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2,999,545

RETRIEVABLE PLUG

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Fig. 1.

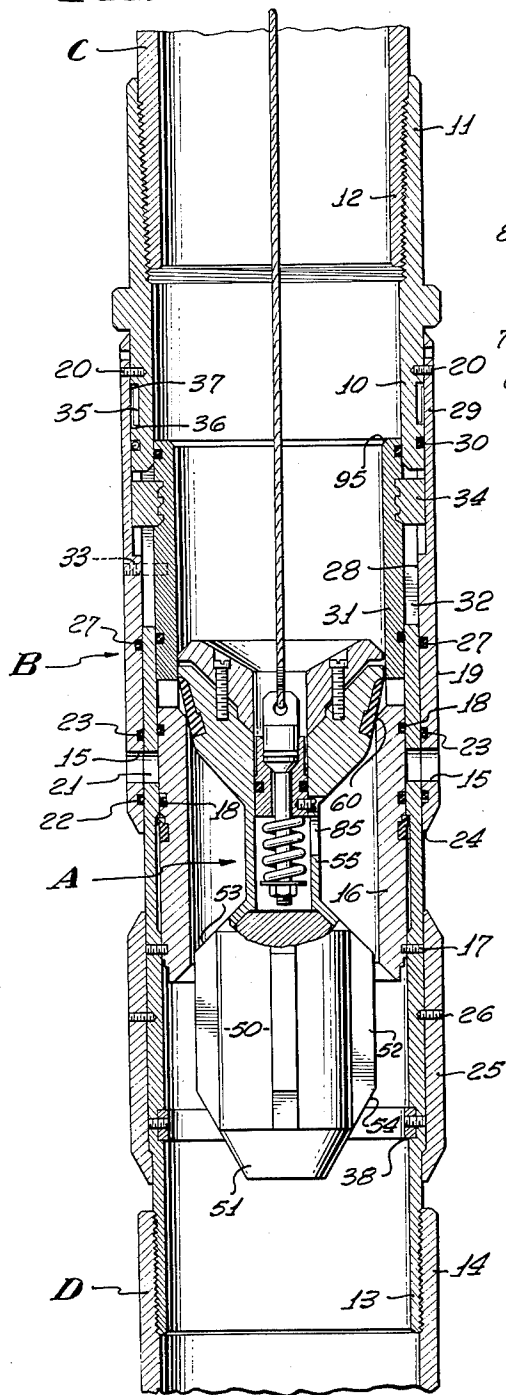
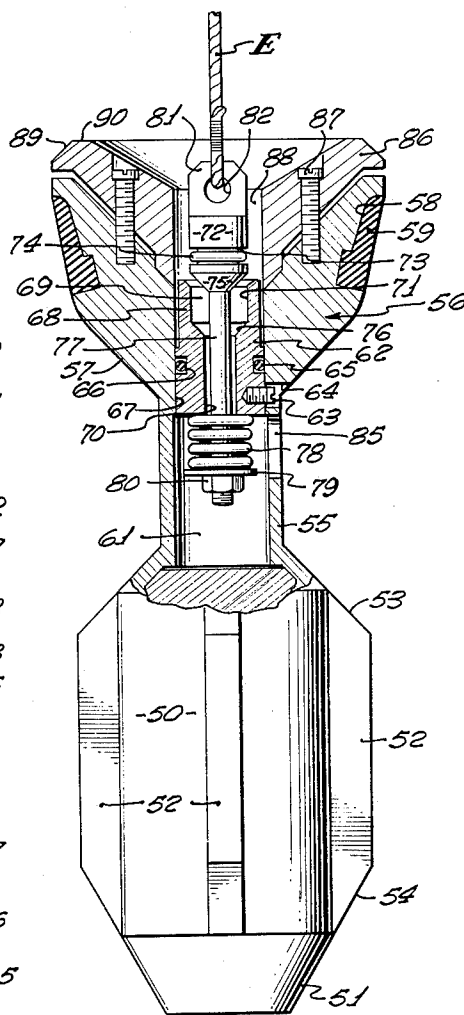


Fig. 2.



