March 15, 1960 R. C. BAKER 2,928,470

WELL CEMENTING APPARATUS

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FIG. 1.

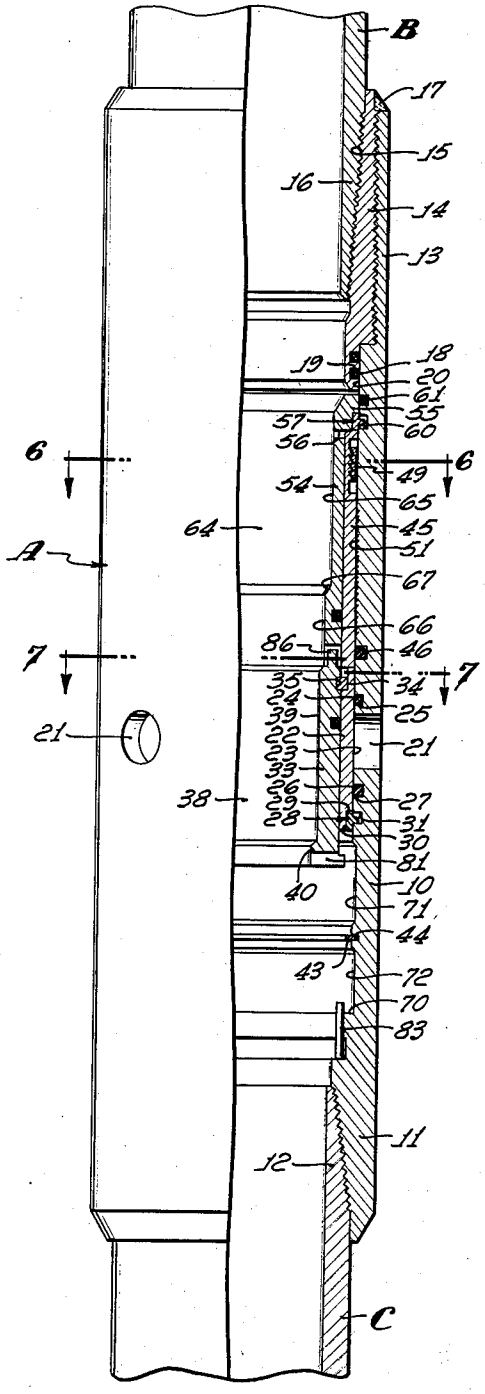
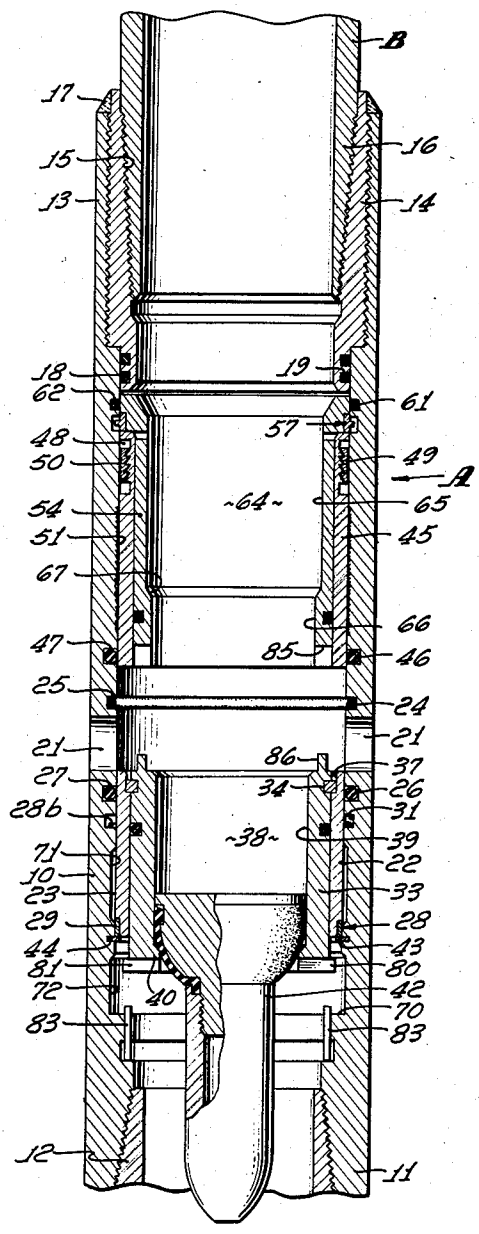



FIG. 2.

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WELL CEMENTING APPARATUS

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FIG. 3.

