Nov. 9, 1965 J. C. WILLIAMS 3,216,452

STAGE COLLARS FOR TUBULAR STRINGS

Original Filed June 29, 1961

FIG. 1.

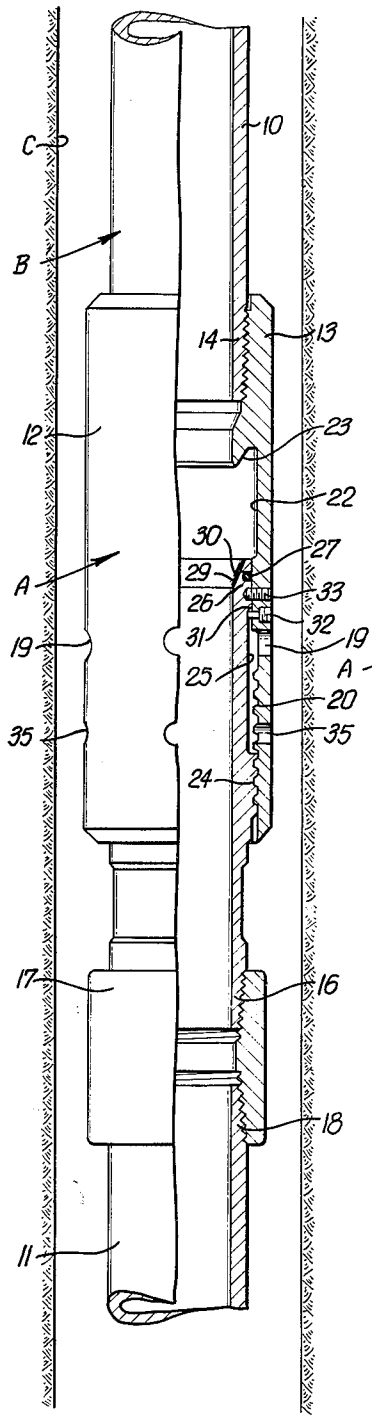


FIG. 2.

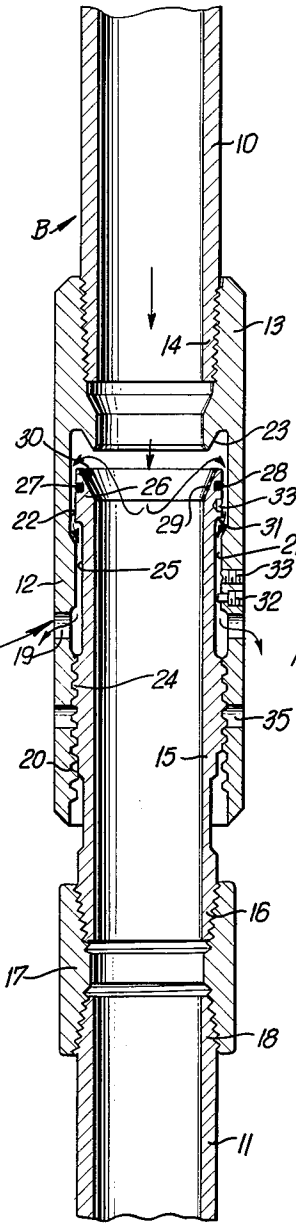
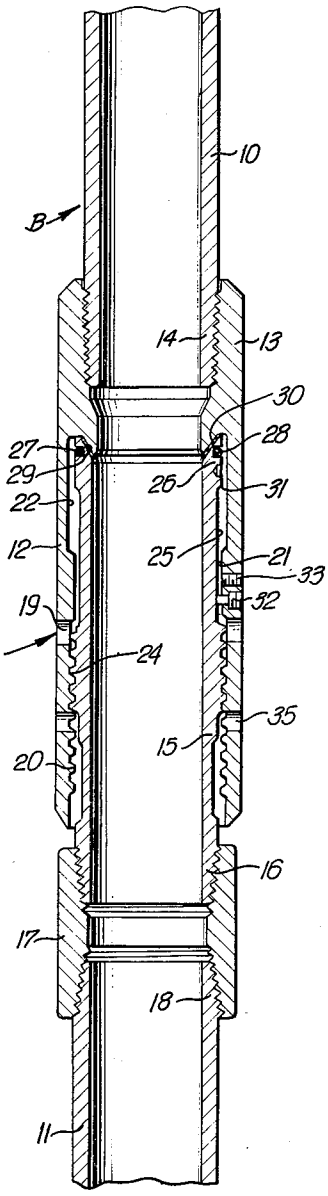


FIG. 3.