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1

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RETRIEVABLE PLUG

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The present invention relates to subsurface well bore devices, and more particularly to a subsurface device useful in the performance of cementing and similar operations in well bores.

An object of the present invention is to provide a plug for closing the passage in a well conduit against downward flow of fluid therethrough, which plug is readily retrievable from the well casing when desired, despite the resisting force of a substantial hydrostatic head of fluid thereabove.

Another object of the invention is to provide a plug for closing the central passage through a sleeve valve that controls the flow of fluid through side ports in a well bore conduit, the plug being readily retrievable whenever reopening of the central passage is required.

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 may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such 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 well casing disclosing a cementing collar apparatus use in conjunction with the invention;

FIG. 2 is a longitudinal section, with parts shown in elevation, of the plug disclosed in FIG. 1 in a condition to be retrieved from the well casing and to be withdrawn to the top of the well bore.

The retrievable plug A illustrated in the drawings is shown by way of example in conjunction with a stage cementing collar B which is secured to upper and lower casing sections C, D. Such cementing collars are used to enable cement to be discharged from a lower point in the string of well casing disposed in a well bore, the collar being in a closed condition. Thereafter, the collar is opened in order to establish circulation therethrough, and another stage of cementing is performed by discharging the cement from the casing outwardly through openings in the stage collar for upward passage around the casing string.

As illustrated in the drawings, the stage collar B is of the specific type shown and described in United States Patent 2,655,216. It is to be understood, however, that the invention is useful in conjunction with other specific apparatus than the one disclosed. This stage collar B includes a main tubular member 10 having an upper threaded box 11 threadedly secured to the lower pin end 12 of the upper casing section C, and a lower threaded pin 13 threadedly secured to the upper box portion 14 of the lower casing section D. The tubular member 10 has a plurality of side ports 21 extending therethrough, initially closed by a lower inner sleeve valve 16 held in the closed condition by one or more shear screws 17 threaded through the tubular member 10 and into the lower inner sleeve valve. When the shear screws 17 are intact, upper and lower side seals 18 on the sleeve valve are located on opposite sides of the ports 15.

After they have been placed in open condition, as described hereinbelow, the side ports 21 can be reclosed

2

by an external sleeve valve 19 slidable along the exterior of the tubular member 10, this sleeve valve being disposed initially in a port opening position by shear screws 20 extending therethrough and into the tubular member.

When the shear screws 20 are intact, side ports 15 extending through the external sleeve valve are aligned with the side ports 21 of the tubular member 10. At this time, lower and intermediate side seal rings 22, 23 mounted on the external sleeve valve 19 are disposed on opposite sides of the tubular member ports 21, sealing against the periphery of the tubular member.

The sleeve valve 19 is shifted downwardly when the shear screws 20 are disrupted to close the tubular member ports 21, the extent of downward movement being limited by engagement of the lower end 24 of the external sleeve valve with a stop sleeve 25 suitably secured to the tubular member 10, as by means of the screws 26. When engaged with this stop sleeve 25, the external sleeve valve member 19 has closed the tubular member side ports 21, leakage between the external sleeve valve member and the tubular member 10 then being prevented by intermediate and upper seal rings 23, 27 on the external sleeve valve member disposed in sealing engagement against the tubular member on opposite sides of the side ports 21.