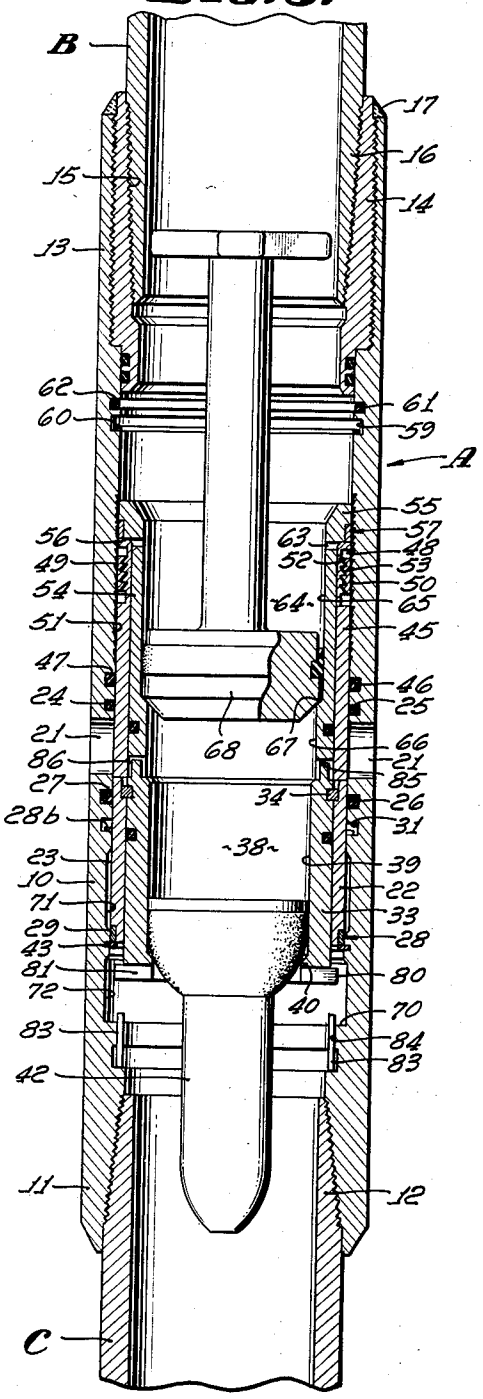


FIG. 4.

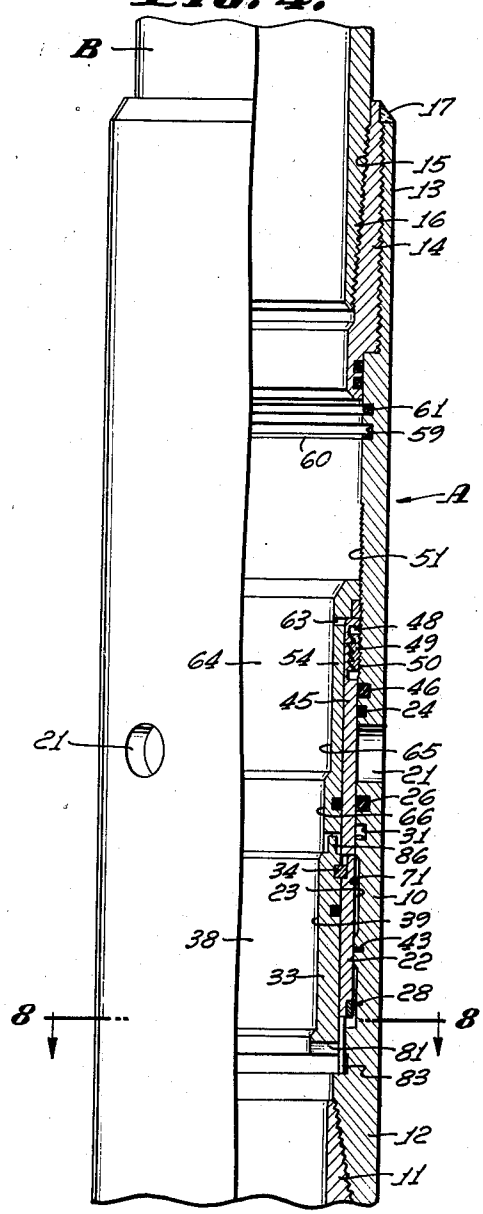


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Fig. 5.

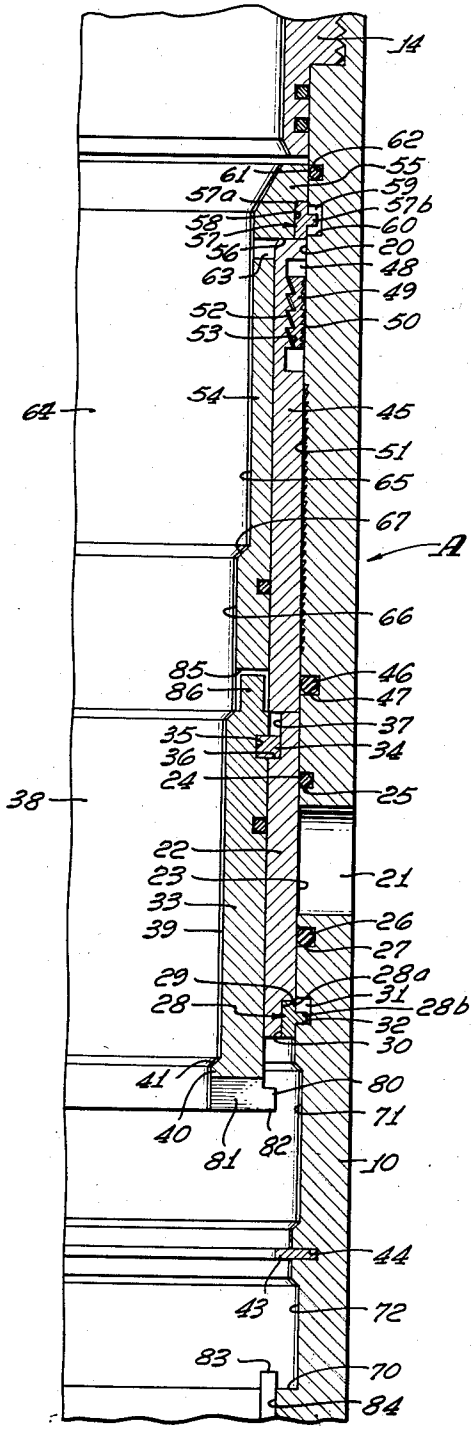



Fig. 6.