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STAGE COLLARS FOR TUBULAR STRINGS

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Continuation of application Ser. No. 120,658, June 29, 1961. This application Nov. 1, 1963, Ser. No. 321,727
17 Claims. (Cl. 137—614.13)

This application is a continuation of my application for "Stage Collars for Tubular Strings," Serial No. 120,658, now abandoned, filed June 29, 1961.

The present invention relates to apparatus adapted to be incorporated in a tubular string of casing, tubing, and the like, to be lowered in a well bore, and through which fluent materials, such as cement slurry, can be pumped from the interior of the tubular string into the surrounding well bore annulus.

An object of the invention is to provide a ported stage collar for tubular strings to be disposed in a well bore and through which cementitious material can be pumped, in which opening and closing of the collar ports is secured by manipulating the tubular string, and in which such manipulation is easily controlled to assure the open and closed conditions of the ports.

Another object of the invention is to provide a ported stage cementing collar to be incorporated in a tubular string in which the ports are opened and closed by relative rotation between the collar ports, and in which the interior of the collar is in an essentially flush condition after the ports have been reclosed, thereby avoiding gaps in the collar in which other equipment might subsequently snag or hang up when lowered in the tubular string.

A further object of the invention is to provide a ported stage cementing collar to be incorporated in a tubular string adapted to be lowered in a well bore, in which the collar ports are opened in response to manipulation of the tubular string, and in which no cement need remain in the tubular string and its collar after cement slurry has been discharged through the open ports, thereby obviating the need for drilling out any cement from the interior of the tubular string and its collar.

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 view and longitudinal section through an apparatus embodying the invention disposed in the well bore, with the collar ports in their initial closed condition;

FIG. 2 is a longitudinal section through the apparatus disclosed in FIG. 1, with the ports in open condition to allow the discharge of cement slurry therethrough;

FIG. 3 is a view similar to FIG. 2, showing the ports reclosed.

As disclosed in the drawings, a collar apparatus A is incorporated in a tubular string B disposed in a well bore C in which the tubular string is to be cemented. The apparatus is placed in the tubular string at an intermediate point along its length, such point being selected a required distance above the lower end of the tubular string. After the tubular string B has been lowered in the well bore C to the desired depth, cementitious material can be pumped down the tubular string for discharge through its lower end or a lower point, after which ports in the collar apparatus A are opened so that an upper stage of cementing can be performed through such collar ports, after which they are closed. The tubular string may be of relatively small size, consisting, for example, of sections of 2⅞ O.D. tubing, or it may be constituted as a string of casing, the sections of which have a much greater diameter than indicated.

The collar A serves to connect an upper portion **10** of the tubular string with a lower portion **11** of the tubular string. As specifically illustrated, the collar A includes an upper outer tubular member **12** having an upper threaded box **13** for threaded attachment to the lower pin end **14** of an adjacent upper tubing section **10**. The collar further includes a lower inner tubular member **15** having a lower threaded pin **16** threadedly secured to a coupling **17**, which is, in turn, threaded on to the upper pin end **18** of a lower tubing section **11** of the lower portion of the tubular string. The outer tubular member **12** has a plurality of circumferentially spaced side ports **19** extending therethrough, there being internal right-hand threads **20** in the outer member below such ports, and an internal cylindrical valve seat **21** above such ports. Above the valve seat **21**, the outer member has a section **22** of enlarged internal diameter extending to the region of an external tapered valve seat **23** which inclines or converges in a downward and inward direction.

