear screws 36 will be disrupted and the outer sleeve valve member 31 shifted downwardly to a position in which its seal rings 32, 33 are located on opposite sides of the ports 14, closing such ports against passage of fluids therethrough in both directions between the interior and exterior of the apparatus. This position of the sleeve valve member 31 is determined by engagement of its depending skirt 41 with the upper end of the stop member 12. It is to be noted that the upper portion of the skirt 41 is spaced outwardly from the tubular member 10 so as to avoid interfering with passage of fluids through the ports 14 after they have been opened. This fluid flows through the ports 14 and through slots 41a in the lower end of the skirt. The end is slidable upon the member 10 and has a lower, knife-like edge 41b capable of cutting through any materials that might coat the member 10, or tend to prevent downward movement of the outer sleeve valve member 31.

After the outer sleeve valve member 31 has been shifted downwardly to port closing position, it is prevented from moving upwardly again by a latch or lock ring 42 disposed within a peripheral groove 43 in the tubular member 10 above its seal ring 39. This lock ring consists of a split, inherently expandable member having a reduced diameter lower portion 42a forming a shoulder 44 with the upper portion 42b. The shoulder is inclined outwardly in a downward direction to a slight extent.

When the outer sleeve valve member 31 has been forced downwardly to essentially its fullest extent, the upper end 35a of the cylinder is disposed below the shoulder 44 of the split lock ring, but not below the lower end of its reduced diameter portion 42a. As a matter of fact, the upper part of the cylinder 35 will be in engagement with the outer surface of the reduced diameter portion 42a, the lock ring 42 inherently expanding outwardly to a certain extent upon riding of the cylinder off its upper portion 42b. Any tendency for the outer sleeve valve member 31 to move upwardly will be limited by engagement of the upper cylinder end 35a with the lock ring shoulder 44, the lock ring being forced against the upper end of the peripheral groove 43. To insure against inward forcing of the lock ring 42 from engagement with the end 35a of the cylinder, the latter is tapered in the same direction as the shoulder 44, so that the two will remain in snug contact with one another.

The force of fluid under pressure is prevented from acting upon the external sleeve valve member 31 by an upper inner sleeve valve member 45 having longitudinally spaced seal rings 46 disposed in ring grooves 47 on opposite sides of the elongate ports or slots 37. This valve member is held in position by one or more shear screws 48 threaded through the tubular member 10 into the upper valve member 45. Disruption of the shear screws 48 and downward shifting of the upper sleeve valve member 45 will expose the ports 37 and permit fluid under pressure to pass through the latter into the cylinder space 38, in order to assist in shearing the cylinder screws

5

36 and moving the outer sleeve valve member 31 downwardly to port closing position.

The upper inner sleeve valve member 45 is not only used for the purpose of controlling the passage of fluid through the elongate ports 37, but is also used in assisting downward movement of the external sleeve valve member 31 to port closing position.

To accomplish this latter purpose, the upper inner sleeve valve member 45 and external sleeve valve 31 have an intervening lost motion connection. As specifically disclosed in the drawings, the outer sleeve valve 31 is formed with a plurality of inner keyways 80, in which are received the lug or arm portions 81 of keys 82 secured to the upper inner sleeve member 45 and extending outwardly through the elongate ports or slots 37. Each key includes a leg portion 83 depending from the arm portion 81 and adapted for movement within the tubular member 10 with the upper inner valve member 45.

It is to be noted that the arm 81 of each key is disposed originally above the lower end or shoulder 84 of the keyway 80. This arrangement is provided for the purpose of permitting the inner valve member 45 to move downwardly to an extent sufficient to shift the upper seal ring 46 below the upper ends of the ports 37, and thereby allow fluid to pass into the annular cylinder space 38 for action upon the sleeve 31 to effect shifting, or at least assisting in shifting, the sleeve valve 31 downwardly to port closing position. As described in detail below, once the elongate ports 37 are open, fluid under pressure may enter the cylinder space 38 through these ports, disrupt the shear screws 36 and shift the outer valve member 31 downwardly to port closing position. If this hydraulic force is insufficient, then pressure may be imposed upon the entire cross-sectional area of the upper inner sleeve valve 45, which will be transmitted to the external sleeve valve 31 through the keys 82 and abutting shoulders 84.