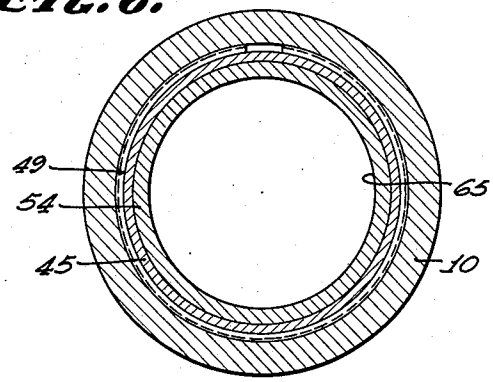



Fig. 7.

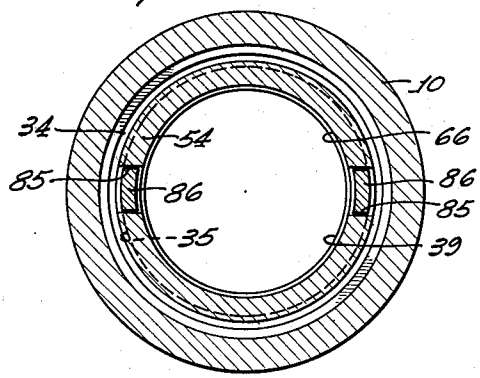
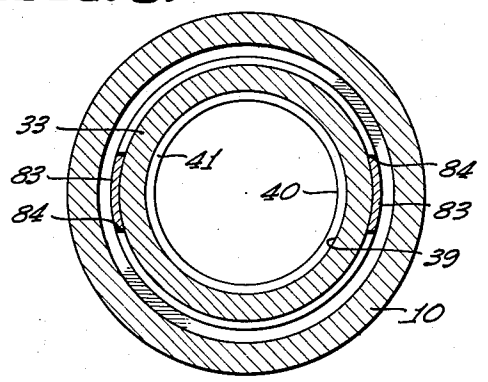



Fig. 8.

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2,928,470

# WELL CEMENTING APPARATUS

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Application December 3, 1956, Serial No. 625,984

7 Claims. (Cl. 166—154)

The present invention relates to subsurface well bore equipment, and more particularly to apparatus especially useful in cementing well casing, liners, and similar conduit strings, in well bores.

An object of the present invention is to provide well cementing apparatus adapted to form part of a casing or similar conduit string to be disposed in a well bore, and embodying a plurality of shiftable internal sleeve valves for opening and closing one or more side ports in the apparatus, in which the sleeve valves are shiftable by devices extending inwardly of the casing which can be readily drilled out after cementing operation has been completed without requiring the drill bit to operate upon the sleeve valves themselves, and thereby potentially disturb the positions to which they have been shifted relative to the one or more side ports.

Another object of the invention is to provide well cementing apparatus of the character indicated, in which fluid leakage around the sleeve valves is prevented by sealing devices that are protected during the cementing operation, so as to remain in proper condition for efficient sealing against one of the sleeve valves to completely close the one or more side ports.

A further object of the invention is to provide well cementing apparatus adapted to form part of a casing or similar conduit string to be disposed in a well bore, and embodying a plurality of shiftable internal sleeve valves for opening and closing one or more side parts in the apparatus, one or more of the sleeve valves being held initially in predetermined positions by shear devices that do not require the use of holes through the apparatus, thereby avoiding potential paths of fluid leakage between the interior and exterior of the apparatus.

An additional object of the invention is to provide well cementing apparatus adapted to form part of a casing or similar conduit string to be disposed in a well bore, and embodying lower and upper shiftable internal sleeve valves for initially and finally closing side ports in the apparatus, in which improved means are provided for retaining the upper sleeve valve in a closed position across the side ports.

Yet another object of the invention is to provide well cementing apparatus adapted to form part of a casing or similar conduit string to be disposed in a well bore, and embodying lower and upper shiftable internal sleeve valves for initially and finally closing the side ports in the apparatus, the lower and upper sleeve valves being shiftable by lower and upper plug devices, respectively, the upper plug and upper sleeve valve being shiftable to port closing position without the necessity for compressing fluid in the apparatus between them and the lower sleeve valve and lower plug device.

Still a further object of the invention is to provide well cementing apparatus adapted to form part of a casing or similar conduit string to be disposed in a well bore, and embodying lower and upper shiftable internal sleeve valves for initially and finally closing the side ports in the apparatus, the lower and upper sleeve valves being shiftable by lower and upper plug devices, respectively, the plug devices fitting within the sleeve valves in a manner to minimize the possibility of leakage therebetween.



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 combined side elevational and longitudinal section through a ported apparatus, with the ports initially closed;

Fig. 2 is a longitudinal section through the apparatus of Fig. 1, with the ports open;

Fig. 3 is a view similar to Fig. 2, with the parts in a position preparatory to final reclosing of the ports;

Fig. 4 is a view like Fig. 1, with the ports fully reclosed;

Fig. 5 is an enlarged quarter section of the major portion of the apparatus in the position shown in Fig. 1;

Fig. 6 is an enlarged cross-section taken along the line 6—6 in Fig. 1;

Fig. 7 is an enlarged cross-section taken along the line 7—7 in Fig. 1;

Fig. 8 is an enlarged cross-section taken along the line 8—8 in Fig. 4.

The embodiment of the invention disclosed in the drawings is essentially a collar A adapted to connect upper and lower casing sections B, C of a casing string in spaced relation, the casing string normally extending to the top of a well bore. The casing string may extend a substantial distance below the collar and may have a shoe (not shown), or the like, at its lower end through which cement slurry, or other cementitious material, is to be forced for upward passage around the lower portion of the casing string toward the collar A itself. The collar is initially closed, being opened when desired to permit subsequent ejection of cementitious material, such as cement slurry, laterally outward for upward passage around the casing string, whereupon the collar is reclosed and retained in such closed position. After the cement ejected through the collar A has set and hardened, the portions of the apparatus lying inwardly of the internal circumference of the casing string are drilled out, to leave an unobstructed passage through the collar apparatus itself.

