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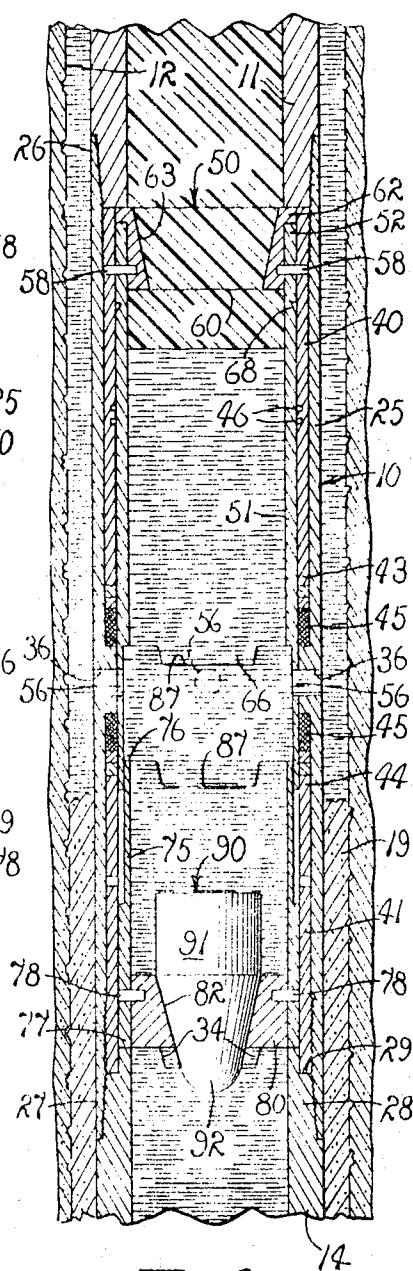
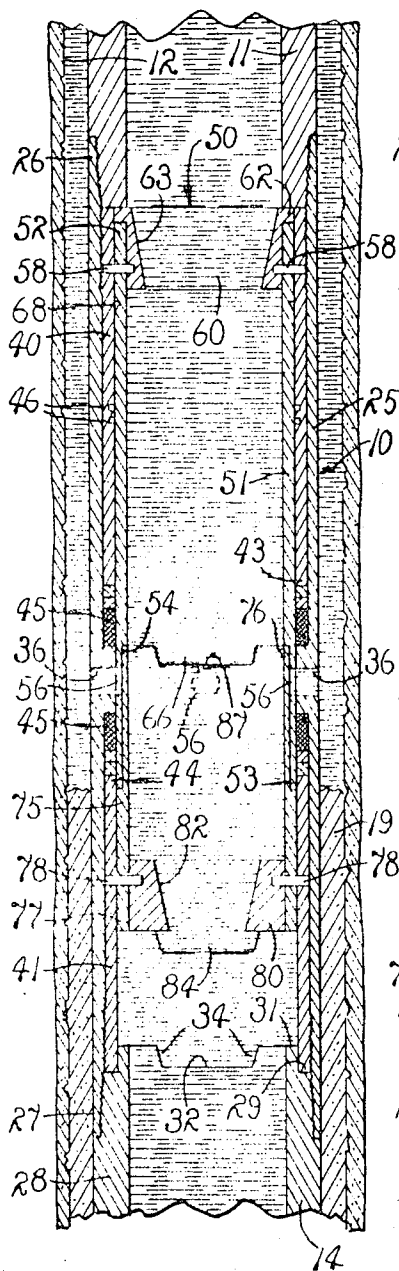
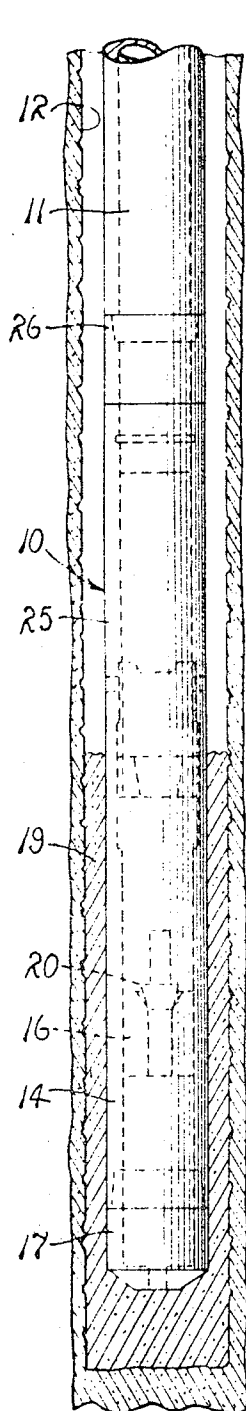
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3,464,493