The external sleeve valve member 19 has an intermediate inner shoulder 28 from which an upper portion 29 of the sleeve valve slidably extends along a side seal ring 30 mounted on the tubular member 10. The shear screws 20 are disrupted and the external sleeve valve member 19 shifted downwardly to a port closing position whenever an upper inner sleeve valve member 31 is shifted downwardly in the tubular member. This upper inner sleeve valve member 31 is initially disposed across longitudinal slots 32 extending through the tubular member, being held in this condition by shear screws 33 attaching it to the tubular member 10. Keys 34 extend through the slots 32 and are secured to the inner sleeve valve member 31. When the inner sleeve valve member keys 34 are shifted downwardly along the tubular member 10, they will engage the internal shoulder 28 on the external sleeve valve member 19. When sufficient force is imposed on the inner sleeve valve member 31, the screws 33 will be disrupted, the inner sleeve valve member 31 moving downwardly to bring the keys 34 into engagement with the shoulder 28 and then disrupting the screws 20 to shift the external sleeve valve member 19 down to its port closing position in engagement with the stop sleeve 25. When this condition obtains, an inherently expandable latch ring 35, mounted in an external groove 36 in the tubular member 10, will have its upper portion 37 spring out across the upper end of the external sleeve valve 19 to hold the latter in its lower port closing position.

The several positions of the inner and outer sleeve valve members 16, 31, 19 are not illustrated in the present case since they are unnecessary to an understanding of the present invention and may be found in the above-identified patent. It is sufficient to state that the trip plug A moves down the casing string whenever the ports 21 and 15 are to be opened, seating upon the lower inner sleeve valve 16, whereupon fluid pressure may be imposed on the plug to overcome the forces of shear screws 17 and thereby shift the lower sleeve valve 16 downwardly below the ports 15 to the extent determined by engagement of its lower portion with a stop ring 38 attached to the tubular member. When in this position, the side ports 15 are opened and circulating fluid can then be pumped down through the casing string and the open ports 15, 21 for upward passage around the exterior of the casing toward the top of the well bore.

After the desired operation has been performed with the ports 21 and 15 open, such as a cementing operation,

a top cementing or shut-off plug (not shown) will engage the upper sleeve valve 31. Pressure imposed on the fluid above such plug will be exerted downwardly on the upper inner sleeve valve 31 to disrupt the screws 33, shifting its keys 34 down into engagement with the external sleeve valve shoulder 28, overcoming the shear strength of the screws 20 to disrupt the latter, and then shifting the external sleeve valve 19 down to its port closing position, the latch ring 35 then engaging the upper end of the external sleeve valve 19 to prevent its return or upward movement to a port opening position.

Under some conditions, it is desirable to retrieve the trip plug A, which is herein illustrated as closing the central passage through the lower inner sleeve valve 16 after it has been shifted downwardly to open the side ports 21 and 15. As an example, it may be desirable to open such side ports 21 to establish circulation around the casing and then run a temperature surveying instrument through the stage collar B to ascertain the location of the lower cementing job, such as the charge of cement slurry that had previously been pumped down through the casing for discharge from a shoe (not shown) or other point in the casing string below the ported collar B. Quite obviously, the presence of the trip plug A would prevent the temperature survey from being taken. Accordingly, the present trip plug is of the retrievable type and can be withdrawn from the well casing after the side ports 21 and 15 through the collar have been opened.

As disclosed, the trip plug A includes a lower body 50 having a tapered guide 51 and circumferentially spaced longitudinally extending centering ribs or wings 52, the upper and lower ends 53, 54 of the wings also being tapered to prevent the plug from hanging up on sharp edges and the like in the casing string, during longitudinal movement of the plug therewithin. The upper tapered portion 53 of the body 50 merges into a tubular neck portion 55, which, in turn, merges into a plug or valve head 56, the bottom portion 57 of which diverges in an upward and outward direction. This head has a circumferential groove 58 to receive a suitable seal ring 59, such as a lip type of rubber or rubber-like annular sealing member, adapted to engage a circumferential seat 60 in the upper portion of the lower inner sleeve valve 16.