As specifically disclosed in the drawings, the collar includes an outer tubular member **10** having a lower threaded box **11** threadedly receiving the upper pin end **12** of the lower casing section C. The upper portion **13** of the tubular member is threaded to threadedly receive an adapter nut **14** having an internal thread **15** receiving the lower pin **16** of the upper casing section B. Inadvertent loosening of the adapter nut **14** from the tubular member **10** may be prevented by integrating these parts, as by use of welding material **17**. In addition, leakage between the adapter nut **14** and the tubular member **10** may be prevented by thread seals in the form of rubber or rubber-like O rings **18** disposed in grooves **19** in the lower portion of the adapter nut and bearing against the inner wall **20** of the tubular member **10**.

The tubular member has one or a plurality of circum-

ferentially spaced side ports 21 through its wall through which fluid may pass when such side ports are in an opened condition. Initially, the side ports are closed by a lower internal sleeve valve 22 having a cylindrical periphery 23, the sleeve valve extending across the side ports and being in sealing engagement with an upper seal ring 24 disposed in an internal groove 25 in the tubular member above the ports 21. The lower portion of the lower sleeve 22 is also in slidable sealing engagement with a lower seal ring 26 disposed in a lower internal groove 27 in the tubular member 10, preferably closely adjacent the side ports 21. The lower sleeve is retained initially in closed position across the side ports 21, and is prevented from moving downwardly relative to the tubular member 10, by a split shear ring 28 which inherently tends to contract, and which is disposed within a lower peripheral recess 29 in the lower sleeve valve, the inner surface 30 of the split ring preferably being serrated or roughened to grip the companion external surface of the lower sleeve valve. The inner portion 28*a* of the split shear ring, when mounted on the sleeve valve 22, has an external diameter no greater than the internal diameter of the tubular member 10, and such inner portion is integral with a relatively thin outer portion 28*b* extending within an internal groove 31 in the tubular member, the outer portion 28*b* initially bearing upon the lower side 32 of such groove.

As explained hereinbelow, the engagement of the relatively thin outer portion 28*b* of the shear ring, which may be made of cast iron, with the lower side 32 of the groove prevents the lower sleeve valve 22 from shifting downwardly along the tubular member to a port opening position. The shearing of the outer portion 28*b* from the inner portion 28*a* permits the lower sleeve valve 22 to shift downwardly to a port opening position. Such shearing will occur when a predetermined downward force is imposed on the lower sleeve valve 22.

For the purpose of shifting the lower sleeve valve 22 downwardly, a lower shifting sleeve 33 is disposed therewithin. The periphery of this shifting sleeve conforms to the internal diameter of the lower sleeve valve 22, the shifting sleeve being adapted to move the lower sleeve valve 22 downwardly by virtue of a split cast iron tie ring 34, mounted in an upper peripheral groove 35 in the shifting sleeve, engaging an upwardly facing shoulder 36 in the lower sleeve valve defining the lower end of an upper counterbore 37 in the latter. The lower shifting sleeve has a central passage 38 therethrough, the inner surface 39 of the shifting sleeve being cylindrical from its upper end to a region adjacent its lower end. Near its lower portion the shifting sleeve has an inwardly directed flange 40 defining an upwardly facing shoulder 41 adapted to be engaged by a lower plug 42 which is to close the passage 38 through the shifting sleeve. When such plug 42 is disposed within the lower shifting sleeve 33 in engagement with its shoulder or flange 41, the pressure of the fluid in the casing may be increased to an extent sufficient to shear the inner portion 28*a* of the shear ring 28 from its outer portion 28*b*, the plug 42, lower shifting sleeve 33, and lower sleeve valve 22 then being moved downwardly, to open the side ports 21, the extent of downward movement being at first limited by engagement of the lower sleeve valve with a split stop and shear ring 43 disposed within an internal groove 44 in the tubular member 10. Such stop ring is located in a position to arrest the lower sleeve valve 22, with its upper end disposed below the side ports 21 but with the sleeve valve itself still covering the lower seal ring 26. By virtue of this arrangement, any fluids or fluent materials that are pumped through the side ports 21 cannot act upon the seal ring 26 and possibly damage it or flush it out of the groove 27, whereupon it would be unavailable for subsequent sealing purposes. The stop ring 43 is also a shear ring, and is preferably of such thickness and type of material as to shear at a substantially higher pressure than the shearing pressure of the shear ring 28 initially holding the lower sleeve valve 22 across the ports 21. Such higher shear pressure is preferred, although it is not essential, inasmuch as the shear rings 28, 43 are disrupted independently of one another.

Following opening of the side ports 21 and the pumping of fluids and other materials, such as cement slurry, therethrough, it is desired to close such ports. Such closing action is performed by an upper sleeve valve 45 slidably mounted within the tubular member 10, and preferably initially occupying a position immediately above the lower sleeve valve 22 when the latter is in closed position across the side ports 21. In fact, the lower end of the upper sleeve valve 45 can contact the upper end of the lower sleeve valve 22. When this occurs, the periphery of the upper sleeve valve 45 is in sealing engagement with a seal ring 46, such as a rubber or rubber-like O ring, disposed in an internal groove 47 in the tubular member 10.