PORT COLLAR FOR WELL CASINGS AND METHOD FOR PACKING WELL BORES

Filed Dec. 26, 1967

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

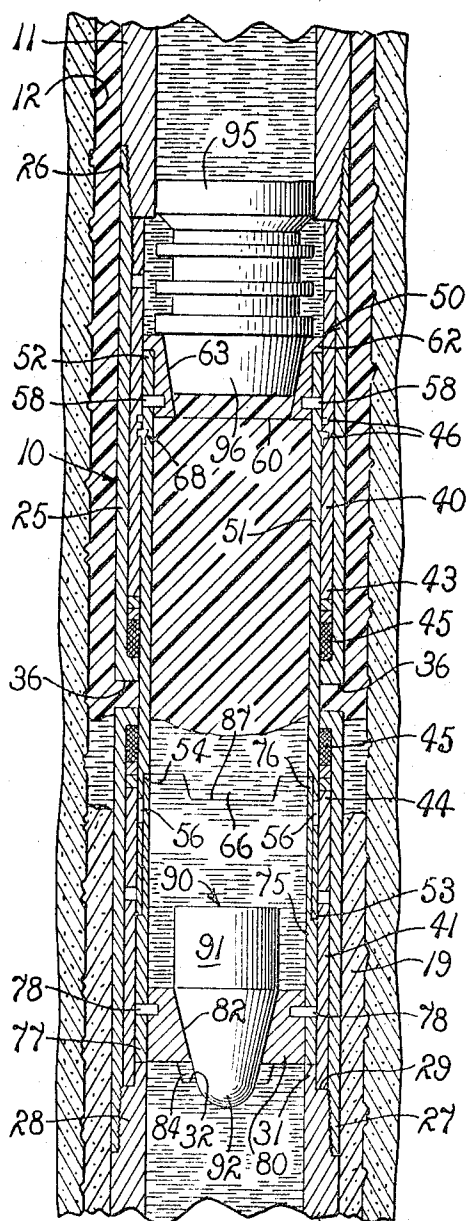
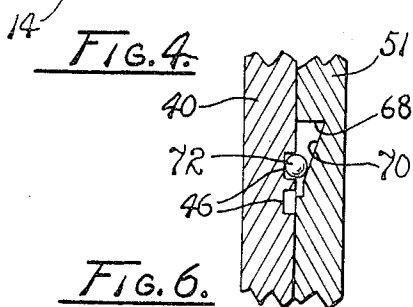
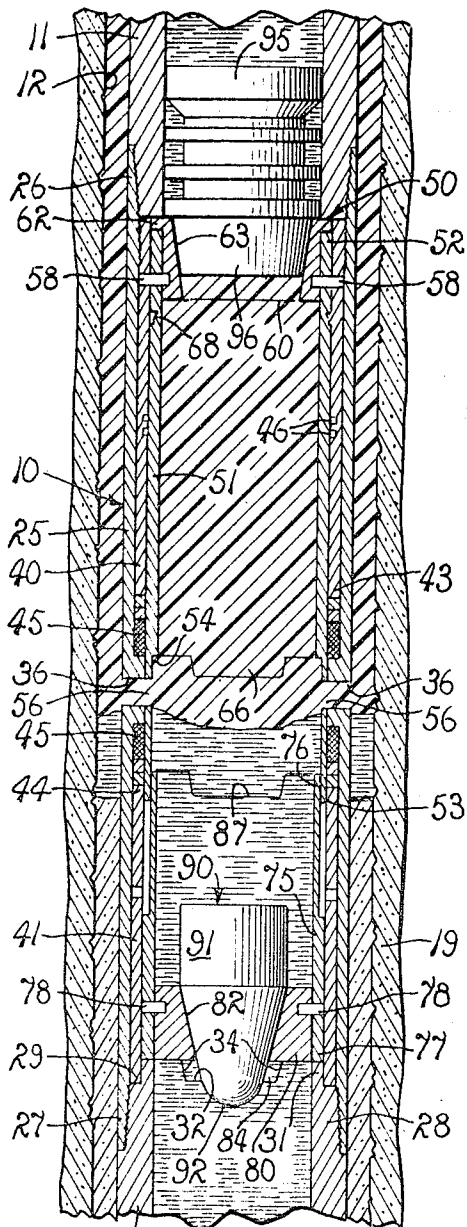


FIG. 5.