As stated above, the lower sleeve valve member 15 is held initially in closed position by its shear screws 19. Similarly, the upper sleeve valve member 45 is held in closed position over the elongate ports 37 by shear screws 48, preferably closely adjacent or in abutting relation with the castellated upper end 15a of the lower valve member 15. The upper valve 45 has a central bore 49 whose wall tapers downwardly and inwardly. Similarly, the lower valve member 15 has a downwardly and inwardly tapering central bore 50, which, in effect, forms a continuation of the upper member bore 49. The cylinder screws 36 hold the outer valve member 31 in its upper position. The parts are all arranged as illustrated in Fig. 1, occupying their relative positions for lowering the apparatus into a well bore.

With both sets of ports 14, 37 closed, a fluent material, such as cement slurry, may be pumped directly into the casing string and through the central bores or passages 49, 50 in both sleeve valve members 45, 15, for discharge from the well casing at some point below the collar, as, for example, from a casing shoe (not shown). This charge of cement slurry will pass upwardly through the annulus around the casing string and may extend approximately to the location of the collar A, or slightly thereabove.

When it is desired to eject a second or upper charge of cement slurry through the collar ports 14, a trip device or plug member 51 is dropped into the well casing and is allowed to gravitate

6

through the fluid therein into engagement with the wall of the central bore 50 in the lower sleeve valve member 15. As disclosed in the drawings, this trip device may consist of a substantially spherical head 52 having a rubber, or equivalent, spherical seal member 53 clamped thereon by a suitable depending extension 54 threaded on a neck 55 projecting downwardly from the head 52. The interior of the extension may be filled with lead 56, or similar weighting material, to insure rapid gravitation or descent of the trip device 51 through the fluid in the well casing.

The seal 53 on the trip device has a lesser external diameter than the minimum diameter of the tapered bore 49 in the upper sleeve valve member 45, to insure its complete passage through the latter. The spherical seal, however, has a diameter greater than the minimum diameter of the bore 50 through the lower valve member 15. As a result, the trip member comes to rest within the lower valve member with its head 52 and seal 53 closing its central bore or passage 50. Pressure may now be applied to the fluid in the casing above the trip member 51 and sleeve 15 in an amount sufficient to shear the screws 19 and shift the lower sleeve valve member 15 downwardly to port opening position, as shown in Fig. 2.

Downward movement of the lower valve member is limited by engagement of the stop ring 25 with the shoulder 30 of the tubular member 10, and of the shoulder 29 on the lower sleeve member 15 with the stop ring. Washing fluid, followed by cement slurry or other cementitious material, may now be discharged outwardly through the open ports 14, passing through the annular space between the tubular member 10 and the depending skirt 41 of the outer valve member 31, and through the slots 41a in the lower end of this skirt, for upward movement through the annulus around the collar A and casing string.

Upon discharging the required quantity of cement slurry, the outer sleeve valve 31 is forced downwardly to port closing position. This act may be accomplished by placing a top cementing plug 58 at the upper end of the charge of cement slurry pumped outwardly through the ports 14. This plug will come to rest within the bore 49 of the upper sleeve valve member 45, allowing the fluid in the casing string above the collar A to be pressurized to an extent sufficient for shearing the screws 48, to shift the upper inner valve member 45 downwardly to a position in which the upper ends of the elongate ports 37 are open (see Fig. 3).