The upper portion of the sleeve valve 45 has an elongate peripheral groove 48 therein, in which a split ratchet ring 49 is disposed. This ratchet ring has circumferential ratchet teeth 50 thereon facing in an upward direction, such teeth initially engaging the smooth cylindrical wall 20 of the tubular member when the upper sleeve valve is in its upper position, such as disclosed in Figs. 1 and 5. Such teeth 50 are adapted to coact with internal circumferential ratchet teeth 51 facing in a downward direction within the tubular member and below its cylindrical portion 20, when the upper sleeve valve 45 is shifted downwardly to port closing position, as described hereinafter, the ratchet ring 49 preventing return upward movement of the upper sleeve valve 45 from the downward position to which it has been shifted. The ratchet ring 49 has longitudinally spaced cam surfaces 52 tapering in an upward and inward direction coacting with companion cam surfaces 53 on the upper sleeve valve 45, so that the tendency of the upper sleeve valve 45 to shift upwardly relative to the ratchet ring 49 forces the latter outwardly to hold its teeth 50 firmly meshed with the companion ratchet teeth 51 of the tubular member. However, the sleeve valve 45 can move downwardly, carrying the ratchet sleeve 49 along with it, the latter ratcheting freely over the internal ratchet teeth 51 of the tubular member, in the manner described hereinafter.

For the purpose of shifting the upper sleeve valve 45 downwardly to port closing position, an upper shifting sleeve 54 fits snugly within the upper sleeve valve 45, having an external diameter corresponding to the internal diameter of the upper sleeve valve. The upper head portion 55 of this shifting sleeve 54 extends outwardly across the upper end of the upper sleeve valve 45, to provide a downwardly facing shoulder 56 engaging the upper end of the upper sleeve valve. Downward shifting of the shifting sleeve 54 and the upper sleeve 45 is at first prevented by an upper shear ring 57 disposed within a peripheral groove 58 in the shifting sleeve head and defined between said head and the upper end of the upper sleeve valve 45. This ring 57 is split, to enable it to be mounted within the groove 58, and has its inner portion 57*a* with a diameter no greater than the internal diameter of the tubular member wall 20. An outer portion 57*b* is integral therewith, which is relatively thin and which is disposed within an internal circumferential groove 59 in the tubular member 10. This outer portion 57*b* is adapted to engage the lower side 60 of the internal groove and can be sheared from the inner portion 57*a* when a sufficient downward force is imposed on the upper shifting sleeve 54, which will then allow the shifting sleeve 54, inner portion 57*a* of the shear ring, and upper sleeve valve 45 to move downwardly within the tubular member 10. Preferably, a dirt or sand seal 61, in the form of a rubber or rubber-like O ring, is disposed in an internal groove 62 in the

tubular member 10 to sealingly engage the periphery of the head 55, to prevent foreign materials from possibly being deposited around the head, which might bind it and interfere with its downward movement. To equalize the pressures internally and externally of the shifting sleeve 54, so as to avoid any pressure differentials thereacross that might tend to deform the sleeve, a bleeder hole 63 is provided through the shifting sleeve immediately below the head 55, which establishes communication between the internal and external surfaces of the shifting sleeve.

The upper shifting sleeve 54 has a central passage 64 therethrough, the inner wall of the upper shifting sleeve having two main internal diameters 65, 66, the lower diameter 66 being greater than the internal diameter 39 through the lower shifting sleeve 33. The upper shifting sleeve has an upper internal diameter 65 which is substantially greater than the lower internal diameter 66, to provide an upwardly facing shoulder or seat 67 in the upper shifting sleeve for the reception of an upper plug 68, such as a top cementing plug, which is adapted to seat within the upper shifting sleeve 54 and enable pressure to be applied to the fluid in the casing string thereabove of sufficient value to shear the outer shearing portion 57*b* of ring 57 from the inner shearing portion 57*a* and shift the upper shifting sleeve 54 and the upper sleeve valve 45 downwardly within the tubular member 10 to a position in which the upper sleeve valve is disposed completely across the side ports 21, to close the same. Actually, the downward shifting will at first occur only to the extent at which the upper sleeve valve 45 engages the upper end of the lower sleeve valve 22, after the latter has been shifted to port opening position, resting upon the lower split stop and shear ring 43. When this occurs, the subjecting of the fluid in the well casing to a still higher pressure will cause the upper or top cementing plug 68, upper shifting sleeve 54, and upper sleeve valve 45 to exert a downward force on the split stop and shear ring 43, through the agency of the lower sleeve valve 22, shearing the ring 43, which will allow the entire mechanism within the tubular member to shift downwardly as a unit to the extent limited by engagement of the lower sleeve valve 22 with an inwardly directed shoulder 70 provided in the lower portion of the tubular member 10, or limited by engagement of the sheared ring 43 with such shoulder, with the lower sleeve valve 22 resting thereon.

When the parts are in this latter position, the upper sleeve 45 is disposed across the ports 21 in engagement with both the upper and the lower seals 24, 26, insuring against leakage of fluid through the side ports 21, and with the ratchet ring 49 engaging the companion teeth 51 in the tubular member to prevent upward or return movement of the upper sleeve valve. Thus, the upper sleeve valve 45 cannot be shifted upwardly to port opening position, its downward movement being prevented by engagement with the lower sleeve valve 22 and the engagement of the latter with the sheared ring 43, which is, in turn, resting upon the upwardly directed shoulder 70 of the tubular member 10.

In order to minimize frictional resistance to movement of the lower sleeve valve 22 in a downward direction, the portion 71 of the tubular member 10 below the groove 31 receiving the shear ring 28 is recessed or enlarged in diameter along a substantial portion of its length and above the location of the stop and shear ring 43, so that the surface of contact between the lower sleeve valve 22 and tubular member 10 will be substantially decreased during its downward movement. Similarly, another enlarged circumferential recess 72 is provided in the tubular member below the location of the stop and shear ring 43, enabling the lower sleeve to shift downwardly with a lesser frictional resistance to movement. As the inner portion 28*a* of the lower shear ring 28 comes opposite the recessed portions 71 or 72 of the member 10, it will remain adhered to the lower sleeve valve 22, in view of the fact that the split shear ring 28 is inherently contractible and tends to grip the base of the recessed portion 29 of the lower sleeve valve, the gripping action being enhanced by the serrating or roughening of the surface 30 of the split ring.