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PORT COLLAR FOR WELL CASINGS AND METHOD FOR PACKING WELL BORES

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7 Claims

ABSTRACT OF THE DISCLOSURE

A port collar for a well casing string and method for discharging packing material under pressure into the well bore about the casing with the collar providing a cylindrical body disposed coaxially within the casing string which includes a valve mechanism to communicate the interior of the casing with the well bore, and valve actuating means insertable into the casing for gravitational descent and engagement with said valve means hydraulically successively to open and to block communication between the interior of the casing and the well bore without any mechanical connection between the collar and the surface of the well.

Background of the invention

Oil wells frequently extend several thousand feet below the surface of the earth and have an elongated tubular casing string disposed therein for housing and guiding the usual production equipment for recovering and directing the oil from the well. In many wells, the bore and casing pass through a water or other contaminant containing strata intermediate the surface and the bottom of the well. In order to insure a high-grade product, the contaminant containing strata must be sealed off by packing the well bore around the casing adjacent to said objectionable strata. This is conventionally accomplished by disposing a packing discharge collar, commonly known in the oil well trade as a "port collar" or "stage collar," between the predetermined sections of the casing downwardly adjacent to the water bearing strata to be sealed from the bore. The stage collar has a plurality of openings and a mechanically actuated valve mechanism which is initially installed with the valve mechanism closing the openings to permit the completion of a preliminary cementing operation around the bottom of the casing which is commonly known as a stub cementing operation and which, in some areas such as the state of California, is required by law. The stub operation is accomplished by forcing a predetermined amount of fluid cement downwardly through the casing with the cement being followed by a non-hardenable drilling mud under pressure to force the cement past the closed openings of the stage collar and out the lower end of the casing for movement upwardly into the well bore around the casing. The amount of cement forming the stub is pre-calculated so as to extend upwardly within the bore to a position terminating just short of the stage collar. A drill tubing string is then introduced into the casing which carries a setting tool mechanically to engage the valve mechanism of the stage collar to actuate the same for opening the ports in the collar to communicate the interior of the casing with the bore. In some instances, however, an excess of cement is pumped into the well bore during the stubbing operation which covers the ports in the collar and which begins to harden before the drill string can be inserted into the casing to actuate the valve mechanism in the collar.

Even if the amount of cement is such that the level is below the collar within the bore, and since the stage collar

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may be disposed several thousand feet below the surface, it is difficult for an operator at the surface precisely to determine when the connection is effected between the setting tool and the valve mechanism. Ordinarily, such valve mechanisms have left-handed screw threads which, during rotation of the drill string, frequently results in loosening of the individual sections of the casing having right-handed screw threaded connections. Such problem is aggravated in slanted well bores where it is impossible to maintain the drill string in centered relation within the casing wherein a substantial amount of frictional drag is imposed by the walls of the casing to resist rotation of the drill string.

If the drill string and setting tool is successful in opening the port collar, an additional charge of cement is forced down the drill string tubing for discharge through the stage collar to complete the packing operation to seal off the adjacent water bearing strata surrounding the well bore. The drill tubing is necessarily formed of a smaller diameter than the casing which imposes a substantially greater restriction to the passage of a fluid cement than the larger diameter casing string. This results in a relatively slow displacement of the fluid cement through the stage collar with a substantially higher pressure exerted against the stage collar and adjacent sections of the casing. Such pressures have been known to exceed fifteen hundred pounds per square inch which frequently causes the collar to rupture and permits the leakage of production fluid outwardly from the casing into the well bore.

This presents a particularly onerous problem when the well is subsequently subjected to any of the well-known thermal treating processes for the secondary recovery of high viscous oil deposits from the well. Furthermore, such cementing of the casing rigidly constrains the casing against any expansion or contraction which usually occurs during such thermal recovery operations. This, of course, results in splitting or complete separation of the individual sections of the casing permitting not only the thermal treating fluids to leak outwardly through the walls of the casing, but also subsequent leakage of production fluid as well.

Summary of the invention

Accordingly, it is an object of the present invention to provide an improved port collar for well casings.

Another object is to provide such an improved port collar through which a fluid packing material can be discharged at relatively low pressures.