The lower inner tubular member **15** has an external or male thread **24** meshing with the internal thread **20**. The length of the threaded portion **24** of the inner member is substantially less than the length of the threaded portion **20** of the outer member **12**, the inner member having a portion **25** of smaller external diameter above its threaded portion **24** spaced inwardly from the inner thread **20** and wall **22** of the outer member, as well as inwardly of its cylindrical seat **21**. Above its reduced diameter portion **25**, the inner member has a valve head **26** of larger external diameter conforming to the diameter of the cylindrical seat **21** and adapted to sealingly engage such seat. To prevent leakage between the head **26** and seat **21** when these parts are coengaged, the head has a suitable side seal ring **27**, such as a rubber or rubber-like O ring, disposed in a peripheral groove **28** and sealingly engaging against the cylindrical seat **21**. The head **26** also has an internal tapered surface **29** conforming to the taper of the valve seat **23** of the outer member **12** and adapted to engage such valve seat. To assure leakproof engagement between the parts, a coating **30** of a relatively soft metal, such as bronze, is provided on the tapered head portion **29**, which may be, for example, 1/16 of an inch thick. This coating **30** may be formed slightly convex, to assure its contact with the tapered seat **23** at a higher unit pressure, thereby assuring leakproof engagement between the head **26** and tapered seat **23**.

The valve head **26** has a downwardly facing shoulder **31** disposed above a stop member **32**, such as a stop screw threaded radially in the outer member **12** with its inner portion disposed under the head. Such stop screw **32** limits the downward threading of the inner tubular member **15** within the outer tubular member **12** and is engaged by the head shoulder **31** to insure the disposition of the head **26** and its seal ring **27** within the cylindrical seat **21** in order to close the side ports **19** and prevent the passage of fluid between the interior and exterior of the collar through such ports. Initially, the parts are retained in the position closing the ports by one or a plurality of shear screws **33** threaded in the outer member **12** and into the valve head **26** of the inner member. If desired, in assembling the inner and outer members, the inner member **15** may be inserted upwardly into the outer member **12** and then threaded thereinto with the valve head **26** and seal ring **27** in appropriate engagement with the cylindrical seat **21**, after which the stop screw **32** is threaded in the

outer member and disposed under the stop shoulder **31**. The inner member **15** may be unthreaded slightly relative to the outer member **12** until the shoulder **31** engages the stop screw **32**, whereupon the hole for the shear screw may be drilled and tapped, after which the shear screw **33** is inserted in place. To facilitate relative threading between the inner and outer members **15, 12**, bleeder ports **35** may be provided in the outer member below the side ports **19** and immediately above the threaded portion **24** of the inner member when the parts are in their initial position (FIG. 1).

In the use of the apparatus A, its parts initially occupy the positions illustrated in FIG. 1, in which the side ports **19** are closed, the valve head **26** and seal **27** being in engagement with the cylindrical seat **21**, the stop screw **32** being disposed below the shoulder **31**, with the shear screw **33** in place. The tubular string B with the collar A in its appropriate location along the length of the string is lowered in the well bore C to the desired depth. The well bore may be appropriately conditioned by circulating fluid down through the tubular string B and upwardly around the annulus D between the tubular string and wall of the well bore. If a lower stage of cementing is to be performed, the desired quantity of cement slurry is pumped down through the tubular string B and through the collar A, discharging at a lower point of the collar, such as from a lower shoe (not shown), the cement slurry rising in the annulus D to the location of the cementing collar A.

After the cement deposited in the annulus around the lower portion **11** of the tubular string has had sufficient time to set, right-hand torque is imposed on the upper portion **10** of the tubular string. The set cement will prevent turning of the lower portion of the tubular string and of the lower inner tubular member **15**, so that the application of sufficient right-hand torque to the upper portion **10** of the tubular string and the outer tubular member **12** will shear the screw or screws **33** and will then cause the outer tubular member **12** to thread downwardly along the inner member **15** to a position opening the side ports **19**, in which th cylindrical seat **21** is moved downwardly from engagement with the head **26**. In a specific stage cementing collar that has been used, about three revolutions of the tubular string B and outer tubular member **12** are necessary to shift the outer tubular member **12** downwardly along the inner tubular member **15**, or to the port opening position illustrated in FIG. 2.

A sufficient quantity of cement slurry for performing the upper or second stage of cementing is now pumped down the tubular string B. Such cement slurry will pass laterally around the valve head **26** of the inner member and into the annular space between the valve head **26** and the outer member **12**, flowing downwardly through such annular space and out through the open side ports **19** into the annulus D surrounding the tubular string, passing upwardly therethrough to the desired height. After substantially all of the cement slurry has been pumped out through the collar A, right-hand rotation of the upper portion **10** of the tubular string B and the outer member **12** is recommenced, which causes the outer tubular member **12** to feed downwardly of the inner member **15** to a further extent until the tapered valve seat **23** engages the metal sealing coated **30** on the tapered portion **29** of the valve head **26**. When this occurs, the side ports **19** are closed and a metal-to-metal seal is secured between the inner and outer members **15, 12**, precluding leakage therebetween.