The upper and lower sleeve valves 45, 22 are made of steel, to remain permanently in the tubular member 10. Their internal diameters are no less than and preferably greater than the internal diameter through the casing string B, C. However, the upper and lower shifting sleeves 54, 33 have internal diameters substantially less than the normal internal diameter through the casing sections themselves, extending inwardly thereof to some extent. This is particularly true of the smaller internal diameter portions 66, 39, 40 of the upper shifting sleeve 54 and of the lower shifting sleeve 33. The shifting sleeves are preferably made of readily drillable material, such as magnesium, aluminum or cast iron, in order that such portions may be disintegrated and flushed from the well casing by a drill bit (not shown) after the cementing operation has been completed, including the operation of shifting the upper sleeve 45 to a fully closed position across the side ports 21, and the hardening of the cement slurry pumped through the side ports.

To facilitate the drilling out of the shiftable sleeves 54, 33, their rotation is prevented. Thus, the lower portion of the lower shifting sleeve 33 has an outwardly extending flange 80 and a plurality of circumferentially spaced radial slots 81 providing lugs 82 adapted to engage companion keys 83 received in longitudinal keyways 84 in the tubular member, the keys being brazed within such keyways and extending upwardly above the shoulder 70 of the tubular member. Such engagement will key or lock the lower shifting sleeve 33 to the tubular member against rotation. Similarly, the lower portion of the uppper shifting sleeve 54 is provided with circumferential radial slots 85 thereacross adapted to receive upwardly extending lugs or keys 86 provided at the upper portion of the lower shifting sleeve 33. When the lower shifting sleeve 33 and lower sleeve valve 22 occupy their lowermost position in the tubular member, with the lugs 82 in engagement with the keys 83 fixed to the tubular member, and following the shifting of the upper shifting sleeve 54 and upper sleeve valve member 45 to their final lower position, the upper lugs or keys 86 of the lower shifting sleeve will be received in the slots 85 in tha upper shifting sleeve 54, the lower shifting sleeve thereby preventing rotation of the upper shifting sleeve. In this manner, both shifting sleeves 54, 33 are prevented from rotating, allowing a drill bit to turn relative to them and effect their ready disintegration.

In the use of the apparatus A, it is connected at the proper location in the casing string, attaching the upper and lower casing sections B, C in spaced relation. Initially, the upper sleeve valve 45 and upper shifting sleeve 54 occupy their uppermost positions, with the upper shear ring 57 disposed in the companion groove 59 in the tubular member 10, the lower shifting sleeve 33 and lower sleeve valve 22 being disposed in their uppermost positions, with the lower shear ring 28 disposed in its companion groove 31 in the tubular member. At this time, the stop and shear ring 43 is intact within its groove 44 in the tubular member (Figs. 1 and 5). The string of well casing is run in the well bore to the desired setting point, after which it is usual to properly condition the well and then pump a first charge of cement slurry down the casing string, such cement slurry and cementing plugs, if such are used, passing through the passages 64, 38 in the shifting sleeves 54, 33 without moving the latter, and the cement slurry being discharged through the casing shoe, or other point in the casing string below the collar A. The cement slurry will pass upwardly around the casing string toward the collar, and may, in fact, rise above the closed side ports 21 in the tubular member.

Following the pumping of the cement slurry out of the casing to perform the lower cementing operation, a cementing plug **42**, or tripping member, is dropped down the casing string, gravitating through the fluid in the well casing and passing freely through the upper shifting sleeve **54**, coming to rest upon the shoulder **41** of the lower shifting sleeve **33** and in sealing engagement therewith. The pressure of the fluid in the well casing can now be increased, such pressure acting upon the lower plug **42**, lower shifting sleeve **33**, and lower sleeve **22**, and when it reaches a sufficient value to shear the inner portion **28***a* of the lower shear ring **28** from its outer portion **28***b*, the lower plug, lower shifting sleeve and lower sleeve valve are moved downwardly to the extent limited by engagement of the inner portion **28***a* of the lower shear ring **28** with the split stop and shear ring **43** (Fig. 2). At this time, the side ports **21** will be open, with the upper end of the sleeve valve **22** disposed therebelow and with its upper portion still disposed across the lower seal ring **24** to protect the same.