Another object is to provide an improved port collar which has a valve mechanism that imposes no measurable restriction within the casing and which is able to utilize the entire inside diameter of the casing for supplying fluid packing material to the well bore.

Another object is to provide an improved port collar in which the valve mechanism is completely hydraulically actuated without any mechanical connection with the surface of the well.

Another object is to provide a port collar wherein the valve mechanism is dependably closed and permanently locked in its closed position subsequent to the bore packing operation to preclude any leakage therethrough of production fluid and the carrier fluids utilized during thermal well operations.

Another object is to provide a port collar which is substantially completely removable by drilling to conform the collar to the inside diameter of the casing so as to present no impediment of the passage of production equipment downwardly within the casing.

Other objects and advantages of the present invention will subsequently become more clearly apparent upon reference to the following description and accompanying drawings.

Brief description of the drawings

FIG. 1 is a fragmentary transverse vertical section through a well bore having a casing disposed therein and providing a port collar embodying the principles of the present invention disposed between adjacent sections of the casing and showing the lower end of the casing conditioned by a preliminary cement stubbing operation.

FIG. 2 is a somewhat enlarged transverse vertical section through the casing and port collar with a valve mechanism within the collar disposed in a position blocking the ports through the collar.

FIG. 3 is a transverse vertical section through the casing and port collar showing a valve actuating member engaged with the valve mechanism and shifting the same to a position opening the ports through the collar.

FIG. 4 is a transverse vertical section through the casing and port collar showing a top plug disposed within the casing to force the well bore packing material outwardly through the ports in the collar.

FIG. 5 is a transverse vertical section through the casing and the port collar with the top plug engaged with the valve mechanism and shifting the same to a position closing the ports and permanently locking the valve mechanism in such position.

FIG. 6 is a somewhat enlarged fragmentary section through the valve mechanism and port collar showing the locking device for constraining the valve mechanism in its port blocking position.

Description of the preferred embodiment

Referring more particularly to the drawings, a port collar 10 embodying the principles of the present invention is disposed coaxially within a well casing string 11 for inserting into a well bore 12. As best shown in FIG. 1, the casing has a lower section 14 disposed in closely spaced relation to the bottom of the well bore. The lower section includes a valve mechanism shown in dotted lines having a float collar indicated by the reference numeral 16, and a fluid discharge shoe indicated by the reference numeral 17 which are both of conventional construction and form no part of the present invention. Such structure is only shown in order briefly to describe the preliminary cement stubbing operation which consists of directing fluid cement outwardly of the lower end of the casing to form the column of cement within the space between the casing and the well bore indicated by the reference numeral 19. This is accomplished by a tool commonly called a flex plug 20 which is shown in dotted lines engaging the float collar 16, which operation will be more fully described hereinafter.

The port collar 10 of the present invention provides an elongated cylindrical body 25 having predetermined upper and lower internally screw-threaded ends 26 and 27, respectively. The body is screw-threadably connected at its ends between adjacent sections of the casing with the casing adjacent to the lower end of the body having a specially formed connector 28. The connector has an external annular shoulder 29 which forms an upwardly endwardly extended flange 31. A pair of diametrically opposed valve locking notches, one of which is indicated by the numeral 32, are formed in the flange and individually provide angularly outwardly diverging sloped sides 34.

The body 25 has a plurality of circumferentially spaced ports 36 extended radially through the wall of the body substantially midway between its ends. A pair of opposite predetermined upper and lower seal retaining liners 40 and 41, respectively, are press fitted into the body adjacent to their corresponding ends of the body with the sleeves including respective inner ends 43 and 44 spaced a predetermined distance on opposite sides of the ports 36. A seal and compression ring assembly 45 is disposed within the body in the space between each of the ends of the sleeves and the ports. A pair of axially closely spaced

annular valve locking grooves 46 are formed within the inner periphery of the upper liner substantially intermediate its ends.