The tubular neck 55 and head 56 have a communicating passage 61 which can be closed by a plug 62 disposed in the upper portion of the passage and releasably held therein by one or more shear screws 63 extending through a transverse hole 64 in the head and threaded into the plug 62. Leakage around the exterior of the plug is prevented by a suitable sealing ring 65, such as a rubber or rubber-like O ring, mounted in a ring groove 66 in the plug and engaging the cylindrical wall 67 of the passage. The upper portion 68 of the plug is reduced in diameter so that fluid above the plug can be displaced around the plug upon disruption of the shear screw 63, in a manner and under the conditions described hereinbelow.

The plug 62 within the head 56 has a central passage 69 therethrough, the lower portion 70 of which is of a much smaller diameter than its upper portion 71. The upper portion 71 actually constitutes a cylindrical valve seat within which an upper valve head 72 may be disposed. This valve head has a peripheral groove 73 therein on which is mounted a side seal 74, such as a rubber or rubber-like O ring, adapted to sealingly engage the cylindrical valve seat 71 when the lower end 75 of the head engages an inner stop shoulder 76 in the plug, as illustrated in FIG. 1. Depending from the head 72 is a stem 77 which may be integral therewith, this stem extending through the smaller diameter plug passage 70 and having a substantially smaller diameter than the internal diameter of this passage. Surrounding the lower portion of the stem is a helical compression spring 78, the upper end of which bears against the lower end of the plug 62 and the lower end of which bears against

a spring seat in the form of a washer 79 prevented from shifting downwardly on the stem by a nut 80 threaded on the lower end of the stem. The spring 78 normally urges the stem 77 and valve head 72 in a downward direction with respect to the plug 62, to hold the head 72 and its seal ring 74 within the valve seat 71, thereby closing the central passage 69 through the plug against downward flow of the fluid therethrough.

The head 72 has an upper extension 81 provided with a hole 82 therethrough into which the lower end of a wire line E can be threaded, the end of the wire line then being suitably secured to the portion of the wire line thereabove, so as to connect the wire line E to the valve member 72. This wire line will extend to the top of the well bore and around suitable winding or reeling equipment (not shown).

The neck 55 of the trip plug has a side port 85 providing communication between the passage below the plug 62 and exterior of the plug, in order to permit fluid to flow between the passage and the exterior of the plug under certain conditions that will be described hereinbelow.

To facilitate the retrieval of the plug A from the well casing and to prevent its hanging up on restrictions and the like, an adapter or extension 86 is secured to the plug head 56, as by means of the cap screws 87. This adapter or extension has a central passage 88 coinciding with the passage 61 through the head, the upper outer portion 89 of the adapter being beveled or tapered in an upward and inward direction so as to guide the trip plug safely past coupling spaces and similar abrupt portions in the casing string. The upper surface 90 of the adapter is frusto-conical in shape, providing a guide or tapered surface for a ball or similar element (not shown) which may be used in conjunction with the apparatus.

The lower body 50, neck 55, head 56, plug 62 and adapter 86 may be considered as constituting a valve device having a passage 88, 69, 61, 85 therethrough. The plug 62 of the valve device has the valve seat 71 therein, which surrounds the portion 69 of the passage.

In using the apparatus, the collar B is suitably secured to the upper and lower casing sections C, D and the casing string is lowered in the well bore to the desired depth. At this time, the collar parts are in the position illustrated in FIG. 1, in which the lower inner sleeve valve 16 is disposed across the ports 15 to close the same. A lower stage cementing operation can be performed by pumping the proper charge of cement slurry down the casing string and through the collar B for discharge from the casing at some point below the collar. Thereafter, it is desired to open the side ports 21 and 15. The trip plug A is secured to the lower end of the wire line E and is then allowed to gravitate through the fluid in the well casing, this plug coming to rest on the inner sleeve valve 16 with the seal ring 59 engaging the seat 60 at the upper portion of this sleeve valve. The central passage through the lower sleeve valve 16 is now closed, which permits fluid pressure above the trip plug to be increased to the point at which the shear strength of the screws 17 is exceeded, these screws being disrupted and the lower plug A and lower inner sleeve valve 16 then being forced downwardly to the extent determined by engagement of the sleeve valve 16 with the top ring 38. At this time, the tubular member ports 21 will be open, and circulation of fluid can be established through such open ports, the fluid being pumped down the casing and out through the ports 21 and 15, then flowing upwardly around the exterior of the casing.