Circulating fluid may now be pumped down the casing string, passing outwardly through the open side ports **21** to wash any cement slurry therearound from the lower stage cementing operation upwardly toward the top of the well bore. After the well bore has been properly conditioned, the required charge of cement slurry is pumped down the casing, passing out through the side ports **21** and then upwardly around the casing string. Such charge of cement slurry usually carries a top cementing plug **68** at its upper end to separate it from the displacement fluid thereabove, this cementing plug being appropriately dimensioned as to pass within the upper shifting sleeve **54** and coming to rest upon the shoulder **67** of said shifting sleeve, with appropriate seals **90** engaging the inner wall **65** of the shifting sleeve to fully close the passage **64** therethrough. With the plug **68** engaging the shoulder **67**, the pressure of the fluid above the plug can be increased, this pressure being exerted downwardly on the plug, as well as on the upper shifting sleeve **54**. When it reaches a value exceeding the shear strength of the outer portion **57***b* of the upper shear ring **57**, the outer portion is sheared from the inner portion **57***a*, whereupon the upper cementing plug **68**, upper shifting sleeve **54** and upper sleeve value **45** will move downwardly to the extent limited by engagement of the upper sleeve valve **45** with the lower sleeve valve **22** (Fig. 3). During this time, the ratchet ring **49** can ratchet freely in a downward direction over the ratchet teeth **51** of the tubular member **10**. After the upper sleeve valve **45** engages the lower sleeve valve **22**, the fluid pressure is increased until the shear strength of the stop ring **43** is exceeded, which shears the inner portion of the latter from its outer portion, allowing the upper plug **68**, upper shifting sleeve **54**, and upper sleeve valve **45** to move downwardly as a unit, pushing the lower plug **42**, lower shifting sleeve **33**, and lower sleeve valve **22** ahead of it until the lower sleeve valve **22** engages the inner portion of the split shear ring **43**, which is now resting upon the tubular member shoulder **70**, with the lugs **82** in a position to engage the teeth or keys **83**. At this time also, the upper lugs or keys **86** of the lower shifting sleeve are received within the radial slots **85** in the upper shifting sleeve **54** to engage the latter sleeve and prevent its rotation (Fig. 5).

During the downward movement of the various elements in the tubular member **10** to their final position, the upper sleeve valve **45** moves completely across the side ports **21** and across the lower seal ring **26**, being simultaneously engaged with the seal rings **24**, **26** on opposite sides of the side ports, preventing leakage between the tubular member **10** and the upper sleeve valve **45** in both longitudinal directions. The ratchet ring **49** ratchets freely over the teeth **51** of the tubular member during the downward shifting of the upper sleeve valve **45** to its final position. However, such ratchet ring will prevent upward or return movement of the sleeve **45** from its closed position completely across the side ports **21**.

Following the hardening of the cement that has been forced out through the side ports **21**, the portions of the apparatus extending inwardly of the casing string may be disintegrated by a drill bit. To facilitate this operation, the upper and lower cementing plugs **68**, **42** are preferably made of readily drillable material, and this factor, coupled with the making of the upper and lower shifting sleeves **54**, **33** of readily drillable material, enables the drill bit to disintegrate substantially all of the mechanism inwardly of the upper and lower sleeve valves **45**, **22**, to leave the well casing in a free and unobstructed condition. The engagement of the lugs **82** with the keys **83** prevents rotation of the lower shifting sleeve **33**, whereas the engagement of the upper lugs or keys **86** with the upper shifting sleeve **54** prevents rotation of the latter under the action of the drill bit, so as not to impede the progress of the latter in disintegrating the internal mechanism. The internal diameters of the upper and lower sleeve valves **45**, **22**, however, are such as to be substantially untouched by the drill bit, which cannot operate upon them.

It is to be noted that the upper sleeve valve **45** engages the lower sleeve valve **22** before the upper sleeve valve moves into sealing relation to the lower seal ring **26**, and that the upper sleeve valve **45** and lower sleeve valve **22**, together with the shifting sleeves **54**, **22** and the plugs **68**, **42** within the latter, move downwardly as a unit as the upper sleeve valve **45** is being shifted to its final, closed position across the side ports **21**. Any liquid or fluid entrapped within the sleeves and between the upper and lower cementing plugs **68**, **42** are, therefore, moved downwardly as a unit with the downwardly moveing parts within the tubular member **10**, avoiding the necessity for compressing such mass of liquid or fluid. Ordinarily, the fluid in the wall casing below the lower plug **42** and lower sleeve valve **22** must be compressed to some extent, but, usually, the length of the fluid column in the apparatus below the apparatus A is so great that the required amount of compression can occur without difficulty and without requiring substantial pressures for the downward shifting of the sleeves **45**, **22** to their final positions. It is, accordingly, evident that by stopping the lower sleeve valve **22** in an intermediate port opening position, and then shifting it downwardly to its final position under the action of the upper sleeve valve **45**, the necessity for shifting the upper sleeve valve toward the lower sleeve valve is avoided, which also obviates the necessity for compressing any trapped fluid between the upper and lower plugs **68**, **42**.

The shoulders **67**, **41** on which the upper and lower plugs **68**, **42** come to rest are disposed a substantial distance below the upper ends of the upper and lower shifting sleeves **54**, **33**, and the inner walls **65**, **39** of the shifting sleeves above the shoulders are cylindrical, which insures appropriate sealing engagement of the sealing devices of the plugs against such wall. The sealing devices ordinarily engage the shifting sleeves **54**, **33** substantially below their upper ends, insuring a coaxial position of the plugs **68**, **42** in the sleeves and their appropriate sealing engagement with the inner walls **65**, **39** of the shifting sleeves.

By virtue of the ratchet arrangement disclosed, it is not essential that the upper sleeve valve be shifted downwardly to the maximum extent. If, for some reason, the upper sleeve valve **45** cannot be shifted downwardly to such a maximum extent, it will still remain in closed position across the side ports **21**, in sealing engagement with both the upper and lower seals **24**, **26**, the ratchet ring **49** preventing upward or return movement of the upper sleeve valve **45** from the lowermost position to which it may have been shifted, although such lowermost position is not the maximum position to which it could be shifted within the design limits of the apparatus.

Whatever the final position of rest of the upper sleeve valve **45**, it will completely close the side ports **21** and prevent leakage therethrough, so long as it simultaneously engages the seals **24, 26** on opposite sides of the side ports.

The shear ring arrangement **28, 57** employed in the present case avoids the necessity for providing threaded holes, or the like, in the tubular member **10**, such as occurs when shear pins or shear screws are used. Such holes are sometimes the source of undesired fluid leakage between the interior and exterior of the casing during the life of the well. The only passages provided through the tubular member with the present cementing apparatus are the side ports **21** themselves, and these are completely and permanently closed by the upper sleeve valve **45** at the end of the well cementing operation.