A valve mechanism for opening and closing the ports 36 is disposed within the body and is generally indicated by the reference numeral 50. The valve mechanism has an elongated tubular upper sleeve 51 having opposite upper and lower ends 52 and 53, respectively, with the lower end including a counterbore 54. A plurality of ports 56 are formed through the lower end of the upper sleeve in circumferentially spaced correspondingly aligned relation to the ports 36 in the body 25. The upper valve sleeve is initially constrained in such position by a plurality of circumferentially spaced shear pins 58 extended through the wall of the upper body liner 40. An annular upper valve seat 60 is press fitted into the upper end 52 of the upper valve sleeve and includes an upper annular flange 62 abutting the upper end of the upper sleeve. The valve seat includes a downwardly tapering bore 63 concentric with the valve sleeve and providing a diameter somewhat less than the diameter of the casing 11. A pair of diametrically opposed tapered locking teeth 66 are formed within the upper end of the counterbore 54 immediately above the ports 56. An annular locking groove 68 is formed in the outer periphery of the upper sleeve closely adjacent to the seat 60. As best shown in FIG. 6, the groove has an inwardly sloping annular ramp 70 with the groove containing a plurality of spherical balls 72 circumferentially of the sleeve in filling relation within the groove.

The valve mechanism 50 further includes a tubular lower valve sleeve 75 disposed adjacent to the lower end 27 of the body 25. The lower sleeve has a stepped upper end 76 of reduced diameter telescopically slidably received within the counterbore 54 of the upper valve sleeve 51. The lower valve sleeve includes a lower end 77 which is initially connected to the lower body liner 41 by a plurality of shear pins 78 extended therethrough. An annular lower valve seat 80 is disposed within the lower end of the lower valve sleeve in tightly press fitted relation and provides a downwardly tapered bore 82 of a diameter smaller than the diameter of the bore 63 in the upper valve seat 60. A pair of diametrically opposed tapered locking teeth 84 are downwardly extended from the lower end of the lower sleeve subsequently to intermesh with the notches 32 in the connector 28. The upper end of the lower valve sleeve further includes diametrically opposed tapered locking notches 87 initially intimately receiving the teeth 66 of the upper valve sleeve 51.

A valve actuating bomb 90 is provided, as shown in FIG. 3, for operation of the lower valve sleeve 75. The actuating device is constructed from a substantially cylindrical hollow aluminum container 91 having a lower frusto-conical end 92 filled with a plurality of lead weights, not shown. An upper valve sleeve actuating top plug 95 is shown in FIGS. 4 and 5 having a lower frusto-conical end 96 engageable with the tapered bore 63 of the upper valve seat 60.

Operation

The operation of the described embodiment of the subject invention is believed to be clearly apparent and is briefly summarized at this point. As previously described, the port collar 10 of the present invention is installed within the casing string 11 with the valve mechanism 50 disposed in the position shown in FIG. 2 with the lower valve sleeve 75 blocking the ports 36 and 56 in order to insure against leakage of fluid cement during the preliminary cement stubbing operation. Such stubbing operation is shown completed in FIG. 1 with the column of cement 19 forming a retaining stub around the lower casing section 14. Such operation is accomplished by forcing the flex plug 20 downwardly through the casing string 11 by pumping drilling mud into the casing behind the flex plug. This forces a previously deposited fluid cement charge downwardly through the float collar 16

and the shoe 17. The cement is discharged outwardly through the bottom end of the casing and upwardly into the well bore to a position terminating short of the ports 56 in the port collar upon engagement of the flex plug with the float collar.

The valve actuating bomb 90 is dropped into the casing for free gravitational descent through the drilling mud to the position shown in FIG. 3 within the port collar 10. The bomb is of a diameter which is permitted freely to pass through the bore 63 of the upper valve seat 60 during its passage downwardly through the collar ultimately to engage the lower valve seat 80. The lower frusto-conical end 92 of the bomb is received within the tapered bore 82 in intimate sealing relation. Upon such setting of the bomb, an increase in the pressure of the drilling mud is developed upwardly within the casing which pressure is imposed against the lower sleeve through the bomb sufficiently to shear the pins 78. Consequently, the lower sleeve is forced downwardly within the lower body liner 41 relative to the body 25 to uncover the ports 36 and 56. Such sliding movement continues until the teeth 84 on the lower end of the lower valve sleeve are received within the notches 32 of the connector 28. The drilling mud within the casing is circulated through the ports and upwardly through the well bore 12 around the casing to flush out any cement particles or other extraneous material and to convey the same outwardly from the well bore at the surface.