With the parts in the position disclosed in FIG. 3, the collar ports **19** are closed and, ordinarily, such closed condition will be a permanent one. With the ports reclosed as shown in FIG. 3, the interior of the collar A is flush, as evidenced by the lack of any material gap between the inner and outer members **15, 12** when the valve head **26** engages the tapered seat **23**. Accordingly, no space or gap exists into which other equipment subsequently lowered in the tubular string B might catch or hang up. The flush condition is achieved with an absence of any cementitious material within the collar A, or, for that matter, within the tubular string B above the collar, since appropriate measurements of the quantity of cement slurry displaced through the open ports **19** will insure that no cement slurry remains within the tubular string, requiring subsequent removal. The absence of cement within the tubular string is of importance, since it avoids the necessity for subsequently drilling out cement in the tubular string. Particularly where the tubular string B is of relatively small diameter, such as when it is composed of sections of tubing, it is difficult to drill such cement slurry out with the small size bits or cutters that must be used.

After the shear screw **33** has been disrupted, as the result of imposing torque on the tubular string B, the latter and the outer tubular member **12** might turn suddenly more than the desired number of revolutions, so that the condition of the collar is not definitely known with respect to the extent of opening of the ports **19** or their closing. Accordingly, after the shear screw has been disrupted, left-hand rotation is applied to the upper portion **10** of the tubular string B and the outer member **12** until the head shoulder **31** engages the stop element or screw **32**, which then assures the operator at the top of the well bore that the collar is in the port closing position shown in FIG. 1. Thereafter, the upper portion **10** of the tubular string and the outer tubular member **12** can be rotated the proper number of turns to place the parts in the position disclosed in FIG. 2 in which the side ports **19** are open. Rotation to the right is effected easily, inasmuch as the upper portion **10** of the tubular string and the outer tubular member **12** feed downwardly of the inner tubular member **15**. Similarly, rotation of the upper portion of the tubular string and of the outer tubular member to reclose the ports **19** is facilitated by the fact that the outer tubular member **12** moves downwardly along the inner tubular member **15** until the tapered seat **23** engages the metallic sealing material **30** at the upper end of the valve head **26** on the inner member. Sufficient torque is applied to insure the proper compression of such sealing material **30** against the tapered valve seat **23**, thereby avoiding leakage between the parts.

It is, accordingly, apparent that a relatively simple and economical stage cementing collar has been provided, which allows a comparatively inexpensive stage cementing operation to be performed in that it is not necessary to drill out any cement that might remain in the tubular string after the cementing job has been performed. The reclosing of the side ports with the apparatus illustrated results in a smooth and flush inside bore in the cementing collar through which other tools, such as swabs, can be run safely without fear of their hanging up or being damaged.

I claim:

1. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper tubular member; a lower tubular member; one of said members being disposed within the other of said members; means on said members for securing them to adjacent upper and lower sections of the tubular string; one of said members having a side port through which fluid may flow between the interior and exterior of said members; coengaging means on said members axially to one side of said port for closing said port when said members are in a relatively extended first position; coengaging means on said members axially on said one side of said port for closing said port when said members are in a relatively contracted second position; and means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and

rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position.

2. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port; a lower, inner tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; coengaging means on said members axially to one side of said port for closing said port when said members are in a relatively extended first position; coengaging means on said members axially on said one side of said port for closing said port when said members are in a relatively contracted second position; and means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position.

3. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper tubular member; a lower tubular member; one of said members being disposed within the other of said members; means on said members for securing them to adjacent upper and lower sections of the tubular string; one of said members having a side port through which fluid may flow between the interior and exterior of said members; one of said members having a pair of longitudinally spaced valve seats thereon to one side of said port; means on the other of said members engaging one of said valve seats when said members are in a relatively extended first position to close said port and engaging the other of said valve seats when said members are in a relatively contracted second position to close said port; and means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position.

4. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port; a lower, inner tubular member within said outer members; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a pair of longitudinally spaced valve seats thereon to one side of said port; means on said inner member engaging one of said valve seats when said members are in a relatively extended first position to close said port and engaging the other of said valve seats when said members are in a relatively contracted second position to close said port; and means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper, outer member by the tubular string relative to the lower, inner member feeds said upper member from said first position downwardly

of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position.

5. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper tubular member; a lower tubular member; one of said members being disposed within the other of said members; means on said members for securing them to adjacent upper and lower sections of the tubular string; one of said members having a side port through which fluid may flow between the interior and exterior of said members; coengaging means on said members axially to one side of said port for closing said port when said members are in a relatively extended first position; coengaging means on said members axially on said one side of said port for closing said port when said members are in a relatively contracted second position; means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position; and coengageable stop means on said members limiting the extent of upward threaded movement of said upper member along said lower member beyond said first position.

6. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port; a lower, inner tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; coengaging means on said members axially to one side of said port for closing said port when said members are in a relatively extended first position; coengaging means on said members axially on said one side of said port for closing said port when said members are in a relatively contracted second position; means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position; and coengageable stop means on said members limiting the extent of upward threaded movement of said outer member along said inner member beyond said first position.

7. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port; a lower, inner tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a pair of longitudinally spaced valve seats thereon to one side of said port; means on said inner member engaging one of said valve seats when said members are in a relatively extended first position to close said port and engaging the other of said valve seats when said members are in a relatively contracted second position to close said

port; means on the other side of said port threadedly interconnecting said tubular members, whereby rotation of said upper, outer member by the tubular string relative to the lower, inner member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position; and coengageable stop means on said members limiting the extent of upward threaded movement of said upper member along said lower member beyond said first position.

8. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an outer tubular member; an inner tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a port and a first cylindrical valve seat to one side of said port, said outer member having a second valve seat longitudinally spaced from said first valve seat and on said one side of said port; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat for closing said port when said members are in a relatively contracted second position; one of said members being an upper member and the other of said members a lower member; and means on the opposite side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position.

9. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port; a lower tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a first cylindrical valve seat above said port and a second valve seat above and longitudinally spaced from said first valve seat; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat when said members are in a relatively contracted second position to close said port; and means below said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position.

10. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an outer tubular member; an inner tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a port and a first cylindrical valve seat to one side of said port, said outer member having a second valve seat longitudinally spaced from said first valve seat and on said one side of said port; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat for closing said port when said members are in a relatively contracted second position; one of said members being an upper member and the other of said members a lower member; means on the opposite side of said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position; and coengageable stop means on said members limiting the extent of upward threaded movement of said upper member along said lower member beyond said first position.

11. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port; a lower tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a first cylindrical valve seat above said port and a second valve seat above and longitudinally spaced from said first valve seat; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat when said members are in a relatively contracted second position to close said port; means below said port threadedly interconnecting said tubular members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said interconnecting means threadedly securing said tubular members to each other with said members in said first position, port opening position and second position; and coengageable stop means on said members limiting the extent of upward threaded movement of said outer member along said inner member beyond said first position.

12. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an outer tubular member having a side port and an internally threaded portion to one side of said port, said outer member also having a first cylindrical valve seat on the opposite side of said port and a second valve seat on said opposite side of said port longitudinally spaced from said first valve seat; an inner tubular member within said outer member; one of said members being an upper member and the other of said members a lower member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second seat when said members are in a relatively contracted second position to close said port; said inner member having an external thread meshing with said internal thread to interconnect said members, whereby rotation of said upper member by the tubular string relative to said lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of

said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said internal and external threads being in threaded mesh with each other to secure said tubular members to each other with said members in said first position, port opening position, and second position; said valve head having a lesser diameter than the internal diameter of said internally threaded portion to permit insertion of said valve head through said internally threaded portion into engagement with said first cylindrical valve seat.

13. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an outer tubular member having a side port and an internally threaded portion to one side of said port, said outer member also having a first cylindrical valve seat on the opposite side of said port and a second valve seat on said opposite side of said port longitudinally spaced from said first valve seat; an inner tubular member within said outer member; one of said members being an upper member and the other of said members a lower member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second seat when said members are in a relatively contracted second position to close said port; said inner member having an external thread meshing with said internal thread to interconnect said members, whereby rotation of said upper member by the tubular string relative to said lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second postion; said internal and external threads being in threaded mesh with each other to secure said tubular members to each other with said members in said first position, port opening position, and second position; said valve head having a lesser diameter than the internal diameter of said internally threaded portion to permit insertion of said valve head through said internally threaded portion into engagement with said first cylindrical valve seat; said inner member between its valve head and external thread having a lesser external diameter than the external diameter of said head to permit fluid to flow between said first cylindrical seat and inner member and into said port when said members are in port opening position.

14. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port and an internally threaded portion below said port; a lower tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a first cylindrical valve seat above said port and a second valve seat above and longitudinally spaced from said first valve seat; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat when said members are in a relatively contracted second position to close said port; said inner member having an external thread below said head meshing with said internal thread to interconnect said members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said external and internal threads being in mesh to secure said tubular members to each other with said members in said first position, port opening position, and second position; said valve head having a lesser diameter than the internal diameter of said internally threaded portion to permit insertion of said valve head through said internally threaded portion into engagement with said first cylindrical valve seat.

15. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port and an internally threaded portion below said port; a lower tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a first cylindrical valve seat above said port and a second valve seat above and longitudinally spaced from said first valve seat; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat when said members are in a relatively contracted second position to close said port; said inner member having an external thread below said head meshing with said internal thread to interconnect said members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said external and internal threads being in mesh to secure said tubular members to each other with said members in said first position, port opening position, and second position; said valve head having a lesser diameter than the internal diameter of said internally threaded portion to permit insertion of said valve head through said internally threaded portion into engagement with said first cylindrical valve seat; said inner member between its valve head and external thread having a lesser external diameter than the external diameter of said head to permit fluid to flow between said first cylindrical seat and inner member and into said port when said members are in port opening position.

16. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port and an internally threaded portion below said port; a lower tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a first cylindrical valve seat above said port and a second valve seat above and longitudinally spaced from said first valve seat; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat when said members are in a relatively contracted second position to close said port; said inner member having an external thread below said head meshing with said internal thread to interconnect said members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said external and internal threads being in mesh to secure said tubular members to each other with said members in said first position, port opening position, and second position; said valve head having a lesser diameter than the internal diameter of said internally threaded portion to permit insertion of said valve head through said internally threaded portion into engagement with said first cylindrical valve seat; and stop means on said outer mem-

ber engageable by the lower end of said valve head when said valve head engages said first seat.

17. In apparatus for incorporation in a tubular string adapted to be disposed in a well bore: an upper, outer tubular member having a side port and an internally threaded portion below said port; a lower tubular member within said outer member; means on said members for securing them to adjacent upper and lower sections of the tubular string; said outer member having a first cylindrical valve seat above said port and a second valve seat above and longitudinally spaced from said first valve seat; said inner member having a valve head engaging said first seat when said members are in a relatively extended first position to close said port and engaging said second valve seat when said members are in a relatively contracted second position to close said port; said inner member having an external thread below said head meshing with said internal thread to interconnect said members, whereby rotation of said upper member by the tubular string relative to the lower member feeds said upper member from said first position downwardly of said lower member to a position opening said port and rotation of said upper member by the tubular string relative to said lower member then feeds said upper member downwardly of said lower member from said port opening position to said second position; said external and internal threads

being in mesh to secure said tubular members to each other with said members in said first position, port opening position, and second position; said valve head having a lesser diameter than the internal diameter of said internally threaded portion to permit insertion of said valve head through said internally threaded portion into engagement with said first cylindrical valve seat; said inner member between its valve head and external thread having a lesser external diameter than the external diameter of said head to permit fluid to flow between said first cylindrical seat and inner member and into said port when said members are in port opening position; and stop means on said outer member engageable by the lower end of said valve head when said valve head engages said first seat.

References Cited by the Examiner

UNITED STATES PATENTS

2,196,664	4/40	Kofahl	251—347 XR
2,214,555	9/40	Hayward	251—343
2,275,938	3/42	Baker	251—347 XR
2,509,470	5/50	Baker	251—341 XR
2,630,999	3/53	Lee	251—347 XR
2,631,000	3/53	Lee	251—343
2,663,307	12/53	Birdwell	251—343 XR

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