The inventor claims:

1. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member; releasable means initially retaining said lower sleeve valve member across said port to close the same, said valve member, when released, being slidable downwardly to port opening position; seal means on said tubular member below said port and engaging said valve member; an upper sleeve valve member in said tubular member; releasable means initially retaining said upper sleeve valve member above said port, said upper sleeve valve member, when released, being slidable downwardly to a position across said port and said seal means; releasable stop means engageable by said lower valve member to limit its downward movement to a position in which said port is open and said lower valve member remains engaged with said seal means; said lower valve member being shiftable below said seal means and said upper valve member being movable to close said port and into sealing engagement with said seal means upon release of said stop means.

2. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member; releasable means initially retaining said lower sleeve valve member across said port to close the same, said valve member, when released, being slidable downwardly to port opening position; seal means on said tubular member below said port and engaging said valve member; releasable stop means engageable by said valve member to limit its downward movement to a position in which said port is open and said valve member remains engaged with said seal means; an upper sleeve valve member in said tubular member; releasable means initially retaining said upper sleeve valve member above said port, said upper sleeve valve member, when released, being slidable downwardly into engagement with said lower valve member when said lower valve member is in engagement with said stop means; and means for imposing a downward force on said upper valve member and through said lower valve member to release said releasable stop means and shift said lower valve member below said seal means and to shift said upper valve member into sealing engagement with said seal means to close said port.

3. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member; releasable means initially retaining said lower sleeve valve member across said port to close the same, said valve member, when released, being slidable downwardly to port opening position; seal means on said tubular member below said port and engaging said valve member; an upper sleeve valve member in said tubular member; releasable means initially retaining said upper sleeve valve member above said port, said upper sleeve valve member, when released, being slidable downwardly to a position across said port and seal means; frangible stop means engageable by said lower valve member to limit its downward movement to a position in which said port is open and said lower valve member remains engaged with said seal means; and means for exerting a downward force on said upper and lower valve members to disrupt said frangible stop means and shift said lower valve member below said seal means and to move said upper valve member into sealing engagement with said seal means to close said port.

4. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member; releasable means initially retaining said lower sleeve valve member across said port to close the same, said valve member, when released, being slidable downwardly to port opening position; seal means on said tubular member below said port and engaging said valve member; an upper sleeve valve member in said tubular member; releasable means initially retaining said upper sleeve valve member above said port, said upper sleeve valve member, when released, being slidable downwardly to a position across said port and said seal means; a frangible ring secured to said tubular member and engageable by said lower valve member to limit its downward movement to a position in which said port is open and said lower valve member remains engaged with said seal means; and means for exerting a downward force on said upper and lower valve members to disrupt said frangible ring and shift said lower valve member below said seal means and to move said upper valve member into sealing engagement with said seal means to close said port.

5. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member; a first frangible ring engaging said valve member and tubular member to locate said valve member across said port to close the same; seal means on said tubular member below said port and engaging said valve member; a second frangible ring secured to said tubular member and engageable with said valve member to limit its downward movement to a position in which said port is open and said valve member remains engaged with said seal means; an upper sleeve valve member in said tubular member; a third frangible ring engaging said upper valve member and tubular member to locate said upper valve member above said port; means for imposing a downward force on said lower valve member to disrupt said first frangible ring and shift said lower valve member downwardly into engagement with said second frangible ring; and means for exerting a downward force on said upper valve member to disrupt said third frangible ring and shift said upper valve member to a position across said port and in engagement with said lower valve member, said last-mentioned means being adapted to then exert a downward force on said upper and lower valve members to disrupt said second frangible ring and shift said lower valve member below said seal means and move said upper valve member into sealing engagement with said seal means to close said port.

6. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member disposed initially across said port to close the same; a readily drillable lower shifting sleeve within and coupled to said sleeve valve, said lower shifting sleeve having a substantially cylindrical central bore terminating at an inwardly directed shoulder against which a plug can seat to close the passage through said shifting sleeve; an upper sleeve valve member in said tubular member disposed initially

above said port; a readily drillable upper shifting sleeve within and coupled to said upper sleeve valve, said upper shifting sleeve having a substantially cylindrical central bore terminating at an inwardly directed shoulder against which a plug can seat to close the passage through said upper shifting sleeve, the passage through said upper shifting sleeve having a minimum diameter which is no smaller than the diameter of the central bore through said lower shifting sleeve.

7. In apparatus of the character described: a tubular member adapted to form part of a conduit string to be disposed in a well bore, said member having a side port; a lower sleeve valve member in said tubular member disposed initially across said port to close the same; a readily drillable lower shifting sleeve within and coupled to said sleeve valve, said lower shifting sleeve having a substantially cylindrical central bore terminating at an inwardly directed shoulder against which a plug can seat to close the passage through said shifting sleeve; an upper sleeve valve member in said tubular member disposed initially above said port; a readily drillable upper shifting sleeve within and coupled to said upper sleeve valve, said upper shifting sleeve having a substantially cylindrical central bore terminating at an inwardly directed shoulder against which a plug can seat to close the passage through said upper shifting sleeve, the passage through said upper shifting sleeve having a minimum diameter which is no smaller than the diameter of the central bore through said lower shifting sleeve; said lower shifting sleeve extending along substantially the entire length of said lower sleeve valve, the shoulder therein being disposed in the lower portion of said lower shifting sleeve; said upper shifting sleeve extending along substantially the entire length of said upper sleeve valve, the shoulder in said upper shifting sleeve being disposed in the lower portion thereof.



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