A charge of a thermoplastic packing material is introduced into the casing 11 and is forced downwardly through the port collar 10 and upwardly within the well bore 12 to displace the drilling mud previously utilized in the flushing operation. Several suitable forms of packing material are commercially available such as the material sold under the name "Ken Pack" by the I. M. C. Chemical Co. As soon as the packing material reaches the surface, the packing operation is terminated with the assurance that the well bore is completely filled. It is noted that the packing material is of the type that hardens sufficiently to provide an effective seal against the ingress of water and other fluid contaminants into the well bore but which is thermoplastic to accommodate expansion and contraction of the casing incident to thermal well operations. The packing material is initially forced downwardly through the casing by the top plug 95 which is followed by a charge of drilling mud to force the plug downwardly through the casing until the lower end 96 of the plug sealably engages the bore 63 of the upper valve seat 60 of the port collar. Upon such engagement, the pressurized drilling mud above the plug is sufficient to shear the pins 58 and to force the upper valve sleeve 51 to slide downwardly within the upper body liner 40 so as axially to displace the ports 56 and to cover the ports 36 in the body thereby effectively to block communication between the interior of the casing and the well bore.

Such sliding movement continues until the upper sleeve 51 abuts the lower sleeve 75 with the locking teeth 66 disposed within the notches 87. Such continued movement causes a substantial increase in pressure in the mud above the top plug after the ports 36 are closed during compression of the material trapped within the collar. This has the beneficial effect of providing an accurate signal to the operator at the surface that the ports are closed. Such high pressure is maintained until the groove 68 in the upper sleeve is aligned with one of the locking grooves 46 in the body liner 40 to permit gravitational descent of the balls 72 along the ramp 70 and radially outwardly into the locking groove 46. It will be apparent that the lower constricted end of the groove 68 effectively precludes return upward movement of the upper valve sleeve and permanently locks the sleeve in its port blocking position.

The well is then prepared for the introduction of production equipment downwardly through the casing by drilling through the top plug 95, the upper valve seat 60,

the bomb 90 and the lower valve seat 80 so that the casing string is of uniform diameter completely through the port collar. It is noted that during such drilling operation, the upper and lower valve sleeves are constrained against rotation by the interfitting tooth and notch connections between their adjacent ends and between the lower end of the lower sleeve and the connector 28.

In view of the foregoing, it is readily apparent that the structure of the present invention provides an improved port collar for a well casing which is able to utilize the full diameter of the casing to minimize the development of excessive pressures experienced by conventional mechanically operated port collars. The valve mechanism of the port collar is positively hydraulically actuated with the operator being assured that the ports are fully opened during the packing operation and upon completion are dependably and permanently closed to preclude any leakage through the casing during production operations. The overlapping relationship between the valve sleeves provides an improved permanent barrier against the high pressures and temperatures encountered during thermal well operations which frequently approach 2000 lbs. per sq. in. and 750° F., respectively.

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and apparatus.

Having described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A port collar, for a well casing string adapted to transport a predetermined amount of packing material under pressure into a well bore about the casing prior to completion of the well, comprising an elongated body disposed coaxially between predetermined sections of the casing string and having a plurality of spaced ports extended therethrough; valve means within the body providing a pair of predetermined upper and lower slidably overlapping members, said upper member providing a plurality of ports initially aligned with said ports in the body and said lower member initially covering said ports in the upper member to block communication between the interior of the casing and the well bore; and valve actuating means selectively engageable with said valve means successively to slide said lower member to a position opening the ports to permit the flow of said packing material therethrough into the well bore and subsequently sliding said upper member to a position covering the ports in the body when said packing operation is completed with said upper and lower members being continually disposed in said overlapping relation throughout their full range of sliding movement.

2. The port collar of claim 1 wherein said body is cylindrical, and said upper and lower members comprise elongated tubular sleeves providing axially slidable, continuously telescopically related adjacent ends for individual movement in successively opening and closing relation to said ports in the body.

3. A port collar, for a well casing string adapted to transport a predetermined amount of packing material under pressure into the well bore about the casing prior to completion of the well, comprising an elongated cylindrical body having predetermined upper and lower ends disposed coaxially between predetermined sections of the casing string and including a plurality of circumferentially spaced ports communicating the interior of the body and the casing with the well bore; valve means within the body providing a pair of predetermined upper and lower tubular sleeves having telescopically related adjacent ends, said upper sleeve providing a plurality of ports initially aligned with said ports in the body and providing an internal annular seat of a predetermined diameter adjacent to the upper end of the body, said