The top cementing plug 58 disclosed in the drawings is of a composite character. It includes a lower nose 59, which may be made of magnesium, aluminum or other suitable, readily drillable material, having a tapered periphery 60 adapted to conform to the taper of the passage 49 in the upper sleeve 45. This nose is so proportioned as to seat within the passage and cause the top cementing plug 58 to come to rest therewithin. From its tapered nose, the lower end of the plug is integral with a central shank 61 terminating in a flange 62, received within a companion bore and recess 63 of a flexible portion 65 of the cementing plug. These two parts are suitably vulcanized together.

The flexible plug 65 is formed essentially of rubber or similar material. It has an inwardly compressible body portion 70 defined by tapered forward and rearward surfaces 71, 72 merging into an annular peripheral sealing surface 73

slidably engageable with the wall of the well casing. The plug 65 also has a tail portion 74 terminating in a fluted guide 75. Its annular sealing portion includes an upwardly extending lip 76 adapted to be forced outwardly by fluid pressure against the wall of the casing.

The tapered nose 59 on the lower plug portion has a greater diameter than the minimum diameter through the upper sleeve valve 45. As a result, it comes to rest within the tapered bore 49 of the latter, closing it against passage of fluid and allowing pressure to be built up in the casing fluid above the cementing plug 58, sufficient in extent to shear the screws 48 and shift the upper member 45 downwardly to a position limited by engagement of the key lugs 81 with the shoulders 84 forming the lower end of the keyways 80 in the outer sleeve 31 (see Fig. 3). When in this position, the upper ends of the elongate ports 37 are exposed, allowing fluid to pass into the cylinder space 38 for the purpose of shearing the cylinder screws 36 and moving the outer sleeve 31 downwardly to port closing position, such as disclosed in Fig. 5.

A standard top cementing plug would not permit fluid to pass by it and enter the ports 37. The flexible plug 65 described above, however, will have its body 70 and annular sealing portion 73 deformed inwardly to a sufficient extent to compress the rubber material into the tapered passage 49 through the upper inner valve member 45, sealing off this passage completely, while removing the annular sealing portion 73 of the plug from engagement with the casing wall or inner wall of the tubular member 10. The plug, therefore, offers no restriction or barrier to passage of fluid through the ports 37, for action upon the outer sleeve valve member 31.

In connection with the shifting of the outer sleeve valve 31 downwardly to port closing position, several conditions might be encountered in the well bore, tending to resist this action. As disclosed in Fig. 3, the upper inner sleeve valve 45 has been shifted downwardly to a position in which the key lugs 81 engage the lower shoulders 84 in the outer sleeve valve member, which, as described above, opens the ports 37. The application of pressure to the casing fluid above the top cementing plug 58 not only acts upon the annular cross-sectional area of the cylinder 35 in the space 38, but also upon the entire cross-sectional area of the flexible plug 65 and inner sleeve member 45. This pressure disrupts the shear screws 36 and shifts the upper inner valve member 45 and the outer valve member 31 downwardly as a unit, until the lower seal ring 33 on the outer member is disposed below the ports 14, thereby closing them.

During movement of the outer valve member 31 and inner valve member 45 to the position just referred to, the fluid in the collar between the upper and lower valve members 45, 15 can pass outwardly through the open ports 14. However, since the lower seal ring 33 is now disposed below the ports 14, this fluid is trapped between the upper and lower sleeves 45, 15 and prevents further downward movement of the upper inner sleeve 45. Thereafter, the fluid pressure can act effectively on the annular cylinder 35 alone, to force the outer valve member 31 downwardly to port closing position, such as disclosed in Fig. 5. The lost motion connection 80, 81 between the inner and outer sleeves 45, 31 permits such occurrence without further downward shifting of the inner member 45. Under some circumstances,

however, insufficient pressure can be built up for shifting the outer valve member 31 completely to its port closing position.