After the circulation has been established, it is desired to retrieve the trip plug A. This is done by elevating the line E. However, it is oftentimes difficult to raise the plug from the collar B because of the hydrostatic head of fluid thereabove. It would be necessary to overcome the force of such fluid over substantially the entire area of the plug A. In the present instance, the pressure both above and below the plug is equalized by taking an

5

upward pull on the wire line E, which will pull the valve head 72 upwardly of the plug 62 and the trip plug head 56 against the force of the spring 78, raising the seal ring 74 above the cylindrical valve seat 71. The force required to shift the head 72 upwardly is relatively small, in view of the apparently small cross-sectional area of the head. Once the seal ring 74 has been elevated above the cylindrical seat 71, the region above the plug A is placed in communication with the region below its side seal ring 59 through the intercommunicating passages 88, 69, 70 in the adapter 86 and the plug 62, the passage 61 below the plug 62, and the side port 85 through the trip plug neck 55. The plug A can now be elevated by the wire line E from the valve seat 60 and withdrawn completely from the well casing without difficulty. During such elevating movement, the beveled edge or guide portion 89 on the adapter 86 will prevent the plug A from hanging up or catching on portions of the well casing, such as the lower ends of casing sections at the points where the sections are coupled to one another.

Following the removal of the trip plug A from the well casing, a temperature survey can be run of the bottom cementing job by lowering the necessary equipment through the casing string and through the collar sleeves 31, 16 to the desired point therebelow. When the surveying instruments have been withdrawn, it may be desired to perform the cementing job through the open ports 21 and 15. At this time the trip plug A detached from the wire line E can be dropped into the well casing, and will gravitate to its companion seat 60 on the lower inner sleeve valve 16. Circulation can now be established by pumping fluid down the casing string and through the open ports 15, 21 for upward passage around the well casing. The required quantity of cement slurry can also be pumped into the casing string and discharged through the open ports, this cement slurry having the usual top cementing plug thereon which will engage a companion seat 95 on the upper, inner sleeve valve 31, shearing the screws 33 and shifting the valve 31 downwardly to disrupt the shear screws 20 and shift the external sleeve valve 19 down along the tubular member 10 to a position fully closing the ports 15, with the side seals 23, 27 on opposite sides of such ports, to prevent leakage through the collar B.

At times during the downward shifting of the top cementing plug and the upper inner sleeve valve 31 to shift the external valve 19 to port closing position, fluid may be trapped between such upper plug and the trip plug A, particularly in the event the external sleeve valve has shifted across the side ports 15 to close the same. The presence of such entrapped fluid can be allowed to bypass through the lower trip plug A. When the pressure imposed on such fluid exceeds the shear strength of the screws 63 holding the inner plug member 62 to the trip plug head 56, the screw will be disrupted and the entire valve assembly 72, 77, 78 and trip plug 62 shifted downwardly to a position in which the lower portion of the trip plug 62 and its seal ring 65 are disposed below the upper end of the side port 85 through the plug neck. The fluid trapped between the upper and lower cementing plugs can now pass downwardly through the central passages 88, 61 through the trip plug, around the upper portion 68 of plug 62, and then out through the port 85.

The shear screw 63 holding the plug 62 to the head 56 is usually selected to shear at a comparatively high unit pressure, so that the unit pressure required is well above the shear value of the screws 17 holding the lower inner sleeve valve 16 to the tubular member 10. Such higher pressure is desired since the passage 88, 61 through the trip plug A should normally be maintained closed, to insure the shearing of the screws 17 holding the inner sleeve valve to the tubular member 10 and its downward movement to a port opening position. It is only when entrapped fluid conditions are encountered that the shear screw 63 is disrupted to permit such trapped fluid to pass

6

through the trip plug A into the collar B and the casing D therebelow.