lower sleeve providing an internal annular seat of a diameter smaller than the diameter of the seat of said upper sleeve and said adjacent end thereof being telescoped within said upper sleeve and initially disposed in covering relation to said ports in the upper sleeve to block communication between the interior thereof and the well bore; and valve actuating means providing a first weighted member adapted gravitationally to pass through said annular seat of said upper sleeve and to engage the seat of the lower sleeve to slide the lower sleeve downwardly within the body to a position opening the ports in the upper sleeve and the body to permit the flow of said packing material therethrough into the well bore but maintaining said telescopic relationship with said upper sleeve to insure precise concentric alignment of said upper and lower sleeves throughout their entire range of movement, and a second weighted member adapted gravitationally to descend within the casing string to engage the seat of said upper sleeve to slide the upper sleeve downwardly within the body toward said lower sleeve in covering relation to said ports in the body when said predetermined amount of packing material is discharged into the well bore.

4. A method of packing a well bore, for sealing off a water zone in the formation surrounding the bore and for permitting expansion and retraction of a casing string disposed within the bore incident to thermal fluctuations occurring in the well, comprising the steps of disposing a port collar between predetermined sections of the casing string, said port collar providing a plurality of ports communicating the interior of the casing with the well bore and including valve means providing a pair of upper and lower slidably overlapping members with the upper member having a plurality of ports aligned with the ports in the collar and with said lower member telescoped therein initially to cover said ports; dropping a valve actuating member downwardly through the casing for gravitational passage through the upper valve member and into sealing engagement with the lower valve member; pumping a predetermined volume of drilling mud downwardly through the casing under pressure against said actuating member to slide said lower valve member downwardly within the collar to open the ports through the upper valve member and the collar but maintaining said overlapping relationship with said upper member to insure precise concentric alignment of said upper and lower members throughout their entire range of movement; circulating said drilling mud through the casing, the collar ports and upwardly through the well bore in flushing relation to the well bore; pumping a predetermined volume of a viscous thermoplastic packing material downwardly within the casing, through said ports and upwardly through the well bore completely to displace said drilling mud; dropping a top plug into the casing for gravitational descent to a position sealably engaging the upper valve member; pumping drilling mud under pressure downwardly within the casing adjacent said top plug to slide said upper valve member downwardly in further overlapping relation to said lower valve member permanently closing said ports through the collar; and permitting said packing material to set within the well bore around the casing to seal off said water zone so as to preclude leakage into the well bore with the packing material accommodating expansion and contraction of the casing during said thermal fluctuations in the well without damage to the casing.

5. A port collar, for a well casing adapted to transport a predetermined amount of packing material under pressure into a well bore about the casing prior to completion of the well and adapted to withstand the relatively high pressures and temperatures developed within the casing during subsequent thermal well treatments and the like, comprising an elongated body disposed coaxially between predetermined sections of the casing string and having a plurality of circumferentially spaced ports extended therethrough; valve means within the body providing a pair of predetermined upper and lower axially slidable sleeves, said upper sleeve providing a plurality of ports initially aligned with said ports in the body and said lower sleeve being disposed telescopically within said upper sleeve in covering relation to said ports initially to block communication between the interior of the casing and the well bore; valve actuating means selectively engageable with said valve means successively to slide said lower sleeve to a position opening the ports to permit the flow of said packing material therethrough into the well bore with said sleeves maintaining their telescoped relation and said actuating means subsequently sliding said upper sleeve to a position covering the ports in the body; and seal means in the body on axially opposite sides of said ports continually sealably engaging said upper sleeve during its full range of movement with said telescoped sleeves and said seals continually providing a permanent barrier against said high pressures and temperatures encountered during subsequent thermal well operations.

6. The port collar of claim 5 in which said seal means comprises a plurality of relatively high pressure high temperature annular seal rings mounted in the body on axially opposite sides of the ports in circumscribing slidably sealing relation to said upper sleeve whereby the seal rings are continually covered by the upper sleeve during the entire packing operation and are never exposed to said packing material.

7. The port collar of claim 6 including lock means between said upper sleeve and the body comprising an annular locking groove in the upper sleeve providing an upper portion of a predetermined depth and an annular ramp sloping downwardly to a lower portion of a reduced depth, a plurality of spherical locking balls of a predetermined diameter disposed in annular filling relation to said upper portion of the locking groove, and at least one annular locking notch of a depth substantially less than the diameter of the balls formed in said body for constraining the balls radially outwardly from the upper sleeve between the lower portion of the groove and the notch when the upper sleeve is disposed in its lower port closing position to preclude return upward axial movement of the upper sleeve within the body.

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