Well conditions, such as a high hydrostatic head of cement slurry around the exterior of the casing string above the ports 14, or hardened cement from the lower cementing operation around the tubular member 10 below the outer sleeve valve 31, and the like, may offer resistance to downward movement of the outer sleeve valve upon application of hydraulic pressure in the annular cylinder 35 alone. To insure an adequate hydraulic force to shift the outer sleeve valve member 31 downwardly to full port closing position, it is desired to transmit the force of the fluid pressure acting across the entire area of the plug 58 and sleeve 45 to the outer sleeve valve. This can be done upon eliminating the entrapped fluid from the region between the upper and lower inner sleeve valve members 45, 15.

This fluid can be removed in several manners, after the ports 14 have been closed by the outer sleeve valve 31 (Fig. 4). As disclosed most clearly in Figs. 2 and 6, the lower plug or trip device 51 includes an upper central passage 90 communicating with side ports 91 below the spherical seal 53. This central passage is originally closed by a plug or valve head 92 held in position by frangible means, such as a shear pin 93 extending between the spherical head 52 and the plug 92. Leakage around the plug can be prevented by a suitable side seal 94 engaging the wall of the central passage 90.

When sufficient pressure is imposed on the fluid entrapped between the upper and lower sleeve valve members 45, 15, the frangible pin 93 is disrupted, and the plug 92 in the trip device moved downwardly into an enlarged bore 95 formed in the extension 54 (Fig. 6). The fluid between the sleeve valve members 45, 15 can then pass through the open passage 90, through the enlarged bore 95, and through the ports 91 into the casing below the collar A. The release of such fluid permits the upper inner sleeve valve member 45 and top cementing plug 53 to move downwardly under the action of the hydraulic pressure thereabove, the hydraulic force being transmitted from the upper valve member through the keys 82 to the outer valve member 31, the inner and outer valve members being moved downwardly to the fullest extent, in which the upper end of the cylinder 35 is disposed below the latch shoulder 44 (see Fig. 6).

The fluid in the casing string below the collar A may also be a trapped body of fluid, but it is of such length (several hundred or several thousand feet) that the small quantity of fluid trapped between the upper and lower sleeves 45, 15 can still be forced through the trip device passages 90, 95, 91 downwardly into it. The fluid below the collar A is ordinarily of such character as to be partially compressible, even if only to a relatively minute extent.

The entrapped fluid may also be released by forming the lower trip device 51 with a chamber 96 that can have the required volume, and which is normally at atmospheric pressure. This chamber is closed by the plug 92 held in place by the shear pin 93, in the same manner as described in connection with the other trip device.

Upon application of sufficient pressure to the top cementing plug 58 and upper inner valve member 45, the shear pin 93 is disrupted and the plug 92 moves downwardly into the air chamber 96, followed by the entrapped fluid between the

members 45, 15. As a matter of fact, the disrupting of the frangible pin 93 will cause the air chamber 96 to effectively suck the entrapped fluid downwardly into it.

Following release of the plug 92, the upper inner valve member 45 cooperates with the outer valve member 31 to shift the latter to port closing position, in the manner described above in connection with the other trip device.

It is, accordingly, apparent that a side ported cementing apparatus has been disclosed, in which the outer sleeve valve member 31 can be shifted to port closing position by fluid under pressure acting over a greater area than the annular cylindrical area associated with the outer valve member itself. The full cross sectional area of the top cementing plug 58 and inner sleeve valve 45 has the fluid pressure imposed upon it, and this entire total force is transmitted to the outer valve member through the keys 82. Accordingly, considerable force is available to overcome the hydrostatic head of cement slurry, or any other forces, tending to resist full movement of the outer valve member 31 to port closing position. Of course, if a large resistance is not encountered, then the upper inner valve member 45 need not offer its assistance to shifting of the outer valve member 31 to port closing position, since the fluid under pressure acting on the annular cylindrical area alone would be sufficient to shift the outer sleeve valve downwardly to the extent required.

Should a greater force than can be exerted on the annular area be necessary, then the entrapped fluid is dissipated and the fluid under pressure, acting upon the entire cross sectional area of the top cementing plug 58 and upper sleeve 45 is available.