The inventor claims:

1. In a plug adapted for longitudinal movement in a well conduit: a valve device having a sealing surface adapted to engage a companion seat in the well conduit; said device having a passage through which fluid may flow between regions externally of said device above and below said sealing surface; said device having a valve seat therein surrounding said passage; a valve member movable downwardly into engagement with said seat; said valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said passage; and means interconnecting said device and valve member with said valve member elevated from said seat, whereby said device and valve member are movable together upwardly in the well conduit.

2. In a plug adapted for longitudinal movement in a well conduit: a valve device having a sealing surface adapted to engage a companion seat in the well conduit; said device having a passage through which fluid may flow between regions externally of said device above and below said sealing surface; said device having a valve seat therein surrounding said passage; a valve member; spring means engaging said device and valve member to urge the valve member downwardly into engagement with said seat; said valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said passage and to move said device and valve member together upwardly in the well conduit.

3. In a plug adapted for longitudinal movement in a well conduit: a valve device having a sealing surface adapted to engage a companion seat in the well conduit; said device having a passage through which fluid may flow between regions externally of said device above and below said sealing surface; said device having a valve seat therein surrounding said passage; a valve member having a depending stem; spring means engaging said stem and valve device to urge said valve member downwardly into engagement with said seat; said valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said passage and to move said device and valve member together upwardly in the well conduit.

4. In a plug adapted for longitudinal movement in a well conduit: a first valve member having a sealing surface adapted to engage a companion seat in the well conduit; said member having a first passage through which fluid may flow between regions externally of said member above and below said sealing surface; a tubular member in said first passage sealingly engaging said first member, said tubular member having a second passage therethrough communicating with said first passage; means releasably securing said tubular member in said first member passage; said tubular member having a valve seat surrounding said second passage; and a second valve member movable downwardly into engagement with said seat; said second valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said second passage.

5. In a plug adapted for longitudinal movement in a well conduit: a first valve member having a sealing surface adapted to engage a companion seat in the well conduit; said member having a first passage through which fluid may flow between regions externally of said member above and below said sealing surface; a tubular member in said first passage sealingly engaging said first member, said tubular member having a second passage therethrough communicating with said first passage; means releasably securing said tubular member in said first member passage; said tubular member having a valve seat surrounding said second passage; a second valve member movable downwardly into engagement with said seat; said second valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said

7

second passage; and means interconnecting said second valve member and tubular member, whereby said valve members and tubular member are movable together upwardly in the well conduit.

6. In a plug adapted for longitudinal movement in a well conduit: a first valve member having a sealing surface adapted to engage a companion seat in the well conduit; said member having a first passage through which fluid may flow between regions externally of said member above and below said sealing surface; a tubular member in said first passage sealingly engaging said first member, said tubular member having a second passage therethrough communicating with said first passage; means releasably securing said tubular member in said first member passage; said tubular member having a valve seat surrounding said second passage; a second valve member; spring means engaging said second valve member and tubular member to urge said second valve member downwardly into engagement with said seat; said second valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said second passage and to move said valve members and tubular member together upwardly in the well conduit.

7. In a plug adapted for longitudinal movement in a well conduit: a first valve member having a sealing surface adapted to engage a companion seat in the well conduit; said member having a first passage through which fluid may flow between regions externally of said member

8

above and below said sealing surface; a tubular member in said first passage sealingly engaging said first member, said tubular member having a second passage therethrough communicating with said first passage; means releasably securing said tubular member in said first member passage; said tubular member having a valve seat surrounding said second passage; a second valve member having a depending stem extending through said second passage; spring means engaging said stem and tubular member to urge said second valve member downwardly into engagement with said seat; said second valve member having means connectible to a wire line to be elevated by said wire line from said seat to open said second passage and to move said valve members and tubular member together upwardly in the well conduit.

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