The top cementing plug 58 serves its normal function of confining the charge of cement slurry in advance of it by slidably sealing with the wall of the casing during its downward passage. The top cementing plug assists in releasing the upper valve member 45, to open the elongate ports 37, but still does not interfere with fluid passage into the annular cylinder space 38.

As indicated above, the lower plug or trip device 51 serves to release the entrapped fluid between the upper and lower sleeve valve members 45, 15.

The inventors claim:

1. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member and disposed initially in position to allow fluid passage through said port; and hydraulically operable means within said tubular member engageable with said valve member for shifting said valve member along said tubular member to port closing position completely over said port upon movement of said hydraulically operable means within said tubular member to prevent flow of fluids through said port between the interior and exterior of said tubular member.

2. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member and disposed initially in position to allow fluid passage through said port; a sleeve within said tubular member having a fluid passage; means operatively engageable with said sleeve and valve member for shifting said valve member along

said tubular member to port closing position upon shifting of said sleeve within said tubular member; and means adapted to be lowered through said conduit string into engagement with said sleeve to obstruct said passage for enabling said sleeve to be shifted hydraulically to effect shifting of said valve member along said tubular member to port closing position completely over said port upon shifting of said sleeve within said tubular member, in order that said sleeve valve member prevents flow of fluid through said port between the interior and exterior of said tubular member.

3. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member and selectively positionable in open or closed position with respect to said port to allow or prevent flow of fluid through said port between the interior and exterior of said tubular member; and shiftably hydraulically operable means within said tubular member engageable with said valve member for shifting said valve member along said tubular member between port opening and port closing positions, upon shifting of said hydraulically operable means within said tubular member, to determine the passage of fluid through said port between the interior and exterior of said tubular member.

4. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member and disposed initially in position to allow fluid passage through said port; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to port closing position to prevent fluid flow through said port between the interior and exterior of said tubular member; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and shiftably means engageable with said valve member and closing said opening; said last-mentioned means being operable to engage and shift said valve member to port closing position.

5. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member and disposed initially in position to allow fluid passage through said port; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to port closing position to prevent fluid flow through said port between the interior and exterior of said tubular member; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and shiftably means within said tubular member extending through said opening and engageable with said valve member to shift said valve member to port closing position.

6. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member

11

and disposed initially in position to allow fluid passage through said port; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to port closing position to prevent fluid flow through said port between the interior and exterior of said tubular member; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and shiftable means within said tubular member extending through said opening into engagement with said valve member to shift said valve member to port closing position; said last-mentioned means being positioned across said opening to close the same.

7. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftable mounted on the exterior of said tubular member and disposed initially in position to allow fluid passage through said port; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to port closing position to prevent fluid flow through said port between the interior and exterior of said tubular member; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and a shiftable sleeve valve within said tubular member engageable with said valve member and closing said opening; said sleeve valve engaging said valve member to shift said valve member to port closing position.

8. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftable mounted on the exterior of said tubular member and disposed initially in position to allow fluid passage through said port; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to port closing position to prevent fluid flow through said port between the interior and exterior of said tubular member; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and a shiftable sleeve valve within said tubular member extending through said opening into engagement with said valve member to shift said valve member to port closing position; said sleeve valve being adapted to close said opening.

9. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftable mounted on the exterior of said tubular member; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to determine the passage of fluid through said port; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and shiftable means engageable with said valve member and closing said opening; said last-mentioned means engaging said valve member to shift said valve member along said tubular member to determine the passage of fluid through said port.

10. In apparatus of the character described: a tubular member having a side port and adapted

12

to form part of a conduit string positionable in a well bore; a sleeve valve member shiftable mounted on the exterior of said tubular member; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to determine the passage of fluid through said port; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and shiftable means within said tubular member extending through said opening into engagement with said valve member; said last-mentioned means being adapted to close said opening; said last-mentioned means engaging said valve member to shift said valve member along said tubular member to determine the passage of fluid through said port.

11. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftable mounted on the exterior of said tubular member; hydraulically operable means on said tubular member for shifting said valve member along said tubular member to determine the passage of fluid through said port; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; and a shiftable sleeve valve within said tubular member extending through said opening into engagement with said valve member; said sleeve valve being adapted to close said opening; said sleeve valve engaging said valve member to shift said valve member along said tubular member to determine the passage of fluid through said port.

12. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a lower sleeve valve in said tubular member disposed initially across said port to close the same; an upper sleeve valve in said tubular member movable toward said lower sleeve valve; and means on one of said sleeve valves communicable with the internal space between said tubular member and between said sleeve valves for enabling fluid to be removed from such internal space while said port is closed.

13. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a lower sleeve valve in said tubular member disposed initially across said port to close the same; said valve having a passage there-through; means for closing said passage; an upper sleeve valve in said tubular member movable toward said lower valve member, said upper sleeve valve having a passage; means for closing said upper valve passage; one of said closing means including instrumentalities communicable with the internal space within said tubular means and between said valve for enabling fluid to be removed from such internal space.

14. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a lower sleeve valve in said tubular member disposed initially across said port to close the same; said valve having a passage there-through; means for closing said passage; an upper sleeve valve in said tubular member movable toward said lower valve, said upper valve having a passage; means for closing said upper valve passage; means for closing the passage

13

through said lower sleeve valve including instrumentalities communicable with the internal space within said tubular means and between said valve for enabling fluid to be removed from such internal space.

15. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member; hydraulically operable means on said tubular member for shifting said valve member longitudinally along said tubular member to determine passage of fluid through said port; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; an inner sleeve valve having a fluid passage and disposed across said opening to close the same; and a plug engageable with said inner sleeve valve to obstruct said fluid passage to enable downward shifting of said inner sleeve valve to expose said opening; said plug being movable down said conduit string with a portion of said plug in slidable sealing engagement with said conduit string, said portion being adapted to enter and be retained within said inner sleeve valve.

16. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string positionable in a well bore; a sleeve valve member shiftably mounted on the exterior of said tubular member; hydraulically operable means on said tubular member for shifting said valve member longitudinally along said tubular member to determine passage of fluid through said port; said tubular member having an opening through which fluid under pressure can be fed into said hydraulically operable means to operate said hydraulically operable means; an inner sleeve valve having a

14

fluid passage and disposed across said opening to close the same; and a plug engageable with said inner sleeve valve to obstruct said fluid passage to enable downward shifting of said inner sleeve valve to expose said opening; said plug comprising flexible material adapted to slidably seal with said conduit string and adapted to be deformed into said inner sleeve valve free from interference with said opening.

17. In apparatus of the character described: a tubular member having a side port and adapted to form part of a conduit string; a sleeve valve within and shiftable with respect to said tubular member and disposed across said port to close the same, said valve having a passage of materially less diameter than the inside diameter of said conduit; and a plug engageable with said sleeve to close said passage, said plug comprising a main inwardly compressible elastic body normally of a diameter corresponding to the inside diameter of the conduit with respect to said tubular member and adapted to be deformed into and retained within said sleeve valve passage free from interference with said port.

REUBEN C. BAKER.

BENJAMIN LEWIS AUSTIN.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,167,747	Dyer	Aug. 1, 1939
2,257,784	Brown	Oct. 7, 1941
2,310,572	Burns	Feb. 9, 1943
2,335,387	Cantin	Nov. 30, 1943
2,370,833	Baker	Mar. 6, 1945
2,382,578	Penick	Aug. 14, 1945
2,429,912	Baker	Oct. 28, 1947
2,435,016	Pitts	Jan. 27, 1948
2,438,992	Childers	Apr. 6, 1948
2,442,544	Johnson	June 1, 1948
2,488,819	Larkin	Nov. 22, 1949